February 2012

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TECHNICAL ARTICLES

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- An Introduction to Coupling Selection for Pump Applications (January 2012)
- Case Study: Fitted Shaft Flange Bolts Vital to Safety at Sea (January 2012)
- Motors Serving Many Masters (December 2011)

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- More OEMs Taking the Direct (Drive) Approach for Wind Turbines (January 2012)
- Machine Tool Upgrades—Then and Now (December 2011)

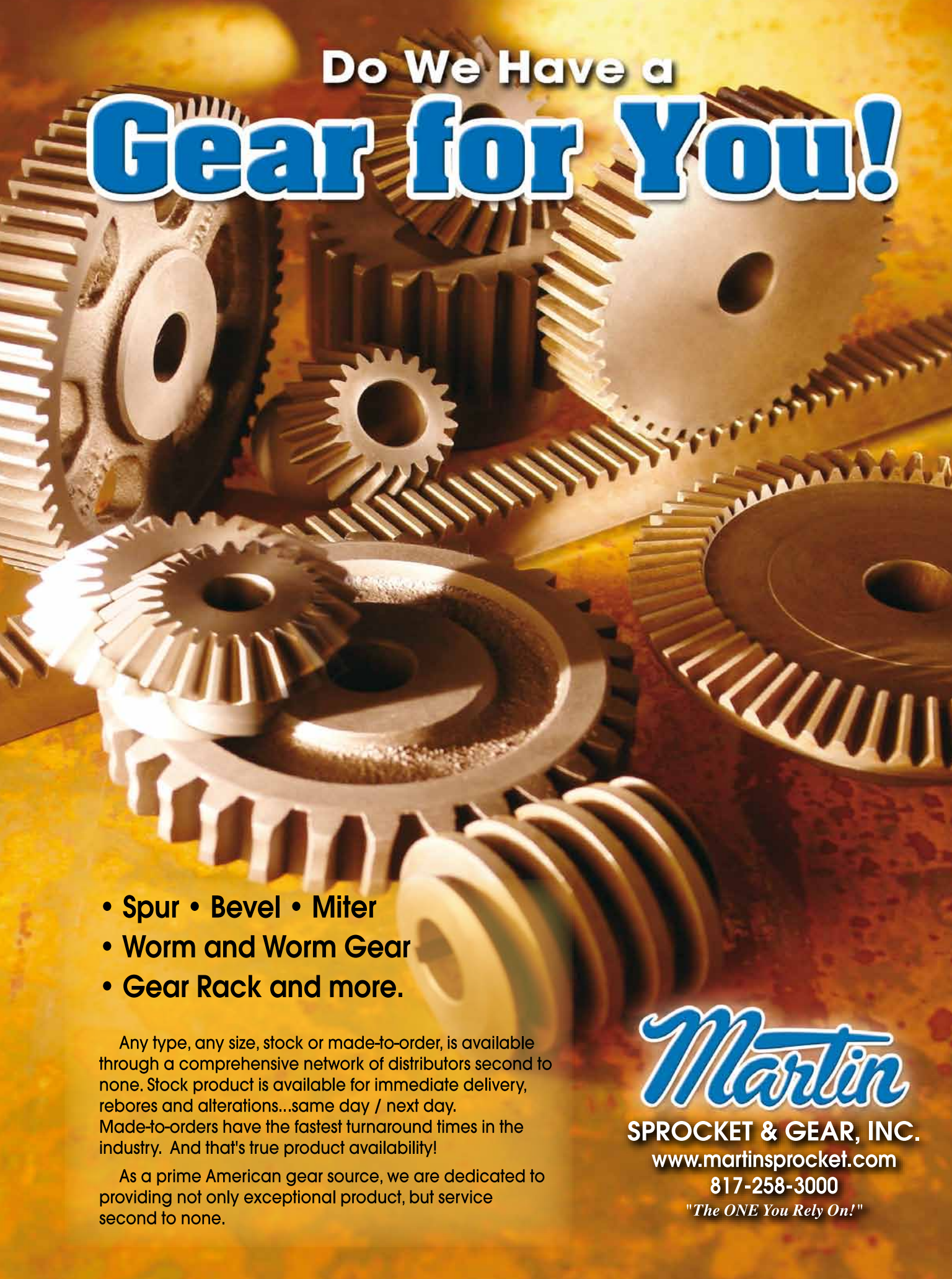
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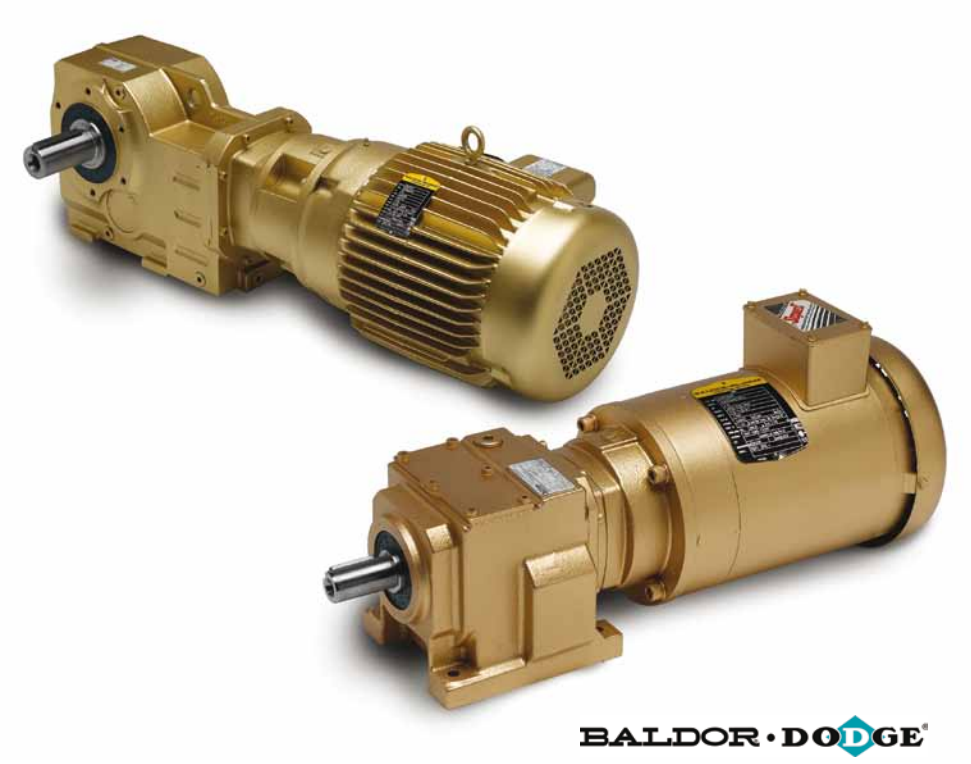
Photo by
David Ropinski

The New Gearmotor Gold Standard



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Free Energy for Sale... Are You Buying?

Every once in awhile I walk into a room at home and discover that someone has left the lights on. Sometimes it's the TV. Other times the stereo. I have four kids between the ages of nine and 16, so it happens more often than I'd like. It's not that they're bad kids, or that they're careless. In fact, if you spent any time with them, I'm sure you'd agree that they're smart, responsible and thoughtful.

But sometimes they get distracted. Occasionally, they need to be reminded of the impact of their decisions. Saving energy isn't always their first concern.

In some ways, they're a lot like engineers.

Of course, engineers have a lot more responsibility than just turning off the lights—and the distractions that keep them from focusing on saving energy aren't trivial. Very often, cost, timing and organizational momentum—that compulsion to continue doing things the way you've always done them—can be overpowering factors in the decision-making process. Budgets may be decided by people in business suits more concerned about the bottom line than saving the environment.

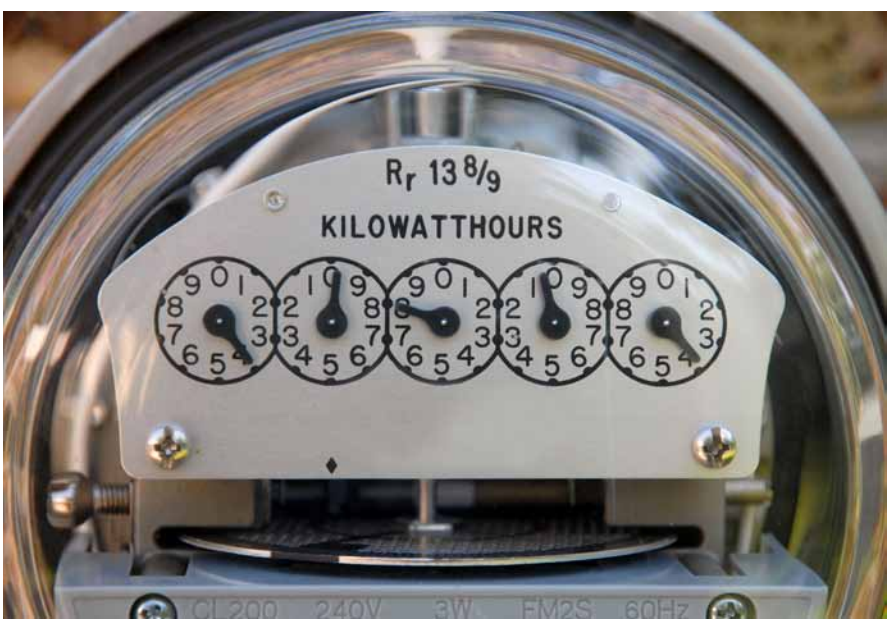
So maybe it's a little unfair to compare engineers to my children. But then again, maybe not. Engineers make a lot of decisions regarding the energy consumption of the machinery they design and operate. And one of the easiest ways to save energy is to use more energy efficient equipment. Improving energy efficiency should be an easy sell. Everyone knows it's in our best interest. Everyone knows it's the smart thing to do. After all, who wants to be wasteful?

Even at the highest levels of industry, business and government, energy efficiency is at the forefront of thinking. For example, President Barack Obama's 2012 State of the Union address was peppered with ideas about how energy efficiency can save money, create jobs and lead to energy independence. "The easiest way to save money is to waste less energy," he said. It's not exactly a controversial idea, either. Democrats, Republicans, Independents—everyone's jumped on that particular bandwagon. Even my kids agree that saving energy is a smart idea.

So what's stopping us?

In this issue, we've delved into the topic of energy efficiency with Matt Jaster's article on page 19. We've talked to several companies who are keenly interested in helping you make the most of the equipment you design or operate. They're experts in developing more efficient processes, recovering energy and upgrading systems. You might also be interested in reading William Gilbert's article on page 42, which examines ways to save energy in the drive systems of paper converting plants. If you're interested in making a difference with your designs or the machinery you operate, both articles are definitely worth a read.

I know—it's easy to continue doing what you've always done. Sometimes you have to convince some guy in a suit that it's the right thing to do. But if Democrats, Republicans and my kids can all agree, then it shouldn't be too hard to get everyone else on board, too.



Randy Stott,

Managing Editor

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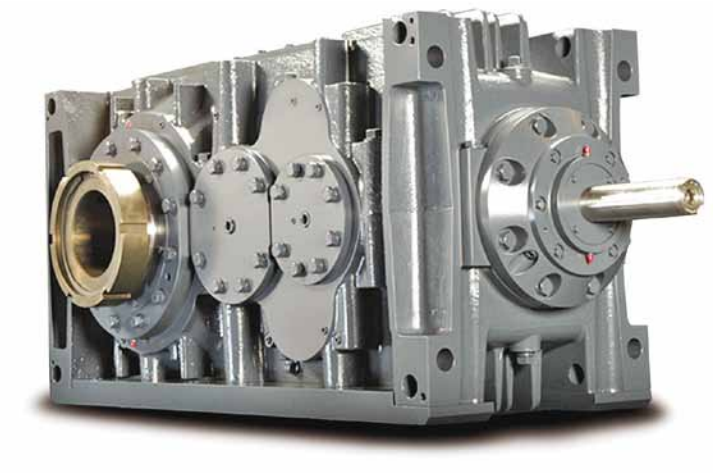
Rexnord's newest gear drive, the Falk V-Class™, is engineered to deliver power, durability and reliability under the toughest conditions. Its unprecedented design and test procedures mean longer seal life, improved thermal performance and increased operating life. The Falk V-Class gear drive provides shorter lead times, convenient serviceability and faster, easy access support.



REXNORD

And, you can find the Rexnord Falk V-Class at your local Motion Industries location. Our local sales and service specialists are experts in application and technical support, providing the parts and the know-how you need to stay up and running.

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ABB Ring-Geared Mill Drives:

SINGLE-AND DUAL-PINION

Introduction

The grinding process is a significant part of the ore winning process (the excavation, loading and removal of coal or ore from the ground; winning follows development). Selection of the drive solution for the mill has a direct impact on performance, flexibility of operation, total efficiency, reliability and the aging of the system.

As the size of mills driven by ring gears has increased, the requirements for soft, controlled starting and operation, optimized process control and increased efficiency have become more demanding.

ABB ring-geared mill drive solutions correspond to the latest technology and are designed for reliable, long life and low maintenance operation. Different configurations can be designed for single- and dual-pinion mills.

The most economical electrical capital expenditure is provided by ABB's high-speed solution—i.e., a combination of frequency converter and squirrel-cage induction motor.

Or, the ABB low-speed solution—including a frequency converter and brushless synchronous motor—eliminates the costly gearboxes of the high-speed solution.

Both solutions start with the motor directly coupled to the mill—thus eliminating the air clutch typically required for a fixed-speed solution. This allows a significant reduction in mechanical parts and maintenance, and improves total efficiency.

In designing a power supply and control center, you can integrate the power, control and ancillaries into your existing E-rooms, or go for a self-contained, pre-commissioned solution. The containerized E-house is fully air-conditioned and includes the power supply and control of the mill auxiliaries such as motor control center, PLC and visualization system.

Competence in grinding. ABB maintains a team of over 200 engineers for designing, installing and commissioning mill electrification and automation systems. ABB provides everything needed, from design to service and equipment support.

An ABB Solution

ABB ring-geared mill drive solutions offer a modular concept that provides a common drive control platform for induction and synchronous motors in single- and dual-pinion configurations. These drives are well-suited for all type of mills and ball mill applications, and are able to cover the power range up to the mechanical limit of the gearbox or the ring gear.

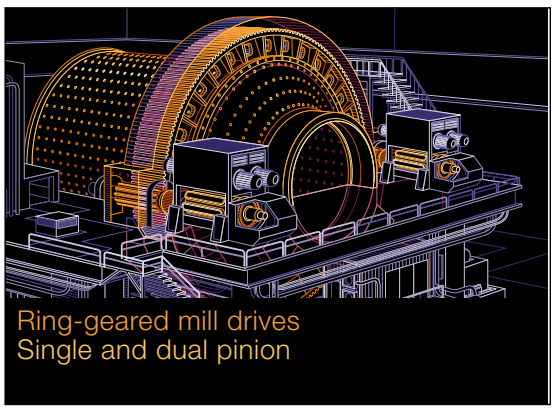
The solution provides adjustable speed for AG and SAG mills, or the opportunity to tune the speed of the ball mills for optimal grinding and maximum throughput, without the need to change any mechanical components (e.g., pinions).

Partial-load operation at any speed is possible; this ability means the grinding throughput can be matched to the up- and down-stream process requirements.

The availability of low operational speed allows filling and emptying of the mills during any process interruption, while still protecting the liners and minimizing their wear.

With the ABB solution, all inherent benefits and possibilities of using drives are available. In addition, the functionality required for grinding applications is implemented in the mill drive controller. This offers operational features such as frozen charge protection and remover, a smooth starting sequence, creeping speed, automatic positioning and controlled rollback without additional equipment such as auxiliary motors.

When dual-pinion mills are used, care must be taken that the load is shared equally between the two pinions. ABB's fast direct torque control (DTC) ensures accurate and coordinated load-sharing. DTC is the ABB advanced motor control method for drives as it allows precise control of the motor's torque and speed.



Ring-geared mill drives
Single and dual pinion

Because the drives show a very smooth starting behavior, with low starting currents, they are well-suited for weak networks. Furthermore, the power factor to the network is greater than 0.95 under all conditions. If an "active front end" is included, then the drive system can operate at unity or leading power factor to the network, as required.

ABB's ring-geared-mill-drive solution protects mechanics during normal operation and starting by limiting the torque and providing frozen charge protection. The mechanical stress on the ring gear is reduced due to the smooth

starting behavior. The precise torque control during all operating states of the mill does not generate significant torque pulsations, thus limiting backlash on the pinions and gearboxes.

Why ABB?

Mill control. The mill drive can be operated manually or remotely. The communication via serial bus contains command and alarm words to control and monitor the drive, as well as for specific functions such as frozen charge protection or operating modes such as inching and creeping.

A dedicated controller is used for the mill-specific programming via an internal, high-speed fiber optic link to achieve best performance. This enables accurate monitoring and control of the system, as well as precise load-sharing in case of dual-pinion mills, for example.

Remote diagnostic. Remote diagnostics can be done through a secure internet connection.

Frozen charge protection. ABB's dedicated mill control system features critical monitoring during the starting period, protecting the mill against damage when dropping a frozen charge.

Service mode. As the mill drive control has operating modes for creeping and positioning, these drives do not need additional equipment for performing maintenance work. Creeping speed can be used for slowly rotating the mill to perform a visual inspection or grinding out the mill. Fast and automatic positioning of the mill based on angle or liner reference reduces the downtime needed for changing liners.

Controlled rollback. The drive has a "controlled rollback" function for bringing the mill smoothly to a rest position where both speed and torque are zero; upon reaching the balance the drive switches off.

Ride-through function. Operation and starting at reduced voltage are possible, so the drive is designed to stay on-line as long as possible. The ride-through function transfers the energy of the rotating mass of the load into the DC link and keeps the drive on-line as long as the DC bus voltage stays above a minimum level. An uninterruptible power supply (UPS) is used to keep the drive control system alive, thereby allowing quick restart after a longer power failure.

For more information:

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Local Business Unit Minerals
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Phone: +(41) 58 586 84 44
Fax: +(41) 58 586 73 33
process.industries@ch.abb.com
www.abb.com/minerals

Air Pressure Series

SUPPORTS VARIETY OF FLOW MONITORING TASKS

The Precision Controls Division (PCD) of Marsh Bellofram Corporation has announced the global market introduction of the Type 41 high-performance air pressure regulator series, designed to support a variety of demanding industrial and OEM flow monitoring requirements. Available in two different packages with identical performance characteristics, both with ¼" NPT BSPT port size, design of the Type 41 incorporates the use of a patented Bellofram rolling diaphragm for greater sensitivity and improved accuracy, along with low-friction operation and extended useful service life, in a compact size. The rugged construction of the Type 41 further incorporates the use of precision die-cast aluminum housings, finished with scratch- and weather-re-

sistant vinyl paint, to increase resistance to harsh environmental conditions. In addition, units are pressure- and chromate-treated for internal corrosion resistance. A rubberized, soft-seat valve stem provides stability and "forgives" dirt and other foreign matter. An aspirator maintains downstream pressure and compensates for droop when high flow occurs. The gauge port is convenient for installation and can also be used as an additional full flow outlet. Users can select from among pipe, panel or bracket mounting options. The unique design and performance characteristics of the Marsh Bellofram Type 41 allow it to be used as a drop-in replacement for other manufacturers' models, particularly in applications where high flow capacity, low droop at high flow, repeatable accuracy, fine adjustment sensitivity or panel mounting may be required, and available installation space is limited. Typical applications include constant flow monitoring, low- or zero-flow monitoring, downstream flow, or corrosive environment air pressure monitoring.

For more information:

Marsh Bellofram
8019 Ohio River Blvd.
Newell, WV 26050
Phone: (304) 387-1200
Fax: 1-304-387-1212
www.marshbellofram.com

MICO Brake System

PROVIDES ADDED CONTROL

MICO, Incorporated offers a full-power brake system with ABS and traction control to provide added control for multi-wheeled vehicles operated both on and off-highway. The system enhances vehicle stability while decreasing stopping distances and improving acceleration under low traction conditions. As many as eight wheels can be controlled independently of the others, making the system easily adaptable to four-wheeled, six-wheeled and eight-wheeled vehicles. The electronic control unit (ECU) monitors wheel speed and brake line pressures with sensors added to the machine. When wheel lock-up or wheel slip conditions exist, the electronic control unit's embedded software algorithms determine the current needed

at the electrohydraulic control valves to improve the operator's control of the vehicle. System status outputs are provided to light ABS and low traction lamps for operator warning and to meet on-highway regulations. In addition to controlling outputs, the embedded program in the electronic control unit allows it to communicate via CAN (controller area network) with a laptop computer running Windows 2000 or XP. Communication between the electronic control unit and the laptop requires a USB-to-CAN dongle and *Diagnostic Interface* software on the laptop. The *Diagnostic Interface* has various user levels that are password protected to allow access to viewing diagnostic information and modifying system parameters.

MICO works with manufacturers to custom design products to meet their specific needs. In addition to providing a full-power brake system with ABS and traction control tailored to particular vehicle requirements, the company also can customize system options. A skid-steer option can be incorporated to shorten the turning distance on long, multi-wheeled vehicles by electronically applying brake pressure to the inside wheels. Downhill speed control can be incorporated, which, when activated, would prevent the vehicle from over-speeding on a decline by applying the brakes to maintain desired speed.

The system is available in whole or in part, based on custom needs. ABS and traction control can be added to a vehicle that already has a full-power brake system installed. Furthermore, the brake system can be implemented with either ABS or traction control—or both.

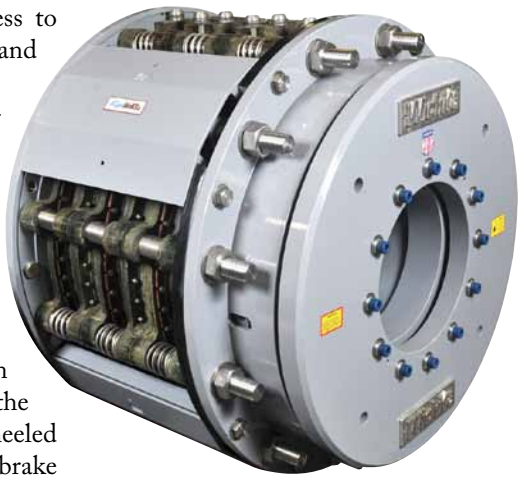
For more information:

MICO Incorporated
1911 Lee Boulevard
North Mankato, MN 56003
Phone: (507) 625-6426
www.mico.com

Water Cooled Brakes

PROVIDE ACCURATE TORQUE CONTROL

Wichita Clutch has developed a new dual action head assembly for their line of AquaMaKKs water cooled brakes that provides both failsafe parking and precision tension braking capability in one unitized assembly. AquaMaKKs water-cooled brakes are optimized to provide accurate torque control for constant tensioning in heavy-duty continuous slip tension applications such as draw works and other hoisting systems. Copper wear plates are utilized for suitable heat absorption. A unique, patent pending water jacket design ensures high heat absorption and torque stability, allowing for greater heat absorption over similar sized competitive units. A spring-set feature can be used to assist primary braking systems in parking and E-stop events by providing additional torque from this dynamic brake during a controlled system failure and adds an additional level of braking redundancy for maximum safety. The dual-action head assembly can be retrofitted onto existing pneumatically controlled 25 and 36 size AquaMaKKs units. Spring-set and tensioning functions can be either



pneumatically or hydraulically operated with fewer parts for simple installation and maintenance, and a shim design that makes it easy to maintain. Adjustment for wear is easily accomplished by removing shims without any unit disassembly. AquaMaKKs can be utilized for field retrofits, rebuilds or new OEM applications.

For more information:
Wichita Clutch
2800 Fisher Road
Wichita Falls TX 76302
Phone: (800) 964-3262
www.wichitaclutch.com

Kollmorgen Stepper Motors

IMPROVE MACHINE PERFORMANCE

Kollmorgen's Powermax II series stepper motors, like most other Kollmorgen stepper motors, are now UL recognized. This enables OEMs who build UL-certified equipment to integrate high-performance stepper technology into existing designs without requiring re-certification. These NEMA 23 (60 mm) step motors are available in half, single and two stack configurations, and provide holding torques from 42 to 253 oz-in. Speeds up to 3,000 rpm more than satisfy the velocity demands of most high torque applications. "UL recognition on high-performance step motors is a relative rarity, so machine builders who might otherwise benefit from this technology are sometimes faced with choosing between moderate performance steppers or other motor options that are less than ideal for the application. So UL recognition of Kollmorgen's Powermax II step motors is significant in that it enables OEMs whose machines need to be UL-certified to improve machine operation with high-performance steppers, without having to re-submit their equipment to UL for re-certification," explains Josh Inman, product manager.

For more information:
Kollmorgen
201 Rock Road
Radford, VA 24141
Phone: (540) 633-3545
www.kollmorgen.com

Pittman 8540 Series

IMPROVES POWER DENSITY

Pittman 8540 Series brush-commutated DC motors are designed using the latest advancements in materials and manufacturing technology. This product line is suitable for customer applications requiring high performance in a small package size. The 8540 Series is a significant improvement over similar sized older generation Pittman motors and is perfect for high-tech applications found in medical devices, lab instrumentation, data storage, and precision automation machinery, to name a few. The most significant feature of the new design is a greatly improved power density through the use of bonded neodymium magnets. The 8540 has approximately twice the continuous torque rating, compared with the previous generation of motors. The 8540 Series motors are 1.18" (30 mm) in diameter and are available in three lengths; 2.114" (53.69 mm), 2.585" (65.66 mm), and 3.057" (77.65 mm). Depending on the model, they can achieve a continuous torque rating from 2.5 oz-in (0.018 Nm) to 8.3 oz-in (0.059 Nm) without the use of a heat sink. The 8540 Series motors are available with 8 standard windings ranging from 9.55 V to 48 V. Customized windings also can be designed to optimize performance for a specific application requirement. The motors have standard pre-loaded ball bearings, allowing high speeds, radial and axial shaft loading, and higher temperatures. A new bearing support system, a 7-slot armature, and improved manufacturing techniques allow more balanced armatures resulting in very low vibration and audible noise characteristics. At low speeds, the motors exhibit very low cogging as a result of an optimized magnetic circuit design. Low vibration and low cogging make the 8540 Series suitable for position control in servo applications. Complementary products include gearboxes, encoders and brakes. The motors have the capability of extensive customization including shaft configurations, lead-wire assemblies, optional EMI/RFI filtering components, transmission components (shaft gears, pulleys or sprockets) and a variety of brush materials (including standard graphite).

For more information:

Ametek
627 Lake Street
Kent, OH 44240
Phone: (215) 256-6601
www.ametektip.com

Cone Drive

LAUNCHES SELECTION PROGRAM

Cone Drive Gearing Solutions has recently launched a new online servo gear head selection program—*AccuMate*. With *AccuMate*, engineering professionals have the ability to match their servomotors with a Cone Drive gear head. *AccuMate* will select the correct gear head for an application based on a number of variables provided by the engineer including size, speed, etc. Once the motor specifications have been entered into the program, *AccuMate* recommends the correct Cone Drive servo gearhead, and can print out the gearhead specifications for the engineer to obtain a quote or to keep in his project file. *AccuMate* also allows a user to download a 2-D or 3-D model.

For more information:

Cone Drive Operations
240 E. 12th Street
PO Box 272
Traverse City, MI 49684-0272
Phone: (231) 929-8269
Fax: (231) 929-8322
www.conedrive.com

ExxonMobil

RELEASES ADVANCED GEAR LUBRICANTS

ExxonMobil Lubricants and Petroleum Specialties recently announced the introduction of its new lineup of high-performance, fully-synthetic industrial gear oils, known as the Mobil SHC Gear series. The latest addition to the Mobil SHC brand of high-performance synthetic lubricants, Mobil SHC Gear fluids are approved by Siemens for use in Flender gearboxes and meet or exceed nearly every other major industry and OEM specification for industrial gearbox applications. Suitable for a wide range of industrial gearbox applications, the new Mobil SHC Gear lubricants also offer valuable energy ef-

ficiency benefits. "For many industrial businesses, gearboxes are a critical source of power transmission. That is why today, as gearbox technology continues to become more advanced, companies are increasingly seeking higher-performing synthetic lubricants, such as our new Mobil SHC Gear lubricants, to protect their gearbox investment," said Mike Hawkins, global brand manager, Mobil SHC Brand, ExxonMobil Lubricants & Petroleum Specialties Company, a division of Exxon Mobil Corporation. "By leveraging ExxonMobil's exceptional application-specific expertise and relationships with leading OEMs, we were able to ensure that our new Mobil SHC Gear lubricants feature the most advanced technology to help our customers reduce equipment downtime, minimize maintenance costs and maximize their productivity."

For more information:

Exxon Mobil Corporation
3225 Gallows Road
Fairfax, Virginia 22037
Phone: (703) 846-4467
www.mobilindustrial.com

R+W

UPDATES RANGE OF LINE SHAFT COUPLINGS

One of the key competencies of R+W, a German based manufacturer of flexible couplings and torque limiters for high speed and high precision applications, is the design and manufacturing of line shaft couplings. Fabricating with highly straight (generally 0.2 mm/m) extruded intermediate tubing allows for the line shaft couplings to span very large distances (> 6 m) unsupported, and at unusually high speeds, depending upon the application requirements. New designs include lightweight CFK tubing, which makes for reduced inertia and higher critical speeds for a given length. New high torque versions handle up to 150,000 Nm with flexible bellows joints and up to 25,000 Nm with elastomer jaw style coupling ends. These newer line shaft coupling designs have been successfully deployed in material handling, printing, and sheet metal fabricating equipment, as well as some custom designed solutions for cooling tower applications.

For more information:

R+W America
1120 Tower Lane
Bensenville, IL 60106
Phone: (630) 521-9911
www.rw-america.com

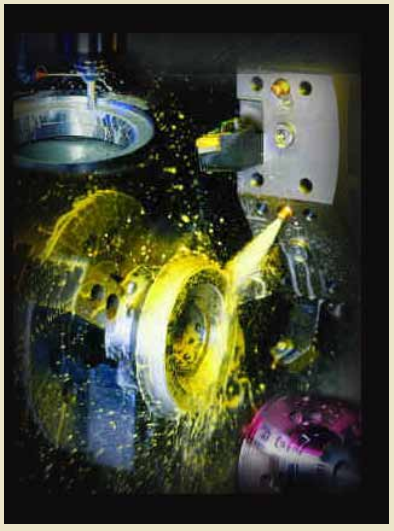
Mach III

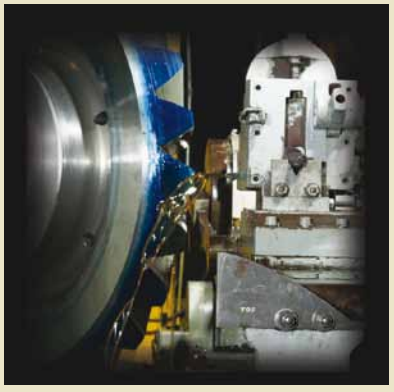
OFFERS INDUSTRIAL FRICTION CLUTCHES

Mach III Clutch, Inc. recently announced a new spring engaged industrial friction clutch for torque transmission in the absence of air pressure or during power-off conditions. Mach III spring engaged clutches are available in both regular duty and heavy duty models offering fixed torque transmission from 506 to 24,375 pound inches. These clutches release when air pressure is applied to overcome spring pressure. Catalog models currently available mount at the end of the shaft and include a finished pilot for easy mounting of a sprocket or pulley. Spring engaged friction clutches are made to order with bore and keyway sizes specified by the buyer for shaft sizes from 0.625 to 3.5 inches. Metric sizes are also available. A rotary air union is included. Mach III is one of a small number of manufacturers offering spring engaged air released industrial clutches. The advantage of a friction design, according to Peter Buckley, the company's senior applications engineer, is that "In contrast with spring engaged tooth clutches which must be engaged at zero or low speed, friction clutches slip slightly when engaged dynamically allowing engagement at any speed." No lubrication or periodic maintenance is required. When worn, friction linings can be replaced in the field. Features include soft start engagement, enclosed design, bored and keyed to suit for easy installation; no bushing required, no anti-rotation arm is required and rotary air union included.

For more information:
Mach III Clutch
101 Cummings Drive
Walton, KY 41094
Phone: 859-291-0849
www.machiii.com

CUSTOM
BEVEL GEAR MANUFACTURING





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The Energy Efficient Agenda

PT MANUFACTURERS PUT SUSTAINABILITY ON TO-DO LIST IN 2012

Matthew Jaster, Associate Editor

Next time you're strolling across a manufacturing plant, check out the hardware on the ground. Shop floors are nothing but cables plugged into machines, cables plugged into computers, cables plugged into other cables. The energy being used at the average factory is mind blowing. It's no great trade secret that the industrial workplace is one of the largest energy wasters in the world, representing one-third of the energy consumption in the United States.

According to Siemens, studies show that up to 80 percent of the energy currently used in the various production, transmission and conversion stages from the energy source to the consumer can be lost. You'd think with every green manufacturing conversation, article, webinar and trade show presentation, the *power transmission* community would be at the forefront to change the status quo—well at least they're trying.

"In my opinion, there are many factors steering companies away from implementing an energy efficient strategy, especially on older machines," says Abdulilah Alzayyat, product manager at Bosch Rexroth Corporation. "Some of the biggest energy wasters on a machine are overlooked. Often servos are oversized, which leads to machines that consume more energy than necessary—something which can easily be avoided through proper design. Also, energy efficiency is still regarded as a low priority in many organizations, despite the potential for savings. Many machine builders are reluctant to implement energy efficient solutions in their machines due to the perception that new technologies will make their machines more expensive to sell. Businesses and end-users are underestimating the returns from energy efficiency investments since it costs more up front and may take years to pay back."

"There *is* a tendency to use the same equipment that was used in the past," says Chad Brown, Baldor product manager, Dodge Gearing. "Another factor may be a lack of understanding about energy efficiency and the potential benefits at a plant operations and maintenance level."

"The way most companies approach it, they're considering energy efficient systems, but nobody has the time to be proactive," says Ken Kerns, marketing manager at Siemens. "You also have manufacturing companies that have simply decided not to implement upgrades or changes to their current systems."

Out With the Old

Three companies that are on the forefront of energy efficiency and sustainability are Siemens, Bosch Rexroth and Baldor (of the ABB Group). Kerns at Siemens says energy efficiency takes off when the entire organization has bought into the philosophy and focuses on the future instead of the past.

"We have a green initiative at the corporate level to pull all of these different efficiency facets together under one umbrella. It's something that is integral to the success of our business

The IndraDrive Mi is an integrated drive/control system that dramatically reduces installation costs (courtesy of Bosch Rexroth).

Rexroth systemizes the latest advances in automation for improving energy efficiency in accordance with the 4EE concepts—Efficient Components, Energy Recovery, Energy on Demand and Energy System Design (courtesy of Bosch Rexroth).

today. We promote energy efficiency as a three-step process: identifying energy flows, evaluating, and realizing the potential of the energy. There's not a department in the company that is not thinking about how they can be more energy efficient now and in the future," Kerns says.

One of Siemens' strongest green industrial segments includes pumps, fans and compressors. Siemens variable frequency drives (VFDs)—a unique way of controlling a motor's speed by converting AC to DC through a series of controllable elements—allow the customer to match the motor speed to the system or output requirements.

"If you have a pump that requires 50 percent output eight hours a day, a drive gets rid of the mechanical element and reduces the speed of the motor for better energy consumption," Kerns says. "One example is in the mining industry where some cross-country conveyor belts are downhill and you have to maintain the speed using dynamic braking. The typical way to control this is to have the motor act as a generator. Technology allows us to take that energy generated in maintaining the speed of the conveyor and feed the energy back into the drive and into the facility."

At Baldor, field representatives train new and existing customers about the benefits of energy efficient systems. "Our industry group combines strong product knowledge and expertise in a particular industry segment to offer the customers solutions that are optimized for their particular needs," Brown says. "Our Installed Base Evaluation team performs equipment surveys at a customer's site and offers recommendations on improving efficiency, reducing downtime and consolidating spares."

Dodge, for example, offers a complete range of high efficiency helical and helical-bevel gear reducers including Quantis, MagnaGear, Motorized Torque Arm and Maxum. "Our products are used in almost every market imaginable—unit and baggage handling, food and beverage, aggregate, mining and the grain handling industry, just to name a few. There can be an efficiency improvement of 50 percent or more when comparing less efficient motor and gearbox technologies to our premium efficient products."

At Bosch Rexroth, machine builders and end users are encouraged to benefit from their own experience in the transition to greater energy efficiency.

"For every measure we recommend, it is already implemented in our own plants to lower CO_2 emissions by 20 percent by the year 2020," Alzayyat says. "The decentralized servo drive is an example of an energy efficient component that is revolutionizing automation. The IndraDrive Mi combines control electronics and a servomotor in an ultra-compact unit. This reduces cabling, saves cabinet space and saves on the energy needed to keep the temperature inside the cabinet cooled down" (*Ed's note: See Bosch Rexroth sidebar page 22*).

Many Happy Returns

Becoming more energy efficient, however, does takes a leap of faith (and typically more cash up front) to start seeing significant improvements over time. The return on investment (ROI) is a question that has kept many organizations from integrating some kind of sustainability plan into their current workflow.

"ROI calculations will vary signifi-

Bosch Rexroth offers a complete line of energy efficient products and services.

Dodge Quantis gearboxes and gear motors are based on a modular design concept to facilitate the implementation of custom configurations (courtesy of Baldor).

cantly by region due to differences in power costs and will vary with the specific application involved," Brown says. "If the existing equipment is operating satisfactorily, we would consider the total cost of the new equipment in the ROI calculation. In this case, ROI will be longer, possibly 3–4 years. If there is a need to repair or replace the existing equipment, we would only look at the added cost of the more efficient equipment vs. the repair or replacement of the existing unit. In this case ROI can often be 1–2 years, sometimes less. There is often less of a price premium for energy efficient equipment than customers might expect."

Bosch Rexroth has conducted a series of tests using its 4EE program to help determine the advantages of energy efficient programs. "Your costs for the transition pay off in only a few years in the form of low electricity costs. How do we know that? Because pilot projects in various Rexroth factories show that a machine manufacturer and industrial user can achieve substantially greater energy efficiency based on the 4EE systematic approach without completely renewing their entire machinery," Alzayyat says.

A recent research project in the U.K. by Siemens Green League indicates that 31 percent of those responsible for energy management in U.K. businesses say energy management is not taken seriously (courtesy of Edie Energy: *www.edie.net*). The survey concludes that more than a quarter of board directors (27 percent) didn't even know what their energy bill was and one-fifth (18 percent) had no idea what their investment in energy management would be over the next three years. Additionally, one in three board directors blame the lack of perceived ROI for preventing a long-term commitment to energy efficiency. Optimistically, however, the report did indicate that 70 percent of businesses are planning to invest in energy efficient projects in the next three years.

London is just one of several cities where Siemens is dedicated to improving energy efficiency and sustainability initiatives (courtesy of Siemens).

Energy Incentives and Rebates

In order to assist manufacturers with energy efficient directives, there are varying incentives and rebates at the federal, state and local levels. Anyone interested in learning what's available can get a state-by-state breakdown at *www.dsireusa.org*. Everyone interviewed for this article believes more *can* and *will* be done in the near future to make green energy management more attainable.

"It would be wonderful if there were greater incentives for U.S. manufacturers who wish to invest in industrial infrastructure here," says John Malinowski, senior product manager, Baldor AC Motors. "This has the potential to create more jobs in the United States and help our economy. Baldor's motor plants, ABB's drive plants, and most of Baldor's Dodge mechanical plants are located in the United States, employing more than 7,000 people."

Alzayyat says incentives and rebates are great, but the manufacturers need to play a larger role in an energy efficient mission. "While state and federal incentives are a great encouragement for machine builders to implement energy efficient designs, I believe this alone is insufficient. In addition, machine builders and their suppliers need to make available products that are performance comparable and price competitive to other standard products."

Adds Kerns at Siemens, "The mentality is there and the government is trying to offer more to the industrial market. The Consortium for Energy Efficiency actually brings these two sides together—both the industrial experts and the politicians—to discuss energy management. You have concerns over pollutions, resources disappearing, etc. This is not a fad that's going to disappear anytime soon."

Moving in the Right Direction

If there is reluctance from PT manufacturers to convert to more efficient equipment—for financial reasons or simply because of time constraints—now's the time to reconsider. *Bloomberg* recently reported that U.S. manufacturing grew in January at the fastest pace in seven months and reports from China all the way to Germany are optimistic as well. This means more equipment, more products and more energy consumption. Those that have embraced green manufacturing will undoubtedly have an easier road ahead than those that ignore it.

"Every element of our business is working on some aspect of energy efficiency and drive technology today, from Europe to China to the United States. We see new hires out of college with a similar mindset on energy efficiency," Kerns says. "I think our leaders believe in that. They talk about this often. We want to strive to set the example. I'm encouraged by what I see and the direction energy management is going."

Siemens Automation & Drives Sinamics S120 system offers an integrated modular drives system for single-axis and multi-axis applications (courtesy of Siemens).

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Rexroth Integrated Motor/Drive System Streamlines Case Packers

Brenton Engineering, a provider of packaging and palletizing equipment, designed a new line of side-loading case packers to exceed current green manufacturing end user trends, featuring servo control to increase speed and reduce energy costs within a compact footprint. Located in Alexandria, Minnesota, Brenton engineers spent months consulting with customers and vendors before designing the next generation of its popular BrentonPro Series of case packer machines.

"We asked our customers how we could improve the machine. The feedback was to make it a faster and simpler all-servo machine," said Mike Grinager, vice president of technology for Brenton Engineering. "With the new design we did everything we could to reduce the complexity of the machine. We took out the pneumatics, which was the most expensive aspect of the machine, and our engineers removed more than 200 moving parts, reducing costs by one-third. Plus, the integrated servomotors and drives that we now use require less space than even the smallest motors we used previously."

As a result, Brenton's new BrentonPro Mach-2 case packer is an all-servo-driven, side-load case packer featuring an IndraDrive Mi integrated motor/drive platform with SERCOS distributed I/O, an IndraMotion MLC motion logic controller and the IndraControl VEP40 human machine interface (HMI)—all from Bosch Rexroth.

According to Grinager, the multi-axis machine reaches speeds of up to 25 cases-per-minute and can accommodate a variety of cases, including RSC, HSC, tray, wraparound, knock down and harness for cartons, bottles, cans and tubs. During operation, an

empty case blank is picked by vacuum and set in the machine. The case is moved through loading and sealing sections of the machine, which are powered by servo-driven flap traps. After loading, the full case is indexed through a compression and sealing area. The completed case is then discharged on the customer's takeaway conveyor. Brenton developed the Mach-2 case packer to minimize the environmental impact of packaging operations through the appropriate use of electric servo drives, resulting in lower energy consumption—including zero air consumption—and less product and packaging waste.

The company worked closely with local Bosch Rexroth distributor Motion Tech Automation during this phase of the development. "We recommended Rexroth's compact, scalable IndraDrive Mi integrated motor/drive system, which is an innovative, cost-effective and simple solution that satisfies the design challenges for today's modular and high-performance packaging equipment," said Shawn Nelson, sales engineer at Motion Tech.

Designed with sustainability in mind, the servos were sized to work out of the box as the most cost-effective solution. A holistic approach was taken, with motor drive and gearing all playing a role to reduce the power requirements of the machine. On average, the Mach-2 is expected to generate energy savings of up to 25 percent compared with the first-generation machine. Nelson said that Rexroth's IndraDrive Mi system combines each servomotor and drive amplifier into one compact unit mounted directly on the machine, outside of the control cabinet. A single cable running from the cabinet is daisy-chained to each motor/drive unit and provides both power and communication.

As a result, Rexroth's design has the potential to reduce a machine's cabling needs by more than 80 percent. The IndraDrive Mi is also 50 percent smaller than a traditional servo system, which uses a separate servo drive and motor. This innovative architecture also eliminates the need for an air conditioning unit in the control cabinet and the need to maintain or replace expensive filters. Conventional servo drives are typically mounted in a large, external control cabinet and are connected to the individual servomotors by separate communication, power and feedback cabling that must be mounted and run through large wire ways that clutter the machine.

"Our machine has a cleaner appearance without all the wires running to and from the electrical cabinet," said Grinager. "Because of the small integrated motor/drive units and fewer cables, the machine features an attractive walk-in design that allows easy access for the operator to clean and maintain it."

"The integrated motor/drive units help reduce the size of the electrical cabinet," added Nelson. Because the drives are integrated directly with the motors outside of the control cabinet, design engineers reduced the size of the Mach-2 control cabinet by 25 percent. Up to 20 IndraDrive Mi units can be connected from one power supply without additional distribution

boxes. The IndraDrive Mi easily accommodates the multiple functions of the Mach-2 case packer without increasing the size of the electrical cabinet. In addition, integrating the drive control and motor into one component provides a more flexible "plug-and-play" capability. More motors can easily be installed for machine upgrades or other machine configurations, such as unique infeeds, said Nelson.

Grinager said there was one additional advantage to using Rexroth's motor/drive system: versatility. Although the compact IndraDrive Mi system allowed Brenton to design a machine with a significantly smaller footprint, reducing size by about 30 percent, the space in the machine's case compression area was too compact to accommodate even the smallest integrated motor/drive unit. The solution was Rexroth's IndraDrive Mi KMS, which is a distributed drive unit that can be mounted on the machine near a conventional servomotor and seamlessly connected with the Indradrive Mi KMS cables.

Brenton Engineering's innovative controls team also used the IndraDrive Mi distributed input/output system (I/O), said Nelson. Having four I/O outputs directly on the motor eliminated the need for extra wiring and other costs associated with purchasing separate I/O outputs from another vendor.

Motion synchronization and control are handled through SERCOS digital communication to each servo drive. The case packer utilizes synchronous, electronic camming technology provided by Rexroth's IndraMotion MLC L40 motion logic controller. The MLC L40 features Flex Profile functionality, seamlessly combining synchronous and time-based steps into a single data function which optimizes system performance and recovery and also reduces the changeover time. In addition, Rexroth's IndraControl VEP 40 HMI, which was mounted to the frame instead of the control panel, integrates easily with the rest of the machine components via OPC communications. The VEP 40 is an embedded terminal with a Windows CE operating system and a high-performance 12-inch TFT touch screen display. Motion Tech provided an application engineer who was on-site for two days to help support Brenton Engineering's controls team after the machine was built.

In addition, Motion Tech and Rexroth engineers conducted in-depth, onsite training sessions for Brenton engineers. "The Mach-2 has become a standard for Brenton Engineering," concluded Grinager. "Rexroth technology allowed us to simplify the design of the Mach-2 case packer and reduce extraneous parts and energy consumption in the machine. The ability to daisy-chain servomotors led to less wiring and contributed to a smaller electrical cabinet and ultimately an overall smaller machine footprint."

For more information, visit *www.boschrexroth.com*.

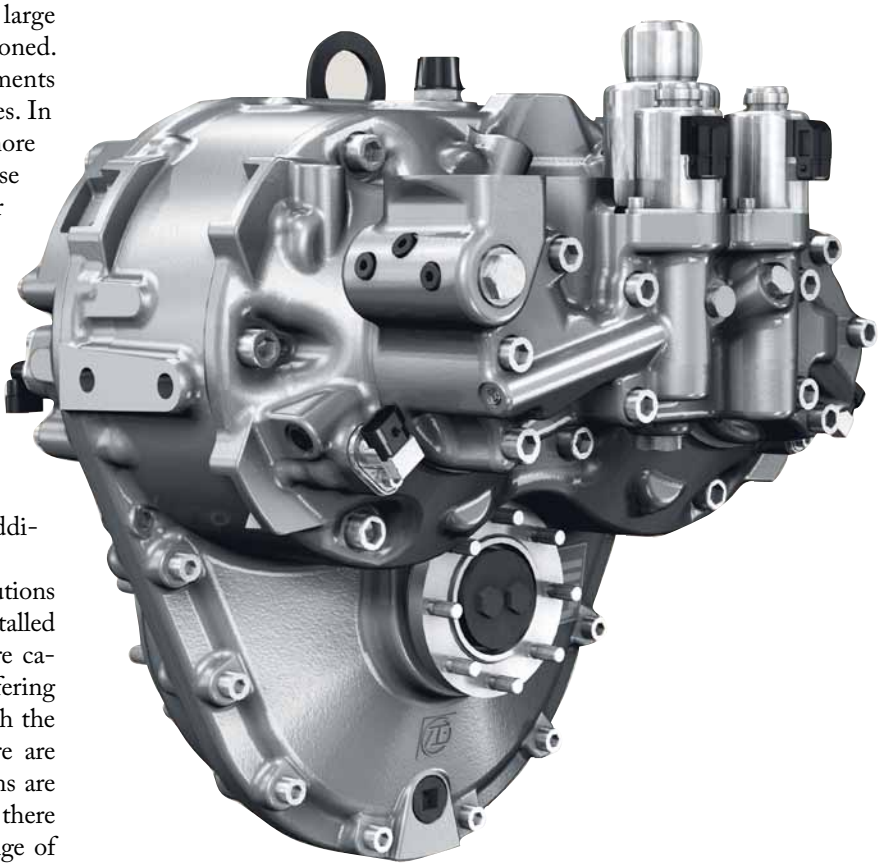
Compact Loaders for Compact Spaces

HYDROSTATIC DRIVE OFFERS FLEXIBILITY IN OFF-HIGHWAY APPLICATIONS

Matthew Jaster, Associate Editor

Compact loaders are employed where large machines have no access or are over dimensioned. Apart from the amount of load, the requirements on the vehicles are similar to large machines. In addition to the known requirements for more compact drive systems with reduced noise level, there is an ever increasing demand for a reduction of fuel consumption. At the same time, however, vehicle speed should be increased. The new hydrostatic drives of the HC-range meet these requirements of the off-highway market. ZF's 2 HC 85 transmission systems with incorporated actuators and sensors for construction machinery up to 10 tons enable continuously variable vehicle speeds up to 50 km/h and do not require any additional shifting devices.

Unlike other hydrostatic driveline solutions with bent axis axial piston motors, ZF installed two crankshaft radial piston motors that are capable of running up to 2,500 rpm while offering constant output torque characteristics. "With the crankshaft radial piston motor design there are fewer leakages thanks to piston seals. Pistons are guided in pivoted cylinders, and as a result there are no lateral forces. This allows a wide range of displacement variation, speeds up to 2,500 rpm with high pressure, high starting torque, high efficiency and low noise," says Alexander Eisner, marketing communications product manager at ZF.



ZF's 2 HC 85 transmission systems with incorporated actuators and sensors for construction machinery up to 10 tons enable continuously variable vehicle speeds up to 50 km/h and do not require any additional shifting devices (courtesy of ZF).

Other advantages to the 2 HC 85 transmission system include increased riding comfort; continuously variable transmission without gear shifts; no interruption of traction (therefore improved handling performance); low start speed due to electronically controlled driveline management; better performance (no interruption of tractive effort); an electronic propulsion control that ensures a low starting speed; an output control (limit load control) that also adjusts the diesel engine to the optimum speed when driving at full throttle; enhanced efficiency and reduced fuel consumption up to 15 percent by crankshaft radial piston motors; and noise reduction by lower hydrostatic motor speeds.

Thanks to its compact design there's an increased degree of freedom regarding vehicle construction. The integration of hydrostatic motors into the transmission system reduces the number of external hose pipes and valves, leading to a reduction of interfaces to the vehicle and one-source supply of the complete driveline: i.e., transmission, axles and driveline control.

"Highly precise maneuvering during loading and unloading plays a key role in any off-road machinery application," Eisner adds. "This is possible at full traction through the entire speed range thanks to the hydrostatic 2 HC 85 drive. The whole accelerator pedal play can be used to position the vehicle exactly by selecting the desired driving range."

ZF rigid axles MT-L 3010/15/20/25 feature a particularly slim design. The high ratio in the wheel heads' final drive provides increased ground clearance. The system comprises a directly mounted transfer box for hydrostatic drive suitable for 55 to 160 ccm engines. A service and parking brake are offered as a drum brake, plus the series offers a low-wear multi-disc brake at the axle input. The MT-L 3045/55 axles provided by ZF are optimally suited for the on-site operation of compact loaders. Their durability and robustness have been tested at the in-house test bench, both alone and in connection with the relating compact loader transmissions. In addition, the axles are characterized by the direct mounting of the HC 85 to rear axle MT-L 3045/55, an above center pivot mount of rear axle, front with parking brake (disc brake) on the drive, as well as integrated wet multi-disk brakes and differential options.

ZF is now profiting from its established hybrid solutions in vehicle transmissions in the construction, material handling and agricultural machinery markets (courtesy of ZF).

ZF also offers a hydrodynamic axle configuration. The power shift transmission from the range 4WG 98 with torque converter in this case is arranged as a separate unit between these two axles. For this driveline a central oscillation of the rear axle is available.

"ZF has also identified the 2 HC 85 as a technological solution for use in telescopic handlers. Based on the experience with the already existing driveline solutions from ZF, this is the next step for applications that are used both in construction and agricultural," Eisner says.

Precise maneuvering when loading and unloading plays a key role in all fields of a telescopic handler application. This is possible at full traction throughout the entire speed range thanks to the hydrostatic transmission 2 HC 85. The complete accelerator pedal play can be used for exactly positioning the vehicle by selecting the desired driving range. Flexibility and maneuverability become the system's calling card thanks in part to the intelligent driveline technology by ZF.

Easy handling is ensured by transmissions and axles offered by ZF as a complete driveline. The telescopic handler can be quickly fitted with shovel, fork, grab, working platform and other mounted implements for doing the most varied jobs. This variety of possible applications is highly appreciated, particularly by users in the agricultural sector, and becomes even more valuable with ZF's enhanced driveline technology.

ZF Optisteer, for example, is an innovative steering kinematics optionally available for telescopic handler steering axles. It optimizes steering geometry by a variable length tie rod, improves steering and reduces tire wear. The steering angle error can be reduced by more than 50 percent and it reduces the tire side force by a minimum of 40 percent and contributes to fuel efficiency.

ZF offers heavy-duty transmissions, axles and electronic systems that combine for a driveline package that provides flexibility and precision for construction equipment. These driveline components are matched more precisely to the relevant vehicle requirements in cooperation with the various manufacturers. Additionally, attention is paid to the requirements of the fleet operator and the driver, both in their work with the machine, as well as with upkeep and maintenance.

Today, ZF is focused on reducing fuel consumption, lowering wear and emissions, increasing productivity, extending service intervals and providing better handling and more automation services. The 2 HC 85 drive system is just one example of ZF's efforts in off-highway transmission technology. Here are a few other transmission systems developed by ZF for the off-highway market:

ZF-Ergopower: This tried and tested transmission system has been optimized for different construction machinery types and offers the optional feature of five instead of four gears. Therefore, the noise-optimized transmission allows even more comfortable and easier handling, high shifting quality and flexibility. Moreover, the operating costs can be further reduced. The ZF-Ergopower provides additional possibilities for connecting an electronic driveline thus enabling vehicle-specific controls. With the modular construction and optimized design operating costs are kept as low as possible. Helical gears with high tooth contact reduce the noise level. Extremely short shafts reduce deflection and tooth contact faults. The vertical arrangement of the spur gear ratios bridges the height difference between the input and output shafts. Consequently, the axle differential can be integrated into the housing. An additional transfer box is then unnecessary.

ZF-Ergopower LII: This transmission is a complete new countershaft design for the application especially in dump trucks, motor graders and heavy wheel loaders. The main features for this new development are high efficiency, higher speed, higher tractive effort and less noise emissions. Well known and accepted design criteria like rotational pressure compensation, set right bearings or short and stiff shafts are combined now with a remarkably reduced internal speed which results in less fuel consumption. The new transmission features onboard electronics, and can optionally be mounted to the axle drive.

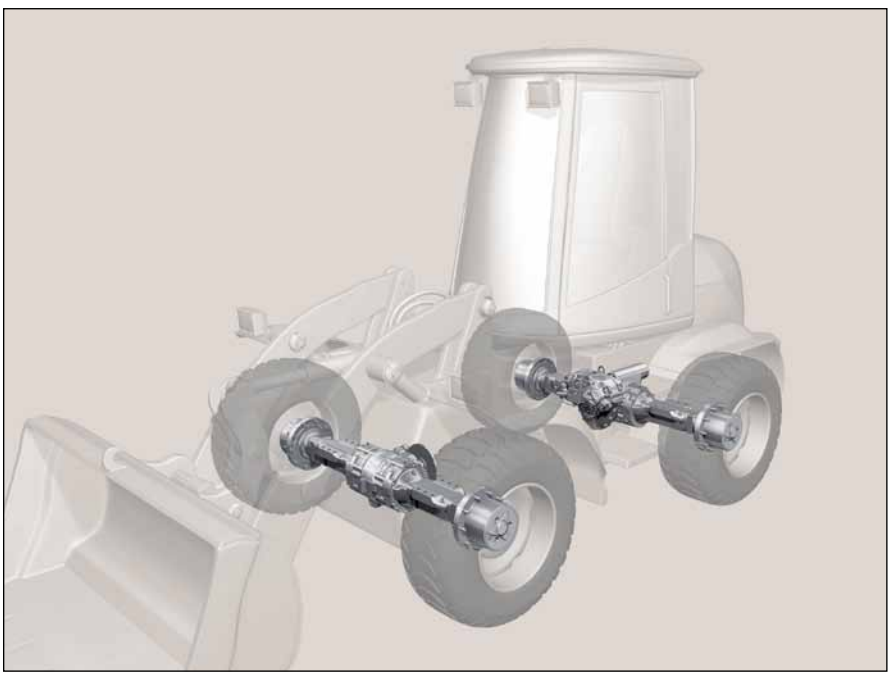
ZF Hydrostar HL: This transmission mainly used in wheel excavators is produced in three capacity ranges and can be mounted directly to the ZF rigid axle MT-E 3000 range or mounted separately to the chassis. It can be used for an input torque from 550 Nm up to 950 Nm and an empty vehicle weight from 15 to 25 tons.

ZF 4 WG 94/98: This powershift transmission is specially designed for the application backhoe loader up to an engine power of approx. 80 kW and a gross vehicle weight of up to 9,000 kg. Engineered by ZF in Germany, this transmission is produced in the United States by ZF Gainesville, Georgia.

ZF WG 160-310: Graders are specialists for flat terrain. In rough conditions, for construction-site roadways or laser controlled leveling of large areas, a grader is suitable. ZF develops system transmissions representing a high added value for any construction machine. Maximum power utilization, optimum shifting quality without tractive effort interruption, easy maintenance and diagnostics combined with low noise emission delivers transmission technology being of equal benefit to the vehicle owner and the driver. For mobile cranes ZF-Ergopower transmissions are used in various dimensions according to the necessary performance of the individual vehicles. ZF-Ergopower transmissions offer completely new standards to the market. Helical gears with high tooth contact area. Vertical arrangements of spur gear ratios bridge the difference in height between input and output shaft, allowing the axle differential to be integrated into the housing. No additional transfer box is required.

ZF WG 98 TC/WG 98 TSC: ZF transmissions in telescopic handlers are designed for a maximum engine power of 90 kW. These transmissions in connection with the MS-T 3000 series allow the installation of different mountings of the boom (low and high, middle and center mounted boom up to a payload of 5.6 tons). More than 15 years of experience and a production of more than 42,000 transmissions have solidified ZF's design and quality success in this field.

ZF-Ecomix II: This transmission is the new generation for concrete mixers up to 10 m^3 (13 yd^3) drum capacity and an output torque up to 62,000 Nm (45,700 lb-ft). The compact lightweight construction makes Ecomix II 20 percent lighter and 50 percent shorter in comparison to previous models. The



ZF has met the increasing demands of lower fuel consumption in compact loaders with its hydrostatic drive technology (courtesy of ZF).

ZF-Ergopower transmissions offer completely new standards to the construction and machinery markets (courtesy of ZF).

use of patented elastomer units allow an increase of the axial run-out at drum bottom and an increase of misalignment of the drum. The acoustic and mechanical decoupling of the drum and vehicle frame leads to considerable noise reduction during operation and improved driving comfort. Serviceability has been improved thanks to separate oil for transmission and hydrostatic system as well as an improved accessibility.

ZF WG 90-311: ZF fully automatic powershift transmissions are specially designed as a short drop version and are used mainly in IC (internal combustion) lift trucks and reach stacker applications up to 60 tons lifting capacity (140 tons gross vehicle weight) but also in terminal Trucks, yard tractors and aircraft tow tractors. These transmissions are used in the range of 65 to 330 kW.

ZF is one of the few independent automotive suppliers, whose hybrid technology is being used as a standard. The Group has adjusted its product program to the increasing demand for hybrid technology and thus covers the entire range: components, modules, and complete hybrid systems based on the parallel hybrid design. They can be used as a basis for all hybrid designs, from the micro and mild hybrid to the full hybrid, which leads to roughly 30 percent fuel savings compared to a conventional driveline.

With these and other system developments, ZF follows a trend to market continuous variable transmissions in the construction- and agricultural machinery market. Hydrostatic technology is more and more displacing hydrodynamic (torque converter) transmissions especially in construction machinery systems. Lowering engine speed and slowdown of the engine through a continuous drive concept is the main focus.

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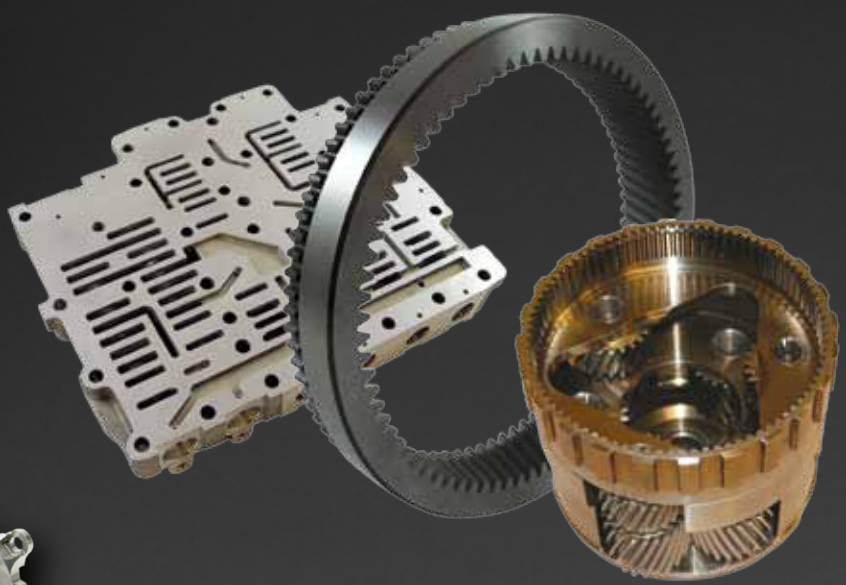

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Guidelines for Designing Better Motion Control Systems

Lee Stephens, Kollmorgen

Introduction

Motion control system engineers work chiefly in two well-defined areas: 1) new designs and 2) redesigns—or retrofits. Of course, the new design task starts with a clean sheet of paper. Since the system did not exist before, all the specifications must be derived from calculations, simulations or actual measurements on existing machinery. They can measure feeds, speeds, loads and torques on similar equipment that operates without servo controls, or they can simulate them with a variety of software packages.

Design or Redesign? What's Best?

Some might expect that designing a new system would be more difficult than replacing an old one, but this is often not the case. Although the loads, speeds and torques needed might be known, a newer digital controller that replaces an old analog system using brushed DC motors behaves differently. New control laws often enter the equation, and when the designer is not aware or does not anticipate these differences, the first system off the drawing board might not live up to expectations.

One major factor to consider in the new system is calculation time. A digital system works in three serial, quantifiable steps—i.e., measure, calculate and output. The controller requires specific time slices to run through these three functions. The calculation period might be so long as to let the system wander out of control. An analog system does not have this particular drawback to the same degree. By comparison, the analog system calculates, measures and outputs almost simultaneously and continuously. Typically, the lag time is not as severe as the calculation delays of a sampled system.

Both new and replacement systems follow the same basic laws of physics—but different control laws—so the design approach and hardware shopping list could be very different for each system. For example, a new system design can be defined in two ways.

The first is straightforward, where the controls engineer designs a system totally on his own from the ground up. He completely defines the system and orders the components needed to do the job. He alone is responsible for the outcome.

Or, a new system might involve a client that has a resident engineer who helps define the system parameters and selects the components. The consulting motion controls expert may help design the client's new system after its resident engineer had already selected a few key components. The resident engineer may have determined loads, speeds and torques from actual measurements, calculations or simulations based on a few assumptions. He also may have purchased some major components—motors and transmissions, for example, based on these determinations—before hiring the consultant. The consultant's initial posture is to assume that the components that the resident engineer selected are perfectly suitable. Unfortunately, this sometimes is not the case. Assumptions may have been made under static conditions, when they

should have been dynamic—particularly regarding the load. The result is that the consultant now has no choice but to revise the model to include the proper parameters.

Strategy

Calculation delay is especially troublesome when a control system contains multiple axes. In a three-axis, pick-and-place system, for example, the *x*, *y* and *z* axes all must converge simultaneously on a particular point. If a lag appears in any one or more axes, the component part could be set in the wrong place or delayed long enough to affect throughput of the machine. To avoid this, first determine the bandwidth of the system. Measure the load inertia, determine how fast it must move, and, more importantly, how fast it needs to settle. Settling time really dictates the bandwidth. Bandwidth does not determine the speed; it determines how quickly and precisely the load stops or follows a contour.

The bandwidth is usually defined in terms of its –3 dB point and the 45° phase shift. Don't prefer one parameter over the other; exceeding the – 3 dB point and the 45° phase shift indicates that the system is out of control. For example, if the closed-loop system is at –3 dB but it has a 60° phase shift, it was significantly out of control long before it hit the –3 dB point.

In digital systems, other functions affect the phase angle, which sometimes surprises the customer. It concerns current-loop bandwidth; it is calculated digitally and the calculation delays become apparent. Although the delay is worse than a phase shift, it is essentially the same thing; i.e., phase is time in the frequency domain. The digital system may not have optimized control algorithms to calculate current, velocity or position. It is then that the digital system may have more of a calculation delay than the system can tolerate; it did not achieve the intended bandwidth.

High-performance drives offer sample rates for current and velocity that are generated in the field-programmable gate array (FPGA—*an integrated circuit that is configured by a user or designer post-manufacture; i.e., field-programmable*) that minimize the effects of sample and hold errors and the calculation delays since the FPGA is operating much faster than would a typical processor. The combination of digital signal processing—DSP and the FPGA technology are a step ahead of standard processing —(*DSPs take real-world signals like voice, audio, video, temperature, pressure, or position that have been digitized and then mathematically manipulates them. A DSP is designed for performing mathematical functions like "add," "subtract," "multiply" and "divide" very quickly.* Source: Analog Devices, Inc.). Performance now approaching the analog systems has been achieved, making replacement and retrofit easier.

Modeling

Some of the design work is carried out by modeling with a variety of software packages. Systems may be modeled in a digital format to determine not only the bandwidth but also the position accuracy. The model can become as detailed as necessary. Widely used software packages include *VisSim*, *LabView*, *Mathcad*, *Matlab* and *Motioneering*, the latter available from Kollmorgen.

VisSim is a widely used simulation software package; a trial version may be downloaded free of charge from their Web site. It can run and modify the model but it cannot be saved in the limited version. *LabView,* from National Instruments, can be used to model as well as control an EtherCat-based drive; this becomes valuable for breadboard applications. *Motioneering* is free and determines how much current and power the motor needs to function properly. *Matlab* has some options available like *Simulink* to help modeling control systems. This is also the basis of the *Mechaware* models within the *SynqNet* control systems from Kollmorgen. *Mathcad* is another mathematic-based modeler that many designers use.

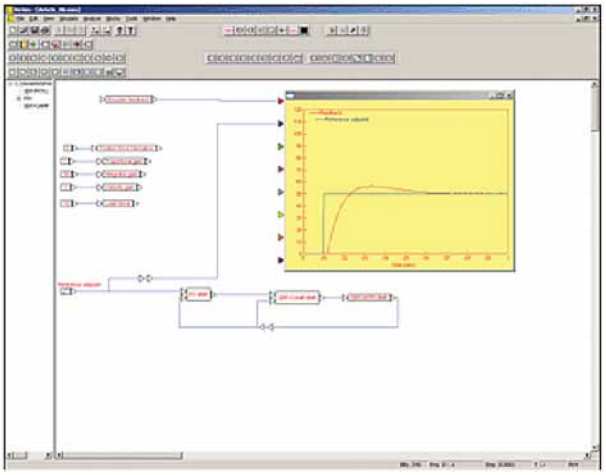

Figure 1—Screen simulation of a PIV control system response using *VisSim* modeling software. The ideal step-response curve or set point shown in black is compared to the feedback response signal (in red) when the system is programmed with constants for proportional gain of 1.0, integrator gain of 50, velocity gain of 0.1 and a load force of 10.

When modeling, it can be difficult to decide when to stop. As designers gain sufficient experience, however, they can recognize when some parameters are not relevant enough to consider. If you start with a basic motor/load-with damping model, you then add the parameters that are generally relevant to the control system. In the beginning, try everything on the list, then narrow it down to the few parameters needed to adequately and sufficiently model the system. Any adjustments after that are usually minor. Stop when further detailing does not make the model any better or does not gain any more advantage in the design. Often, designers return to the model after

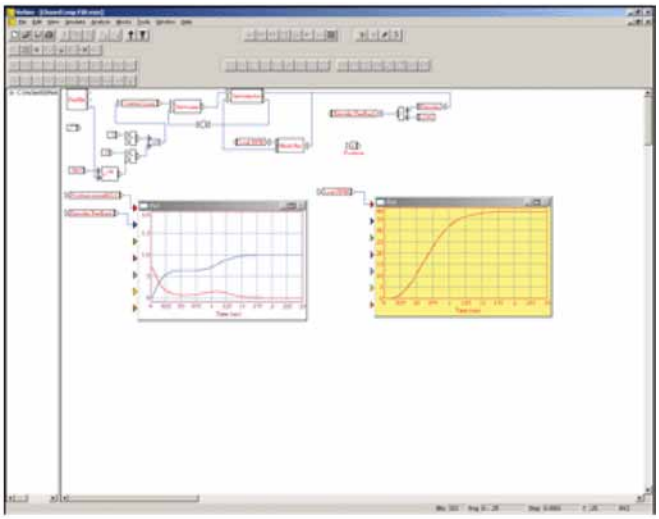

Figure 2—Simulation illustrating a screen shot of a block functional diagram of a closed-loop system. The left-hand graph depicts the position error in red and the encoder feedback in black. The load speed (rpm) vs. time is shown in the right-hand graph. The result of different gain, acceleration and velocity constants can be seen as they are changed.

the system did not meet specifications, and they find errors; they go through the system and might find that they should have considered something else that was more important. Always try to validate the model, as it is only as good as the information that goes into it. Some information is difficult to determine mathematically and has to be done empirically. However, the empirical information determined for the model may not be sufficient, so use multiple formats including the frequency domain and time domain. *VisSim* and *Mathcad*, for example, work well together for this, so take advantage of them.

Validation

After the model is completed, the hardware may not yet be available. The customer may have the breadboard and prove that the supplier's products will work in his system, but the consultant may not be in control of how close the breadboard represents the real system. He may use the model as supplied, or he may revise it and find changes in pulley ratios, motors, inertias or miscalculated inertias. However, assume the physical breadboard is sufficient to model and validate the system. In the next step, the customer now implements the alpha or beta stage of the project and buys the needed components.

On occasions when the system does not meet expectations, sometimes the reason is a miscalculation. The system was expected to operate under certain circumstances, but perhaps could not. The model should have shown how much headroom there was, and how close it was. If not, then it may be necessary to construct a Bode plot or run a Fast Fourier Transform (FFT) algorithm to find out why the system is vibrating, resonating or not rejecting the disturbance.

The ability of a control system to reject disturbances is a figure of merit that goes beyond a number; it is intuitive. It is through feedback that the disturbances will be rejected. The proper feedback loop will let the load reach the intended position. This might involve velocity, position or torque feedback. The nature of the feedback loop depends on the function that is specifically needed, such as torque or current for machining operations.

During the build stages (breadboard, prototype, alpha, beta and first piece) the model should be visited to verify and modify accordingly to the empirical data or corrections to the physical system for validation. The largest pitfall can be allowing the model to become obsolete with empirical tests; in later stages of development, problems could arise where the model can supply useful data. This is the tool for validating each stage of the project with the original specification and intention.

Feedback

Feedback system complexity varies with the application; it can be as simple as an incremental encoder or a resolver, and there are different reasons for using one or the other. A resolver is extremely robust and can tolerate harsh environments well. It can be a sine/cosine encoder, which can handle very high bandwidth, but typically, does not do well in a high-vibration, high-temperature environment.

Some systems become more complex when a secondary feedback device is needed. For instance, a system may require a feedback device mounted directly on the motor, and another closer to the load. The feedback device on the motor could be used for velocity control, but the feedback device on the load would be used for final position. It doesn't sound too difficult, but as the feedback device moves farther from the transmission device—the motor, in this case—the more items will be enclosed in the loop. Another example: when a resonance appears at a certain

Figure 3—A *Motioneering* model for a typical PID controller lets designers examine the system behavior with numerous gains and other parameters. It can show a plot of this behavior with certain perturbations.

frequency that is outside the intended control bandwidth, having the feedback device outside of the load is certainly going to help move the load to its final position. But tuning this system—i.e., getting the position system up to the desired performance level—is extremely difficult. Therefore, when a very high bandwidth position loop is needed, a secondary encoder is typically placed at the end of the position loop. Elimination of the mechanical transmission (belts, gearboxes) through the use of direct drive technology is also a potential solution, enabling easier tuning as well.

Redesign

Occasionally, during tuning, the controls engineer will find that rather large modifications must be made to the system to gain the intended control. He may even have to change his entire theory regarding the method needed to tune the system.

The simplest control method—either PID (proportional, integral, derivative) or PIV (proportional, integral, velocity)—is typical in a great number of systems. A standard PID control system is relatively easy to tune; it can be used for either a new system or an old one. Here, the damping is a derivative of position error. The proportional term is a gain factor. In PIV, the velocity is calculated and used for the damping of the system.

Other control laws exist and may be a good selection. Kollmorgen's *MechaWare* allows custom algorithms and filters that can accommodate the most stringent of applications and needs. Custom filters generated from the four individual bi-quad filters in the aforementioned AKD servo drive should minimize redesign challenges.

Stiffness

System stiffness—or a lack of it—continues to be a major, chronic problem. Say, for example, resonance problems indicate that a system is not stiff enough. And backlash in a system is another serious problem. Here, the customer may have a linear motion control system that specifies a rack-and-pinion transmission on a precision axis. However, such a single-format gearing system produces troublesome backlash; not even anti-backlash gears can solve the problem. They often still have enough backlash to create instability and typically contain two gears in an interference fit; some friction losses are inevitable. That arrangement does not guarantee zero-backlash—only that the backlash is taken up by another mechanism. They have a spring rate to contend with, which is a dilemma when trying to control a frequency in the domain of the spring rate. It is a common problem, usually found in a system designed by someone lacking controls experience.

To overcome these problems, conduct Bode plots and La Place transforms in the frequency domain. Compare the Bode plot performance with the La Place transforms and tune the system based on that information. Observe the frequencies, disturbances and amplitudes, and then determine the best method of attack to eliminate the disturbances or insert compensation to reject them. In addition, stiffen the system to eliminate resonances and raise the frequencies above the frequency of disturbance. Also, at times the system may be damped, but this could also affect the compliance. High-frequency damping usually does not add compliance; but at low frequencies, damping certainly cannot be used because it adds compliance that exacerbates the disturbance itself. Try using acceleration feedback, a Lowenburger observer (a relatively complex algorithm) or select a suitable filter.

Conclusion

With a "living" model documented, updated and validated, a nearly seamless path from concept to final product can be achieved. This process can only be guaranteed with periodic updates, validation to empirical data and proper use of tools for modeling. Good vendor data and upfront modeling minimize surprises and unexpected—or unwanted—results. The motion control vendor should have experience in providing accurate data on the products and rudimentary product information should it be required. A good quality vendor will alleviate many of the pitfalls.

Lee Stephens *possesses an engineering science degree from Broome Community College in New York. Stephens has 25+ years experience in the semiconductor industry—primarily in motion control—and has spent the past nine years as senior motion control engineer/systems support, for Kollmorgen. He has written and published numerous technical articles on various motion control topics.*

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Applying Open Gear Lubricants

Lawrence G. Ludwig Jr., Schaeffer Manufacturing

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When selecting an open gear lubricant for use in a particular application, the method of application used must be considered. The typical methods of application used in open gear systems are:

- Spray/atomization systems
- Gravity feed or drip feed
- Oil bath (splash and idler immersion systems)
- Hand, brush or pour on

Generally, if the open gear lubricant is to be applied by a drip system, force-feed lubricator or spray system, it must be sufficiently fluid in order to flow easily through the application equipment. For brush applications, the open gear lubricant must be fluid enough to allow uniform, brush-on coverage on the teeth. In any case, during operation, the open gear lubricant must be viscous and tacky enough to resist squeeze-out from the gear teeth. When open gears are lubricated by dripping into a splash pan or through the use of splash and idler immersion systems, the open gear lubricant must not be so heavy that it channels as the gear teeth dip into it. Finally, when open gears are lubricated, the consistency or grade and its ease of pumping must permit easy application under prevailing, ambient conditions.

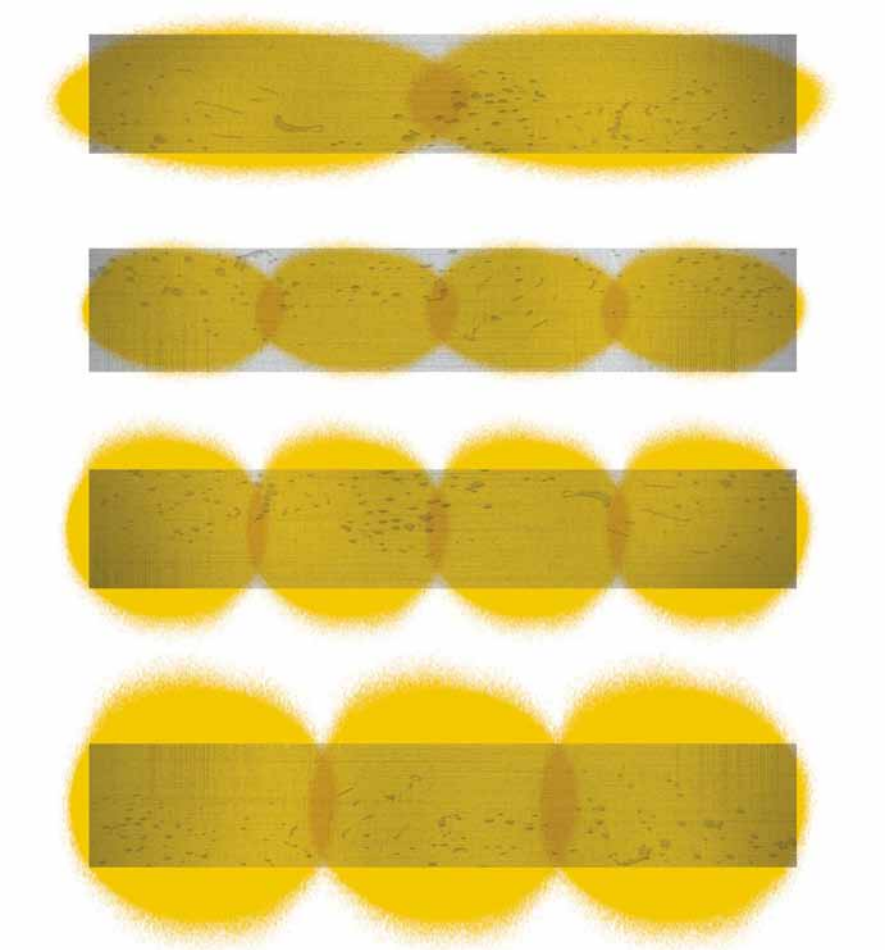

Figure 1—Correct lubricant spray patterns on tooth flanks.

Spray/Atomization Systems

The most common type of spray/atomization system used in the lubrication of open gearing is the intermit-

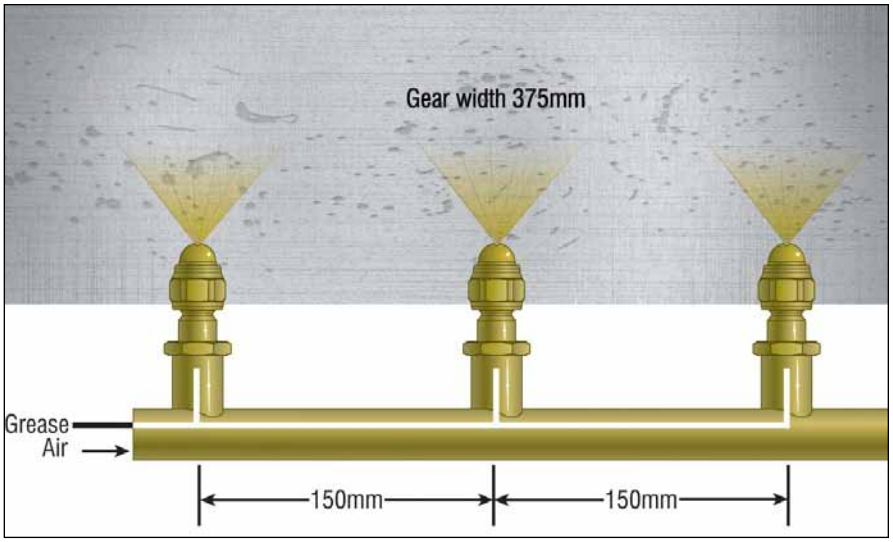

Figure 2—Placement of spray nozzles; example of three-nozzle spray bar with spray nozzle spaced apart at 150 mm.

tent, mechanical spray system. Its usage depends upon the open gear lubricant remaining on the gear teeth through several revolutions. Intermittent spray systems utilize metering valves that direct the lubricant to an air/grease nozzle that sprays the lubricant onto the open gears with the assist of air pressure. The basic components of this type of system are a pump, controller, metering valve, spray manifold and spray nozzles.

The operation of this type of system is very straightforward; a signal from a controller turns on the pump to supply the open gear lubricant to a positive-displacement metering valve. The metering valve can be a progressive, two-line or injector type. The metered lubricant is sent down a passage in a spray manifold, where the open gear lubricant is directed to a nozzle. A second passage of pressurized air (usually in the range of 80 to 120 pounds-per-square-inch) is directed to the same nozzle. This pressurized air blows the open gear lubricant out of the nozzle and onto the open gear. After a predetermined amount of open gear lubricant is dispensed, both the air system and the pump shut off until the next lubrication cycle. Usually there is a delay in shutting off the air, so as to ensure that the open gear lubricant has cleared the nozzle. This removes the open gear lubricant from the nozzle tip, thus preventing it from drying and clogging the nozzle.

Table 1—Lubricant quantity guidelines for intermittent methods of application (Ref. 1)

Gear diameter in meters (feet)	¼ Hour[1] Face width in meter (inches)					1 Hour[1] Face width in meter (inches)					2 Hour[1,2] Face width in meter (inches)				
	0.2 (8)	0.4 (16)	0.6 (24)	0.8 (32)	1.0 (40)	0.2 (8)	0.4 (16)	0.6 (24)	0.8 (32)	1.0 (40)	0.2 (8)	0.4 (16)	0.6 (24)	0.8 (32)	1.0 (40)
3.0 (10)	5.9	8.9	11.8	14.8	7.8	23.7	35.5	47.3	59.2	71	59.1	88.8	118	148	178
3.7 (12)	8.9	8.9	11.8	14.8	17.8	35.5	41.4	53.3	65.1	76.9	88.8	104	133	163	192
4.3 (14)	8.9	11.8	14.8	17.8	20.7	41.4	47.3	59.2	71.0	82.8	104	118	148	178	207
4.9 (16)	11.8	14.8	17.8	20.7	23.7	47.3	59.2	71.0	82.8	94.7	118	148	163	207	237
5.5 (18)	14.8	17.8	20.7	23.7	26.6	59.2	71.0	82.8	94.7	107	148	178	207	237	266
6.1 (20)	17.7	20.7	23.7	26.6	29.6	71.0	82.8	94.7	107	130	178	207	237	266	325
6.7 (22)	20.7	23.7	26.6	29.6	32.5	82.8	94.7	107	118	142	207	237	266	296	355
7.3 (24)	23.7	26.6	29.6	32.5	35.5	94.7	107	118	130	154	237	266	296	325	385
7.9 (26)	26.6	29.6	32.5	35.5	38.5	107	118	130	142	166	266	196	325	355	414
8.5 (28)	29.6	32.5	35.5	8.5	41.4	118	130	142	154	178	296	325	355	385	444

1 The spraying time should equal the time for one and preferably two revolutions of the gear to insure complete coverage. Periodic inspections should be made to insure that sufficient lubricant is being applied to give proper protection.

2 Two hours is the maximum interval permitted between applications of lubricant. More frequent application of smaller quantities is preferred. However, where diluents are used to tin lubricants for spraying, intervals must be so short as to prevent diluent evaporation.

The spraying time should equal the amount of time it takes for one or two revolutions to ensure complete coverage. Periodic inspections must be made to ensure that a sufficient amount of open gear lubricant is being applied to provide proper protection. Two hours is the maximum interval time permitted between applications, per AGMA 9005-D94 guidelines.

The amount of open gear lubricant to use is dependent upon the application—e.g., mills, kilns, dragline, etc.—and the pitch line velocity of the gearing; the rated electrical power draw on the electric motor powering the gear (for mills and kilns); the type of gearing; and the type of open gear lubricant to be applied. In many applications, your lubricant supplier can recommend the starting amount to use. These application rates are expressed in grams-per-centimeter-face width-per-hour. In lieu of a starting recommendation from the lubricant supplier, AGMA has issued lubricant quantity guidelines in the AGMA 9005-D94 standard that can be used for intermittent methods of application.

- The spraying time should equal the time for one—preferably two—revolutions of the gear to ensure complete coverage. Periodic inspections should be made to ensure that sufficient lubricant is being applied to give proper protection.
- Two hours is the maximum interval permitted between lubricant applications, although a more frequent application of smaller quantities is ideal. However, where diluents are used to thin lubricants for spraying, intervals must be brief enough so as to prevent diluent evaporation.

To ensure that the correct amount of open gear lubricant is applied and operation reliability maintained, it is important to maintain a perfect spray pattern, without any gaps. Distribute the open gear lubricant evenly over the entire height and width of the tooth flank on the loaded side of the gear. The number of spray nozzles to use for a given application is determined by the gear width. Typically, four to six spray nozzles are required; they must be properly spaced to provide adequate lubricant coverage across the entire face of the gear teeth.

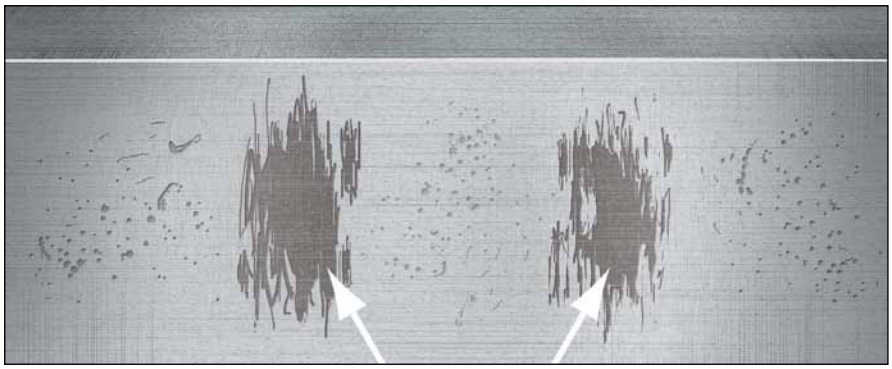

Figure 3—Inadequate spray pattern on the tooth flank; inadequate spray patterns normally lead to scuffing in these highlighted areas. Additional, correctly spaced spray nozzles and higher air pressure are required to improve the lubrication film.

As a guideline, for slow-speed, open gearing operating up to 2,000-feet-per-minute (10 meters per second), the end nozzles should be placed 2 to 2.5 inches (50 to 65 millimeters) from the gear face edge, with the remaining nozzles spaced 5 to 7 inches (130 to 180 millimeters) from center. Nozzle location is also a function of the spray pattern. Spray nozzles are generally positioned to direct the open gear lubricant at the loaded profiles of the gear teeth (not the pinion) at a maximum distance of 6 to 8 inches (150 to 200 millimeters) from the gear teeth (Ref. 2). The correct spray pattern on the tooth flanks and an illustration of the correct spacing of spray nozzles are illustrated in Figures 1 and 2.

The air pressure to the spray bar also must be properly set; otherwise, the open gear lubricant will not be atomized correctly. Insufficient air pressure will result in a splattering, lumpy or stringy appearance (Fig. 3), while excessive air pressure will tend to blow the open gear lubricant off of the gear. For most open gear lubricants, the air pressure seating must not be set lower than 75 psi (35 kilopascals or 5 bar) and not higher than 90 psi (42 kpa or 6 bar).

Even if the spray nozzles are monitored using control flow mechanisms, periodic checks of the spray pattern are recommended as part of maintaining full and even coverage of the open gearing on the gear face. Spray bars have many different designs, and many of the older spray systems do not allow easy access to check the spray pattern while the open gearing is operational. If the

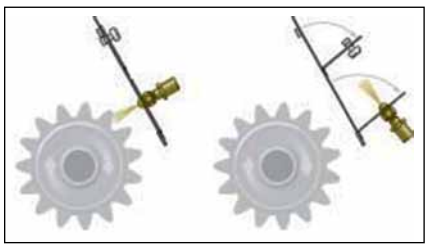

Figure 4—Recommended spray bar design for easy checking of spray pattern.

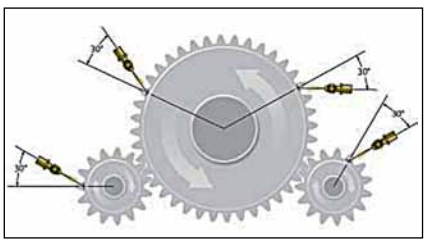

Figure 5—Spray bars can be located at four different directions of rotation.

Figure 6—Properly lubricated open gear.

spray bar does not swing out or open outward with the door, the safest way to check the spray pattern is when the machine is shut down. A recommended procedure for inspecting spray patterns is as follows:

- Ensure isolation procedures are adhered to, then open the inspection door and place a clean piece of cardboard or paper on the gear set, where the spray nozzle atomizes the open gear lubricant onto the gear set.
- Operate the lube system and check the lubricant coverage on the cardboard or paper. The coverage should overlap from one spray nozzle to the next, and there should not be any gaps within the appropriate height and width to cover the load-carrying gear teeth.
- If gaps are found, the air pressure, spray angle and spray cap need to be adjusted to obtain the appropriate coverage.
- Once the adjustments have been made, repeat the process until the perfect spray pattern (Fig. 1) is achieved.

If the spray bar requires changing, the spray bar design should be altered so that the spray pattern can be checked during equipment operation (Fig. 4).

The spray bar should be set at a 30° angle to spray the open gear lubricant onto the drive or loaded side of the pinion or girth gear. Setting the spray angle at 30° (Fig. 5.) will achieve a very good distribution of the lubricant in an upward or downward direction—always to the load-carrying tooth flank. The spray nozzle distance set back from the gear is approximately eight inches, plus or minus two inches (200 millimeters plus or minus 50 mm)—depending on the air pressure and tooth height. The width of the gear tooth will determine the amount of spray nozzles required to adequately lubricate the gear drive.

To further ensure that the proper amount of lubricant is being applied once the spray bar nozzles and patterns are set, it is recommended that the amount of lubricant being expelled from each injector be weighed. Over time, injector spray nozzles do not deliver the appropriate amount of lubricant-per-cycle that they are designed to deliver. Too much open gear lubricant being applied can cause waste, while under-lubrication can lead to increased wear and eventual component failure. The amount of lubricant needed to be expelled from each injector can be obtained from the manufacturer of the automatic lubrication system. For example, a Lincoln SL-1 style injector typically expels 0.046 ounces (1.31 grams) per cycle of lubricant.

The timer settings on the automatic lubrication system should eventually be set to the shortest frequency, depending upon the type of open gear lubricant used. For asphaltic and high-viscosity synthetic/ high-viscosity base fluids, the typical time-setting interval is 10 to 20 minutes, while for semi-fluid greases and gel/polymer-thickened type open gear lubricants, the typical time-setting interval is 15 to 30 minutes.

A strobe light can be used to check the appearance of the gears during operation. The strobe light should be set at the same speed that the gear is turning. A well-lubricated gear will have a dark-color to semi-transparent appearance—depending upon the type of open gear lubricant being used—and strings of lubricant will appear as the gear and pinion teeth separate. An over-lubricated gear will be black, with excess lubricant dripping and flinging off, or built up on the teeth and root zones of the gear.

Taking temperature readings across the gear face using a non-contact thermometer can be also be done to check if the open gearing is being properly lubricated. An even temperature across the gear tooth indicates that the gear is being properly lubricated.

In addition to being used to check for proper lubrication, strobe lighting and temperature reading can be used to check for misalignment. Any misalignment results in less contact across the meshing gears, resulting in increased wear. Roughly a 30°F difference across the gear tooth and darker to lighter areas of lubricant across the contact film indicate misalignment.

Gravity-feed or drip-feed systems. Gravity-feed or drip-feed systems are found on mills, kilns, shovels, draglines and excavators. These systems consist of one or more oilers, cascade pans, pressurized feed lines or applicator wheels. They allow the open lubricant to drip into the gear mesh at a set rate. This method of application is limited to open gearing with pitch line velocities of 1,500-feet-per-minute (7.5 meters-per-second) or less.

For these types of systems, asphaltic, high-viscosity-synthetic-oil open gear lubricants are generally used. If pressured feed lines or applicator wheels are used in these systems, a semi-fluid grease or gel/polymer-thickened type of open gear lubricant can be used.

Oil bath (splash and idler immersion) system. Oil bath systems are the simplest method of lubricating open gears. The gear or an idler in mesh with the gear is allowed to dip into the open gear lubricant, carrying it around to the mesh. Idler immersion systems are generally limited to open gear systems with pitch line velocities below 300 feet-per-minute (1.5 meters-per-second). Some systems will also include re-circulating pumps and filtration systems. A splash and idler immersion system can be found on mill and kiln applications.

As a general recommendation, asphaltic, high-viscosity synthetic oil, semi-fluid grease-type and gel/polymer-type open gear lubricant can be used in these systems. If a semi-fluid grease-type of gel/polymer is used, the open gear lubricant must be semi-fluid to fluid in consistency. If the open gear lubricant is an asphaltic or high-viscosity, synthetic-based fluid-type, the viscosity of the fluid should be a minimum of 1,000 centistokes (cSt), at 40°C.

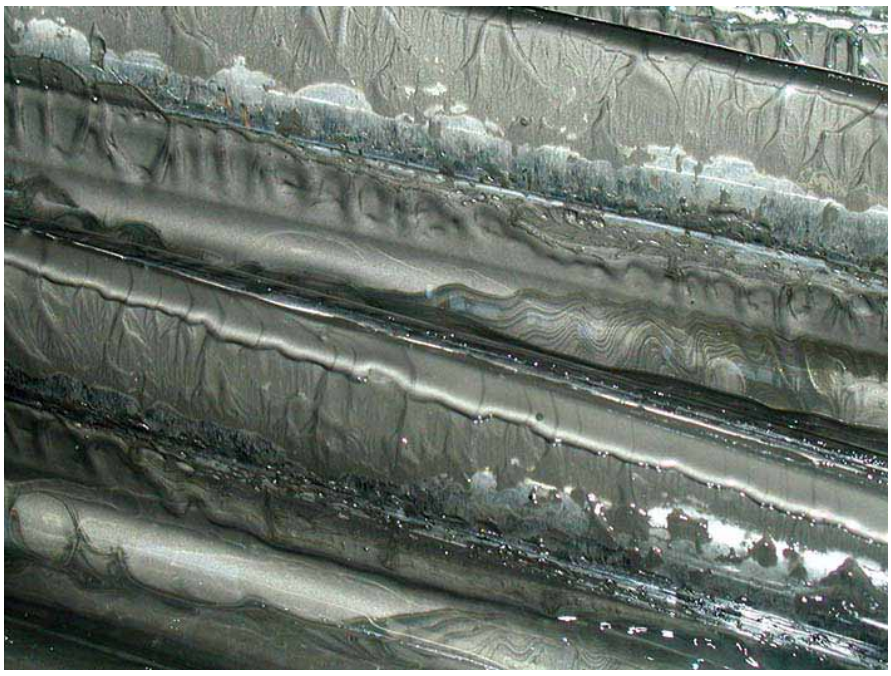

Figure 7—Over-lubricated open gear.

Hand-, brush- or pour-apply it. Manual application is one of the oldest—and most dangerous—methods used to apply open gear lubricants. It has been used to apply open gear lubricants on mills, kilns, shovels, draglines and excavators. Generally, asphaltic-type and high-viscosity synthetic-type open gear lubricants are applied by this method.

But using this method can result in not only the improper amount of open gear lubricant being applied, but also can result in the introduction of contaminants into the gearing. Further application by this method while the open gearing is operational can compromise safety and result in injury—or death—to the person applying the open gear lube.

Lubricating film thickness and selection criteria. The primary lubrication regime required to lubricate open gearing is elastrohydrodynamic (EHD) lubrication. According to the EHD theory, the critical factor is the open gear lubricant's film thickness, which is dependent upon the dynamic viscosity of the open gear lubricant at operating temperatures, average surface velocity of the gear temperature, the loads and geometry of the gearing, etc. It has been established that

the lubrication condition present in most gears is predominately elastrohydrodynamic. Gear teeth are subject to enormous contact pressures over relatively small areas (possibly as great as 435,000 psi), and yet they are successfully lubricated with very thin films of lubricant. There are two reasons for this:

- The high pressure causes the surfaces to deform elastically and spread the load over a wider area.
- The viscosity of the lubricant increases considerably with pressure, thus increasing the lubricant's load-carrying capacity.

Once the film thickness is determined, another important parameter to be calculated is the Lambda ratio. This ratio is defined as the ration of EHD film thickness of the lubricant to the composite surface roughness of the contacting metal surfaces. As the Lambda ratio approaches one—i.e., the film thickness is of the same order as the surface roughness—one can expect that there will be increased contact between the two contacting gears.

It should be noted that this calculation is based solely on the base oil viscosity of the open gear lubricant; it does not take into account any film thickness contribution that may be made by the open gear lubricant's thickener system or its solid lubricants. In addition, some types of open gear lubricants, such as grease-like and gel/polymer-thickened types, may contain light-viscosity base fluids. These light-viscosity base fluids are used as a cutback of the heavy-viscosity base fluids present in the formulation in order to enhance pumping of the product during low-ambient-temperature conditions. The light-viscosity base fluids are volatile and dissipate under operating conditions. Subsequently, the base viscosity of these open gear lubricants increases, generating a tacky, durable lubricant film that adheres to the gearing.

Besides taking into consideration the lubricant film thickness provided by the selected open gear lubricant, other considerations must be taken into consideration when recommending the proper type, grade and amount to be applied:

- OEM requirements
- Type of open gear application—mills, kilns, shovels, draglines, etc.
- Ambient temperature encountered in the area where the machine operates
- Climate condition where the machine operates, e.g.—ice, snow, wet, dusty, etc.
- How lubricant is applied
- If applied by a spray or automatic lubrication system, the type of lube system that is installed—Farval, Lincoln, Worner, Droppsa, etc.
- Type and ratio of the pump utilized on the automatic lube system
- Width of pinion gear
- Is gearing double or single pinion?
- Power rating of the electric motor
- Position and number of spray nozzles

Once all of these conditions are known, the proper open gear lubricant for the given application can be selected based upon the different topics, methods of application and characteristics discussed in this paper.

Finally, when switching open gear lubricants or applying open gear lubricants on new equipment where no prior lubricant was used, the following procedures should be followed:

Procedure to follow on new equipment:

- Clean all coating and debris from the gears.
- Coat the gear and pinion with a light film of open gear lubricant employing some sort of spray method.

Start-up procedure:

- Run equipment slowly under no load to verify that there is lubricant throughout the entire load zone.
- Gradually increase speed and load while turning on the automatic lube system.
- Monitor continuously until a proper coating is maintained.

For spray systems:

- Prior to startup, purge the lube lines and check spray patterns for complete coverage.
- Adjust the air pressure and volume as needed.

For drip systems:

- Most open gear lubricants are designed to adhere where applied. Drip tubes should be spaced no farther than two inches apart.

***Procedure for switching from one type of open gear lube to another*:** Although it is best to completely clean the gear, pinion and gear guards, conversion of one type of open gear lubricant to another can be made by applying the open gear lubricant to be used directly over most existing applications.

Procedure:

- Purge the lube lines thoroughly.
- Start the timing settings 50 percent higher than the operational settings to ensure all of the lines are purged and flushed and have built up a sufficient lubricant coverage film before reducing the lubricant consumption rate to the operational settings.
- Readjust the timer to maintain an adequate lubricant film. The lubricant quantity should not be reduced abruptly, but at five-minute intervals of 150 to 200 hours for mills and 100 to 150 hours for shovels, draglines and excavators.
- Product performance should be monitored.
- When reducing consumption quantity to the control unit of the spray system, it should be set to ensure the intervals between spray cycles are as short as possible. Short and frequent spray cycles ensure the lubricant is supplied evenly to the component, which increases functional reliability.
- Adjust the air pressure and volume as needed.
- Inspections of the lubricating systems, tooth flank conditions and spray pattern are required to ensure reliable operation. The spray system should be maintained thoroughly in accordance with the manufacturer's instructions.

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1. ANSI/AGMA 9005-D-94. "Industrial Gear Lubrication," Table 10, Page 10.
2. Ibid, Page 11.

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Optimizing Drive Systems for Energy Savings

William B. Gilbert

Management Summary

In looking for potential opportunities to reduce energy consumption via the drive system, a number of areas should be considered:

- The use of a common DC bus architecture as an alternative to individually powered AC drives will conserve energy by sharing the normally wasted regenerative energy from unwinds and other regenerating driven sections.
- In addition to sharing and saving energy, true common DC bus systems also conserve energy by eliminating many of the typical energy-wasting system components.
- Utilization of active front end (AFE) power sections to reduce system power factor and harmonics. AFEs provide near-unity power factor and produce minimal harmonics. AFE's can also compensate for the effects of poor power quality issues.
- Reducing mechanical losses with direct-drives, as certain power transmission components can waste significant energy.
- Optimizing drive sizes and tuning through mechatronic practices and tools. Oversized drives will use more power and adversely affect the system power factor. Poorly tuned drive systems can be a common source of energy waste.
- Retrofitting older DC drive systems with more efficient AC drive systems. AC drive systems offer greater energy efficiency over older DC technology. Some AC drives can automatically reduce their magnetizing current under low load conditions.
- Utilizing energy efficient motors for across-the-line applications, and AC drives in front of the motors in place of mechanical dampers and valves.

Introduction

Energy savings are an extremely important topic in virtually every segment of industry today. This paper will discuss the ideal areas where energy savings can be realized from the major power consumers in converting lines and machinery.

In general, the largest consumer of power in a converting line or machine is the drive system. But as energy costs continue to increase and energy conservation becomes a greater priority, do technologies or methods exist that can be implemented to reduce converting machinery energy consumption?

Saving Energy with a Common DC Bus

Pulse width modulation (PWM) technology review. Before looking into the details and benefits of DC common bus drive systems, consider the typical standalone AC drive. The power design of today's pulse width modulated AC drive is made up of three sections: 1) the input section is the rectifier that converts single- or three-phase AC voltage into DC voltage; 2) the DC link is the middle section containing a capacitor bank to smooth and buffer the DC voltage; 3) and third, the fast-switching inverter section that pulses the DC voltage into a three-phase power signal suitable for an inverter duty-rated AC motor.

AC/AC drive systems. Figure 2 shows the configuration of standard AC/AC

drives that are applied in a multi-axis, coordinated drive system. Here each individual drive is connected to the AC line via individual line components—fuses, reactors, contactors and component wiring. Each drive section must deal with its regenerative power individually.

Now let's consider a drive system for a converting line with unwind, pull-roll master section, coater, laminator and rewind. In this scenario the machine sections that add tension to the web—unwind and laminator—must return their power to the drive, and in turn this energy is subsequently dissipated by the re-gen resistors connected to the individual drives. The result: 75A of current is wasted as heat.

In some cases a pseudo-common DC bus is created with AC/AC drives that have an external bus connection by wiring the bus connections together. However this application is problematic, as the current-carrying capability of these bus connections do not always match the drive power rating. Precaution also must be taken to prevent the smaller drives from charging the larger drives. In any case, the added components required to create a pseudo-common DC bus are costly and inefficient.

Common DC bus architecture. True common DC bus drive systems are far more efficient in several ways than systems composed of standalone AC/AC drives. When drive systems utilize a common DC bus design, a shared rectifier section is used to convert the AC power supply into a DC bus common to the parallel connected motor modules (inverters).

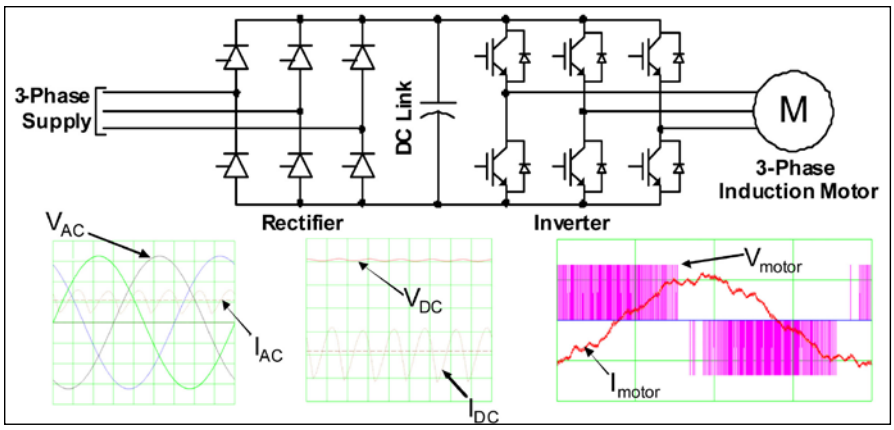

Figure 1—Standalone AC/AC drive.

Power sharing is now enabled between each different drive section linked on the DC bus. When power sharing occurs on the DC bus between drives that are motoring and generating simultaneously, the drive system now uses less power from the rectifier and the generating drive sections can return their power to the DC bus for sharing with the motoring or consuming drive sections. In contrast with the above example, the common DC bus system will use almost 75A *less* than the AC/AC drive system.

Additionally, the line components (i.e., contactor, reactor, fuses) and rectifier can be sized based on the maximum current draw of the system—not the summation of the individual motors. This also results in a more size-optimized and energy-efficient design be-

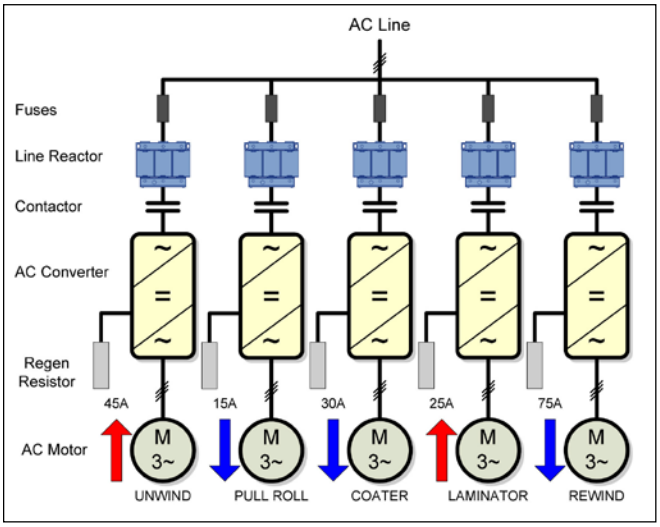

Figure 2—AC/AC-coordinated drive lineup.

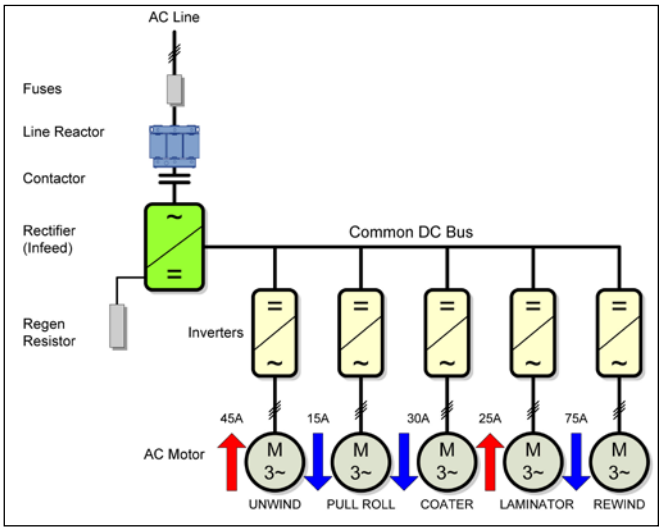

Figure 3—Common DC bus-coordinated drive lineup.

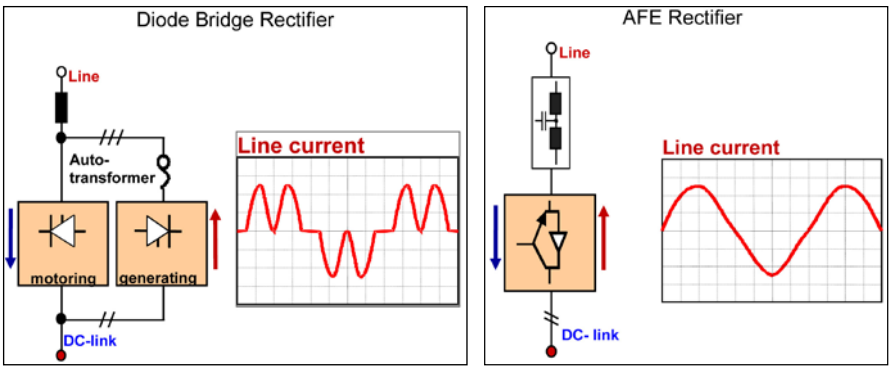

Figure 4—Comparison of line current diode bridge vs. AFE rectifier.

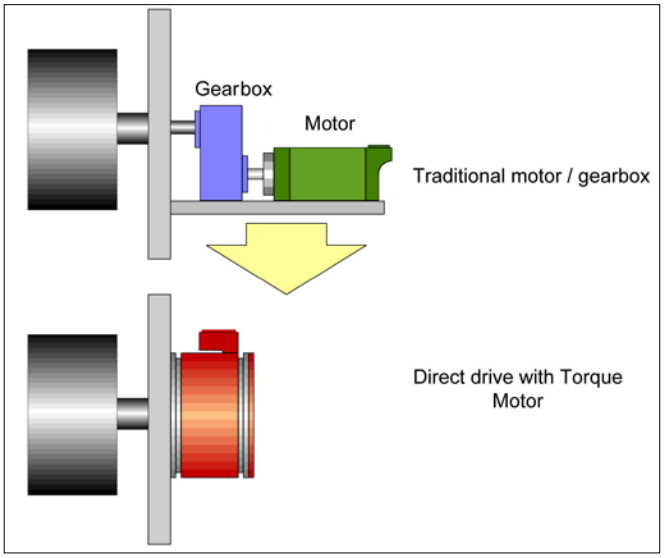

Figure 5—Gear drive vs. direct drive.

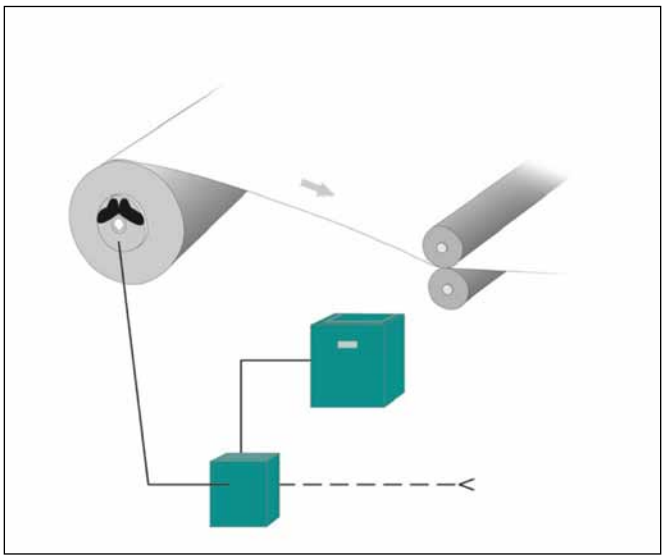

Figure 6—Mechanical brake unwind.

cause losses are realized in each individual line component and rectifier.

Active-Front-End Technology

Active-front-end (AFE), in-feed technology transforms the DC common bus system to a level of additional energy savings. An AFE is an IGBP (insulated gate bipolar transistor)-based rectifier that regulates or controls the DC bus level for both over and under voltage. This type of rectifier is suitable as either a substitute or replacement for the basic or re-gen SCR (silicon-controlled rectifier)-based modules discussed in the common bus overview.

In addition to line re-gen capability, this functionality also allows the input voltage and current waveforms to the drive to be sinusoidal, prevents harmonics from being generated back to the line and offers near-unity power factor. Although a reduction in harmonics can be very important to plant operation, the main energy savings from the AFE derive from the improvement in power factor. Indeed, AFE-controlled drives can have a .99+ power factor. In Figure 4 the effective line current in a diode bridge rectifier and AFE rectifier is detailed.

Power factor savings. "Power factor" (*Ed.'s Note*: *The offset in time—or the delay—between voltage and current being delivered, defined as the cosine of that offset. Source:* the-power-factor-site.com) is a measure of how effectively electrical power is used; a high power factor approaching unity) indicates efficient use of the electrical distribution system, while low power factor indicates ongoing inefficiency.

Power factor is the ratio of *real* power to *apparent* power. To determine power factor (*PF*), divide real power (*kW*) by apparent power (*kVA*). In a sinusoidal system, the result is also referred to as the cosine *0*.

When a utility serves an industrial plant that has poor power factor, the utility must supply higher current levels to accommodate a given load. A utility is paid primarily on the basis of energy consumed and peak demand supplied; without a power factor billing mechanism, the utility would receive no more income from the second plant than from the first. As a means of compensation for

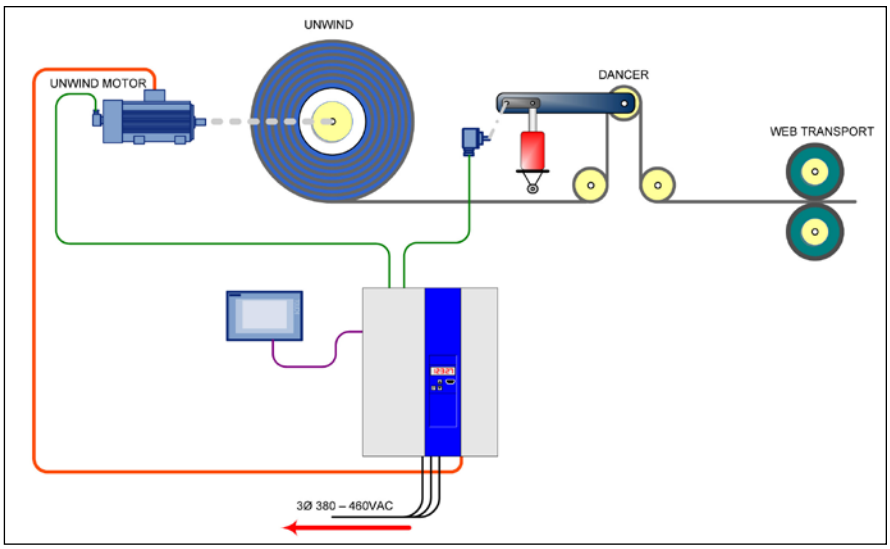

Figure 7—Driven unwind.

the burden of supplying extra current, utilities typically apply what is industry-known as a "power factor penalty" in their rate schedules. A minimum power factor value is established—usually 95 percent; when the customer's power factor drops below the minimum value, the utility imposes the penalty.

Eliminating Mechanical Losses

There are two major areas in converting machinery where significant energy is lost through friction and mechanical inefficiency—mechanical drive systems or gearboxes with high ratios; and unwinds with mechanical tension-control brakes.

Replacing gearboxes with direct-drive torque motors. High gear ratios are required when optimizing motor sizes for driving large-diameter rolls or for very-low-speed web applications. Where planetary gearboxes are fairly efficient, it is common for high-ratio, multistage worm gearboxes to experience efficiencies under 60 percent.

Low-speed applications previously limited to inefficient gearboxes are now commonly direct-driven with torque motors—and even conventional motors—thus eliminating the energy losses. Typical applications on converting lines utilizing torque motors with direct-drive are chill rolls, large-diameter casting rolls and very-low-speed web control in applications such as sputtering metallizers.

Driven unwinds vs. mechanical brakes. Unwinds with mechanical brakes are an ideal source for recovering energy. Mechanical brakes friction creates web tension and the heat generated in this process is recoverable energy.

Pneumatic or electromechanical tension-control brakes are commonly replaced with an AC drive system with line-regenerative capability.

A driven unwind must return the tension energy back to the AC line. In the past, re-gen DC drives have been

100 HP		
FLA Motor Current	125.0	A
Magnetizing Current	50.0	A

30 HP		
FLA Motor Current	40.0	A
Magnetizing Current	16.0	A

Figure 8—Single-drive energy savings.

MOTOR / DRIVE SYSTEM EFFICIENCY					
SYSTEM	Drive Eff. (%)	Motor Eff. (%)	System Eff. (%)	kWH / year	Annual Power Cost
DC	99.0%	88.0%	87.1%	336,625	$26,930
AC	97.0%	93.5%	90.7%	323,356	$25,868
Kilowatt hours = HP × .746 × annual hours of operation/system efficiency. 100hp motor is running at 90 percent load; 12 hours per day, 7 days a week Assume $.08/kWH					

Figure 9—Drive system efficiency.

Efficiency Rating	System Eff. (%)	kWH / year	Annual Power Cost	Annual Savings
Standard Efficiency	93.5%	348,506	$27,880.45	
High Efficiency IEC IE3	95.0%	343,003	$27,440.24	$440.22
NEMA Premium IEC IE3	96.2%	338,724	$27,097.95	$782.51
Kilowatt hours = HP × .746 × annual hours of operation/system efficiency. 100hp motor is runni ng at 90% load; 12 hours per day/7 days a week Assume $.08/kWH				

Figure 10—Savings from improved motor efficiency.

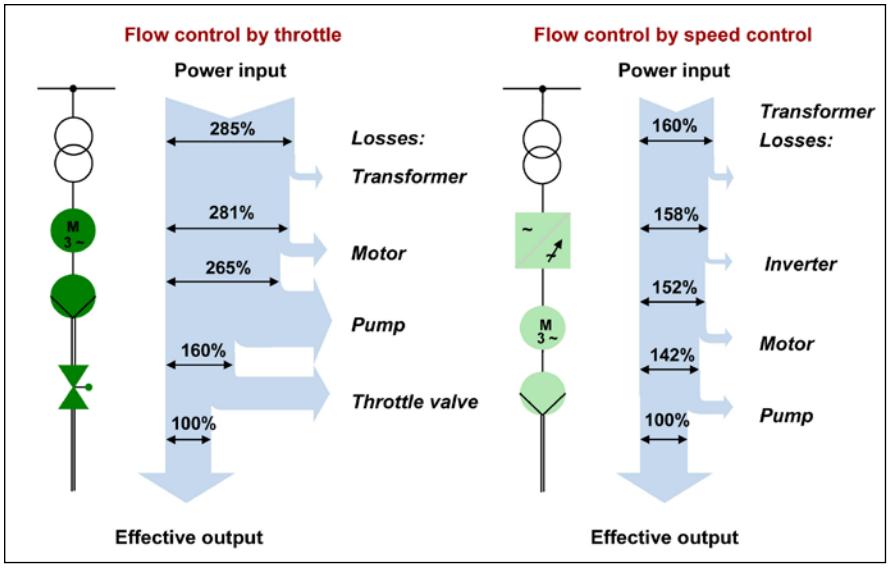

Figure 11—Mechanical throttling vs. speed control.

successfully applied in these applications, but DC drive systems are no longer common; even during their prime they were very costly when compared to their mechanical counterparts. And, older-generation AC drive technology did not have the capability to regenerate power back to the AC line; when applied as unwind brakes, they required re-gen resistors to dissipate the tension energy—a wasteful and costly practice.

Today's AC drive systems have the technology to regenerate the energy to the AC line—just as the DC drive did—but with added benefits to user and machine designer alike. Returning the tension energy to the line means that once-wasted power is now retained and not producing heat and worn parts. And if the drive is AFE-equipped, it will return the energy with near-unity power factor—impossible for any DC drive system.

Drive Optimization (Mechatronics)

Dedicated attention to drive and motor sizes vis-à-vis actual load requirements for specific applications and ensuring that coordinated drives are properly tuned will aid in harvesting energy savings.

Optimal sizing = energy savings. Oversized drive systems simply waste energy. The cost of energy waste is realized in the higher magnetizing current. An AC drive system's magnetizing current can be nearly half of the full-load current (FLC). Consider the example of a 100hp AC drive system applied to an actual 30hp load requirement. In this example, 40 amperes of line current are wasted. That relates to energy savings of 34A for a *single* drive.

Mechatronics and drive-tuning for energy savings. Poorly tuned drives not only affect machine performance and product quality—they waste significant energy. Drive systems tuned beyond the optimal waste energy as they drive the current loop harder, and the overactive current loop wastes energy in the form of motor heat.

As industry trends push drive system performance, mechatronics can ensure higher performance without wasting energy. The main issues are:

- Complex loads
- Compliance
- Lost motion
- Machine resonances

Applied mechatronics support can help archive the required system performance without wasting energy and affecting machine life.

Making the Switch: Replacing DC Drives with AC

Replacing outdated DC drive and motor systems with AC drive technology offers energy savings derived from the improved energy efficiency of the AC system over its DC counterpart. In addition, savings are gained from improved power factor.

Efficiency comparison. While the DC motor—putting aside, for a moment,

the drive component—is more efficient than an AC motor, the AC PWM (pulse width modulator) drive is far superior to a DC SCR drive. When considering drive system efficiency, the AC drive system can offer an efficiency improvement in the range of ~ three percent when operating at near-full-load, where the DC drive efficiency is at its highest.

Consider the example of a *single* standalone drive system at 100 hp and running at 90 percent load, 12 hours a day, seven days a week: a single AC/AC drive replacement can provide over $1,000 of energy savings per year.

Enhanced drive system efficiency. In keeping with drive technology's continued pursuit of energy savings, a recent drive feature now available aids the drive system in energy savings by reducing the AC motor's magnetizing current under no- or light-load conditions. As discussed earlier, asynchronous motor magnetizing current can approach half of the full-load motor current, meaning that drives enabled under no or light loads can realize significant energy savings from the drive system.

Motor Efficiency: Pump and Fan Losses

In certain conditions, AC motors are used in converting lines for which pumps and fans are typically used.

Energy-efficient, across-the-line motors. Today's standards for NEMA and IEC motors have led to their vastly improved efficiency. Consider replacing older AC motors with high-efficiency motors. There are currently three levels of motor efficiency:

1. Standard-Efficiency and IEC IE1; Pre-EPAct = Least Efficient
2. NEMA High-Efficiency and IEC IE2; EPAct Level = More Efficient
3. Nema Premium and IEC IE3 = Best Efficiency

See Figure 10 for details on potential savings from a single 100hp AC motor running at 90 percent load.

Pump and fan losses. In the applications where across-the-line motors are utilized—such as flow control—energy savings can be gained by adding an AC drive. The biggest potential for savings is found in those pumps, fans and compressors still operated with mechanical throttles and valves. Converting to variable-speed drives can produce considerable economic benefits.

With mechanical flow control, the motor runs continuously at a speed required for the maximum delivery rate — rarely needed in practice. Additionally, throttles and valves lose energy and cause high temperatures and vibration levels that can have a negative impact on the drive and production operation.

Variable-speed drives with inverters offer a more economic alternative for a number of reasons—e.g., they can be controlled much more quickly and precisely. But mainly, by adapting the flow rate directly to actual requirements, energy savings of up to 60 percent can be achieved—especially in energy-intensive applications. Consider the comparison of a mechanical throttle to a speed control example shown in Figure 11 for an overview of typical losses. In this example the input power requirement of the driven fan or pump is only 56 percent of the input power requirement of the mechanical throttle example.

Conclusions

Drives and driven systems in converting lines are major energy consumers, but advances in technology continue to offer multiple avenues for reducing total energy costs. In this paper we have addressed some of the areas where significant energy savings or recovery can be found on converting lines and machinery. As technology continues advancing in drive systems, more saving options will soon follow.

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Morris

BECOMES FIRST WOMAN CHAIR OF RIA

Catherine Morris, senior account manager, ATI Industrial Automation, Apex, North Carolina, has been named the first woman chair of Robotic Industries Association (RIA), the industry trade group representing more than 265 companies involved in robotics in North America. Morris becomes RIA's 20th chair since its founding in 1974, succeeding Dean Elkins of Yaskawa Motoman, who served as chair in 2010 and 2011. Elkins remains on the RIA Board as past chair.


Catherine Morris

Morris was first elected to the RIA Board in 2003 and most recently served as the board's first vice chair. She is a past chair and current member of the RIA Membership Committee and also chairs the show committee for Automate 2013, RIA's flagship event. She has been an account manager with ATI for 16 years, with a primary focus on key OEMs and automotive customers. In addition to being RIA's first woman chair, she also is the first to represent a component supplier company. Previous chairs have either represented robot manufacturer or system integrator companies.

"I hope to bring a new perspective and energy to the chair role," said Morris. "I'm passionate about robotics and know that automation is the key to our country's future economic success. My primary focus as chair will be to expand the Automate 2013 trade show and conference in order to spread the message about why and how companies can benefit by automating. Additionally, I will focus on making our new Certified Robotic Integrator program a success. This will have enormous benefit to integrators and end users alike and will lead to more successful automation systems. Finally, I will focus on strengthening the links between RIA and the educational community. In order to get students excited about robotics and automation and prepare them for future career opportunities, RIA will work more closely with community colleges and universities that offer automation courses."

Morris then added, "I am truly honored and humbled by the confidence placed in me by my mentors and peers and will do my best to lead our industry forward. I want companies of all types and sizes to recognize the importance of being a vital part of their industry's trade association."

Morris and past chair Elkins are joined on the RIA Executive Committee by first vice chair Stu Shepherd of KUKA Robotics, second vice chair John Dulchinos of Adept Technology, secretary Curtis Richardson of Spirit Aerosystems and RIA president Jeff Burnstein. The RIA board is composed of 19 industry leaders.

Re-elected to new two-year terms for 2012-13 are Joe Campbell of ABB Robotics, Mick Estes of FANUC Robotics America, and Michael Jacobs of Applied Manufacturing Technologies. Tom Tobin of Comau was elected to his first two-year term. The remaining board members for 2012 include John Burg, Ellison Technologies Automation; Tim DeRosett, Motoman Robotics; Joe Gemma, Staubli Robotics; Joyce Guthrie, USPS; Dana Komin, General Motors; Kevin Lambton, Pepperidge Farm; Mark Lewandowski, Procter & Gamble; Scot Lindemann, JR Automation; and Steve Rock, Rensselaer Polytechnic Institute. For more information, visit *www.robotics.org*.

Magnet Applications

EXPANDS STAFF

Magnet Applications, Inc. (MAI), a subsidiary of Bunting Magnetics Company, is pleased to announce the promotion of Jerry DePrator to production manager, and the additions of Janice Pandullo as quality engineer and Joe Benden as magnetic components engineer. DePrator has worked for MAI as a process engineer since 1999. In his new role, DePrator will oversee the entire manufacturing process for compression-molded and injection-molded magnet product lines. He will be involved in the installation of new equipment, capital improvement projects, quality initiatives and the management of all production-related personnel. DePrator holds a bachelor of science degree in plastics engineering from The Pennsylvania State University.


Janice Pandullo

"Jerry's in-depth knowledge of our customers, products and production capabilities is impressive and will allow us to streamline our production process to satisfy the timelines required by our clients," stated Dr. Pete Lipetzky, Ph.D., magnet applications general manager. "As our production manager, he has guided our shop in a positive manner and our customers have noticed a difference. The ability of our plant to meet changing production needs has been vital to our recent growth."

For over the last eight years, Pandullo has served in various quality control roles within metals and wind energy industries. She is a senior member of the American Society for Quality (ASQ) and is an ASQ Certified Quality Auditor. Pandullo has been trained on ISO 9001 & 14000 and has received auditor training in both categories. In her role as quality engineer,

she will be responsible for the ISO certified quality system, be involved in operations, product development, and continuous improvement with specific responsibility for the quality management system program. Pandullo holds a bachelor of science degree in industrial engineering from The Pennsylvania State University.

Benden will be responsible for preparing quotes, designing magnetic circuits and working with customers on small motor assembly projects. Prior to joining MAI, he worked in several electrical engineering and magnetic components roles. Benden has a bachelor of science degree in electrical engineering from The Pennsylvania State University. "The demand for our products has risen dramatically over the last 18 months," stated Lipetzky. "Our magnets and related products are custom built for applications in industries ranging from defense, energy, automotive, telecommunications, and medical to basic manufacturing; more than people realize. Janice and Joe will help us meet the high standards our customers need."

Gerard Karpik

JOINS GATES CVT GROUP

Gates Corporation recently announced the addition of champion Cross Country/Snow-X racer Gerard Karpik to its CVT systems development group in Rochester Hills, Michigan. Gates Director of Global CVT Systems David Hanes stated: "Gates is aggressively entering the hardware side of power transmissions with the introduction of our complete Gates CVT System featuring proprietary drive and driven clutch technologies. Gerard's extensive experience in recreation vehicle design and application will enable Gates to continue pursuing growth in new and emerging markets. As a longtime user of Gates products, he racked up thousands of miles doing durability and race testing for Gates drive belts as Bombardier's champion in-house racer. Later he co-founded his family's business and they are credited with starting a suspension revolution in snowmobiling by developing a coupled

Gerard Karpik

long travel suspension technology and other patented forward looking chassis and suspension designs. His company has assisted in racing and product development for great companies like Bombardier, Polaris and Yamaha. Coupling his knowledge and experience with our team's commitment to building the very best in drivetrain technology will ultimately fast-track our products to world-class OEMs. This is a great match-up of experience, product and company. We're excited to have him on our team."

"Over the years I've had some good offers to work with R&D groups of differing OEMs and suppliers. Knowing more work was needed to advance my own company TeamFAST," says Karpik, "I had to pass on these offers. When Gates approached me about their program and the strides and commitments they've made to become a 'hard components' supplier to the world markets utilizing CVTs, it intrigued me. With the knowledge that right now TeamFAST has its best line of suspension products ever in the M-20 Platform and the experienced team to keep advancing them, I could consider joining Gates. There's no group more knowledgeable, nor a company more committed to power delivery through CVTs than Gates. As an ongoing business owner, product developer, and marketer the opportunities here at Gates have me energized and engaged."

Siemens

SELECTED AUTOMATION PARTNER FOR DOW CORNING

Siemens Industry, Inc. announced that it has been selected as the strategic process automation partner for Dow Corning, following an extensive review and evaluation process using Manufacturing Automation Platform Selection (MAPS) Six Sigma (Define, Measure, Explore, Develop, Implement) processes. The global supply contract will feature Siemens Simatic PCS 7 as the strategic platform for Dow Corning's batch, continuous and discrete process automation solutions. Siemens process control system manages the automation of all ancillary, upstream and downstream processes, while providing the mechanism to improve process efficiency resulting in improved production and reductions in the total cost of ownership. "Siemens PCS 7 platform best meets Dow Corning batch, continuous, and discrete process requirements to achieve higher productivity, improved safety and lower cost of production through the use of automation solutions," says Barry MacGregor, manager, global process automation at Dow Corning.

Simatic PCS 7 can be specifically extended through the integration of functionalities such as batch process automation, material transport control, advanced process control, asset management, safety applications, process data analysis/management or MES integration. And, with Siemens Totally Integrated Automation (TIA), PCS 7 can meet the demands for automation solutions along multiple hierarchy levels, including enterprise, management, control and field device levels. "There are core advantages to using Siemens Simatic PCS 7 control system, and Siemens has set a global standard for control systems," says Raj Batra, president, Siemens Industry Automation Division. "Through PCS 7, Dow Corning will realize a lower cost of ownership through integration, using a system that combines performance, quality, efficient engineering, reliability, flexibility and availability. Siemens also continually modernizes its systems for the safety and security of employees, equipment and operations."

According to Pat Dean, manager of global manufacturing automation at Dow Corning, the company's Six Sigma Quality is a key element of Dow Corning's commitment to delivering value for its customers by having a solid understanding of their needs and solving their problems. "Dow Corning has developed an integrated management system and has obtained a global ISO9001 registration under a single certificate, providing its customers with a consistent solution worldwide."

Boca

CELEBRATES 25 YEARS WITH INNOVATION CONTEST

The Boca Bearing Company recently announced that it is celebrating its 25th year in business by giving away over $20,000 in cash and prizes as part of its international 2012 Boca Bearings Innovation Contest. Boca Bearing Company believes in supporting innovators who push the limits of new technologies that will drive the future economy. Boca Bearing Company has a long-standing commitment to innovation, including its involvement with the 10,000-year-clock, a clock that is designed to run for ten millennia with very little maintenance and interruption. It is powered by mechanical energy harvested from sunlight as well as the people who visit it. The primary materials used in the clock are marine grade 316 stainless steel, titanium and dry running ceramic ball bearings from the Boca Bearing Company. The clock is being funded and built on property owned by Jeff Bezos, the founder and CEO of Amazon. Boca Bearing Company's customers have also been heavily involved in creativity and invention, and the global Innovation Contest is a way to thank them for their commitment not only to the company but also to helping drive advancements in the world around us.

Contest winners will be chosen based on a video submission of their innovative, progressive or overall "cool" projects that utilize ball bearings, roller bearings or linear bearings. One finalist will be chosen by the voting public each month in 2012 to win an iPad2, and the Grand Prize winner will be chosen by the

Boca Bearing Company to receive a grant check for $10,000.

Any project can be submitted for entry such as Unmanned Autonomous Vehicles (UAV's), Robots, Kinetic Art Sculptures, Engine Hacks, Performance Racing Applications, Sustainable Energy Projects and much more. "Boca Bearing Company started with humble beginnings as a ball bearing supplier to the Radio Control (RC) hobby market. As the years progressed, we started offering a wider variety of bearings appropriate for use in various different applications from industrial to hobby and recreational uses. Many of the young men and women that enjoyed playing with RC vehicles as kids eventually grew up and went to work in advanced manufacturing industries such as robotics, optics, engineering, applied physics and other hands-on fields," said Allen Baum, president of Boca Bearing Company. "These customers took us along with them and helped to expand the company's product line and focus. Today Boca Bearing Company's product line can not only be found in RC cars, RC helicopters and RC engines but also in turbine flow meters, unmanned autonomous vehicles, robots, semiconductor manufacturing, MRI machines, packaging equipment and much more. We've created this contest as a way to thank our global customers for their commitment to our business and to innovation.

BDI

EXPANDS OPERATIONS

BDI (Bearing Distributors Inc.), headquartered in Cleveland, Ohio, recently announced the opening of two new branch offices. BDI Branch #58 is located at 1570 Brookford Industrial Rd., Unit B, Kernersville, North Carolina 27284 and BDI Branch #32 at 2093 Thomas Rd., Suite 3, Memphis, Tennessee 38134. Jim Chrapek, a veteran of the Greater Triad Area bearing/power transmission industry, has joined BDI as branch manager of the company's newest location in North Carolina. Other members of the new branch team are operations manager Lee Noble and customer service representative Lisa Taylor. "BDI Winston-Salem will support BDI's missions of delivering products and solutions to both existing and new customers in Winston-Salem and the Greater Triad Area and continued growth in the Southeastern U.S. market," according to John Ruth, president, BDI-USA. Newly appointed branch manager Richard (Ricky) Swann has relocated from BDI-Decatur, Alabama to oversee the company's entry into the Memphis market. Swann has nearly 30 years of industrial distribution experience and will draw on that experience to deliver solutions to Mid-south customers. "BDI-Memphis will support a number of existing customers in Western Tennessee and North Eastern Arkansas and support our continued growth in the Midsouth," Ruth adds. For more information, visit *www.bdi-usa.com*.

CORRECTION

Some incorrect data appeared in the article, "Application of Ceramics to NU-Type Cylindrical Roller Bearings for Machine Tool Main Spindles," which appeared in the December 2011 issue of *Power Transmission Engineering.*

On page 31, Table 2, the "Test conditions category" section should read: Initial radial clearance -3 – -4 mm

On page 33, Table 3, the "N-type with ceramic inner ring" section should read:

Fit between shaft and inner ring 2 mm, interference-fit

On page 33, Table 3, the "Test conditions category" section should read: Initial radial clearance 0-3 mm

The complete and corrected version can be found online at *www.powertransmission.com/issues/1211/ntn.pdf*

Power Transmission Engineering apologizes for the error.

calendar

March 3–6—GEAPS Exchange 2012

Minneapolis Convention Center. Once known as the grain milling capital of the world, Minneapolis will again be the focus of the grain handling industry when the Grain Elevator and Process Society (GEAPS) brings the Exchange back to the Twin Cities. GEAPS 83rd annual technical conference and exposition will bring attendees from around the world to generate leadership, innovation and excellence in grain-related industry operations. From companies that have been at every Exchange for more than 40 years, to new exhibitors eager to be a part of the premier show in the industry, attendees will enjoy a diverse slate of topical education sessions on equipment, safety and new technologies. The Educational Programming Committee has carefully planned workshops on developing a culture of safety as well as the Idea Exchange which highlights innovative ideas from industry professionals. The Expo Hall will feature exhibitors like Baldor, Gates Corporation, Nord Gear Corp., Siemens, SEW-Eurodrive and Rexnord. For more information, visit *www.geaps.com*.

March 7–8—Lean Transformation Summit

Jacksonville, FL. The Lean Enterprise Institute (LEI) summit raises consciousness, generates enthusiasm and explores new frontiers in lean thinking. Attendees will learn from leading lean practitioners and colleagues who have faced the same challenges. Summits are two-day events designed for mid- to upper-level managers, with a focus on sustaining the lean journey, and insights into innovative ways to enhance your lean journey. LEI present a series of summits and conferences globally throughout the year to teach actual applications, not just concepts, in plain language with the case studies, worksheets, formulas, and methodologies needed for implementing lean into your business *(www.lean.org)*.

March 13–15—AGG1 Aggregates Forum & Expo

Charlotte Convention Center, Charlotte, NC. AGG1 Aggregates Forum & Expo focuses exclusively on the aggregates industry and features in-depth industry-focused educational programming and comprehensive exhibits that showcase the latest technologies and innovations in aggregates-related equipment, products and services. The 2012 AGG1 Aggregates Forum & Expo is co-located with the 2012 World of Asphalt Show & Conference, providing an enhanced show experience for attendees by offering additional exhibits and education opportunities. AGG1 is geared to the decision makers and buyers from the companies that produce the vast majority of crushed stone, sand and gravel in the marketplace, including company owners, senior managers, plant managers, superintendents, regional managers, engineers, technical professionals and safety managers. AGG1 features a New Products & Technology Program as another way for attendees to quickly find new and innovative products and services on the show floor. In addition, product-focused exhibit pavilions will make it easier for attendees and exhibitors to connect and discuss specific operational functions. The AGG1 education program offers courses on a full range of topics so that industry professionals can have a choice about the topics they want to learn about and the areas where they want to focus, based on their unique situation. For more information, visit *www.agg1.org*.

March 13–15—Composites Manufacturing 2012

The Composites Manufacturing conference and exhibition provides knowledge on composite applications, processes and best practices. This three-day program features a combination of education, networking, exhibits, exclusive tours, industry keynotes and in-depth manufacturing insight. Manufacturing engineers and management from the aerospace, medical, wind energy, transportation, recreational, consumer products and green manufacturing will come together to discover new ways to stay relevant and competitive. This dynamic event continues to evolve, grow and improve to provide an array of different learning and networking opportunities. Developed by a team of SME professionals who work hand-in-hand with an industry advisory board, this team has its finger on the pulse of composites manufacturing and understands what attendees need to succeed. For more information, visit *www.sme.org*.

March 27–29—Westec 2012

Los Angeles Convention Center, Los Angeles. Westec returns in 2012 redefined with a renewed commitment to local manufacturing. The manufacturing event includes keynote presentations from industry leaders in aerospace/defense, renewable energy and the manufacturing economy. The show also consists of technical sessions on topics that include small parts machining, high-speed alloy machining, milling, drilling, cutting advanced carbon fiber, carbon laminates and advances in additive manufacturing. Attendees view emerging technologies and emerging equipment applications and many other topics with an emphasis on using technology to innovate. Westec offers a place to network, form relationships and build partnerships, putting an emphasis on new developments, integration, lean methods, and how to manufacture with composites, titanium or other advanced materials. For more information, visit *www.westeconline.com*.

April 29–May 1—BSA Annual Convention

Bonita Springs, FL. Business programming at BSA's 2012 Annual Convention will help attendees plan strategically for the latest developments in technology. Help your company focus on the cost- and time-saving ways in which the latest mobile technologies deliver sales and solutions. How will you move your business forward in this new mobile communications culture? How will you and your customers benefit? How will this differentiate you from your competition? BSA challenges the industry to consider how to best leverage the latest business tools with "Technology Drives Productivity." Business programming at the 2012 event will provide an overview of how authorized distributors and their supply chain partners can differentiate themselves in the marketplace, providing customer solutions and products using the latest technology. Speakers at this year's convention include Daniel Burrus, Guy Blissett, Matthew Bookspan and Brian Eccles. For registration information, visit *www.bsaconventions.org*.

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3) Name:_____ (print) Job Title/Position: _____

4) Signature _____ Date: _____

5) Please tell us about your company:

Company Name:_____
Company Address:_____
_____
City:_____
State/Province:_____
ZIP/Postal Code:_____
Telephone:_____ Fax:_____
E-mail:_____
Co. Internet Address:_____

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

☐ WE MAKE power transmission products (10)
☐ WE BUY power transmission products (12)
☐ WE SELL power transmission products (Distributors, sales reps. etc.) (14)
☐ WE DESIGN products with power transmission components in them. (16)
☐ Other (please describe) (15)_____
_____

7) Which of the following products and services do you personally specify, recommend or purchase? (Check all that apply)

- ❑ Actuators (30)
- ❑ Adjustable-Variable Speed Drives (31)
- ❑ Bearings (32)
- ❑ Belting and Belt Drives (33)
- ❑ Brakes (34)
- ❑ Clutches (35)
- ❑ Controls (36)
- ❑ Chain & Chain Drives (37)
- ❑ Couplings & U-Joints (38)
- ❑ Gears (39)
- ❑ Gear Drives (40)
- ❑ Gear Mfg. Services (41)
- ❑ Hydraulic Power (42)
- ❑ Linear Motion (43)
- ❑ Motors (44)
- ❑ PT Accessories (45)
- ❑ Sensors (46)

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

- ❑ Corporate Management (1)
- ❑ Plant Engineering (2)
- ❑ Design Engineering (3)
- ❑ Marketing & Sales (4)
- ❑ Manufacturing Engineering (5)
- ❑ Purchasing (6)
- ❑ Quality Control (7)
- ❑ Factory Automation (8)
- ❑ Maintenance (9)
- ❑ Other (10) _____

9) What is the principal product manufactured or service performed at **THIS LOCATION?**

_____

10) How many employees are at THIS LOCATION (Check one)
☐ 1-19 ☐ 20-49 ☐ 50-99 ☐ 100-499 ☐ 500+

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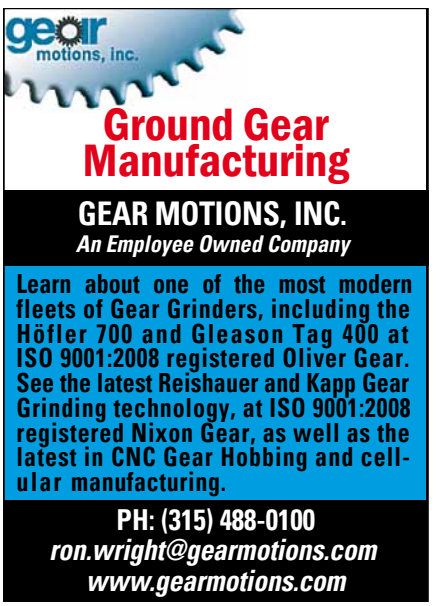

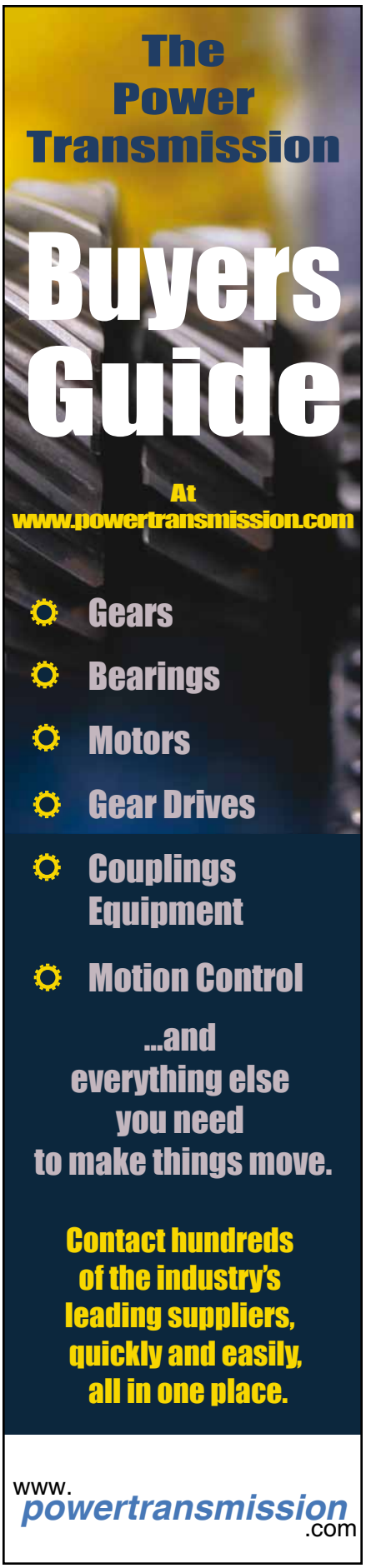

Major Tom Meets Rocket Man:
NASA Launches Third Rock Radio

Reports from various media segments lamenting the reluctance of this country's best, brightest—and youngest—citizens to embark upon a career in high-tech manufacturing continue to proliferate. They appear in print or broadcast outlets seemingly every day. And if there is one common thread running through these accounts—one which can also be readily found in past issues of this magazine—it is that manufacturing is not sufficiently "sexy" to attract the young and the restless.

Why is that? Aside from a very long history of literature, movies and television—and you may as well toss in music as well—depicting manufacturing work as something one accepts—not aspires to—could it also be that attempts to date in luring young folk to industry are themselves devoid of that four-letter word?

It may be a question without an answer, but look who is jumping into the fray with a decidedly different approach: Our National Aeronautics and Space Administration—yes, NASA—has launched (first and last space pun, I swear) a new, advertiser-supported radio station—Third Rock Radio (***www.nasa.gov***)—devoted to appealing to the "4G Generation" and its latent, insufficiently tapped science acumen.

As the press release announcing the station states, "Building bridges to connect with the hard-to-reach generation starts with knowing what they want." And Houston-based RFC Media, NASA's partner in the venture, believes they have the answer. They have, the release continues, "successfully repackaged NASA's message around something the 4G audience already cares a lot about, their music! And, for the first time, America's best brands can ride along."

Pat Fant is co-founder and CEO of RFC Media, a company that produces custom-designed, private-label radio stations for high-profile brands. Third Rock is his brainchild.

The station's advertiser (*no taxpayer dollars used*)-supported programming includes NASA highlights and features in science, technology and education that are presented in a casual, "street-smart tone," all available via NASA iPhone and iPad mobile apps for anywhere/anytime access.

Significantly, Third Rock will help partner-companies fill high-tech job openings in the engineering, science and IT fields. In addition to the NASA Web Portal, the station will be available online under the radio tab of Apple's iTunes and other sites.

To lure sponsors, RFC has proposed a "customized," comprehensive branding plan that would include on-air messages, on-site exposure (at live events) and special Third Rock programming features

"Third Rock, as a creative NASA outreach, is a direct pipeline to a highly qualified crowd in science, technology, engineering and math," says Fant. "We are programmed for both the newly graduated job seeker as well as the pro with years of experience. The new rock/alternative speaks the language of both very well. The audience for the station is worldwide, so offering positions on any continent is fair game. We are looking for our first engineering firm that wants to invite young professionals to give them a look."

And the reported 8.1 million monthly visitors to NASA's site should provide a wide and deep gene pool.

Fant hopes to leverage the radio venue to develop ways in which Third Rock can provide "direct access to students, young parents and tech-savvy young adults (taste makers and early adopters), along with some of the world's most influential scientists, researchers, innovators, astronauts, engineers and, without a doubt, music lovers."

Indeed, the music is the hook for this enterprise—and its best chance for success.

Pat Fant (above right) helms NASA's Third Rock Radio.

"The music is the glue that holds it all together," says Fant. "It gives the station street cred with the smart, skeptical and tech-savvy crowd. Plus, we talk to them, not advertise to them. We pull, not push. We are messaging experts in engaging, not selling."

The station is heralded in the release as a "fresh entertainment environment tuned to awaken and inspire a worldwide audience by exploring new worlds of music." To that end, "Music Explorers (hosts)" will present "discoveries in new music in a rock/alternative format that is known to index among the highest in education and income."

"The delivery system for music and entertainment has permanently changed and it's never going back," says Fant. "NASA's Third Rock is the first online radio station developed by professionals who have led many of the nation's most influential major market radio stations for over three decades. Now, NASA's Third Rock is taking new music discovery to a whole new height. Computers shouldn't pick records. People should."

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