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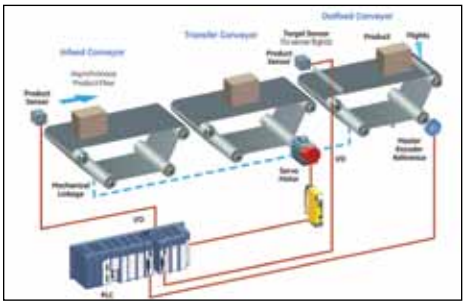

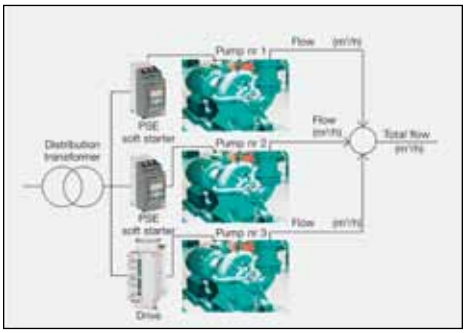

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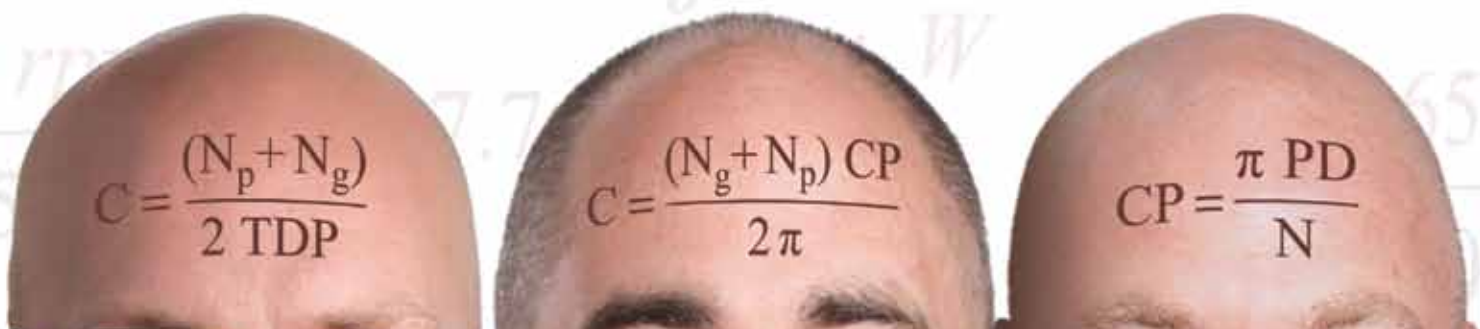

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VOL. 5, NO. 3

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Going Green on the High Seas

LOAD ADAPTOR LEADS TO ENERGY SAVINGS FOR COMMERCIAL FISHING

Saving thousands of gallons of fuel while battling through thunderous 50-foot waves are challenges for today's commercial fishing boats operating in the Bering Sea. Those challenges are met by the Gen-Tech system, a patented workboat power generation improvement that is a major energy and fuel saver. The Gen-Tech system eliminates running a separate auxiliary engine for generator operation when the main engine is in travel mode. When equipped with the Overhung Load Adaptor (OHLA) from Zero-Max, the two hydraulic pumps connected to the primary engine work effortlessly, providing generator power so auxiliary engine operation is unnecessary. A fuel cost savings of $2,300 or more in an eight-day fishing excursion is typical using this system according to Gen-Tech.

"The auxiliary engine is not fuel efficient when in the travel mode," reports Erling Skaar, president of Gen-Tech. "Our system maximizes the operating efficiency of the primary engine with the help of the Overhung Load Adaptor so running a secondary engine is unnecessary. The additional load on the main engine from operating the Gen-Tech system is negligible, and therefore highly efficient and fuel saving. There is no added wear to the engine or connecting components. Thanks to the OHLA's rugged design, we're assured of smooth and reliable pump and generator operation. That's extremely important in the adverse and hostile environments that these fishing vessels are subjected to."

The first application for Gen-Tech system was a state-of-the-art workboat called the North American, a 35-year-old, 110-foot house forward fishing vessel capable of carrying a full load of king crabs weighing 170,000 lbs. The North American is a crab boat that ventures forth for the Alaskan king crab fishing season. As movies and TV shows have accurately depicted, the king crab season is a high-risk business where crews and boats frequently face catastrophic storms, injury and death. The equipment needed to deal with these conditions requires the best and most robust technology, exactly the way the North American was designed and outfitted. What makes the North American's power system so unique is the Gen-Tech system aboard. According to Skaar, that system is a product of over nine years of innovative research, rigorous testing, the development of new technology and a dedicated mission statement. "When the fishing vessel isn't risking it all for a quick fortune and the continuation of an epic lineage," according to the North American's website, "it's being put to use as a working model for the environmentally conscious vessels of the future." Its fuel savings and pollutant reduction features make for a greener fishing operation, which has a positive global impact.

Gen-Tech's secret is in the patented controller and software design. The controller actually "learns" the power requirement for the input to the hydraulic pumps from the ship's main engine. Using that information, the controller then adjusts the displacement of the hydraulic pump to maintain stable frequency and voltage through the entire RPM range of the main engine.

In the Gen-Tech system, the OHLA from Zero-Max provides a solid, permanent mounting surface. It transmits rotary motion from the main engine to the hydraulic pumps. Using the OHLA in the system eliminates the need for a secondary gearbox to operate the hydraulic pumps that can be more costly. Also, the OHLA adds much more stability in the drivetrain than a gearbox. Most important, the OHLA enhances motor operation by eliminating

premature motor or pump failure due to overhung loads (axial or radial) on the pump and motor shaft. In high seas, violent shifting motion multiplies power train stress so the OHLA's stability role is even more important than in calm operating conditions. It allows the Gen-Tech system to operate flawlessly in wildly fluctuating conditions.

The OHLA (Model 1036S) is belt driven off the main engine (Caterpillar Model 399-1,125 hp) via a 2.8 to 1-speed ratio using a Gates polychain drive. With a SAE-D face mount, the OHLA has a 13-tooth 8/16 spline input, a 2-1/4 inch output shaft and a seven-inch pitch diameter on the OHLA's pulley. For added durability, spherical bearings were selected for this application. Extra rugged to meet all operating conditions, the OHLA housing is made of 25,000 PSI tensile cast iron with shafts of 130,000 PSI stress-proof steel. Weight is 195 lbs.

The OHLA operates at 1,540 idling rpm, 2,500 cruising rpm and 3,360 maximum rpm. Connected to the two variable displacement hydraulic pumps mounted "piggyback," the pumps produce 3,000 psi pressure and deliver 120 gallons per minute. "With Gen-Tech, the North American cruises at 10 knots using only 21 gallons of fuel an hour," reports Skaar. "Without Gen-Tech, the North American cruises at 10 knots using 25 to 26 gallons of fuel an hour. While the dollar savings for an actual eight-day fishing excursion is huge at $2,300, also huge is the reduced carbon emissions and pollutants that help preserve our fishing environment. We're pleased to have discovered the Zero-Max OHLA and having it integrate so effectively in the Gen-Tech system."

For more information:

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www.gentechglobal.com

Zero-Max, Inc.
13200 Sixth Avenue North
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Wittenstein motors are produced with the highest quality materials with well proven brushless three-phase technology, according to the company's press release. Minimum weight and high-power density allow designers to create compact, high-performing machines for application in robots, medical and automation.

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Wittenstein, Inc.
1249 Humbracht Circle
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www.wittenstein-us.com

Bosch Rexroth

EXTENDS
INDRALOGIC PLC FAMILY

Bosch Rexroth's IndraLogic XLC PLC family enables scalable, controller-based and embedded PC solutions in conjunction with the company's latest IndraControl device platform. Industrial PC-based hardware variants will round off the device portfolio later this year. Rexroth advanced the PLC programming using state-of-the-art PLC kernel, IndraLogic 2G, integrated homogeneously into the company's *IndraWorks* software tool and the multitasking runtime system. This allows users to take advantage of many new functions for creating modular software projects in an end-to-end overall system in less time than before. Functions include convenient editor tools, object orientation as an extension to IEC 61131-3 and comprehensive function libraries as well as fast compilers for efficient generation of machine

codes. The modular GATcompact (Generic Application Template) project template simplifies the process of designing new machines with enhanced software quality while reducing effort considerably.

End-to-end communication between the controller and decentralized system peripherals, such as inputs and outputs or drives, takes place via real-time Ethernet Sercos III. Fast PLC cycles to 250 µs enable optimum response times for handling time-critical process signals. IndraLogic XLC controllers come with versatile motion control functions, integrated into the run-time systems, to enhance the previous IndraLogic systems.

With its motion control functionality, the XLC handles machine applications ranging from simple point-to-point motion to the syn-chronization of multiple axes that use Rexroth's FlexProfile to integrate complex motion sequences. The graphical profile editor in the Rexroth *IndraWorks* software tool offers numerous offline and online functions for this purpose. Master and slave interfaces for Profinet RT, Profibus and EtherNet/IP are also available, in addition to Sercos III, for integrating into a wide range of communication networks.

For more information:

Bosch Rexroth Corporation
5150 Prairie Stone Parkway
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www.boschrexroth-us.com

Fanuc Controls

DELIVER HIGH-SPEED LASER PROCESSING

Fanuc Factory Automation America (Fanuc FA America) recently introduced the Series 30i/31i-L Model B high-speed laser controls capable of supporting advanced levels of high speed laser processing. The new Series 30i/31i-L Model B CNCs have the capacity to deliver seamless choreography between axes motion and power modulation,

continued

even in cases of extremely high speeds when processing thin-gage materials. Impressive internal laser power stabilizing characteristics deliver edge conditions on thicker materials which redefine the norm of RZ and RA (measured length of surface roughness). Truly unique in laser processing, smooth edge cross sections with superior edge finishes quantify smoothness rather than surface roughness.

Relative to other CNCs in its class, the Fanuc Series 30i/31i-L Model B laser control has update rates of 125 microseconds, arguably 40 times faster than the rate at which a single neuron can fire within the human brain. These technological features translate to superior cut quality and accuracy; which translates into premium quality parts and a realized competitive distinction.

In line with other new Fanuc CNCs offerings, the Series 30i/31i-L Model B provides up to eight MB of high-capacity, non-volatile internal memory that is available to store constant inventory nests, which need not require network access to activate and run during surplus machine availability. External interaction via ATA or Compact Flash memory cards bump up an additional 2 GB of part program storage. Added flexibility includes a USB port, where any commercially available USB storage device may also be connected to store and transfer large programs. For increased processing capability, a fast data server can also be installed in the CNC, providing up to 4 GB of flash memory and a 100-GBit Ethernet connection. A high-speed, error-immune fiber optic connection between the CNC and an integrated PC front-end allows the hard disk be used for part program storage.

The Series 30i/31i-L Model B CNC has an embedded Ethernet interface, allowing the user to integrate the CNC control system into a company network for data collection or for high-speed part program transfers. Links can be set up via the Internet, making remote diagnosis, maintenance and online training possible. Because the integrated Ethernet interface does not use a public operating system, it is practically "hacker-free" and immune to viruses, providing a safe and worry-free connection to business networks. Minimal training and programming are needed with the new Series 30i/31i-L Model B CNCs for operators that already use Fanuc controls. Upward compatibility is guaranteed and older part programs will run smoothly on the new controls.

The Series 30i/31i-L Model B CNCs for laser cutting can be combined with rugged, energy efficient, high-performance servo drive systems that are specifically designed to deliver the industry's leading reliability and performance—even in dusty, high-vibration environments of the most challenging fabricating shops. Laser systems with Fanuc technology benefit from Fanuc's world renowned reliability and energy efficiency; delivering increased productivity.

The laser control series has dual energy savings settings which interpret short term and long term beam off times and adjust the laser current and energy consumption accordingly, once cutting resumes, the laser quickly engages full production. Power save features result in reduced energy costs without a loss in part production and part quality.

For more information:

Fanuc Factory Automation
1800 Lakewood Blvd
Hoffman Estates, IL 60192
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www.fanucfa.com

Meggitt Accelerometers

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Meggitt Sensing Systems, a Meggitt group division, recently introduced the Endevco model 7251A series, a family of small, lightweight, hermetically sealed piezoelectric accelerometers with integral electronics. The centrally located thru-bolt mounting hole of this series provides both 360 degree cable and connector orientation, allowing the sensor to offer a flat mounting surface, even when not fully perpendicular, for ease of use in a variety of applications. Available in standard model sensitivity ranges from 500 mV/g to 10 mV/g with optional high-temperature (to +150 degrees C) and TEDS versions, design of the Endevco model 7251A series incorporates an annular shear piezoelectric

sensing element, along with an internal hybrid signal conditioner, within a two-wire system. The system transmits its low-impedance voltage output through the same cable that supplies constant current

power, with high-output sensitivity and wide bandwidth, while exhibiting low base strain sensitivity and excellent output stability over time. Its lightweight construction, weighing just 10.5 grams, effectively minimizes mass loading effects. Signal ground is connected to the outer case of the unit and, when used with the supplied isolated mounting screw, it is electrically isolated from ground. Units are supplied with a 10-foot cable, isolated mounting screw and installation wrench. Recommended signal conditioners for the Endevco model 7251A series include the model 133 three-channel signal conditioner, the model 2775B benchtop amplifier, the model 6634C vibration amplifier and the model 4990a (Oasis) multi-channel system. Recommended mounting accessories include the model 2987 adhesive mounting adaptor and the model 2950M3 triaxial mounting block.

For more information:

Meggitt PLC
Aviation Park West
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Dorset
BH23 6EW
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www.meggitt.com

AAC

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Advanced Antivibration Components (AAC) offers functional vibration isolators for the medical industry including silicone gel pads, sheets and silicone gel as well as wire rope isolators for larger applications. Applications include medical equipment such as flow cytometers, blood analyzers, life science cameras, sensitive electronic scales, handheld devices, carts, motors and pumps. These silicone gel products are effective in isolating vibration in low frequency applications with loads ranging from 0.11 to 165 lbs. per mount. AAC provides products related to the elimination of vibration, energy absorption and protection of components and devices from shock and possible destruction. AAC stocks a wide range of shock and vibration isolation products which include: stud and nut type mounts, base plate fastened mounts, wheels, leveling and foot mounts, suspension mounts, spring, steel mesh and cable mounts, bumpers, channel mounts, bushings and grommets, pads and tapes and couplings. These products are stocked in different materials including: rubber, neoprene,

continued

urethane, Sorbothane, stainless steel mesh and springs. Many are suitable for use in extreme environmental conditions. Of special interest is a complete selection of silicone gel floor mounts, pads, sheets, plus paste-type thermal gel.

For more information:

Advanced Antivibration Components
2101 Jericho Turnpike,
New Hyde Park, NY 11042
Phone: (516) 328-3662
www.vibrationmounts.com

Boca Bearings

EXPANDS
ONE WAY SERIES

Boca Bearings recently announced the release of their new and expanded One Way Bearing series. One Way Bearings have a small radial section height and are also commonly known as Anti-Reverse Bearings. This design uses the same small radial section as drawn cup needle roller bearings which make better use of reduced space. One Way Bearings are compact, lightweight, operate directly on a shaft and are also suitable for transmitting high torque. These bearings are designed to transmit torque between the shaft and housing in one direction and allow free motion in the opposite direction. One Way Bearings with and without bearing assemblies are offered both in an inch and metric series.

One Way Bearings without bearing assemblies are available in HF, FC and RC versions. One Way Bearings with bearing assemblies are available in HFL, FCB and RCB series. The HFL series has two integral radial bearings arranged on both sides of a needle roller clutch. They can therefore support radial forces in particularly tight or small areas. Plastic springs (HFL...KF) are available for some sizes. Partially knurled outer rings (HFL...R) are also available upon request. The clutch and bearing assembly can be used in a temperature range from –30 degrees C to 120 degrees C. For a working environment above 70 degrees C, oil lubrication is recommended.

Boca Bearings also offers the OWC and the EWC One Way Bearing Series. The One Way Clutch bearings (OWC), also known as Origin One Way bearings are extra narrow and high performance bearings available as small as a 5.4 mm width. These bearings allow free overrun in the opposite direction; they consist of drawn cup roller clutch and cage and springs. Lastly the CSK series is available in two different designs: PP-two keyway notch or the P-one keyway notch series. The keyway allows the bearing to perfectly and securely fit into the shaft and give the machine, conveyor belt or appliance extra torque.

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Non-Metallic Bearings: An Alternative Worth Considering

ALT-MATERIAL BEARINGS NOW SUPPLYING BOTH MATURE AND NEW-GROWTH MARKETS, APPLICATIONS

Jack McGuinn, Senior Editor

Bearings make the world go 'round. Much like gears, bearings are used in practically anything you can think of—from toys to titanic machinery and beyond. Another similarity to gears: they've been around since the beginning of recorded history, as Timken Process Industries' Steve Johnson, director–process technology, explains. (*Ed.'s note: Statements from Timken in this article pertain to rolling element bearings only—ball, cylindrical roller, spherical roller and tapered roller. Other friction management systems such as fluid film bearings, magnetic bearings etc., were not considered.*)

An SKF bearing cage produced with Victrex-supplied materials (courtesy Victrex).

"I believe the first non-metal bearings were wood. The ancient Egyptians/Greeks, etc., used wooden logs as simple roller bearings to move large objects. During the industrial revolution, early rolling element bearings were also wooden. In modern times, certainly low-cost plastic bearings have been used in toys, household appliances, etc., for many years."

So there you go—this article is a look at alternative-material, non-metal bearings, and it turns out the first bearings of that type—wood, in this case, were the norm—not an alternative.

But there are indeed alternatives out there today. We now have bearings made from—or coated with—ceramics, reinforced and non-reinforced polymers, carbons and graphite, for example, with other, next-generation engineered materials almost sure to follow. And given the ever-fluctuating cost, quality and availability of steel worldwide, it is no wonder that non-metallic bearings have made tremendous gains in many markets and applications.

"Full non-metal (ceramic) bearings are used in some space flight and semiconductor applications," says Johnson. "Metal bearings with non-metal components such as polymer cages or ceramic rollers are used extensively in markets such as rail, light-vehicle systems and machine tools. The use of hybrid ceramic bearings in high-speed machine tool spindles as the standard has occurred over the last 15 years or so."

Tom Miller, Igus Inc. bearings unit manager/North America, adds this:

"Plastic bearings can be used in many different industries and applications. Just some of the industries in which plastic bearings are being used include automotive, medical, food and drug, farming, solar, bikes, packaging, textile, offshore, marine, aerospace and office furniture.

"Over the past few decades, the applications for self-lubricating plastic bearings have become almost endless. Some design engineers do not believe plastic—a material that most people equate with a disposable commodity like a plastic fork or spoon—will deliver superior performance. If you are using high-performance plastic bearings, they can be used in almost any application—from packaging machines and medical equipment to environments with chemicals, extreme loads or high temperatures."

Looking at things from a leading material supplier's perspective, Victrex technical manager Patrick Clemensen adds, "The largest markets for non-metal bearings are automotive transmissions, followed by industrial pumps, compressors and material handling applications."

Speaking of automotive, one can safely assume that industry has been among the greatest consumers of bearings—of all kinds.

"The auto industry has driven the use of non-metal bearings in some of the largest volume applications," says Clemensen. "Victrex's PEEK material advantages in automotive applications include high resistance against aging and creeping at high operating temperatures and high circumferential speeds."

At Igus, Miller adds that "The automotive industry has certainly contributed to the increased use of self-lubricating plastic bearings, as they are an ideal choice for this sector. They are lightweight, dry-running, dirt and dust-resistant, maintenance-free and corrosion-resistant. Plastic bearings also deliver extremely quiet operation and eliminate vibration, which is a key concern for many operators. In many instances, plastic bearings are replacing metal roller bearings in axle journals and can be used in place of metal bearings in shock absorbers thanks to their low static and dynamic friction properties.

Alt-material NBR needle roller bearings (courtesy Victrex).

"Plastic bearings can be found in numerous automotive applications, including convertible tops, door hinges, seats, headrests, shock absorbers, brakes, control arms, windshield wipers, steering systems, foot pedals, gear boxes and engine compartments."

And while Timken's Johnson acknowledges there is "very limited (usage) in engine and driveline applications," he adds, "Polymer cages are used in several automotive applications. In addition, the increasing use of turbochargers and the drive to reduce turbo lag and increase operating pressure ratios for higher efficiency are driving a fundamental change in turbocharger bearings. The move is from fluid film bearings to rolling element bearings which are typically employing a hybrid ceramic solution—ceramic balls with high-temperature metal rings.

"Full non-metal (ceramic) bearings are used in some space flight and semiconductor applications. Metal bearings with non-metal components such as polymer cages or ceramic rollers are used extensively in markets such as rail, light vehicle systems and machine tools."

Other major markets for non-metal bearings are toys, household products, the food industry, semi-conductors and computer equipment.

Says Victrex's Clemensen, "Besides automotive, other industries benefiting from (our) PEEK polymer bearings include aerospace/defense, food and beverage, material handling, recreational vehicles and the energy industry including oil, gas and wind energy."

So what are the benefits of alternative-material bearings over metal?

"There are benefits such as lower mass—which supports operating at higher speeds—chemically inert, high thermal stability, high strength, higher temperature performance and low friction," says Johnson. (*Ed.'s note: Please see sidebar for additional benefits.*)

But despite the increasingly widening use of alt-material bearings, the question must still be asked: What dictates whether to use metal or non-metal bearings in a given application?

"Application requirements such as load, speed, temperature, lubrication, weight etc.," says Johnson.

"There are many factors that contribute to choosing the right bearing for an application," Igus's Miller explains. "With the advancements in plastic materials over the past few decades, plastic bearings have proven to be a cost-effective, maintenance-free alternative for bronze and metal bearings. They can endure extreme temperatures, heavy loads and high speeds. However, it is important to understand both the advantages and disadvantages of the options available."

At Victrex, Clemensen points out that "High-corrosive environments require polymers such as the company's PEEK offering. In addition, if there is minimal lubrication, PEEK may be a better choice. Operating temperatures may limit the use of polymer bearings, but Victrex polymers can handle continuous-

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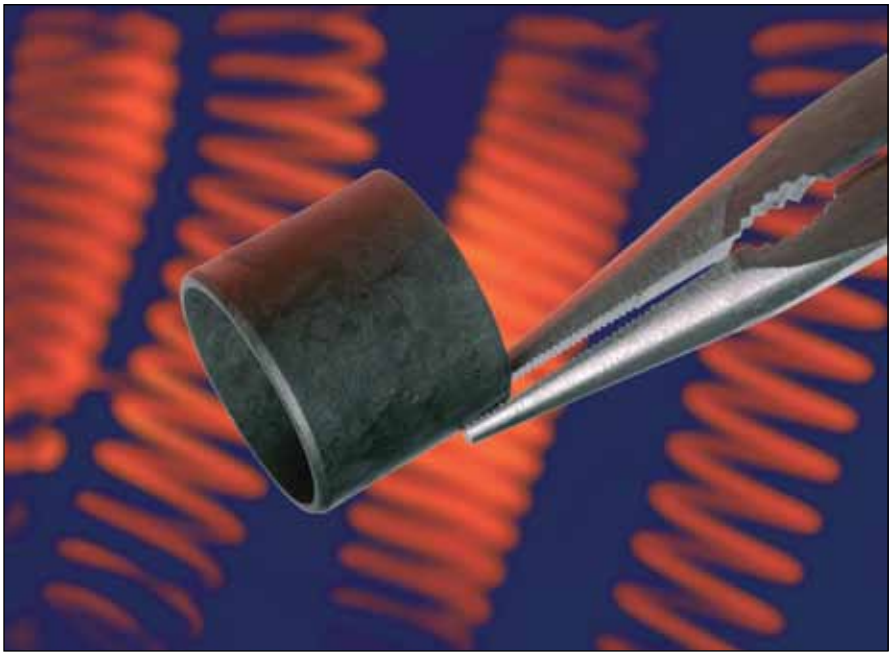
The Timken Company offers a variety of synthetic material bearings and bearings components (courtesy The Timken Company).



A high-temp, non-metal offering from Igus, Inc. (courtesy Igus, Inc.).

use temperatures up to 260° C," he says.

And then there are lubrication issues to address. But while proper lubrication is a must-have component of metallic bearings, its use in alt-material bearings is not as clear-cut. In many cases—while certainly not all—lubrication is not a factor with non-metallic bearings. Or, at minimum, synthetic bearings often provide a reduction in lubrication.

As Timken's Johnson explains, "Running hybrid bearings, i.e.—ceramic rolling elements with metal rings or full-ceramic bearings—can offer significant advantages in reducing/removing traditional lubrication requirements."

At Igus, Miller points out that "In most cases it is acceptable to use lubrication, as it does not affect plastic bearings. However, one of the major benefits of using self-lubricating bearings is the elimination of lubrication and maintenance. If lubricant is used, once it wears out, the self-lubricating properties of the plastic bearing will start working and transfer dry lubricant onto the shaft."

And if the bearings are full-polymer, such as, for example, Victrex's PEEK products, "Lubrication is not an issue for non-metal bearings," says Clemensen. "Polymers are typically better than metal in un-lubricated environments."

Predictive lifetime for alt-material bearings is another part of the mix. And as with their metal counterparts, it can get complicated, given the lack of international standards coupled with other factors, such as application and specification of synthetic to be used.

But in many cases, lifetime is determined "the same way as for metal bearings," says Johnson—"stress analysis of the application compared with strength and fatigue endurance limit of the material(s) being considered to predict system life."

At Victrex, "In lubricated environments we are comfortable looking at the PV and operating temperature," says Clemensen. "In un-lubricated environments we look at PV and wear factors."

But there can be major distinctions to be made, dependent once again on the application at hand and the synthetic specified for it.

"It is important not to confuse high-performance plastic bearings with plastic bearings from a local injection molder," says Miller. "With (Igus's) Iglide plastic plain bearings, you can accurately calculate the life of a bearing according to wear rates, actual testing results and specific application parameters.

"(We also) provide the Expert System—a complimentary database where users enter the maximum loads, speeds, temperatures and shaft and housing materials, which then prompts the system to calculate the appropriate plastic bearing and its expected lifetime based on decades of real-world testing."

As one might expect—at least for now—there are indeed limitations to when alt-material bearings may be used. Johnson points to "application, market requirements and regulation factors" such as extreme loading, temperature and dimensional stability as determinants in whether non-metallic materials may be safely used.

But conversely, in some cases, as Igus's Miller explains, "When using plastic bearings, some safety concerns can actually be eliminated. Since they do not require lubrication, there are less instances where a maintenance worker could be injured while re-lubricating a bearing system or taking apart a machine. Also, Igus offers decades of empirical test data that enables us to predict how it will perform

and if certain safety considerations need to be kept in mind."

Speaking of decades, one wonders how much time and R&D are required in developing these highly engineered materials.

"Developing a reliable, high-performance polymer material blend can take years of research and testing," says Miller.

Victrex's Clemensen offers that "Twelve to 24 months is typical to go from concept to production. Overall development time is dependent on design complexity, typical operating environment and the range of testing required for qualification. Our early involvement can reduce the application development time by sharing material test data, reviewing part and tooling designs before cutting, interpreting FEA/mold-filling results and referring experienced molding/machining sources."

Another question comes to mind—How "green" are non-metal bearings? The short answer—As green as they can be at this stage of development. They are, for the most part, a petroleum-based product. But advantages do exist.

"Some materials are low coefficient of friction, which reduces parasitic loss in mechanical systems and enhances energy efficiency," says Timken's Johnson. "In addition, certain material systems require less lubrication, which has a number of benefits in reducing the lubricant quantity as well as the size of the lubricant delivery system and resulting energy utilization."

And, Igus's Miller points out, "Self-lubricating plastic bearings do feature some 'green' attributes. Nearly every time plastics are mentioned, the fact that they are petroleum-based is brought up, but they still use considerably less oil to produce than steel or aluminum parts. Also, since they do not require external lubrication, they will not contaminate the environment when, for example, being used in farming equipment, lawn mowers or off-road vehicles."

So what's next for the alt-material bearings industry? Who can say for certain? But consider that in just the past 15 years or so, says Johnson, "The use of hybrid ceramic bearings in high-speed machine tool spindles (has become) the standard" material of choice. But, "Simple polymers only are applicable for very lightly loaded, low-speed, low-precision applications such as toys. This market is mature."

Yet on the other hand, he continues, "High-speed mechanical systems and turbo machines can benefit from the use of ceramics/hybrids. This will be driven by cultural acceptance in various markets (aerospace, for example) as well as ongoing improvements in the performance/cost equation that will result from volume increases, as has already been seen in the machine tool industry. For other applications, alternative material systems such as ceramics and reinforced polymers have niche applications based on product attributes, but there is no indication that any of these will make major inroads into the traditional metal bearing markets."

At Victrex, Clemensen states that "The wind turbine market is expected to grow significantly over the next decade, so this could fuel growth of non-metal bearings for longer life and lower maintenance. Aerospace engineers are also highly motivated to replace metal in order to hit weight-reduction goals, so this could increase the adoption of non-metal bearings in aircraft engines and mechanical actuators."

Why Use Alternative-Material Bearings?

There remains no doubt that in some cases, only metal bearings will do. But there are many exceptions. Among them are:

- **Cost**. Commodity-type plain bearings can reduce costs up to 25 percent and can replace more costly alternatives in a variety of applications.
- **Extended life.** Plastic bearings are designed to maintain a low coefficient of friction (COF) consistently over the lifetime of the bearing. Compared to metal-backed bearings, which can become scratched and increase the COF, plastic bearings often last longer.
- **Energy savings.** Reduced energy consumption via lighter weights and lower friction.
- **Maintenance-free.** Plastic plain bearings can replace bronze, metal-backed and custom injection-molded bearings in many applications and provide resistance to dirt, dust and chemicals.
- **Corrosion and chemical resistance.** Plastic bearings can be used in wash-down applications, salt water and harsh chemicals without compromising performance.

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Microprocessor-Controlled Prosthetic Leg

HIGH-TECH SOLUTIONS DELIVER IMPROVED QUALITY OF LIFE

Lightweight DC micromotors, combined with intelligent control technology, offer the chance to walk in a way that feels very similar to natural movement.

When it comes to finding technological ways of dealing with the loss of a limb, as, for example, the result of the amputation of a leg, two key things need to be taken into account. Firstly, it took nature a long time to develop the perfect "apparatus" to allow humans to move around. Secondly, people are creatures of habit—they tend to carry on moving in the way they're used to. All the solutions which have been tried to date, from wooden legs to high-tech prostheses using state-of-the-art materials, have worked in a purely passive way. Something that these devices all have in common is that their function doesn't change during movement. Now, however, a new solution has been developed around the use of microprocessor-controlled prostheses. Just like natural limbs, these can react automatically, adapting to the current situation.

Lightweight DC micromotors, combined with intelligent control technology, offer the chance to walk in a way that feels very similar to natural movement—providing clear benefits for users in terms of both safety and comfort.

A prosthesis is always a complex medical device which needs to be adapted to suit the individual. Technical components, however, can only be manufactured economically on a large scale. It was thus clear to prosthesis specialist Otto Bock from Vienna that a new, advanced prosthesis would need both to be suitable for use on a global scale and to offer top performance under all possible conditions.

His solution was to develop a so-called active prosthesis, whose success is based on the reliable and smooth interaction of mechanics, electronics and the user. To achieve this, the prosthesis specialist called in the micromotor experts from Faulhaber. Faulhaber's many years of experience with DC micromotors translated into a reliable, custom made motor solution for the high-tech Bock prostheses.

Following Nature's Lead

After leaving the factory, each prosthesis is fine-tuned by the local orthopedic specialist to suit the individual user. This is now standard practice with high-quality prostheses. What's special about this device, however, is that it uses its electromechanical systems to adapt to the individual's walking style and create a truly natural feeling for the user. Walking is not just a matter of putting one foot in front of the other; therefore, simply "improving" on a wooden leg by adding a hinge to act as the knee is not an option. Nature uses tendons and muscles to provide damping and adapt limb movement with each individual step; hence, people are able to make optimal use of their weight and force—whatever the conditions and depending on whether they are walking, running, cycling or standing.

Finding a way to simulate this natural damping requires great attention to be paid to the mechanics and electronics. Thanks to modern high-power microprocessors, miniature precision sensors and micromechanical motors, the technology now exists to achieve very impressive results. Compact prosthetic technology allows the user to walk slowly or fast, run, climb slopes or cycle—without needing to pay much special attention to what the limb is doing. In addition, the fact that the knee joint can react immediately to changes in speed or surface conditions improves safety considerably. Even in the case of a stumble, the real-time electronics will reliably prevent the prosthesis from buckling. Over the long term, the ability of the prosthesis to react intelligently safeguards the health of the user, avoiding undue wear and tear on the other joints or problems arising from poor posture and thus overstraining of the healthy leg.

A Practical Solution

Natural movement can only be achieved by the prosthesis reacting in a highly accurate and subtle way to the changes that occur with every step. In order to ensure that this occurs, highly sensitive sensors provide reports on the current situation and stresses 50 times per second. A knee angle sensor provides information used for dynamic control, while load sensors in the lower leg measure the pressures at the heel and front part of the foot. A high-power processor then analyzes these results and passes on appropriate instructions to the damping mechanism.

Hydraulic damping has proved to be of particular value. This allows the appropriate damping values to be implemented quickly and accurately. Prosthesis specialists make use of proven technology for the interface between the electronics and the damping mechanism: easy to control miniature DC motors. These micromotors, equipped with precious metal brushes, offer high performance in combination with a slim design. The high efficiency of their motors means that prostheses can work without needing recharging for periods of up to two days, even with the limited capacities of lithium batteries. In the current example, the high-performance 10 mm motors function via friction gears in a planetary set. This serves to adjust the actual damping valve. With each step, the damping is adjusted from its maximum level to almost zero and then back again.

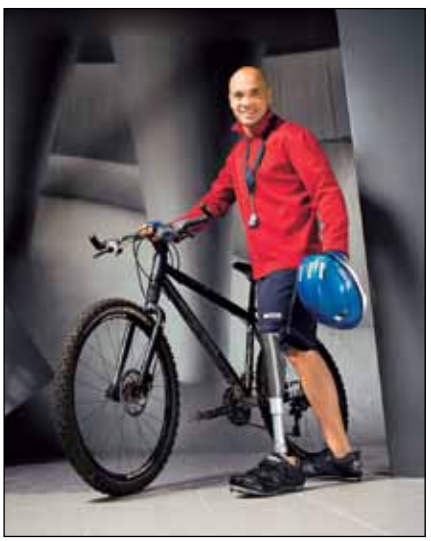
Durability Reigns Supreme

All components need to be able to stand up to years of continuous use. This is no problem for the precious metal miniature DC motors deployed within this area. Use of the prostheses around the globe places considerable demands on the technology, which must be able to cope with temperatures ranging from –15 degrees C to +65 degrees C. It must also be able to function without problems in all climates, from dry to wet, and withstand salty air or desert sand. With this in mind, all relevant components are sealed, with some being additionally housed within an extra casing.

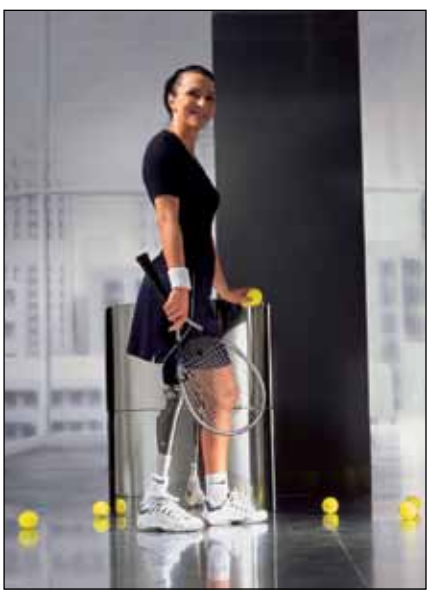
Despite the use of robust and sealed components, as with all medical devices, provision must be made for the possibility of the failure of all and any components, including, for example, a drained battery. In such a case, the prosthesis will automatically provide maximum damping, in effect functioning as a wooden leg and thus providing the maximum possible level of safety. The wearer is thus always able

continued

A new mechanical prosthesis from Otto Bock of Vienna allows more natural movement for patients.



Individual movement programs can be set for different activities.



Walking, running, sprinting and cycling are made possible once again.

A knee angle sensor provides information used for dynamic control, while load sensors in the lower leg measure the pressures at the heel and front part of the foot. A high-power processor then analyzes these results and passes on appropriate instructions to the damping mechanism.

to continue walking, albeit at a lower level of comfort. All levels of damping between virtually zero and the highest level can be individually set by a certified orthopedic technician, using the *C-Soft* software. The user is also able to choose between two settings—for example, one optimized for walking and one for cycling. The former would use active stance phase damping to allow easier standing and walking, while this would be switched off when cycling. The prosthesis can also be set for inline skating, cross-country skiing or many other activities.

The combination of modern electronics with robust, high-performance miniature DC motors provides an enormous improvement to the comfort of those using prostheses. Dynamic motors, real-time electronics and high resolution sensors mean that it is now possible to fit all the components required for natural movement into the limited space provided by a prosthesis.

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Integrated Motion Control

IN PACKAGING MACHINES DELIVERS VALUE

Paul Derstine, Motion Product Manager, GE Intelligent Platforms

Introduction

For some time now, packaging has been a key source of competitive differentiation for many companies, offering everything from food products, office products and consumer products, all of which require packaging. Packaging has developed from being merely a way to deliver a product to being part of the product itself. Ideas such as the "fridge-door-fit" ketchup bottles to milk cartons that stack better for decreased shipping costs have changed the way we view packaging.

The explosion of new products and increasing customer expectations require OEMs to provide better flexibility, openness and performance for their manufacturing and production customers.

Maximizing machine productivity and performance is imperative to success and is driving OEMs to adopt and invest in the latest technologies that can meet their customers' challenges.

At the forefront of these performance-driven technologies is an integrated control system—or programmable automation controller (PAC)—and latest-generation motion solutions. PACs provide easy integration for multi-domain functionality such as motion control, process control, logic control and HMI (human-machine interface), enabling the operational excellence that allows companies to become more productive and more efficient. PACs with integrated motion control can especially benefit applications in the packaging industry that require high-performance, multi-axis motion control.

This article discusses the background and recent trends that have led to the need for integrated motion control in packaging machines and how they deliver value in their applications.

The Packaging Industry Drives Innovation in Automation

Consumer desire can be a fickle target to satisfy, so companies rely on an endless variety of new product introductions of manufactured goods and multiple line extensions to fuel interest and remain competitive. Strolling through a typical supermarket presents this reality, for example, with six different versions of the same brand of cheese on the shelf—one-kilo block, one-half kilo block, shredded, cubed and a two-flavor mix.

Likewise, there may be five different sizes for the same flavor of pretzels—school snack pack, 100-calorie pack, 20-ounce, 32-ounce and family-size packaging. Shelf life is much shorter as products come in and out of vogue, and stores are continually restocking their shelves to meet consumers' demands for new offerings. This explosion of SKUs requires packaging machinery manufacturers to have more flexibility, speed and innovation in their machines to stay apace.

OEMs and end-users are driving a major shift in automation solutions to adapt to these trends. In the past, end-users would choose to standardize on a given automation platform and specify to OEMs what control platform they should use, even if it did not allow the level of performance, openness and flexibility to maximize productivity. The primary reason was to reduce the learning curve for their engineers and to leverage their existing expertise and intellectual property on a particular system.

However, to keep pace with the growing demand for increased productivity and product variability, more end-users are allowing OEMs to select a control platform that maximizes productivity by leveraging the highest degree of innovation and latest technology. To maximize asset utilization, end-users must have the ability to run more products on the same line and at increasing production speeds. This flexibility to handle frequent line changes and increase machine or line throughput is raising the bar on performance for new machine designs.

Packaging machines represent the largest application of general motion control systems; greater than 20% of general motion control systems go into some sort of packaging application, with form/fill/seal equipment most widely

used, and labeling and coding machines (e.g., thermal transfer bar code printers) recording the highest growth in recent years. OEMs of packaging equipment are leading with performance-driven solutions that enable a higher level of flexibility, accuracy and speed. And they continue seeking to deliver automation systems that can handle faster product turnover, greater variability and shorter production runs—all while delivering increased product quality—thus driving much of the innovation in automation for all industries.

The Marketplace Move to PACs and Integrated Motion Control

Since productivity and time-to-market have become more critical—indeed, essential—to end-users, integrating disparate plant floor packaging and production equipment—and networking them to operations and enterprise-level systems as a way to improve productivity—have led to greater demand for integrated control systems such as PACs along with ever-greater motion control performance and flexibility. Furthermore, the successful integration of systems such as HMI/SCADA, process data collection and overall enterprise data connectivity is becoming critical for end-users in our information-driven world.

While a PAC's form factor can be similar to that of a traditional PLC, the PAC's capabilities are far more comprehensive. PACs are multifunctional controller platforms that encompass various technologies and products that users can implement as needed. PACs include motion control, process control, logic control and HMI—enabling true convergence (Fig. 1). Since their introduction in 2003, PACs have become attractive to end-users because they can greatly reduce the total cost of ownership.

***Key PAC features include*:**

- A single-integrated, multi-discipline development environment
- Common tag names and a single-tag database for access by all functions
- Open architecture for interoperability with other suppliers' solutions based on interface standards such as TCP/IP,

continued

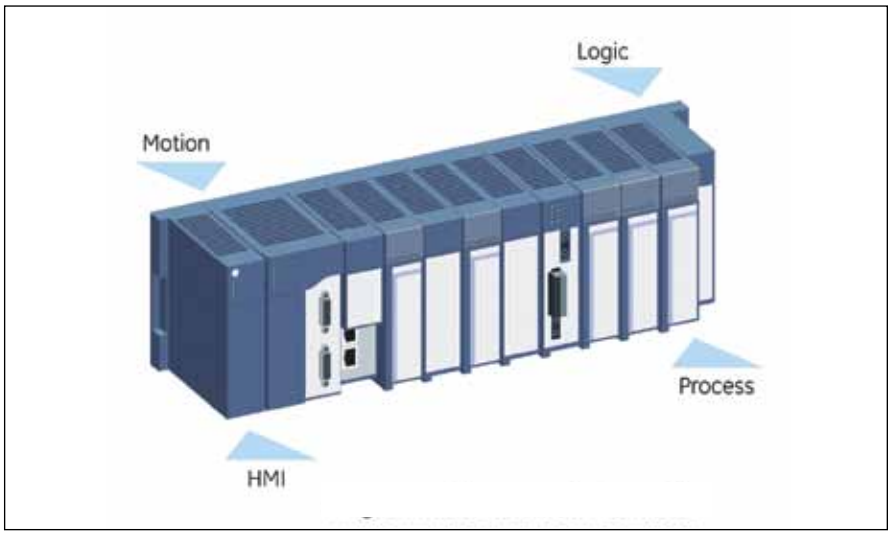

Figure 1—Programmable automation controller (PAC)—Easy integration of multi-domain functionality in one controller.

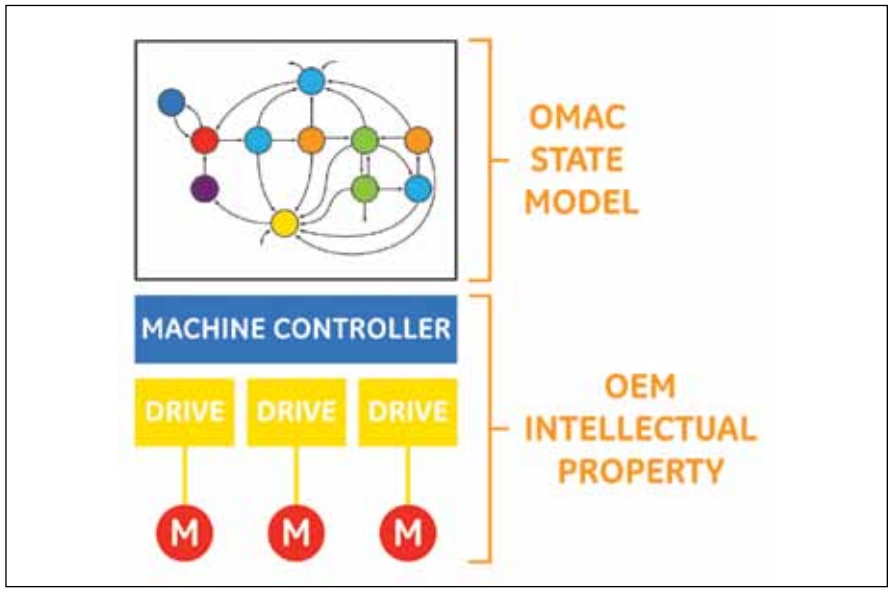

Figure 2—A noteworthy trend affecting engineering efficiency is a shift toward open standards that reduce engineering development effort.

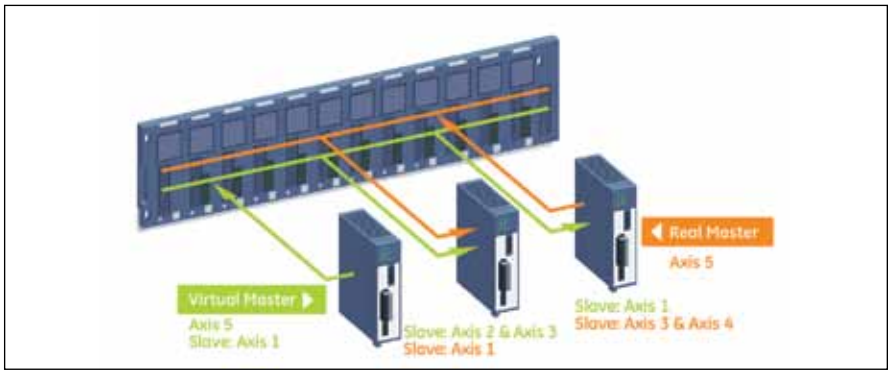

Figure 3—Being integrated directly into the PAC provides the flexibility to tightly synchronize all axes in the system by passing master axes over the backplane, and any axis can be a master or a slave to any other axis in the system without any additional wiring.

OPC and XML, and open-communication standards such as Ethernet/IP, Profibus and CAN

Motion control is easily integrated into a comprehensive PAC package. The latest generation of motion control—tightly coupled with a PAC controller, such as GE Intelligent Platforms' PACMotion and PACSystems RX3i,—can provide significant customer benefits, including:

- Improved machine productivity
- Increased engineering efficiency
- Enhanced machine flexibility and modularity

Improved Machine Productivity

In a recent study done by Chicago-based DDR Direct Response Communications, the single-greatest decision criteria cited by end-users for purchasing packaging machines was high productivity—for which they were willing to pay an up-charge—followed by greater throughput.

There are three major ways to increase productivity:

- Increase throughput
- Improve production yield (reduce scrap)
- Increase machine availability

Increasing throughput. Accelerating the control systems of a machine is dependent upon the ability to process the many inputs and outputs more efficiently. PACs integrated with motion controllers use a very high-speed backplane and real-time data exchange techniques to provide tighter synchronization of multi-axis motion, and between motion and logic events. GE's PACMotion, for example, employs a demand-driven data exchange model with the PAC CPU, which reduces scan time impact and ensures the most recent motion data is readily available to the application program.

While in traditional architectures that include a PLC and a standalone motion unit, you have to pass motion data (for example, axis actual position) at specific times within each CPU scan; an integrated motion control module in a backplane passes instance data to the program motion function blocks asynchronously as soon as new data is available—thus providing access to the motion data without waiting for the next CPU scan. This level of data synchronization is critical for accurate control of high-speed machines such as labelers, as a scan delay can cause phase errors to occur because the data may be stale by the next CPU scan.

Improving production yield. Production output also increases machine productivity, as more good parts are made using the same amount of resources. In some products using a non-integrated architecture—or even an integrated architecture that is not optimized—the main host controller CPU is also used to execute motion path planning for each axis. Motion-path planning is computationally intensive; with this additional processor load, therefore, the time between position-loop updates must increase as more axes are added.

In some cases, the servo position loop for each axis is also closed by the main CPU, resulting in even further reduction in motion update rates. This means that the motor's actual position and commanded position are compared less frequently—resulting in larger position errors. The reduced update rate may force a reduction of machine cycle rate (throughput), and larger position errors can have a direct impact on product quality.

For example, imagine a home that is trying to maintain a set temperature (the *command*). If the thermostat checks the temperature once every hour (the *feedback*), there can be large swings in the actual temperature over that hour (the *error*).

On the next update cycle, the tem-

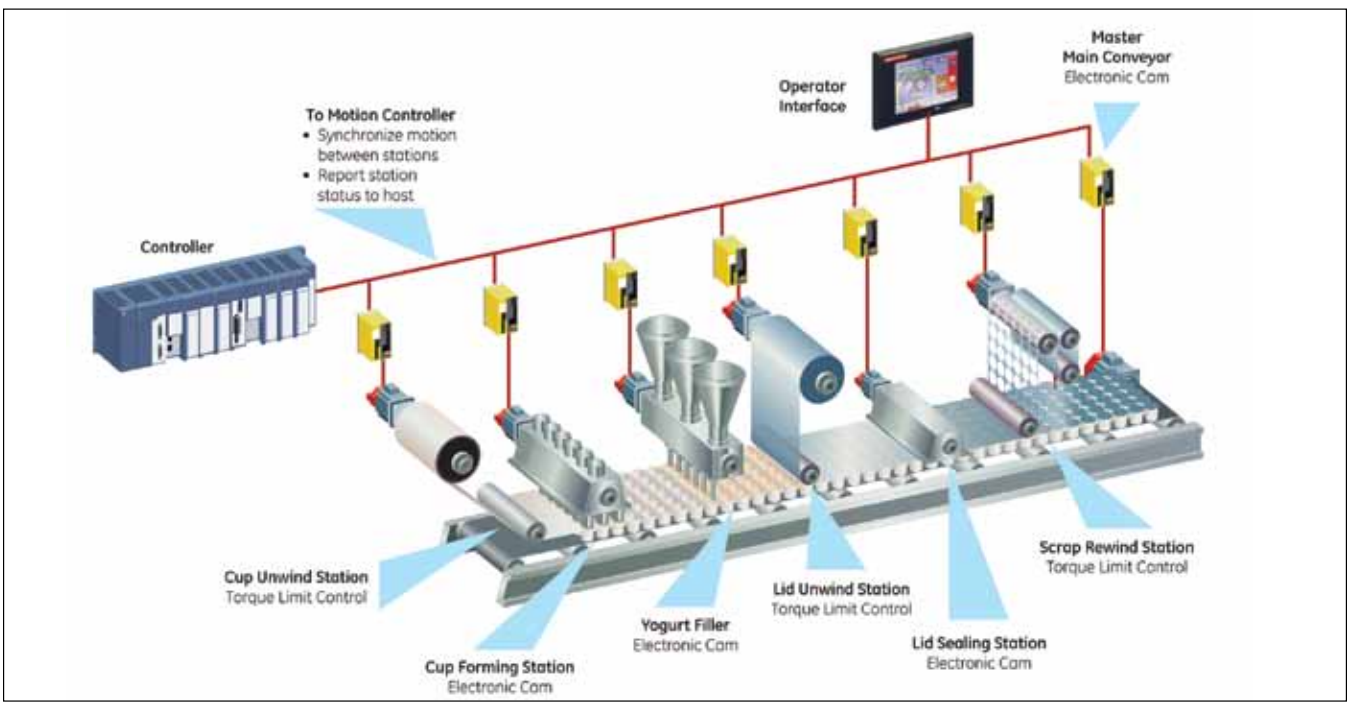

Figure 4—This electronic synchronization not only simplifies the wiring and reduces I/O; it enables instant line conversion at any time. For example, in a line used to manufacture, fill and seal plastic yogurt cups, each operation must be synchronized to the main conveyor that is moving through the line.

perature is checked against the set point, and the thermostat detects the temperature error and activates the air conditioner in an attempt to return the temperature to the desired level. However, an A/C system can quickly cool a house, and over the next one-hour cycle of the thermostat the temperature drops well below the desired temperature set point—again resulting in significant error in the desired temperature. The same thermostat, if checked once every five minutes, would maintain a much more constant temperature in the house.

Servo position loops work in much the same way. The more frequently they are checked, the more accurately they will control axis motion on the machine. Timely position-loop updates keep position deviation small when torque disturbances are encountered that can arise from machine binding, excessive friction, impact loads, etc. The faster the servo recognizes the disturbance, the more quickly a root cause is identified and corrective action initiated.

A rotary cut/seal machine cuts and heat-seals a continuously moving web of material at defined lengths; there is a high cycle rate on the knife axis for productivity and high-speed registration inputs to detect printed registration cut marks. The knife speed must match material speed during the cut to prevent tearing or bunching, as well as size accuracy with the material being cut. If the machine encounters a phase error due to asynchronous position updates or long servo updated loop times, it could, for example, introduce a 1-ms phase error. If the machine is throughputting product at 1-meter-per-second, a variation in cut length of up to 1 mm could occur—causing scrap or rework.

Increasing machine availability. Packaging equipment has also become more important as product life cycles have drastically shrunk; long gone are the days of putting one product on one line and letting it run for days. Manufacturing today requires rapid line changeovers in order to run different products and virtually no downtime during those changeovers. Companies are adopting new tactics to achieve these goals by increasing the automation of their machines—most of which have gone from a mechanical line shaft to an electronic line shaft—and have increased the integration of servos.

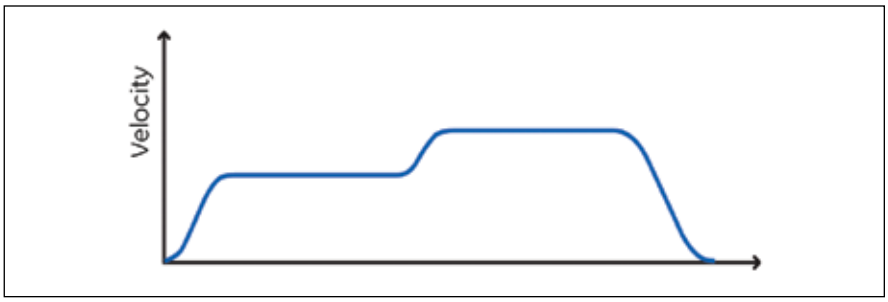

Figure 5—100% jerk control requires exactly twice the acceleration torque from the motor compared to linear acceleration in the same amount of time.

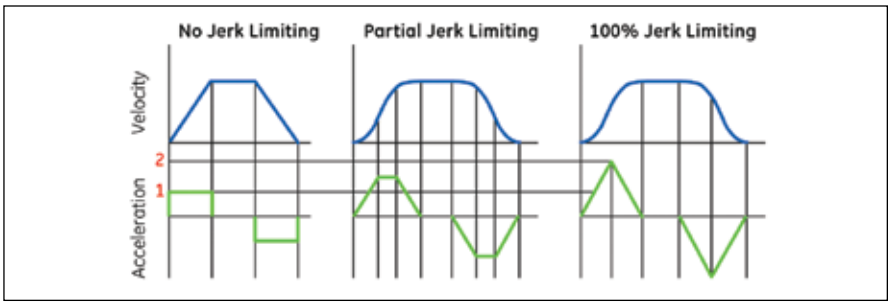

Figure 6—The same concept of blending jerk-limited profiles at non-zero velocity can be used to change the speed of a moving web without tearing or stretching the material, resulting in higher product quality and reduced downtime.

In evaluating integrated motion control systems, OEMs have come to realize that the reliability of all system components is critical and in acknowledging that it only takes one part of the system to "crash" the entire machine. The servo systems orchestrating these parts undergo more physical stress than any other part of the system; too, these application programs tend to be some of the most complex programs running on the system.

With that said, the evaluation criteria of a motion control system for reliability should include low-mean-time-to-repair (MTTR) for fast recovery and reduced downtime. Manufacturers should publish mean-time-to-failure based on historical information that helps you gage component reliability in real-world applications. For example, GE's PACMotion controller uses the highly reliable FANUC servos that boast a mean-time-before-failure (MTBF) measured in *decades*. The FANUC amplifiers have no stored configuration or tuning parameters that need loading when replaced, so they are easily swapped out in the rare case of failure. This type of design in any motion control system can directly impact the reliability of the entire machine.

Increased engineering efficiency. As time-to-market is critical for success in today's competitive packaging marketplace, integrating motion into one common environment with HMI, logic and process control substantially increases engineering efficiency. With a common open standard programming language, tag database and function blocks, engineers can spend less time and effort learning new programming environments and synchronizing different programs. The result is faster program development, quicker time to market, and faster machine commissioning.

Machine builders that have used standalone motion products have had the added burden of having to use and learn different programming software environments for the host controller, motion and servo configuration. Each piece of the system requires its own individual application program(s), and the additional programming required

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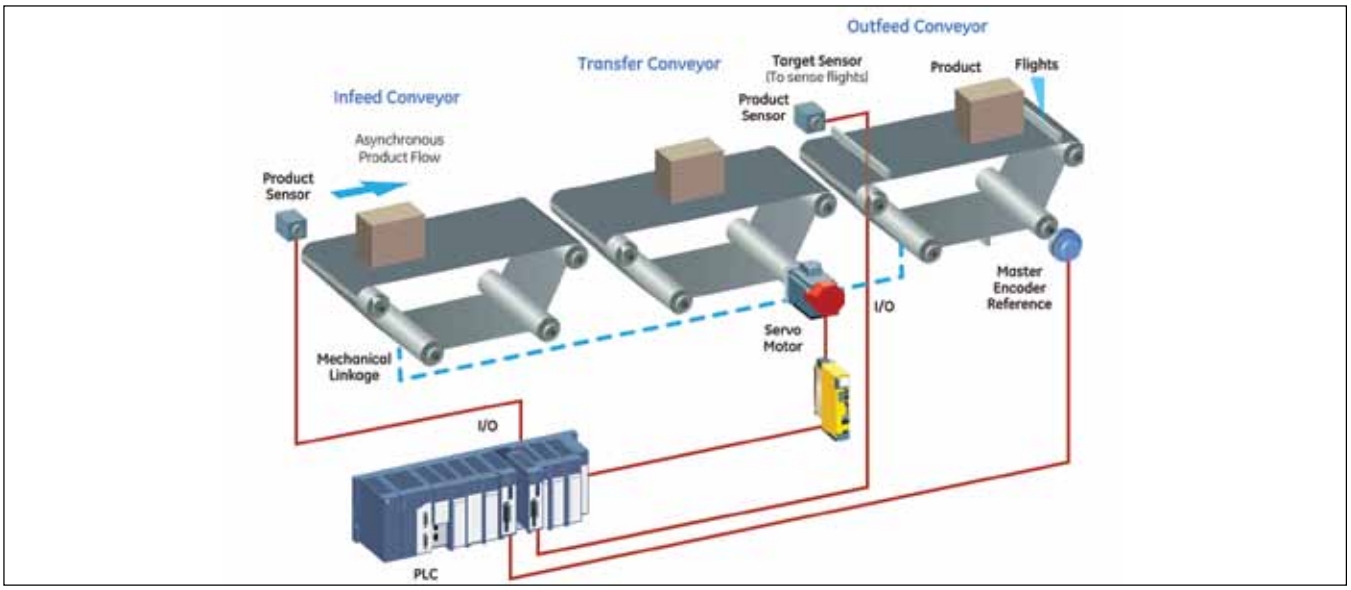

Figure 7—As OEMs increasingly adopt and invest in the latest technologies to meet their customers' challenges, integrated motion with a programmable automation controller provides value by maximizing machine productivity, engineering productivity and machine flexibility.

to synchronize the main machine control (logic) program and the motion program(s) can be significant. As a result, system performance is compromised because of the processor burden to run additional synchronization logic, the timing constraints for asynchronous handshaking between programs, as well as the bandwidth of the motion interface.

The coordination of passing information between the multiple programs forces trade-offs between quantity of data and speed, and also introduces another layer of complexity where errors and bugs may occur. This added program complexity can also impact timely commissioning of new machine designs, leading to longer development cycles.

However, the integrated programming environment of a PAC should not be confused with a "simple" programming environment, as most integrated control programming packages allow users to program in many of the standard IEC languages such as Structured Text, Ladder Logic, C and others. For example, GE's PACSystems features a control engine that is portable to multiple platforms and allows users to choose the hardware and programming language that best suits each particular application. When integrating motion control, the system provides a universal engineering development environment for rapid development, implementation and migration.

A noteworthy trend affecting engineering efficiency is a shift toward open standards that reduce engineering development effort. The Organization for Machine Automation (OMAC) provides many packaging industry standards such as PackTags and PackML, and adoption of OMAC standards can lower multi-machine integration and coordination costs, standardize program structure, increase machine features and reduce the cost of maintenance and training. A library of re-usable OMAC standard machine application code greatly reduces the development cycle.

Motion-specific programming has also followed this paradigm shift away from proprietary languages toward open (PLCopen) standards. PLCopen has developed an open standard motion language that integrates with IEC languages. Open standard programming significantly increases programmer productivity and protects investment in intellectual property by providing portability to different hardware platforms.

Products such as GE's PACMotion support over 50 motion functions—in both Structured Text and ladder diagram function block—and its programming has been developed in compliance with PLCopen standards. Any quality vendor of integrated machine control should provide standards-based programming to reduce engineering development effort.

Enhanced machine flexibility and modularity. As stated, because production runs are routinely turned over multiple times per day, today's production lines require an incredible level of flexibility. In addition to providing the scalability to handle machines with varying levels of performance and different numbers of axes, automation and motion control solutions must also facilitate instant, push-of-a-button line reconfiguration, as a single line might fill 16-ounce, 20-ounce and 2-liter bottles in successive daily production runs.

To realize this capability, current-generation machines utilize electronic line shafts (ELS) to synchronize all axes of motion on a machine or line. An electronic line shaft-synchronized system uses independent axis control at each station, which in turn is synchronized to a master source—either an encoder or time-based profile, i.e.—virtual master.

Typically, a single master axis acts as the pacer for all other axes—or slaves. This master can be a real axis (motor), an external encoder mounted on the machine or a time-based virtual master. For example, each PACMotion motion module includes a master axis that can be configured as a real master tied to an encoder or as a virtual master with full motion programming support. Being integrated directly into the PAC provides the flexibility to tightly synchronize all axes in the system by passing

master axes over the backplane, and any axis can be a master or a slave to any other axis in the system without any additional wiring. More importantly, these master/slave relationships can be redefined in process by the applications program (Fig. 3).

This electronic synchronization not only simplifies the wiring and reduces I/O; it also enables instant line conversion at any time. For example, in a line used to manufacture, fill and seal plastic yogurt cups, each operation must be synchronized to the main conveyor that is moving through the line. The cup-forming press, filling and sealing stations use electronic cam profiles that can be changed or scaled in-line to re-integrate for different cup volume sizes or shapes.

The wind/unwind stations use torque control to control tension in the plastic film used to make the cups and the foil used to form the lid. These torque limits can be quickly and easily changed to conform to the requirements of different materials used across the range of yogurt cups made on this line.

Furthermore, tight integration with the PAC controller leverages flexible system configuration, whereby both centralized- and hybrid-distributed architectures are supported. Hybrid solutions merge the benefits of centralized programming and control with the reduced wiring by distributing the amplifiers and motors. Distributing the amplifiers and motors also facilitates modular machine designs such as wrapping, cartoning and case-packing with multiple stations (Fig. 4).

Advanced features in motion control with PACs. The sweet spot for PACs integrated with motion may be the more complex, higher-speed packaging applications requiring higher cycle rates and tight coordination of multiple axes. Many of these high-end applications benefit from the advanced motion features available in high-performance PACs such as variable jerk control and the blending of jerk-limited profiles.

Jerk control can be advantageous in certain applications such as transporting liquids without spillage, tearing or stretching when pulling paper or plastic film, or in preventing boxes from toppling or slipping on a conveyor belt. Additionally, proper application of variable jerk control can minimize machine wear while optimizing servo motor sizing. However, be advised that there exists a trade-off in using jerk control—greater torque (acceleration) capability from the motor.

As Figure 5 illustrates, 100% jerk control requires exactly twice the acceleration torque from the motor, compared to linear acceleration in the same amount of time. However, variable jerk control can tap the motor reserve torque to minimize machine wear without increasing motor size and cost. Minimizing jerk reduces the repetitive impact loads on mechanical components such as lead screws, gearboxes and couplings that can cause premature failure. And yet, some motion path planners only support linear and/or 100% jerk control, so select a motion control solution that will meet all of your application requirements while reducing maintenance cost and maximizing machine life.

The blending of jerk-limited profiles can provide much tighter control in applications where velocity changes are required during the move. For example, a packaging line transfer conveyor (also known as a "smart belt" or "random in-feed") equalizes the random spacing of products coming off an in-feed conveyor, thus affording their seamless transfer to an out-feed conveyor for wrapping or packaging.

As the product is transferred from the in-feed conveyor to the transfer conveyor, the speeds of the two belts must match. Once the transfer is complete, the transfer conveyor will accelerate or decelerate, based on sensor inputs, to equalize the spacing as it is transferred to the out-feed conveyor. During the transfer conveyor's speed changes, it is critical that product not slip on the belt, which would in turn jumble the product spacing. In this case, it is important to blend two jerk-limited profiles (Fig. 6).

Conclusion

The packaging machinery industry continues evolving and adapting to demanding customer needs through the use of more complex automation. As OEMs increasingly adopt and invest in the latest technologies to meet their customers' challenges, integrated motion with a programmable automation controller provides value by maximizing machine productivity, engineering productivity and machine flexibility.

Companies in high-performance packaging that require multi-axis motion control for mid-to- high-end applications may especially benefit from integrated control systems that help maximize machine productivity for a competitive, sustainable advantage.

For more information:

GE Intelligent Platforms
Phone: (800) 433-2682 or
(434) 978-5100
www.ge-ip.com

Soft Starters vs. Variable Speed—or Both?

Juan Sagarduy, Jesper Kristensson, Sören Kling and Johan Rees

(This paper first appeared in the ABB Review, *April, 2010. Reprinted courtesy ABB Review.)*

Management Summary

In water applications, centrifugal pumps are driven by an induction motor directly fed from the network. Flow regulation is accomplished by a few different means, namely:

- ***Throttling***—A highly inefficient method, as hydraulic losses increase dramatically when the flow is strangled by a valve.
- ***Variable-frequency drives (VFDs)***—Recommended as an effective means of saving energy—that ensure flow regulation by controlling the rotational speed of the motor shaft.
- ***Alternatively, on-and-off pump operation following a precise duty cycle***—The pump is not operated continuously; rather, it is activated when needed for pumping the target water volume and is disconnected for the rest of the time.

Given that many different hydraulic systems recommend the use of either frequency converters or cyclic control (soft starter technologies), the question must be asked—Which one of these solutions is the most cost-effective in reducing energy consumption and providing the most satisfactory payback time?

Introduction

Energy efficiency is key for customers seeking products and systems, and something that suppliers work hard at in improving their product offerings. In fact, the general view held is that the investment linked to the purchase of electrical equipment—as well as the downtime cost incurred from installation and commissioning—is offset by a decrease in electricity consumption due to energy-efficient operation.

Low-voltage solutions in the form of frequency converters and soft starters are especially suitable for maximizing energy savings in water pump and waste applications.

By reducing the applied voltage, a soft starter allows smooth starting of AC motors. During pump stop, water hammer—i.e., a pressure surge or wave resulting when a fluid in motion is forced to stop or change direction suddenly—in the hydraulic system is avoided by a controlled decrease in torque enabled by a dedicated algorithm in the soft starter. Water hammer commonly occurs when a valve is closed suddenly at an end of a pipeline system and a pressure wave propagates in the pipe.

As throttling is highly inefficient, which one of the two technical solutions—variable-speed or cyclic control—is the most cost-effective in reducing energy consumption (Fig. 1). In fact, the nature of the hydraulic system in which the centrifugal pump is to operate is the determining factor in

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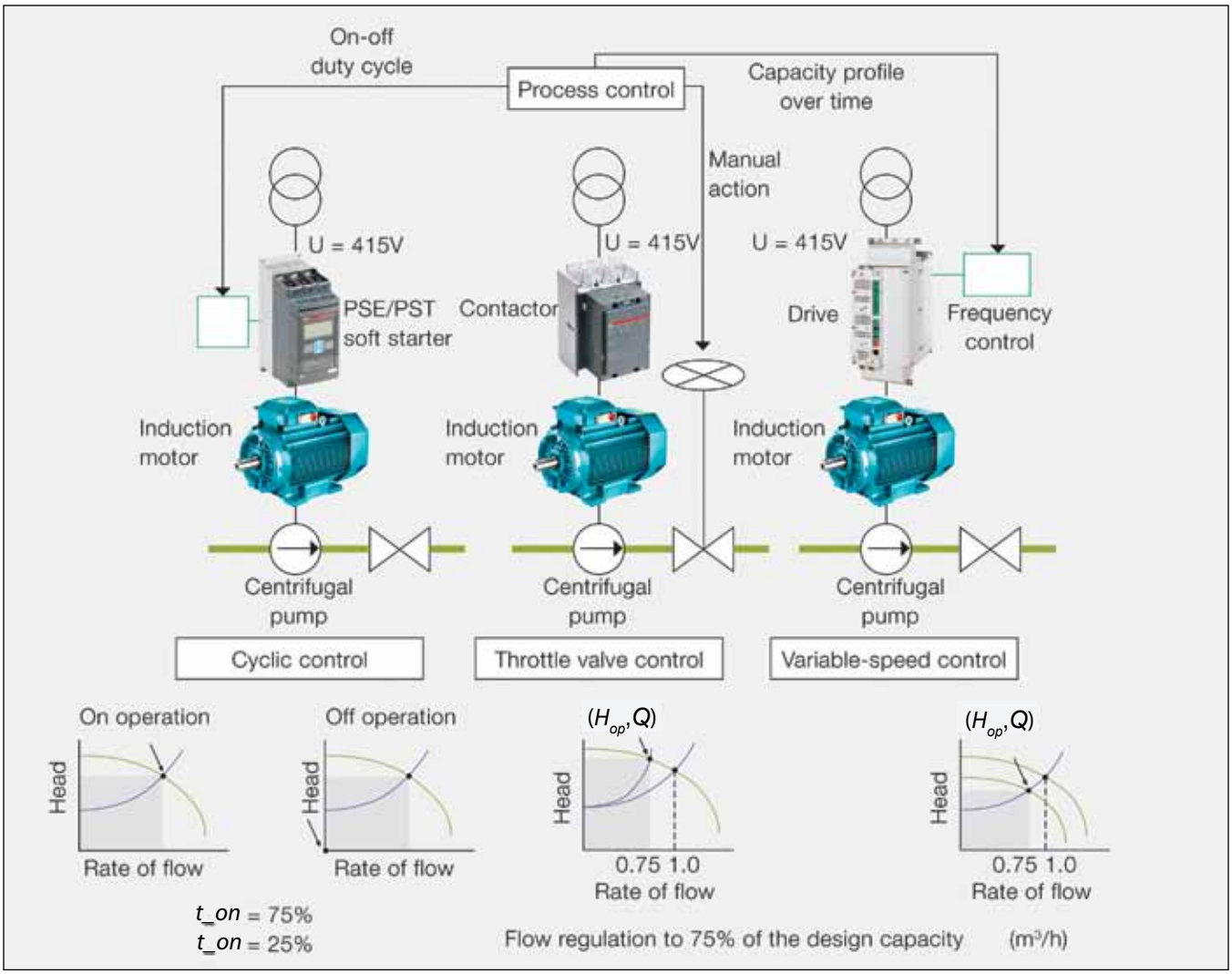

Figure 1—System illustration for cyclic, throttled and VFD (variable frequency drive) flow control methods.

Nomenclature

H_{bep} (m)	Hydraulic head at the best-efficiency point of the centrifugal pump.
Q_{bep} (m³/s)	Capacity at the best-efficiency point of the pump.
H_{st} (m)	Total static head—i.e., the vertical distance the pump must lift the water. If pumping from a well, for example, it is the distance from the pumping water level in the well to the ground surface—plus the vertical distance the water is to be lifted from the ground surface to the discharge point. If pumping from an open water surface, it would be the total vertical distance from the water surface to the discharge point.
Q_{op} (m³/s)	Capacity at the system design point. In practice, this is determined for the occasional peak flows arising—about 5% of the time—in water treatment plants.
H_{op} (m)	Hydraulic head at system design point.
H_{opid} (m)	Hydraulic head at the design point in an ideal system.
H_t (m)	Hydraulic head associated with a generic capacity Q (m³/s) in fixed speed and throttled flow regulation.
H_d (m)	Hydraulic head associated with a generic capacity Q (m³/s) in variable frequency flow regulation.
H_{max} (m)	Maximum height at which liquid can be lifted by a given pump.
Q_{max} (m³/s)	Maximum capacity for a given pump.

Figure 2—ABB's PSE compact soft starter range, used primarily for pumping applications.

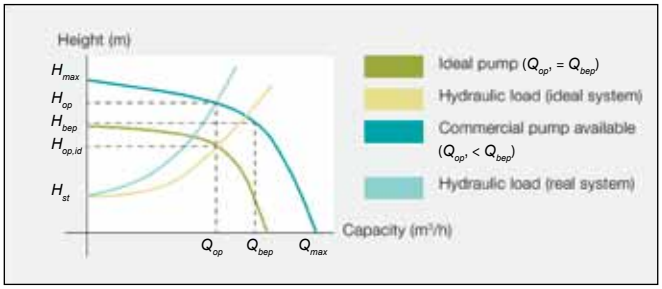

Figure 3a—Pump selection for an industrial installation.

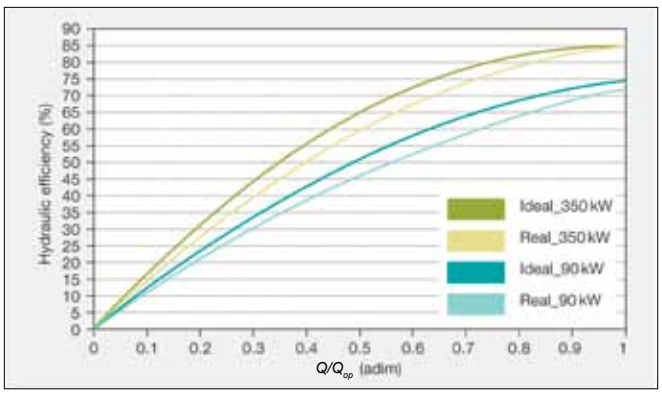

Figure 3b—Hydraulic efficiency loss in 90 kW and 350 kW pumps due to 15% over-sizing.

Manufacturer	Power (kW)	H_{max}(m)	H_{bep} (m)	Q_{bep}(m³/h)	η_{max} (%)
Aurora	90	43.0	37.0	575	74.9
Aurora	350	52.7	38.0	2 500	84.5

Figure 4—Characteristic data of the two pumps studied.

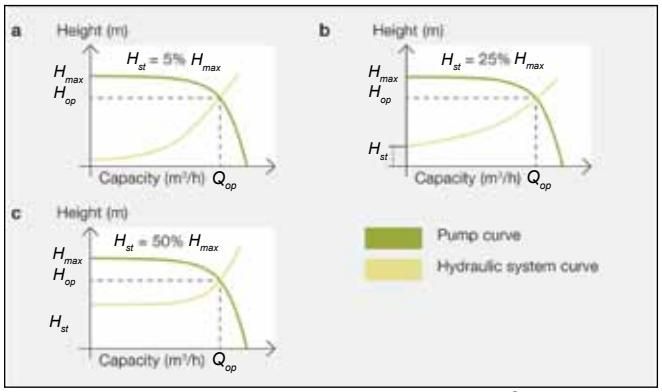

Figure 5—Hydraulic systems selected for energy-saving potential analysis. a: Friction head dominated, b: Mixed head dominated, c: Static head dominated.

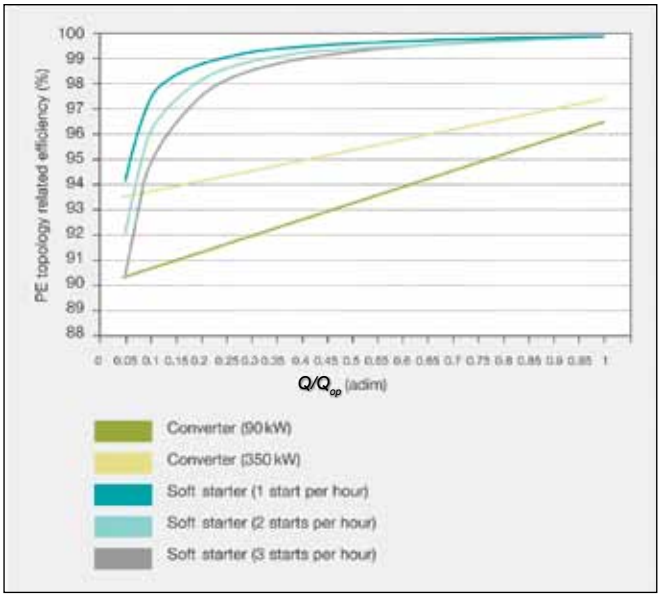

Figure 6—Variation of electrical efficiency (%) in the power electronics circuit (soft starter and converter) with hydraulic load.

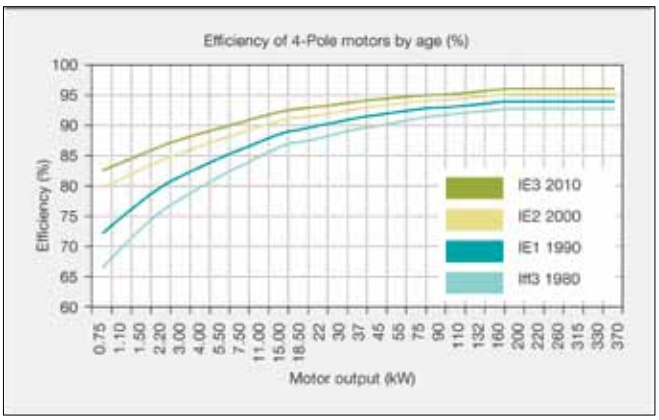

Figure 7a—Impact of class type on motor efficiency.

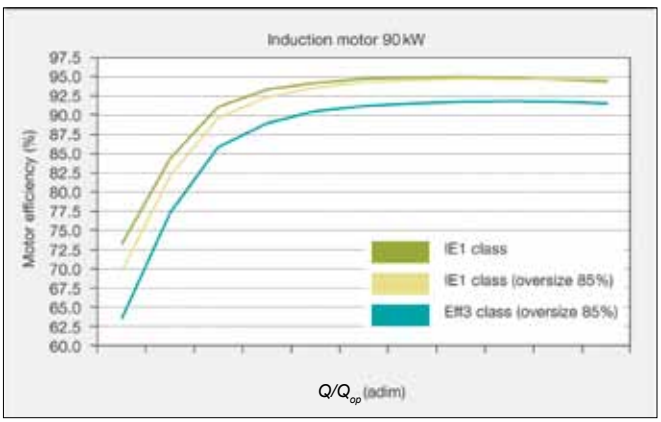

Figure 7b—Variation of motor efficiency with hydraulic load.

selecting one or the other control method.

In wastewater processing, for example, the on/off operation of the centrifugal pumps is, in general, process-control based. Residual water (effluent from residential or commercial buildings) is commonly collected in septic tanks or sewage basins until it is pumped to municipal treatment plants (Ref. 1). Owing to several start events, the use of soft starters significantly reduces the risk of pump clogging due to sludge in the water (Fig. 2). In general, cyclic control is an attractive alternative to the variable-frequency drive (VFD) strategy, despite losing flexibility in flow regulation. In other words, a soft starter is seen as a suitable and competitive technology that preserves the induction motor from electrical strain, mechanical shock and vibration during start-up, and prevents water hammering as the pump stops. Additionally, the motor is used at its best efficiency point and switched off when not needed.

In the following sections, energy savings and payback of variable-speed and cyclic-control solutions are analyzed for two centrifugal pump systems: 90 kW and 350 kW.

A Typical Pump System

When a pump system is assembled, a target flow Q_{op} (m^3/h) must be guaranteed. In an ideal system, the selected pump has a coincident Q_{bep} (m^3/h) with Q_{op} (m^3/h). In reality, however, a larger pump is chosen (Fig. 3). As a result, the pump works under reduced hydraulic efficiency for most of the capacity range. This point is illustrated in Figure 3b for two Aurora centrifugal pumps with power ratings of 90 kW and 350 kW, respectively (Fig. 4; Ref. 2).

To analyze the potential for energy savings in these pumps, three different hydraulic systems were taken into account (Fig. 5):

1. ***Friction head-dominated***—the ratio (υ) of static head H_{st} (m) to maximum hydraulic height H_{max} (m): 5%
2. ***Static head-dominated***: υ is 50%
3. ***Mixed***: υ is 25 %

Converter, Soft Starter and Motor Performance

Frequency converters have a high efficiency (h_{conv}) that drops naturally when the output power decreases with respect to the rated value. The efficiency of soft starters is practically 100% when the motor bypass is activated. Their efficiency decreases noticeably with the number of starts-per-hour and shorter operating time intervals owing to additional joule losses during motor start-and-stop (Fig. 6).

Today's tighter IEC standards guarantee high motor efficiency—in general, greater than 90%—for loads (Refs.3–4; Figs. 7a–7b). This efficiency, which is strongly dependent on its graded class, is affected by the use of either a frequency converter or soft starter. It decreases when supplied by a fast-switching converter due to harmonic current and voltage distortion, but is not altered when the motor is bypassed after soft starting, due to a purely sinusoidal supply.

The impact of system-oversizing, motor class and harmonic losses (drive control) in a real system is shown in Figure 8.

Energy Savings

Energy savings made using VFD and cyclic control in a 90 kW and 350 kW pump system are illustrated in Figures 9a and 9b, respectively. In friction-head-dominated systems (υ = 5%), VFD control ensures higher energy savings across almost the entire operating range, or 7 to 98% in both pump systems. In a 90 kW pump and static-head-dominated system (υ = 50%), cyclic control is a better technical solution than VFD control for all working points, while for the 350 kW system, VFD control guarantees slightly higher energy savings but only between 75 and 92% pump capacity. When a combined hydraulic system (υ = 25%) is considered, VFD control only ensures a larger economic benefit for pump

continued

	Load (%)				
Efficiency drop (%) caused by	**5%**	**25%**	**50%**	**75%**	**100%**
1 – Oversized pump (by 15%)	-1.3	-3.8	-6.0	-4.5	-2.1
2 – Oversized motor (by 15%)	-3.2	-1.2	-0.4	-3.0	0.2
3 – Motor class (Eff 3)	-9.5	-3.4	-3.0	-3.0	-3.0
4 – Harmonic loss	-7.0	-2.1	-2.4	-1.9	-1.3
Increase in power consumption (%)	26.5	11.7	13.3	10.3	6.6

Figure 8—Effect of system over-sizing, motor class and harmonic losses on electric power consumption (*Pn* = 90 kW; switching frequency 4 kHz).

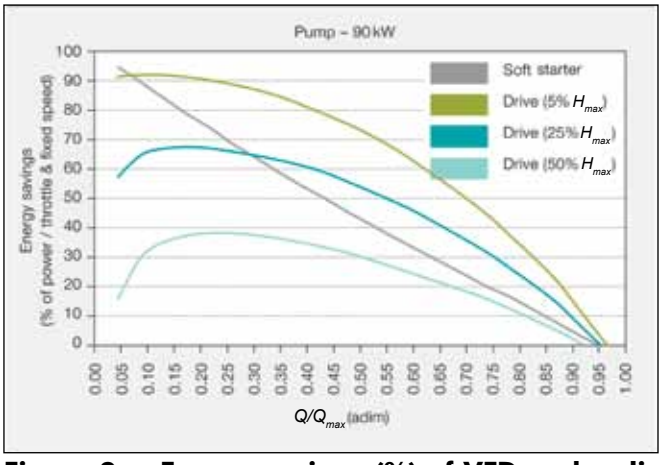

Figure 9a—Energy savings (%) of VFD and cyclic control in the 90 kW pump system.

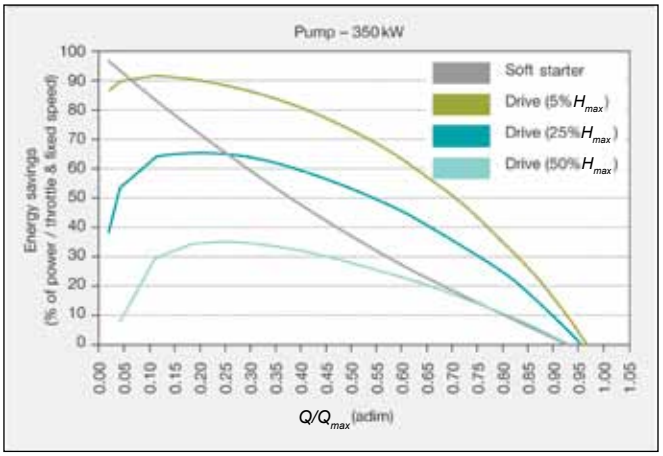

Figure 9b—Energy savings (%) of VFD and cyclic control in the 350 kW pump system.

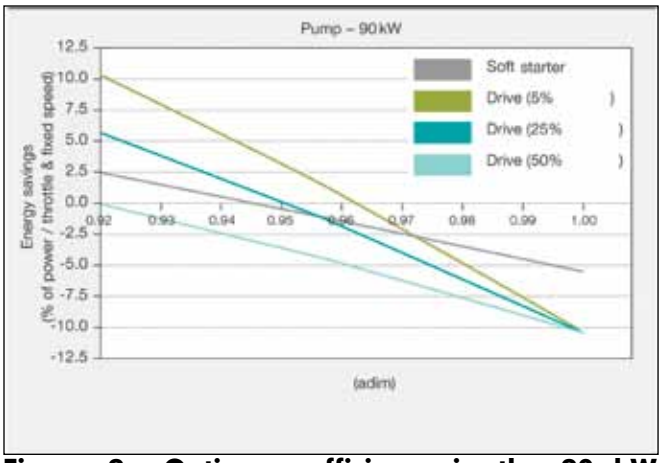

Figure 9c—Optimum efficiency in the 90 kW pump due to soft starter bypass capability at high loads—90–100% of design capacity.

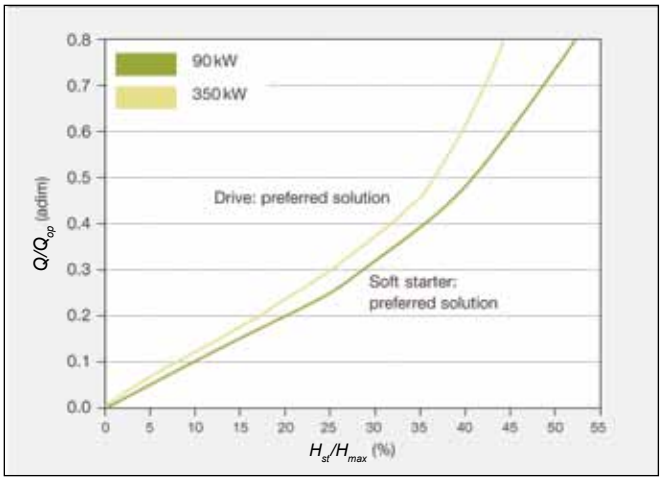

Figure 10—Breakpoint where economic savings with cyclic control (soft starter) exceed a VFD solution.

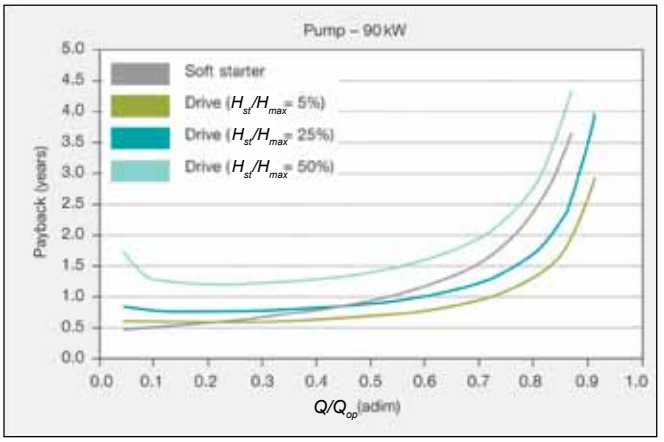

Figure 11a—Payback time of VFD and cyclic (soft starter) solutions for the 90 kW pump.

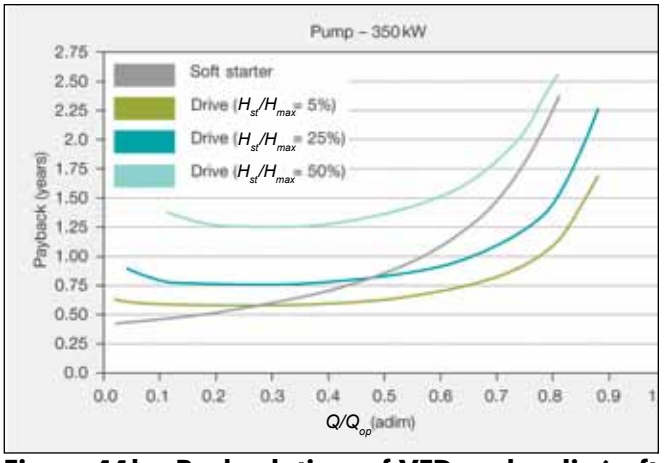

Figure 11b—Payback time of VFD and cyclic (soft starter) solutions for the 350 kW pump.

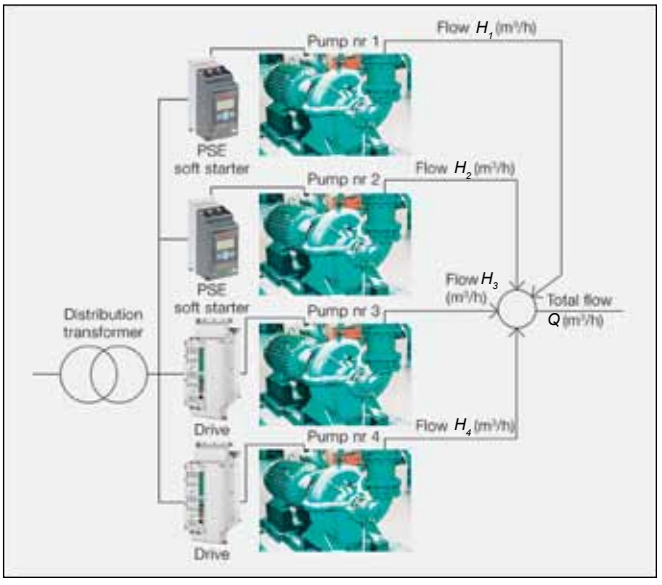

Figure 12—Recommended power electronics solution for a four-parallel pump system (friction-dominated hydraulic system).

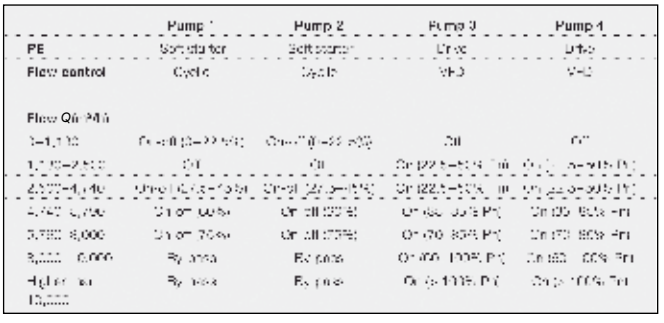

Figure 13—Flow control scheme in a four-parallel pump system (friction-loss-dominated).

capacities above 28% (for the 90 kW system) and 24% (for the 350 kW system). In fact, the highest gain with VFD control is found at between 15 and 20% capacity.

Unlike frequency converters (characterized by semiconductor losses at nominal load), soft starters operate in bypass state at nominal load (Fig. 9c). No additional losses in the thyristors are thus accounted for. The operating and system conditions—when either cyclic control or VFD is the preferred solution for pump flow regulation—are illustrated in Figure 10. (*Authors' note: Converting percentage energy savings—with respect to fixed speed and throttle—into economic benefits assumes that the pump works for 8,760 hours per year (330 x 24) at a price of $0.065 for 1 kWh of electricity; see also Ref. 5*).

Return on Investment

Customers will inevitably want to know when they can reasonably expect a return on their investment—which, keep in mind, includes the additional costs incurred by production downtime while the drive or soft starter is being installed and commissioned.

For pumps with a power rating of around 25 kW, the price ratio of converter to soft starter is around three, and reaches an approximate value of five for 350 kW pumps (Ref. 6). The total initial investment associated with VFD and cyclic solutions is calculated as the sum of the cost of the drive or soft starter plus a percentage of the lifecycle costs to cover production downtime (Ref. 7). For both power electronic topologies, a value of 7.5% is used.

Too, cost of individual components may vary for a number of reasons. Primarily, low-voltage VFDs operate on a continuous—rather than stop-start basis—and enable more sophisticated control. However, they use insulated gate bipolar transistors (IGBTs) and so must be designed with sufficient cooling capability, making them more expensive when compared to soft starters with the same power rating. Soft starters, on the other hand, which operate during reduced time intervals of up to 15 seconds, incorporate robust and cost-competitive thyristors and benefit from natural cooling.

The payback times for VFD and cyclic flow control are shown in Figures 11a and 11b—for the 90 kW and 350 kW pumps, respectively—for the three hydraulic systems: υ = 5%, 25% and 50%.

Parallel Pump System Solutions

In many hydraulic systems, optimum energy savings and a good return on investment can be achieved using parallel pump solutions (*Authors' note: For optimal flow regulation in parallel systems, one individual pump is operated until a breakpoint in the target flow is reached, at which time two pumps simultaneously share the hydraulic load—see Ref. 8. When a second breakpoint is attained, three pumps become active, and so on.*) that combine both drives and soft starters.

For example, in a friction-dominated hydraulic system (υ = 5%), a recommended power electronics solution for a four-parallel pump system—each pump with a power rating of 350 kW (2,500 m^3/h)—consists of two converters and two soft starters (Fig. 12). The scheme providing the optimum solution in terms of payback time and control functionality equips Pump 1 and Pump 2 with a soft starter, and Pump 3 and Pump 4 with a frequency converter (Fig. 13). Pumps equipped with a soft starter are directly connected to the network at high capacity; by increasing the rotational speed in a pre-defined range—over 50 Hz—pumps driven by converters can deliver a peak flow if occasionally required.

In a mixed hydraulic system (υ = 5%), the scheme providing an optimum solution in terms of payback time and control functionality uses three pumps—the first two of which are equipped with soft starters, the third with a drive (Figs. 14–15).

For both systems the initial investment in power electronics solutions is translated into economic profit in less than 1.5 years, provided the regulated flow is below 80% of the total capacity (Fig. 16).

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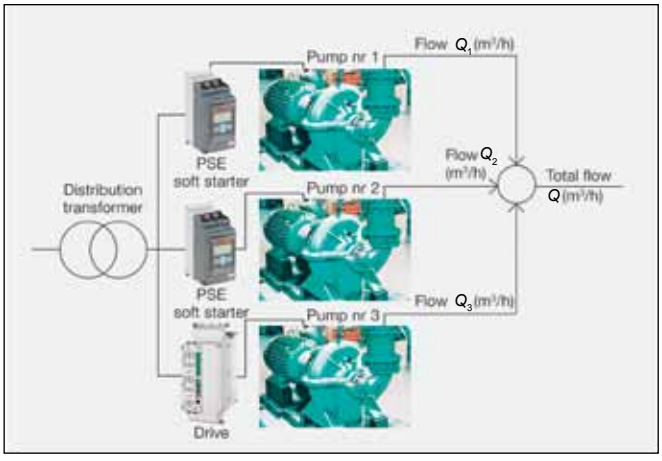

Figure 14—Recommended power electronics solution for a three-parallel pump system (static head-, friction-dominated hydraulic system).

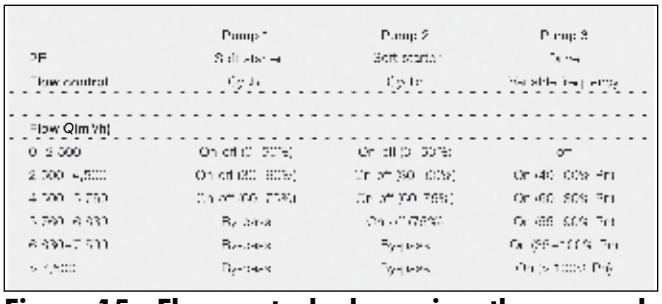

Figure 15—Flow control scheme in a three-parallel pump system (mixed hydraulic system).

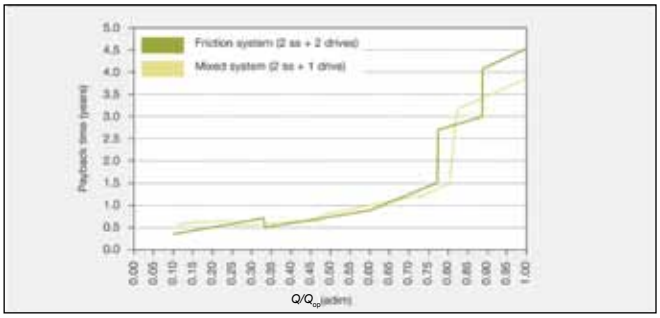

Figure 16—Estimated payback time for two installations consisting of parallel pumps and different power electronics solutions.

Would an Integrated Control System Benefit Your Business?

Switching your automation or motion control platform requires careful consideration. Ultimately, the decision may come down to risk management—whether the benefits of a PAC controller with integrated, high-performance motion control outweigh any potential risks. Some questions to ask in assessing the potential benefits of an integrated control system include:

- Are your customers getting the machine through put they desire with current motion controls? What is the bottleneck in your current machine?
- Does adding more axes to your system degrade system performance?
- Is the throughput of your machine limited by the slow servo update rates, the ability to respond to motion events quickly enough, or long program scan time resulting from sharing a single processor for motion and logic control?
- Does your motion control solution allow you to make changes to end position, velocity acceleration or jerk to active motion profiles at any point along the profile?
- Are you able to synchronize the position loop of all axes in the system to eliminate position phase errors?
- Are you able to instantly reconfigure your machine or line to handle different products? Can you programmatically change master/slave axis assignments and scaling, electronic gear ratios, cam profiles, and engineering units (e.g., English to metric) on the fly?
- Could your solution benefit from the reduced wiring, improved noise immunity and reliability provided by distributing servo amplifiers and motion-centric machine I/O via a fiber optic link?
- Does your solution include multiple programming software packages and/or different programs for logic, motion and operator interface control that require synchronization?
- Would an integrated programming environment reduce risk or improve engineering efficiency?
- Would your engineering resources benefit from an integrated environment?

Figure 17—Pump system in a water treatment installation.

Conclusion

The suitability of variable-speed and cyclic-flow regulation in centrifugal pump applications has been analyzed for two pumps (90 kW and 350 kW) in the low-voltage range. The data show that variable-frequency control is the best solution in friction-loss-dominated hydraulic systems (fluid transportation without height difference) while cyclic control is recommended for static-head-dominated systems. Speed control in systems with very flat pump and load characteristics should be avoided due to the risk of instability and pump damage (Ref. 9).

Soft starters are a very competitive technical solution, especially for water and waste applications in which the regular on/off operation for emptying a tank and pumping up fluid for further treatment are common practice. They are robust, have good bypass capability and dedicated control algorithms for start (kick boost) and stop (no water hammering) sequences. However, optimum energy savings and good payback times can be achieved in a wide range of hydraulic systems by employing parallel-pump schemes that use a combination of drives and soft starters (Fig. 17).

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(Material) Moving into the Future

STRADDLE CARRIER IS EQUIPPED WITH ELECTROHYDRAULIC BRAKES, INTELLIGENT CONTROLS

Mico Incorporated

Mico's electrohydraulic brake system offered Great Lakes Power a variety of electronic control functions (all photos courtesy of Mico).

In the world of industrial equipment, there are plenty of roles to be filled. There are the end users who need specific types of machinery to run effective operations. There are distributors and dealers who supply and service a variety of products. And, of course, there are manufacturers who engineer and develop equipment. Most companies are perfectly content to put their full energies into successfully serving only one of these purposes. But other businesses may find themselves branching out from one area to another.

Take Great Lakes Power, for example, an Ohio-based company that has been anything but complacent throughout its history. Founded in 1973 by Harry Allen, Jr., Great Lakes Power began primarily as a franchised distributor for Twin Disc, Inc., a manufacturer of transmissions, clutches and powertrain components. Through organic growth and strategic acquisitions over 37 years, the company has evolved into a unique organization that focuses not just on service and distribution, but on engineering and manufacturing as well.

"We are problem solvers," said Harry Allen III, vice president of sales for Great Lakes Power, and one of five family members actively involved in the second-generation family business. "We pride ourselves in developing and sustaining long-lasting relationships with our customers and suppliers, and they trust us to deliver solutions."

A rather notable demonstration of Great Lakes Power's customer commitment took shape back in 1989 about five years after the company began distributing Hyster material handling equipment, when Hyster announced they would discontinue their straddle carrier product line. While the move by Hyster closed off a supply chain, it also served to open the door for Great Lakes Power's remanufacturing business.

"Ever since Hyster's Legacy straddle carriers have been out of production, we have been rebuilding and upgrading these units for our customers," said Allen. "These machines were originally manufactured anywhere from the 1960s to about 1990. So there are some challenges in providing obsolete spare parts and servicing vehicles of that age and condition."

Some of the potential applications for straddle carriers include material handling in steel mills, refineries and lumber mills, as well as transporting goods and components for shipbuilding, steel erection on construction projects, wind turbine assembly, and military activities. With such a wide range of possible uses for the machines, there was a diverse population of customers looking to keep their older units up and running.

In recent years, as it became apparent that the Hyster straddle carriers were reaching or exceeding the point where rebuilds were still economically viable, Great Lakes Power began to explore the possibility of engineering and producing its own new replacement option. "Bringing our own product to market is important to our company's future for two key reasons," said Allen. "First off, we are not geographically limited to a regional, domestic customer base as is the norm for a distribution business. This is particularly crucial because we think a significant percentage of sales for the new straddle carrier will come from outside North America. Second, as a distributor we can only be as successful as our partners allow us to be, but as the manufacturer we can control how we market and sell the product."

Development of a new straddle carrier was naturally assisted by 20 years of experience remanufacturing the Hyster product, during which time Great Lakes Power had incorporated various engineered upgrades of its own to address weak points or chronic problem areas. "We were able to take into account many customer suggestions and wish lists," Allen said. "The concept was to produce a state-of-the-art straddle carrier that would excel in new applications and be compatible for customers still operating Hyster Legacy fleets."

As Great Lakes Power prepared to build the prototype of its first production straddle carrier, the ST35, it determined that it would be advantageous to seek out an existing customer partner located in close proximity to the company's manufacturing facility. They found the perfect collaborator in The Timken Company, a global manufacturer of bearings and alloy steels and longtime user of Hyster straddle carriers. With Timken running the unit just an hour away, Great Lakes Power would be able to closely monitor and support the machine, while also having a demonstration area nearby for prospective customers.

The concept of Great Lakes Power's straddle carrier was to produce a state-of-the-art vehicle that provides advantages over alternative types of material handling equipment.

As is the usual case with straddle carriers, the ST 35 was engineered to provide certain advantages over alternative types of material handling equipment—like forklift trucks—in regard to factors such as travel speed, adaptability to road conditions, and the ability to efficiently move long and heavy loads in intra-plant transport.

Where the new design took on a revolutionary look was in its ambition to drastically improve upon several aspects of the Hyster Legacy, from improved safety and operator ergonomics to higher performance and lower operating costs. "One of the factors that sets a straddle carrier apart to begin with is the ability to pick up and deliver a load with only one operator," said Allen. "We focused on furthering this advantage by enhancing the operator experience."

This effort can be seen quickly in the ST35's center-mounted panoramic view operator cabin, which offers improved visibility of the load and surrounding area. Roof-mounted windows also make it possible to see overhead cranes and suspended loads in the operating area. The operator's seat itself is also more practical, enabling 180-degree rotation so that the operator can always face the direction of travel—although this functional requirement dictated that Great Lakes Power would have to think outside traditional means when it came to the machine's braking system. "A conventional hydraulic brake system would have required two sets of fixed pedals due to the operating fluid connections," said Allen. "So using a brake-by-wire, or electrohydraulic, system was definitely on our radar screen because that would allow the brake pedal to be mounted so it would rotate with the operator."

There was no question that Great Lakes Power was undertaking a huge project introducing significant technological integrations, but braking was one endeavor they felt was best left to a dedicated expert. "We did not want to be 'pioneers' with a safety critical system like the brakes," said Allen. "So we connected with Mico, Incorporated. I've known them to be a high quality supplier of brake systems for off-highway equipment, and by partnering with them we were confident we would provide a reliable and efficient braking system for the ST35."

Not only did the Mico electrohydraulic brake system allow Great Lakes Power to design the operator's cab as desired,

Because the straddle carrier has a lifting capacity in excess of its own empty weight, the brake system must have the ability to modulate the braking pressure.

but it also was inherently consistent with the wide array of sophisticated electronic control functions built into the machine. "This electrohydraulic system provides a lot of flexibility," said Allen. "It simplifies the hydraulic plumbing that would otherwise be required. It eliminates the need to protect the operator from pressurized hydraulic lines in the cab, and we can more easily remove the cab for vehicle transport. Overall it's compatible with our goals of being able to monitor complete machine performance at one location, that being our master controller. There is no need to modify components. All it takes is simple parameter changes in the master controller to tailor a machine's braking requirements to a specific customer's request."

The ST35 can handle loads of up to 35 metric tons. Because the straddle carrier has a lifting capacity in excess of its own empty weight, the brake system must have the ability to modulate the applied braking pressures, especially when the machine is unloaded. Traditionally straddle carriers used air over hydraulic systems, but operators often complained about overly aggressive braking performance when the unit was empty. Additionally, sometimes straddle carrier loads can shift under aggressive braking conditions. According to Allen, the electrohydraulic system on the ST35 provides faster and smoother brake response for better control of the situation.

Electrohydraulic braking also makes it easier to adjust the machine for specific uses. "All straddle carriers are custom built with regard to the inside frame height and width dimensions to accommodate a particular bolster or pallet size," said Allen. "These dimensions can vary greatly from one customer to another. This electrohydraulic system can be easily adapted to the range of frame sizes we expect to build."

As for how the electrohydraulic braking system actually works, it originates at the Mico brake foot pedal, where two crossing outputs from the pedal are monitored by the straddle carrier's master controller, which in turn sends a message via a J1939 CAN BUS network to the I/O modules mounted in the side frames. These modules provide a proportional current output directly to the Mico solenoid service brake valves, each of which is located at a corner of the machine as close as possible to the service brake it controls.

The ST35's 365-horsepower Cummins engine includes an auxiliary PTO location with a dual section gear pump. One section of the pump supplies the accumulator charging valve to provide 2,500 psi of pressure to both sides of the braking system. Once charged, the excess flow from this circuit combines with pump flow from the second gear pump section and then is equally distributed to provide cooling for all four brakes. Brake valve and brake coolant returns are combined and filtered to 10 microns before passing through an oil to brake cooler and returning to the tank. "The brake system has a separate reservoir for two reasons," said Allen. "It prevents any brake friction media from contaminating the hydraulic system, and it enables us to use a specific specialty brake fluid with friction modifiers to optimize wet disc brake operation."

Another key consideration in the design of the ST35 braking system was redundancy. "In wired systems there is no mechanical connection between the brake pedal and the service brakes," said Allen. "We need a level of redundancy to ensure that control is maintained and the system is safe against any one failure. The braking system must continue to function in the event of something like a loss of power to the master controller." To ensure braking function is never lost, Great Lakes Power added a redundant brake controller (RBC) to the ST35. The RBC is very similar to the I/O modules that supply current to the hydraulic brake valves. It provides reference voltage and monitors a third voltage output from the brake pedal. The RBC is always active but is placed in "standby" mode when a digital input is received from the master controller.

In addition to advanced braking technology, the straddle carrier also features a steer-by-wire system with four different steering modes—four wheel coordinated, two wheel front, two wheel rear, and crab steering. The electronically controlled steering restricts the steering angles of the rear wheels at high travel speeds to improve stability.

The machine's electronic controls system also monitors operating conditions and alerts the operator if any maintenance is required. A telematics package transmits information like load weights, GPS-based location and alert messages to a dispatch office, and future enhancements will allow remote monitoring and

parameter changes to the straddle carrier, eliminating the need to send a service technician to the job site.

The Timken Company took delivery of the first ST35 in April 2010, and early reviews have been extremely positive. "This machine is state of the art compared to the vehicles we already have," said Howard Millar, Timken's material movement training coordinator. "The brake system is outstanding. It provides controlled braking in a straight line, and the variation in brake modulation is excellent. We're very confident in the vehicle brakes."

Great Lakes Power intends to develop two additional straddle carrier models in the near future, the ST20 (20 metric ton capacity) and ST50 (50 metric ton capacity). "We feel that our design is scalable to meet the requirements for efficiently handling these load capacities," said Allen.

With its first straddle carrier having already met expectations, it shouldn't be long before Great Lakes Power is producing machines for more and more customers in need of material handling equipment. And at that point it will be clear that the company made the correct strategic move in taking the technical expertise it gained as a supplier, and putting it to use in becoming the innovative manufacturer of the next generation straddle carrier.

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Mico Takes On Efficiency, Size, Weight and Costs of New Vehicle Components

Matthew Jaster, Associate Editor

Mico first approaches a new component design by fully understanding the customer requirements including component features, potential improvements, cost targets and lead times. "We also evaluate the internal processes that will be used to manufacture the new component including machining processes, tooling, fixtures, etc.," says Mark Werner, marketing manager at Mico, Incorporated. "The goal is always to design a component that maximizes the value to both the customer and Mico."

Thanks to new Tier 4 requirements in off-highway vehicles, Mico is getting a great deal of customer requests for custom components. "Some of this involves slight modifications to an existing product while others require a complete new product design that is unique to the customer and the application," Werner says.

Pedal-actuated modulating valve.

Mico also works with its customers to design a solution for each model in a particular product line. "A customer may produce four different models of wheel loaders and we will design a custom component that maximizes the performance and value of each wheel loader that the customer manufactures," Werner says.

While the construction, agriculture, material handling and mining industries are a hot bed so to speak for custom components, many of these markets are also looking for more efficiency by using electrohydraulic components in their designs. "It is important for us to understand if there are any vehicle performance issues or upgrades that we could address in our components that would in turn help the customer increase their vehicle's value in the marketplace," Werner says. "The customer's design engineers have direct access to our product engineers and through this partnership Mico is able to design components that meet the customer's requirements."

If the lead time will not fit the customer's requirements, Mico will work with them to see if there are some design characteristics or other considerations that will shorten the lead time. "The customer usually has a predetermined time line for new vehicle development and due to the nature of our components, we are usually able to meet the lead time of the new vehicle development without issue," Werner adds.

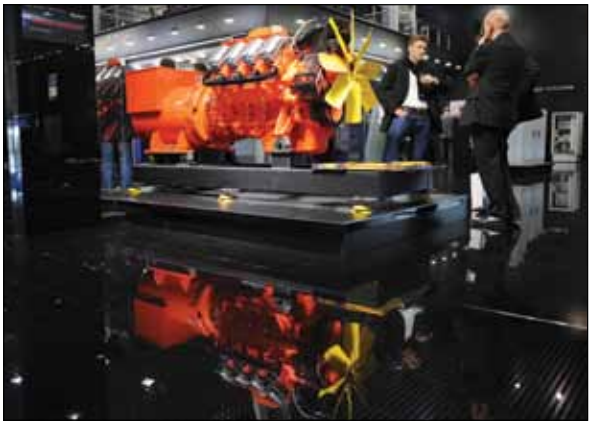
Electrohydraulic brake valve.

For 65 years, the company has engineered and manufactured custom designed components, and its experience and reputation have played a large role in the markets it currently serves. "Potential customers frequently approach Mico because of this reputation," Werner adds. "Mico needs to continue to market this recognition. Our new 'You Build It, We Brake It' ad campaign specifically focuses on custom designed solutions."

For more information on Mico's various custom braking solutions, visit *www.mico.com*.

Energy and Automation

CREATE BUZZ AT HANNOVER MESSE 2011



With its "Smart Efficiency" theme, Hannover Messe 2011 drew greater attendance from its forums and exhibits than ever before. "This year's event in Hannover has given industry a real boost, powering it up to drive the economic recovery," commented Deutsche Messe managing board chairman Dr. Wolfram von Fritsch at the end-of-show press conference. "This Hannover Messe has generated even more momentum for industry as the force behind the economic upswing."

More than 6,500 businesses from 65 countries came to Hannover to display their solutions with energy and automation the main topics of discussion. Looking ahead to next year, von Fritsch announced plans to expand the scope of the Metropolitan Solutions show launched in 2011. "Metropolitan Solutions has met with a tremendous response. Urbanization is an incredibly dynamic process in the world today. The last few days have demonstrated that industry already has a wide range of very specific answers to today's pressing urbanization challenges, and that Hannover is the ideal home for this important topic."

Hannover Messe 2011 attracted more than 230,000 visitors. This represents growth of 10 to 15 percent over the 2009 event. Some 60,000 of these visitors were from abroad, which is over a third more than in 2009. "Our foreign visitors, alone, would have filled over 150 jumbo jets," said von Fritsch. "Attendance was up from every country, thus bringing tangible benefit to exhibitors in every sub-section of the event."

Germany's Federal Chancellor Dr. Angela Merkel and the French Prime Minister Francois Fillon opened Hannover before an audience of 2,400 invited VIPs, among whom were over 120 political delegations from abroad. "France as this year's Partner Country presented its profile as an innovative industrial nation and a strong partner for the German economy," commented von Fritsch.

The Industrial Automation fair for process, factory and building automation systems and solutions was a strong drawing card for visitors interested in every conceivable aspect of industrial automation—particularly holistic automation solutions for manufacturing. Another major attraction was the Energy Efficiency in Industrial Processes Forum.

The production automation area covered the gamut of networked solutions and innovations in plant and mechanical engineering as well as robotics. Coverage of electric automation was rounded off by displays on IT solutions for real-world production challenges. At its Hannover debut this year, this topic was featured both on the exhibition floor and in the Industrial IT Forum.

Exhibitors also featured new mobile robot solutions for use in manufacturing and processing, the public sector and the services industry. Stand-out displays included flying robots, automatic cleaning systems for photovoltaic plants and driverless transport systems. Across the show, the automation sector demonstrated its key importance to each and every field of industry.

At the Motion, Drive & Automation fair (MDA) achievements in the electrical and mechanical power transmission and control sector, along with advances in hydraulics and pneumatics were readily available. The market leaders were on hand to show off their latest energy-efficient gears, roller bearings, clutches and brake systems, plus a wide variety of hydraulic pumps, motors and transmission systems.

The MDA Forum in Hall 24 covered topics such as energy efficiency in industrial processes, power transmission systems for wind energy, sealing systems and condition monitoring systems. There were extensive synergies between MDA and this year's Wind fair, with many manufacturers now supplying transmission systems and components for wind parks.

The Energy fair, the world's largest and most prominent trade show for its field according to Hannover, put the spotlight on conventional and renewable power generation, transmission and distribution systems. All these stops were also covered by a rich array of special displays, events and forums. At the "Life Needs Power" forum, for example, experts from political and R&D circles got together with experts from the energy industry to debate all of today's pressing themes and salient trends.

All the model regions selected by the German Federal Ministry of Economics and vendors serving the energy industry with hardware and software solutions were on hand to display their solutions for renewing and extending the existing energy infrastructure. 'Smart grids' was a major buzzword for everyone in search of ways to bring more renewable energy into the overall mix. For more information, please visit *www.hannovermesse.de*.

calendar

June 21–24—Expo Pack Mexico 2011. CentroBanamex, Mexico City. Expo Pack will showcase the latest solutions in packaging and processing machinery, materials, containers and other related goods and services. It offers direct access to the packaging and processing industries in Latin America, attracting buyers from throughout the region including professionals from the food, beverage, pharmaceutical, personal care, graphic arts, medical, chemical and automotive industries. Expo Pack Verde, returning for a second year, will display sustainable packaging technologies and the new Procesa pavilion will feature the latest developments in processing machinery and technology. The new Containers and Materials pavilion will include innovations that increase visual impact, enhance convenience and maximize shelf life. For more information, visit *www.expopack.com.mx*.

June 21–25—World Congress on Intelligent Control and Automation. Taipei, Taiwan. The ninth WCICA offers a variety of technical sessions, workshops and tutorials on various control and automation applications. Keynote presentations include "Towards General-Purpose Simple Hands," presented by Professor Matthew T. Mason of The Robotics Institute at Carnegie Mellon University, "Of Humans and Robots," by Professor Raja Chatila, LAAS-CNRS, France, "Control of Energy and Steering in Electric Hybrid Vehicles," by Professor Xu Yangsheng, The Chinese University of Hong Kong and "Wireless Sensing and Power Transmission," by Professor Hideki Hashimoto, University of Tokyo. Panel discussions include topics on Intelligent Control and Robotics and Intelligent Automation. For more information, visit *www.wcica2011.org*.

June 23–25—9th Shenzhen China International Small Motor Exhibition and Electric Machinery Exhibition. Shenzhen Convention and Exhibition Centre. The ninth installment of this trade show features forums, general assemblies, product conferences and technology seminars taking place in eight exhibition halls. Co-located events include the International Magnetic Materials and Equipment Exhibition; the International Magnet Wired Insulating Materials Exhibition; International Electronic Equipment, Components, Photonics and Laser Exhibition; and the 17th China International Power Supply Exhibition. Exhibits cover a broad scope including motor technology, test equipment, manufacturing apparatus, parts and auxiliary products, motor control systems and devices, servo systems, digital control devices, frequency converters, switch devices and more. For additional information, visit *www.motor-expo.cn/en/dj.asp*.

August 1–4—CAR Management Briefing Seminars. Grand Traverse Resort and Spa. Traverse City, Michigan. The Center for Automotive Research (CAR) presents its traditional summer gathering for the automotive industry. This year's scheduled sessions will focus on world class manufacturing, advanced powertrain, designing for technology, money matters, bargaining for a competitive future and many more. The briefing seminars will be a networking opportunity for automotive manufacturers and suppliers, purchasing and marketing executives, energy industry representatives, financial analysts, government and education representatives, information managers, labor leadership, manufacturing managers and engineers, media members and plant managers and superintendents. For more information, visit *www.mbs.cargroup.org*.

August 10–12—7th China (Beijing) International Gear Transmission and Equipment Expo. Beijing. With China's gear industry continuing to develop on the global stage, the International Gear Transmission and Equipment Expo looks to build a more efficienct platform for display, exchange and trade cooperation. Sponsored by the China Machinery Enterprise Management Association, this exhibition will feature industry professionals involved in gear transmission, gear processing, gear inspection, cutting tools, gear oil, chain drives and other transmission parts. For more information, visit *www.bjksexpo.com.cn/english.htm*.

September 20–22—Design and Manufacturing Midwest. Chicago. This UBM Canon event provides attendees with the newest technologies, equipment, products and services for the design and manufacturing industry. Products and services include computer-aided design and manufacturing, rapid prototyping, engineering, components, production and automation machinery, lasers, motors and drives, packaging, materials handling, electronics, quality systems, networking, enterprise IT, contract services and more. One badge gives attendees unlimited access to seven other trade shows including MidPack, Quality Expo, Medical Design and Manufacturing Chicago, AeroCon, Plastec Midwest, Assembly and Automation Expo and the Green Manufacturing Expo. For more information, visit *www.canontradeshows.com*.

September 26–28—Pack Expo 2011. Las Vegas Convention Center. Pack Expo allows visitors to connect with colleagues and suppliers and evaluate new technology in packaging equipment, converting machinery, processing technology, containers and materials. New features in 2011 include a keynote address by General Colin Powell titled "Diplomacy: Persuasion, Trust and Values," the Pharmaceutical Pavilion, the Processing Zone, the Confectionary Pavilion and the Reusable Packaging Pavilion. An expanded technical conference includes topics on safety and security, sustainability, operational reliability, simulation and modeling techniques and tracking and identification. Pack Expo 2011 is co-located with the Converting and Package Printing Expo (CPP). For more information, visit *www.packexpo.com*.

Igus

ANNOUNCES MANUS COMPETITION WINNERS

Carmelo Lagunas, a design engineer from Spain, was awarded the gold manus for his machine that produces potato omelettes.

Polymer developer and bearings specialist Igus presented the results of its fifth manus competition for plastic plain bearings at an awards ceremony during the Hannover 2011 trade show. The expert judging panel had been overwhelmed by the 301 entries received from 28 countries. Competition entries were still coming in after the official closing date. Due to the enormous success of previous manus competitions, the contest for design engineers accepted entries from all over the world for the first time this year, in cooperation with academic partners such as the Institute for Composite Materials in Kaiserslautern, a city in southwest Germany. The search was on again for innovative applications using lubrication- and maintenance-free plastic bearings that stand distinguished by technical or economic efficiency and creativity. Any applications using a solid plastic plain bearing and plastic compounds was eligible for entry, but not applications using plastic-coated bearings. Around 80 entries were received for the last manus competition, which accepted entries from Germany, Austria and Switzerland. This year, the judges noted exactly 301 entries from all over the world: including the United States, Canada, Brazil, South Africa, Australia, Malaysia, Singapore, India, China, Taiwan, Korea, Iran, Lebanon and across Europe. For other award winners, visit *www.igus.com.*

MAG

ACQUIRES FOREST LINÉ INDUSTRIES

MAG reinforces its global technology position in metal cutting and composites processing by acquiring the French company, Forest Liné Industries Group (FLI). Forest Liné specializes in manufacturing systems for aerospace applications, dies/molds, large parts, titanium and composites processing. The company is a technology leader in composite wing and wing box applications, and operates sites in France, Germany, China and Canada, employing about 300. Mr. Jean Bertrand Prot will continue as president and CEO of FLI and join the MAG executive board.

"This acquisition gives MAG another significant point of access to aerospace composites technology, manufacturing resources and demonstration facilities, as well as additional market and customer segments," said Dan Janka, president of MAG Global Industrial Systems. "Liné has always been an innovator, and its technology portfolio is highly complementary with our own, so we anticipate a wide range of new opportunities to result from this acquisition."

Like MAG, Liné is a supplier of both automated tape laying and fiber placement systems. Lightweight and rigid composites are widely used throughout the aerospace industry and in renewable energy systems, such as wind turbines. "MAG enthusiastically looks forward to increasing demand in the wind industry over the next few years, and has strongly positioned itself for growth in all segments of renewable energy, as well as the automotive sector, for which we have developed new composites production technology," Janka added. MAG, through its European business, MAG Europe GmbH, with headquarters in Göppingen, Germany, has acquired 100 percent of the shares in the Forest Liné Group.

Timken

AGREES TO PURCHASE PHILADELPHIA GEAR

The Timken Company, located in Canton, Ohio, has announced plans to purchase Philadelphia Gear Corp. for $200 million. Based in King of Prussia, Pennsylvania, Philadelphia Gear provides gear drives and components to the industrial and military sectors. Timken makes bearings, assemblies and alloy steels for auto producers and other manufacturers. The addition of Philadelphia Gear to Timken's Process Industries segment significantly expands the range of industrial services capabilities for both companies to offer their customers. The acquisition advances Timken's strategy to offer comprehensive services and solutions to end-users that enhance the performance and productivity of their mission-critical mechanical applications.

"Philadelphia Gear is an excellent fit with Timken," said Chris Coughlin, president of Timken's Process Industries segment. "Like Timken, it is a leader in industrial services

providing highly engineered solutions and replacement components for mechanical power transmission equipment. It will strengthen our presence precisely in the areas we've targeted, with excellent prospects for profitable growth via extension to our customer base around the world."

Timken plans to combine Philadelphia Gear, which employs approximately 220, with its Industrial Services business to leverage the best capabilities of each organization across the global markets. Coughlin noted that Timken plans to expand the business with the existing management team. "The synergies in this combination are all about growth," he said. Timken expects Philadelphia Gear to be accretive to earnings in its first full year and to generate income exceeding the cost of capital by 2014. The company plans to complete the acquisition through its Timken Gears & Services Inc. subsidiary by the third quarter of 2011, pending certain government and regulatory approvals.

U.S. Tsubaki

COMPLETES KABELSCHLEPP INTEGRATION

U.S. Tsubaki Power Transmission, LLC (formerly known as U.S. Tsubaki Inc.) recently announced the integration of KabelSchlepp America, of Milwaukee, Wisconsin as a new division of U.S. Tsubaki. The acquisition is a significant step forward for U.S. Tsubaki, adding value and broadening the range of industrial products available to new and existing customers. With nearly 60 years of innovation, KabelSchlepp has had a proven track record of manufacturing cable and hose carrier systems designed to protect and guide moving wires, cables, and hoses in a wide variety of applications including machine tools, packaging machinery, automotive, offshore and a host of other industries. KabelSchlepp's ISO 9001:2008 certified Milwaukee manufacturing, warehousing and sales support facility will continue to operate as a division of U.S. Tsubaki, providing expanded manufacturing capabilities and customer support for the cable and hose carrier product line. Kevin Powers, president of U.S. Tsubaki, states: "Both companies have a long tradition of innovation and commitment to serving customers' needs. We are confident that the KabelSchlepp division's manufacturing capabilities and extensive technical expertise will provide our customers with the industry's best value in cable and hose carrier systems. At U.S. Tsubaki we are excited about our new venture and look forward to passing on the benefits of these new products and services to our valued customers."

continued

Gates Corp.

CONTINUES RACING SPONSORSHIP

Gates Corporation, a manufacturer of industrial and automotive products, recently announced the continuation of its Associate Sponsorship of Don Schumacher Racing (DSR) for the 2011 National Hot Rod Association (NHRA) Full Throttle Drag Racing Series. The announcement marks Gates' 11th year of association with the racing organization. DSR is one of the premier teams in NHRA drag racing. Tony Schumacher, son of Don Schumacher, has won seven Top Fuel Dragster national championship titles. Don Schumacher, owner of DSR, noted, "Gates is one our oldest sponsors, and we value the partnership very much. We're honored to have Gates onboard again this year." In addition to sponsoring the teams, Gates provides DSR teams with Poly Chain belts that drive the dragsters' 7,000-horsepower engine superchargers. "Motorsports continues to be a logical marketing vehicle for Gates," commented Dave Miller, vice president of marketing for the automotive aftermarket business unit. He continued, "Gates involvement reinforces our ties with the professional automotive technician as well as providing a sales platform for a variety of brand-building activities."

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

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- ❑ 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)
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Carnage and Mayhem 101

STEM Education Gets Fanfare in Documentary Film

What did you learn in school today? This typical parental inquiry is met with several responses but rarely followed with, "The complete and total annihilation of robotic machines in a no-holds-barred death match." While most students complain about science and math homework, the high school students featured in the documentary film *Bots High* were able to apply their expertise to a national robotics competition that rewarded chaos, carnage and mayhem equally to ingenuity, craftsmanship and engineering.

Filmmaker Joey Daoud was interested in what it took to build a robot and the people behind them rather than focus the film on a robotics competition. "I was a big fan of robot shows as a kid and when I found out that not only did robots still fight and compete, but that high school kids were doing it, I was really intrigued."

Bots High follows three high school robotics teams battling for first place at the national robotics competition in Miami, Florida. As mentioned, the focus is more on the students than the competition itself, a perfect example of how differently high school engineering and science students are viewed in 2011. "The stereotype of the outcast, anti-social nerd tinkering away in solitude is dead," Daoud comments. "These are kids who build robots during the day and go out and have fun at night. They're extremely smart and talented. It goes to show that given the resources and guidance kids can do amazing things."

One of the strongest areas of the film is the girls involved in the competition. "One of the main schools competing in Miami is an all-girls school, so they're used to half a robotic competition being full of girls. But some of the older girls that went to different competitions around the country talk about some of the adversity they met simply for being girls at a robot competition," Daoud says. "I wanted the film to portray girls doing things that are generally associated with boys—and in many cases, kicking butt."

Daoud was quick to point out that although both boys and girls are equally prepared to study engineering after high school, less than one-fifth of engineering students are girls. In the film, The Mechanical Misfits are an all girls team that will stop at nothing to prove they belong while sacrificing school, relationships and friends to win the competition.

After completing the documentary, Daoud is more optimistic about science education in the United States. "There's still a long way to go and it's been great that there's been a big push by the president for STEM education. There should be more robotics competitions, whether its task or combat. I don't think there's a better way to reinforce what you learn from the text book than applying all that into a practical challenge."

So far the response for *Bots High* has been fantastic. "Young kids have gotten more excited about robotics, adults find it fun and entertaining and everyone loves robots smashing each other."

Daoud doesn't have any plans to return to high school for his next project (he just finished a short film called *Space Miami* about an abandoned rocket site in the Everglades) but he would love to do another high school subject in the future. The Florida State University film graduate got into the documentary segment for practical reasons. "I wanted to make my own projects and documentaries are easier to get made. Daoud says. "Lower costs, small crews, no actors. About 90 percent of the time it was just me and a camera, no one else."

For more information on *Bots High* visit *www.botshigh.com.*

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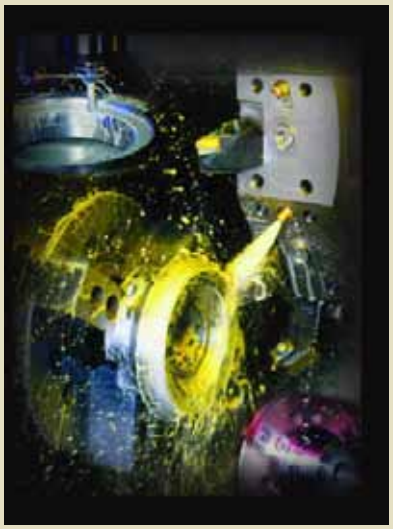

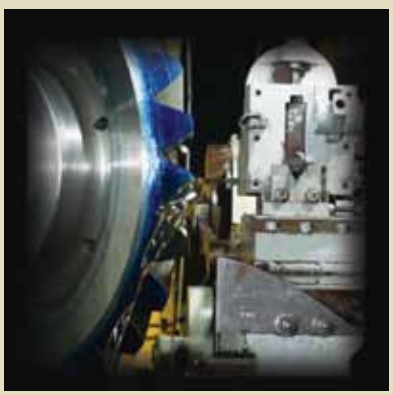

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