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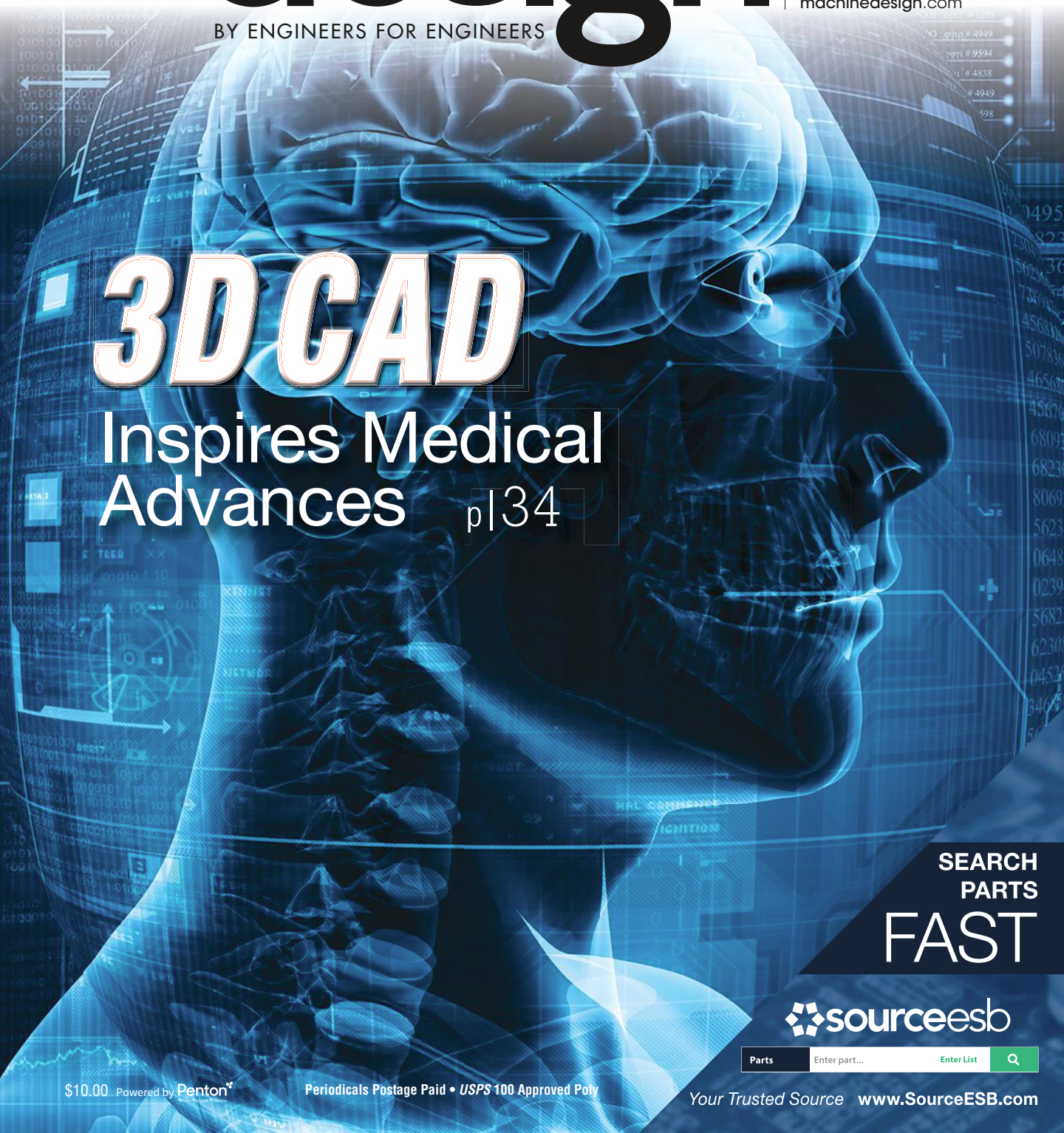

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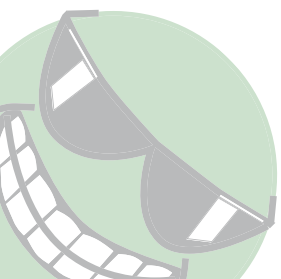

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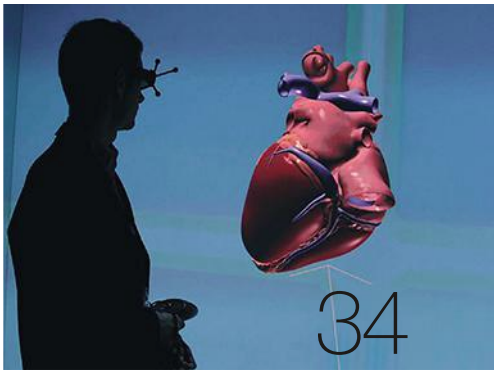

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NOW IS THE TIME FOR ENERGY HARVESTING

http://machinedesign.com/iot/7-signs-now-time-energy-harvesting

Energy harvesting collects energy that would otherwise go to waste, such as heat, vibrations, and sunlight, then converts it to electricity and puts it to use. It may not be a technology you are familiar with, but it is poised to become mainstream and change the way we power our electronic devices and what we think of as an energy source.

COMMON MISCONCEPTIONS ABOUT STEPPER MOTORS

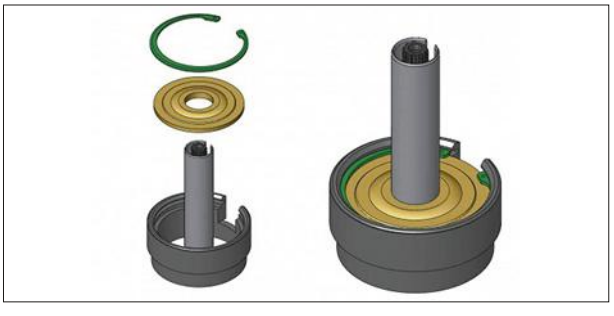
http://machinedesign.com/motorsdrives/misconceptions-about-stepper-motors-explained

Even veteran engineers often suffer from a lot of misconceptions about stepper motors and how to drive them. Understanding bipolar stepper motors will give engineers the confidence they need when selecting a driver.

THE DIFFERENCE BETWEEN WEAK AND STRONG AI

http://machinedesign.com/robotics/what-s-difference-between-weak-and-strong-ai

The conversation about artificial intelligence is often met with scrutiny and confusion. This is largely because there is no concrete definition of AI. Here, Tech Editor Jeff Kerns talks about what type of technology you might want in your factory.



10 WAYS TO USE THE UBIQUITOUS RETAINING RING

http://machinedesign.com/fasteners/10-ways-use-ubiquitous-retaining-ring

Engineers are increasingly turning to retaining rings to replace traditional fasteners and deliver savings in labor, materials, and overall costs. Here are just 10 examples of products that use a retaining ring as a fastening component.

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Editorial

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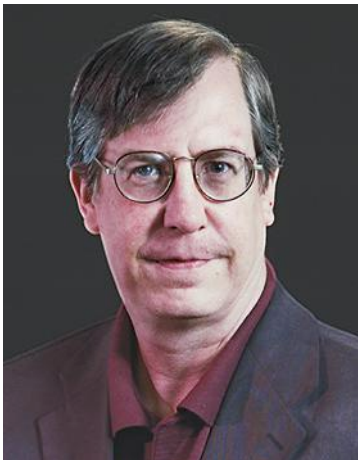
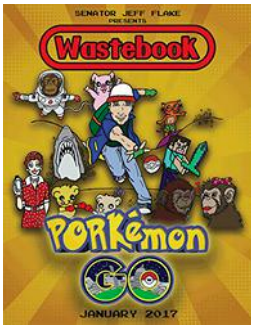
Government-Funded Projects: What Could Go Wrong?



It's not as if the government can't do anything right. After all, even a blind pig can find an acorn once in a while, as my father used to say. But finding worthwhile engineering projects and funding them appropriately is not one of our government's core competencies. I'm not sure it's any government's competency. (If there is a country out there doing a top-notch job at funding engineering and science, please let me know.)



If you want proof? Take a gander at this year's *Wastebook (http://bit.ly/2j0J7Gs)* put out by Sen. Jeff Flake (R-Ariz.). It describes dozens of highly questionable engineering and science projects that have brought few if any benefits to citizens. Here are just two of them.

Robots' Inaction: The VA bought two robots in 2021 to help distribute supplies throughout its Madison, Wisc., facility. Cost: $313,000. After about 18 months, during which the robots clogged hallways and did a less than adequate job at delivery, the robots were sent to a VA site in Milwaukee, where they sat unused for about a year, then sent a VA site in Chicago, where they again sat unused for a year.

The VA eventually decided to cut its losses and auctioned them off. The winning bid was about $2,000, and it came from the company that designed and built the robots. A VA Inspector general concluded the VA had wasted $311,000 on robots that could not operate effectively within the facility due to inadequate planning.

High-Speed Train Derails: California's high-speed train, the largest U.S. public works project currently underway, is supposed to stretch 520 miles from L.A. to San Francisco when it is competed, but the project seems to be chronically overbudget and behind schedule. The project team estimated the train and tracks would cost $64 billion and passenger service would start by 2020. That soon jumped to a cost of nearly $100 billion and passenger service would be delayed until 2033.

Construction has been delayed as local, state, and federal authorities argue over the path the tracks should take and where train stations should be. There have also been legal, financial, and environment hurdles that have been difficult to overcome. So far, no track has been laid, though some work on has been done building overpasses, tearing down structures, and moving utilities.

If the country were flush with all pensions fully funded and a future of non-stop budget surpluses and full employment on the horizon, some goofy projects would be more tolerable. But the U.S. has a $20 trillion national debt, the largest of any country in history and growing. Needless to say, it's time to reprioritize government spending. I am not hopeful. md

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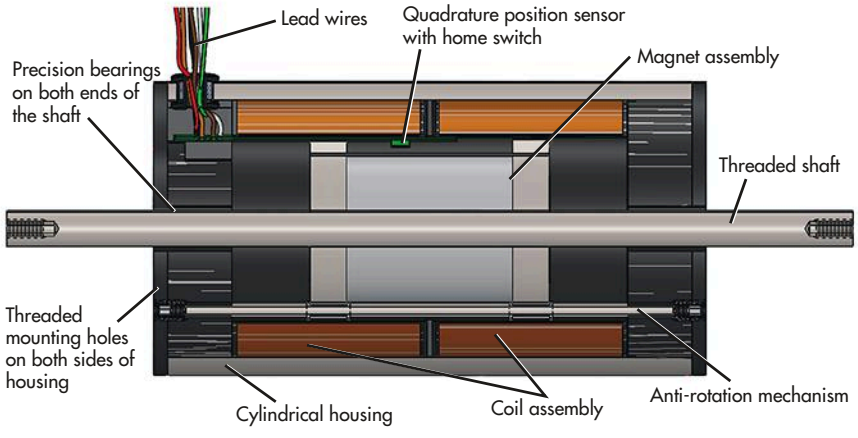
THE ENGINEERS AT MOTICONT (*www. moticont.com*), Van Nuys, Calif., designed two new high-speed, direct-drive linear motors, part of the company's SDLM series also known as Electric Cylinders. The compact motors measure an inch in diameter and 2.75 and 3.75 inches long with half-inch and one-inch strokes, respectively. They include a linear optical quadrature encoder directly connected to the motor shaft for the best possible accuracy. Each motor is rated for 20 oz. (5.7 N) of continuous force and a peak force of 66.0 oz. (18.3 N) at 10% duty cycle.

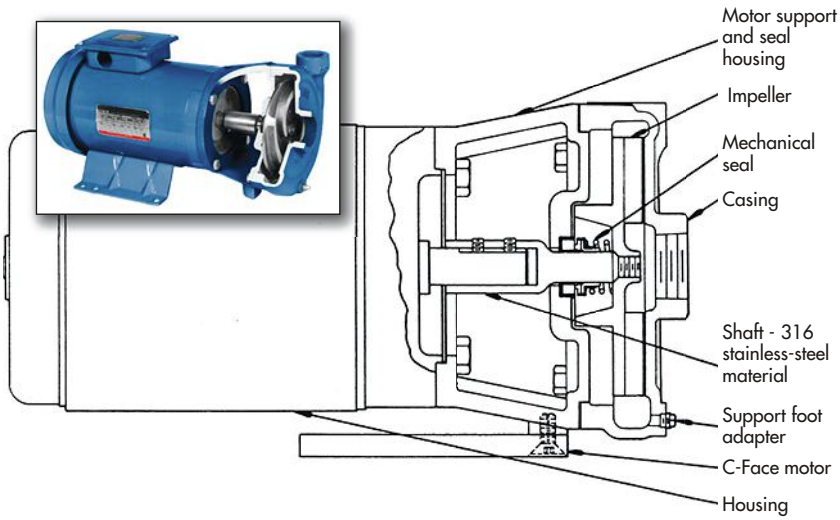


Both motors also feature long-life plain linear bearings, a non-rotating shaft, threaded mounting holes, and threaded shaft ends that make it easy to put into new or existing applications. The motors are directly coupled to the load, so acceleration and speed are high and there is no cogging and/or backlash, which are common on other devices such as ball screws, gears, and rack-and-pinion drives.

The motors are well suited for inspection, pharmaceutical, biotechnology, aerospace, ophthalmic, non-contact examination, medical, electronic assembly, laser machining, and robotics surgery equipment. md

Pumps Add Value by Cutting Back on Space

AS SPACE BECOMES increasingly valuable, companies must expand their lines in order to offer multiple types of pumps. Value is added to compact pump designs that can fit into small spaces. One design option is having the pump's casting be able to rotate or provide multiple mounting capabilities to accommodate various piping requirements.



On that front, the Vertiflo Pump Company (*www.vertiflopump.com)* developed the Model 1312, an industrial, horizontal, end suction pump that will find homes in general pumping, chemicals, wash systems, deionized water, process, and OEM applications. Designed for long life, it is able to achieve up to 160 feet TDH (total dynamic head) and flows to 240 gallons per minute. The pump, which features a close-coupled design to save installation space, comes in two sizes—1750 and 3500 RPM. Construction options include cast iron, 316 stainless-steel fitted, or all 316 stainless steel to handle different types of liquid chemicals. md

News

Large Growth Projected
for Motors and Drives Through 2022

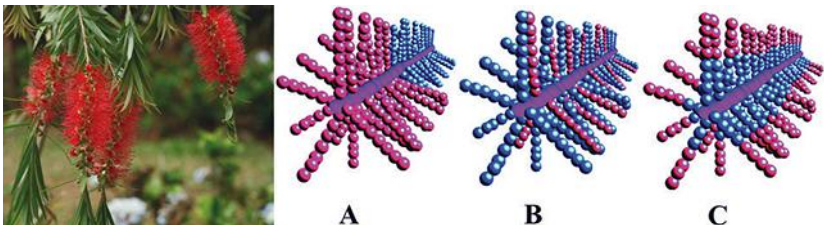
According to MarketsandMarkets *(www.marketsandmarkets.com)*, a market research and consulting firm, the market for servo motors and drives is expected to grow from $10.26 billion in 2015 to $15.92 billion by 2022, at a compound annual growth rate of 6.25%. The major drivers for growth in this market include the advance and rapid growth in automation, adoption of energy-efficient international standards, ease of use, adding motion-control components to motors and drives, and energy efficiency regulations.

The automotive and transportation industry is expected to hold the largest market share in numbers and value in servo motors and drives through 2022 due to rapid changes in manufacturing technology, innovation, and technical advancement. There is also a high demand for servo drives, controllers, and motors across the globe, as they help companies improve the efficiency of production and manufacturing. But the packaging industry segment's use of servo motors and drives is expected to grow the fastest during that period.

Looking inside the drives and servo motors market, the segment for linear servo motors is expected to have the highest growth rate through 2022 based on growing applications in semiconductors & electronics, manufacturing machines, machine tools, food processing, packaging machines, textile machines, robotics, chip mounters, and other automation industries. The market for medium-voltage servo motors and drives is also expected to grow faster than most other segments due to the growing demand for them in industries such as metal, mining, power generation, and water and wastewater treatment.

Form a geographical perspective, the Asia and Pacific (APAC) region will sell the largest share of servo motors and drives, followed by Europe, and then the Americas. The APAC will hold the major share of the mainly because growth is increasing industrial activity along with the demand for faster and accurate motors and drives for higher production rates. Large investments in manufacturing are also driving the growth of servo motors and drives in the region.

The major challenges for the companies in the market are risk and uncertainty and lack of a skilled work force and trained workers. Major vendors in the market include Yaskawa Electric Corp. (Japan), Mitsubishi Electric Corp. (Japan), Siemens AG (Germany), Schneider Electric (France), and Rockwell Automation Inc. (U.S.). All of these firms have adopted various strategies such as new product developments, mergers, partnerships, collaborations, and business expansion to cater to the needs of their servo motor and drive customers. ■



Bottlebrush polymers are so-named because of their resemblance to bottlebrush plants.
(Courtesy of Austin Native Landscaping, left, and the Royal Society of Chemistry Publishing, right)

FREESTANDING DIELECTRIC ELASTOMERS
Offer New Capabilities in Actuation, Soft Robotics

DIELECTRIC ELASTOMERS ARE researched for use in artificial muscles, soft robotics, and medical actuators. Made up of dipolar molecules that align with an electric field, they can expand or shape-shift in response to an applied voltage. A dielectric elastomer from North Carolina State University, Raleigh, is enhanced with electroactive "bottlebrush" polymers that allow it to deform under relatively low electric fields. The polymers also enable the elastomer to hold its final shape after the field is removed. The team's work is published in *Advanced Materials* and received funding from the National Science Foundation.

While dielectric elastomers usually require an external structure, such as a frame or support, to keep their shape after the electric field is turned off, the enhanced elastomer from NCSU is freestanding. The bottlebrush polymers added to the elastomer have long sidechains that cause them to act almost like microscopic Velcro. The side chains intertwine with one another and do not so easily unravel so that they elastomer can keep its shape after activation. In addition, they are thick, but quite flexible, so they actually reduce the elastomer's overall stiffness without the need for liquid fractions or other materials that could alter the elastomer's electrical response and freestanding capabilities.

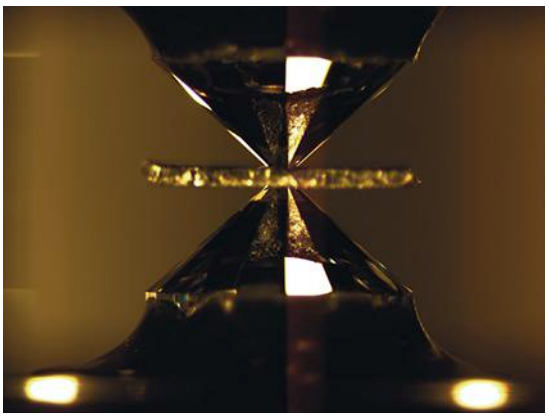
The electroactive bottlebrush polymers also significantly reduce the electric field strength needed to activate the elastomer. Dielectric elastomers usually require electric fields on the order of 100 kV/mm to expand. However, the team saw expansion with electric fields on the order of 10 kV/mm in their circular sample.

The bottlebrush elastomers were synthesized by grafting long polymer side chains onto a polymer backbone. By altering the grafting methods, the scientists could produce various degrees of polymerization and densities to affect the mass mechanical properties and stiffness of the elastomer.

While more research is still needed to determine the applicability of the material, a freestanding dielectric elastomer could stand out in the medical industry for applications like permanent stents or other implants. "We're at the earliest stages of identifying all the potential ways in which we could use this new class of material," says Richard J. Spontak, co-author of the paper and distinguished professor of chemical and biomolecular engineering and professor of materials science and engineering at NC State. "It works better than anticipated, and now we're beginning to consider potential applications." ■

HARVARD MAKES THE LATEST CLAIM

for Creating Metallic Hydrogen



Cell diamond anvils are used to generate pressures that are higher than those at the earth's core. Harvard's claims that it created metallic hydrogen are still met with skepticism by other researchers in the field. *(Courtesy of SERC Carleton-Carleton College)*

HARVARD SCIENTISTS claim to have synthesized metallic hydrogen in the lab for the first time. In a study submitted to the journal *Science* last October, the scientists described how they used a cell-diamond anvil to pressurize a small sample of hydrogen between the tips of two diamonds.

Upon reaching 495 gigapascals—nearly 5 million atmospheres—they report that the hydrogen transitioned to a solid metallic phase, which has eluded scientists since it was hypothesized 80 years ago. They used a special coating to protect the diamonds from breaking under such high pressures and to secure the sample. For now, the sample remains stored between the diamond tips until the team removes it in a controlled environment. Solid metallic hydrogen is theorized to be superconductive at room temperature, expelling magnetic fields and conducting electricity with little to no resistance or heat dissipation. Some theorists think it could remain in its metallic state when the high pressure is released—a phenomenon called metastability.

If the metallic hydrogen is indeed a metastable superconductor, it will be useful for a range of applications. It could be used as a high-energy rocket propellant or as a room-temperature superconductor for MRI machines and magnetic transport rails. It could also be used in low-energy electronics that dissipate less heat through conductive wires.

But knowing the pressure required to drive the phase transition is just the first step in that direction. More research would be needed to make the metallic hydrogen in larger quantities. Furthermore, other scientists are questioning the validity of Harvard's findings; they demand more proof that it has been created at all. Last January, Edinburgh scientists published in Nature that they had converted hydrogen gas—an insulator—into a precursor of metallic hydrogen (phase V) using a cell-diamond anvil at room temperature and 384 GPa.

One of the authors of the paper, Eugene Gregoryanz has been quoted in various news outlets saying that if the Harvard team was successful, it should be able to reproduce its results and use less ambiguous imaging techniques to prove that there were phase changes. For example, the Edinburgh team used Raman spectroscopy to identify phase changes in the sample as it converted from a gas to a crystal.

Dr. Isaac F. Silvera, a professor of physics at Harvard and one of the leading authors of the paper, says that his team plans to reproduce its results and use Raman spectroscopy to identify modes of vibrations that characterize each phase in future experiments. The team has also been prompted to provide more proof that the phase change is occurring in the hydrogen sample, not in the aluminum-oxide coating that was used on the diamonds to ensure that they don't break. ■

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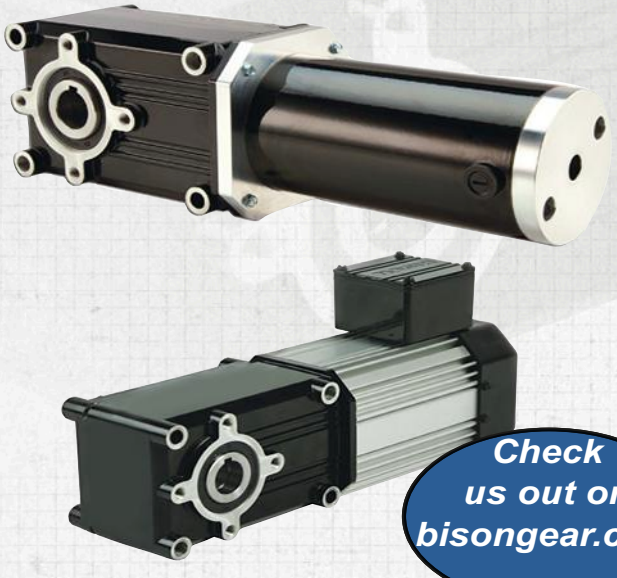

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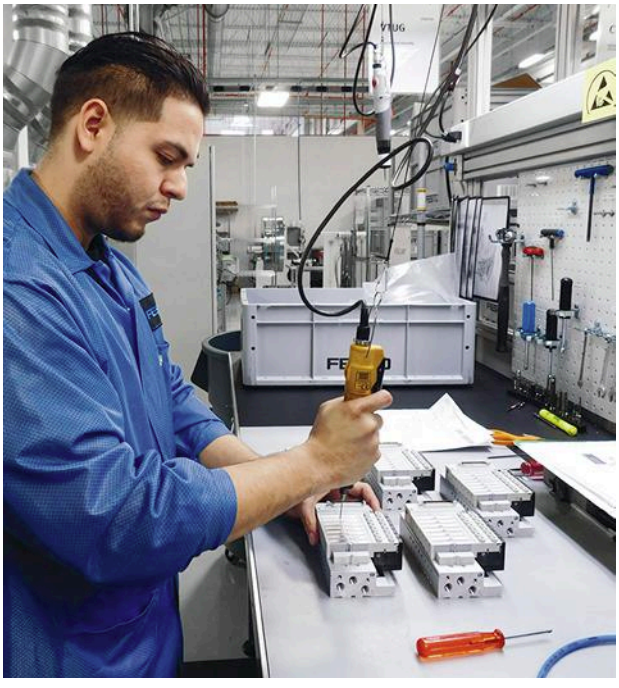
The Automation Boom in Mexico

Jeff Burnstein, President of A3, says Mexico may be the next global player in the automation arena, but the international skills gap could be problematic.

Interview by JEFF KERNS

Last year proved record-setting for robotics in terms of orders and shipments in North America, according to the Robotic Industries Association (RIA). A total of 34,606 robots valued at approximately $1.9 billion were ordered in North America—a 10% jump from 2015. Orders for robots spiked 61% in assembly applications and spot welding saw a 24% increase. And orders for robots in the food and consumer goods industry rose by 32% in 2016.

These numbers represent North America as a whole, but some of these results are influenced by the surge in automation in Mexico. Consequently, companies like Festo are planning strategic locations for shipments to Mexico and even Central America. Festo recently published a news release stating that a facility in Cincinnati was strategically close to the airport to support the expected growth in Mexico, which is becoming a recognized hub for the automotive industry. Festo's new center has Foreign Trade Zone status, making it faster and more efficient to support customers in the U.S., Canada, and Mexico from a central U.S. location.



An assembly worker builds automation equipment at Festo's new facility, which is strategically located to ship parts anywhere in North America, specifically to Mexico.

With automation continuing on the upswing in North America, *Machine Design* talked to Jeff Burnstein, President of the Association for Advancing Automation (A3), about what this means for the U.S. and global competition.

What is your background?

I have been working to promote the use of robotics, machine vision, and motion control for more than 32 years. I see automation changing all facets of our lives for the better, creating new and better jobs, giving us higher-quality and lower-priced products, and helping us live longer and healthier.

How fast is Mexican automation growing?

With the world's 11th largest economy, Mexico is home to a vast array of industries, including substantial automotive and aerospace manufacturing sectors. In 2015, industry-wide sales of robots in Mexico almost tripled to 6,320 units, exceeding $243 million. A3 is embracing Mexico's broad-based growth and potential with this new association, which will help support Mexico's rapidly growing automation industry. Automation investments can also help increase the number of well-paying jobs in Mexico, which has high rates of engineering graduation per capita.

How fast is automation growing in North America?

We [A3] just announced that 2016 North American robotics industry orders and shipments once again broke all-time records. In 2016, 34,606 robots valued at approximately $1.9

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billion were ordered in North America, representing growth of 10% in units over 2015. The automotive industry experienced another strong year with orders growing 17%. Units shipped to North American customers also grew by 10%, with 30,875 robots valued at $1.8 billion shipped in 2016. Shipments into the automotive market grew 25% relative to 2015.

What does this foreshadow, or what can we expect from these numbers?

These numbers reinforce the vital role played by automation in spurring economic growth in North American manufacturing and services industries in 2016. We think this is only the beginning. As automation spreads around the world, companies everywhere will get more competitive, prices of products will come down, quality will go up, and demand will go up. For example, years ago you may have had one TV in your house. Today, due to reduced cost and increased quality, you might have five. I expect to see this happen with more products as automation becomes more prevalent around the world.

As things become cheaper, people will buy more and this will drive employment. Automation represents a strategic area for the global economy going forward, as it brings accelerated growth based on smarter, more mobile, and more collaborative robots in the coming years.

What is being produced in Mexico, or what are its markets?

The automotive, aerospace, and food and beverage industries are strong growth areas. With the boom of Mexican automation, it's inherently increasing growth in any company that works with robotics or more advanced automation in the region, too. In the past, some companies may have avoided Mexico, or only used it for a cheap labor. However, the automation in Mexico is becoming more advanced, with processes rivaling any other country. I was at Expo Manufactura in Monterrey, Mexico [Feb. 7-9], and there was a lot of the same robotics and advanced systems you would see in any show in the U.S.

This growth is also from multiple countries. Mexico has 10 free-trade agreements with 45 countries. U.S. companies that manufacture in Mexico can export tax-free to 45 countries that are not tax-free from the U.S.

What are the drivers pushing the Mexican automation market?

An increasing focus on efficiency improvement is one of the primary drivers of automation in Mexico. Industrial control devices are making it possible for organizations to standardize their production activities while cutting costs, reducing waste and improving safety.

Will this be a trend and will this move more U.S. jobs to Mexico?

A robust automation industry in Mexico will create jobs and broaden the Mexican middle class, providing the means and incentives for individuals to participate in Mexico's growing economy. As Mexican purchasing power increases, it provides an expanding market for U.S. exporters. A strong Mexico is a robust and stable trading partner with its neighbors. U.S. companies will continue to automate as well, to help both small and large corporations be more globally competitive so that they can grow and fill new jobs in the U.S.

What does Mexico need to advance its automation—basic CNC or more advanced robotics, and machine vision?

Automation will allow Mexican companies to boost worker safety, reduce costs, decrease cycle time, improve quality, utilize space more efficiently, reduce waste, and stay competitive. A3 Mexico will promote the benefits of automation while facilitating gatherings and interchange between stakeholders and members of the automation

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> "A robust automation industry in Mexico will create jobs and broaden the Mexican middle class, providing the means and incentives for individuals to participate in Mexico's growing economy." —Jeff Burnstein, President of A3

community in Mexico. Mexico's robust engineering and technical education programs throughout the country will lead to continued progress and expertise in advanced robotics, machine vision, etc.

While robots are popular, the biggest challenge is finding trained people who know how to set up and run the automated tools that are showing up in the Mexican factories. They need highly trained, quality system integrators. This skills gap is an international problem. We are moving less brawn and more brain. Some skills will take a four-year degree, but most of it will be setting up and running the machines that can be taught in a technical school or a community college.

How is A3 helping this movement?

A3 is embracing Mexico's growth and potential by forming a new association geared to this booming market. A3 is a global umbrella association for three leading industry associations that collectively form an ecosystem of automation: the Robotic Industries Association (RIA), Advancing Vision + Imaging (AIA), and the Motion Control & Motor Association (MCMA). In addition, every other year we host the Automate show.

A3 Mexico is dedicated to helping Mexican companies attain the advantages of automation so that they can compete more effectively on a global stage, resulting in economic improvements and safer, better conditions for workers. As a leading proponent of robotics, vision technology, motion control, and motors worldwide, A3 is helping develop the Mexican market for automation equipment suppliers along with system integrators. It's also helping to develop better processes in Mexico that can improve product quality, consistency, and output to meet consumer demands.

What do you think the role of automation and robotics is globally?

Automation, which includes robotics, is coming front and center on the world stage, and has the potential to impact the global economy. As societies move forward, we have to embrace the changes and innovations introduced by technology and automation and learn to evolve with it. Today's automation technologies—like every other technological revolution in the past—will change jobs and their required skills, and present opportunities for brand new jobs. Workers must begin now to prepare for that future, and governments and industries need to support that preparation.

How will automation increase the standard of living globally, or will it just help us make more stuff faster with less people?

Automation fundamentally changes everything and improves the standard of living globally. It's not just about efficiency and productivity in manufacturing. Automation is speeding the development of new drugs and medical processes, improving surgical outcomes, and allowing products to be shipped faster. In the future, automation will even be saving lives on freeways and helping seniors and disabled individuals live more satisfying, independent lives. md

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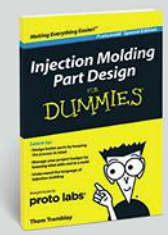

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STEPHEN MRAZ | Senior Editor
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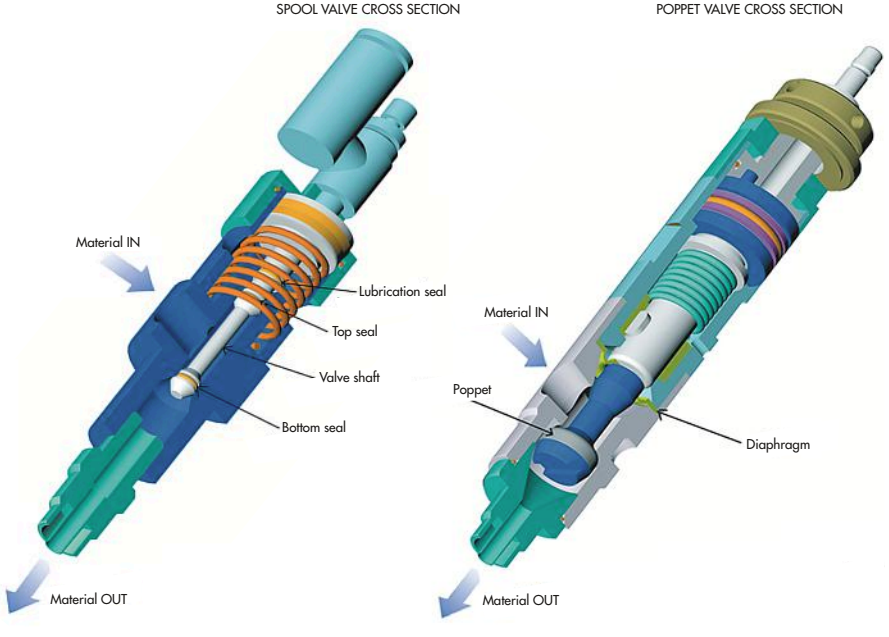
What's the Difference Between POPPET AND PISTON SPOOL VALVES?

When designing pneumatic circuits, there are two valve designs to consider. We will examine the differences between a poppet and a spool valve and determine which fits best for your design.

Deciding which valve to use for a hydraulic or pneumatic system depends on a couple of design factors: the internal design of your circuit and the overall function of your valves. The two major valves used most commonly are the poppet and piston spool varieties. These valves are primarily involved with controlling compressed air.

"The main difference between a spool and a poppet valve is the construction," explains Daniella Gonzalez-Olgren, a valve product specialist from Festo (www.festo.com). "Because of the way a poppet valve is constructed, there is no need for lubrication, simplifying your air preparation units. However, spool valves usually have higher flows than poppet valves within the same footprint. This is because a poppet valve needs a large poppet area to create a large enough shifting force to overcome the pressure."

Both valves have their advantages and disadvantages, but the biggest factor will be understanding your operating conditions.

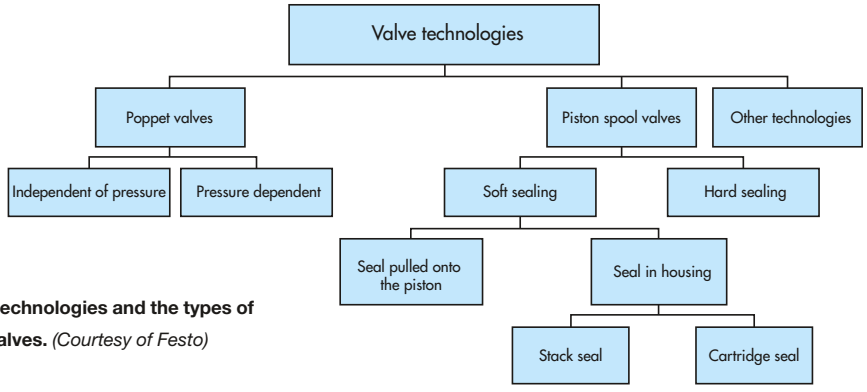


The images above are simple cross sections of a typical spool valve (left) and a poppet valve (right). *(Courtesy of Unicontrols Signapore)*

THE POPPET VALVE

Poppet valves have a simple construction and can be used with any material. The valve functions as fluid at the inlet port passes through the control office and reaches the backside of the poppet. The tip of the spring-loaded armature closes the outflow orifice to keep the fluid trapped behind the poppet. The valve is a check valve that stops the flow, in the normal condition, from inlet to outlet. The flow in the opposite direction, outlet to inlet, occurs at a reduced rate.

The solenoid coil is energized to create a magnetic field that raises the armature to open the outflow orifice. This orifice is larger than the control orifice, which creates greater flow and a pressure drop behind the poppet. The inlet pressure on the poppet's annulus area outside the seat diameter ousts it to let fluid flow to the poppet's outlet.



This chart breaks down the different valve technologies and the types of seals available for both poppet and spool valves. *(Courtesy of Festo)*

When the solenoid coil is de-energized, the spring force reseats the armature tip—once again trapping the fluid behind the poppet and allowing it to close. Poppet valves are typically preferred in sorting applications, industrial environments with possible contamination, and any applications that need fast switching times.

Advantages

Unlike spool valves, poppet valves open an immediate flow path to the outlet. This results in a fast response time. Poppet valves only open as much as is needed by the flow going through it, traveling a minimum distance to do so, which increases its response time. The large surface area that is essential for poppets results in a higher flow rate. Poppet valves require small actuation strokes, which allows for shorter switching times.

The fact that poppets can be used with any material also makes them very inexpensive and easy to use. Other benefits of poppet valves are that the axial sealing used is resistant to soiling, and they do not require lubrication. This makes them chemically compatible with lubricated compressed air. Poppets are also beneficial when it comes to longevity, as less wear on the internal seals leads to a longer product life.

Disadvantages

Due to the constructional constraints, poppet valves are not advantageous when it comes to the relationship between space and flow. The disadvantage of poppet valves is that, as the poppets shift from one flow path to another, air is free to travel in any direction. This is known as "crossover." With pressure-independent models, poppet valves offer a lower flow than slide valves.

This is due to the greater structural demand—in pressure-dependent valves, the control pressure depends on the operating pressure. The valves are unbalanced and pressure must be supplied under the poppet to hold the valve in the unactuated position. To allow air flow, a higher force is required to actuate the valves since it has to overcome the spring and the air pressure. It is also possible for the valve to open due to back pressure if the supply pressure is removed. This makes them poor choices for holding pressure downstream.

Poppet valves also typically operate in one manner. For example, a two-way, normally closed poppet valve cannot be changed to open. Poppets are typically not recommended for vacuum conditions. Lastly, the valve construction is not always without overlap. Depending on the design of the poppet valve, the switching of positions can lead to overflowing between channels. This may cause unnecessary leakage and noise.

PISTON SPOOL VALVES

A spool valve features seals along its surface. By actuating the valve, the spool shifts, causing the seals to travel down the bore and opening the ports to allow for airflow. For systems that have a flow of 100 gpm or less, spool valves are most commonly used to direct flow. By counting the number of ports that fluid can travel in any given valve provides you with its number of ways.

For example, a two-ported valve is also a two-way valve. The two-way valve will only have two positions, since it can only stop or allow flow. Other spool-valve configurations are three-way, four-way, and five-way. Five-way valves are special cases in the fact that an exhaust port is not a concern.

A four-way valve may have five ports with its tank ports connected internally in order to eliminate an extra port in the body. This configuration is important for hydraulic purposes because it helps reduce leak points and piping. Spool valves are typically preferred in light-weight machines or end-of-arm robot

tooling; clean work environments; and especially cabinet installations or whenever there are space constraints.

Spool values can adopt one of two types of sealing systems: hard or soft sealing. Hard-sealing systems are more durable. The absence of the soft rubber sealing elements in the piston spool valve is what makes them more durable. A valve using this type of seal is immediately ready for a full dynamic use, regardless of whether it has been inactive for a long period. However, this makes hard seals more demanding.

The challenge is that the air gap surrounding the moving piston cannot be larger than a few micrometers. The often-used metal sleeve acts as both a seal and a guide for the valve spool. The sleeve and the spool must be made of the same material, since a difference in thermal expansion coefficients can cause greater leakage and even jamming of the spool.

Even a small deformation in the housing can damage the sleeve and affect the life valve and increase leakage. While being robust and durable, hard-sealed spool valves will always have a certain amount of leakage due to the air gap, and their flow capacity is lower when compared to other valves of similar dimensions.

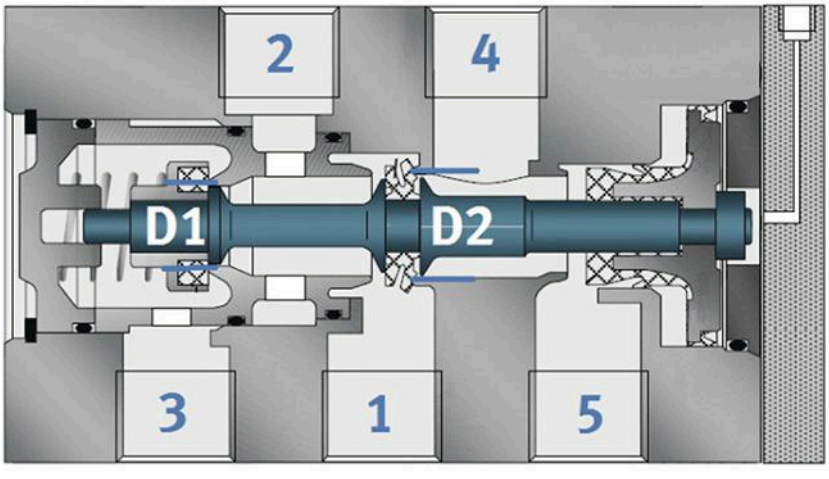
Soft-sealed spool valves use rubber gaskets (O-rings or molded elastomer seals) on the piston. By using soft-sealed spool valves, you avoid the complications of having metal-on-metal configurations. However, soft-sealed spool valves will wear down quickly over time when in contact with the channel edge or control edge. Optimal planning for the control edge is necessary, and careful consideration must be given to the molded elastomer seal and piston guide, to ensure a soft passage with minimum degree of wear.

The seals can be mounted directly onto the valve housing. Again, the required recesses are difficult to manufacture, and the Bernoulli effect will cause the seals to dislodge at a pressure of 8 bar or higher. This creates greater wear on the seal.

To solve this problem, one can use molded seals in metal cages, hence keeping them in the recesses. This is known as the cartridge principal. The advantage is that the valve will not be pulled out of position even at high operating pressures. The seals could maintain in the metal cages with pressures as high as 16 bar. This type of configuration will have a long valve life, and the seal can be used in vacuum operations.

Advantages

The main advantage of spool valves is that the spool movement is not affected



In a poppet valve, the control pressure depends on the operating pressure. This is due to air flow. In the pressure-dependent poppet valve above, the air flows through the valve from channel 1 to channel 2. Since the surface area D2 is larger than D1, an imbalance of forces occurs because the same operating pressure is exerted on both surfaces. This needs to be compensated to maintain a balance in the valve. *(Courtesy of Festo)*

(Continued on page 56)

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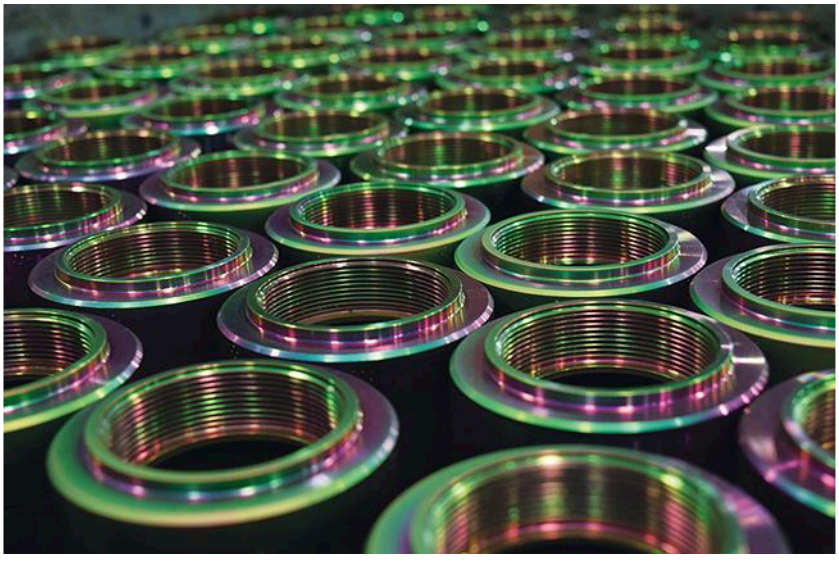
What Engineers Should Know About Zinc-Nickel Coatings

They protect against corrosion, wear, and thermal stress, but are not always applicable.

The development and practical application of electroplated zinc-nickel alloy coatings began during the 1980s, and its acceptance and use have grown slowly but consistently ever since. So Zn-Ni coatings are not as widely used as other traditional protective coatings. This is unfortunate and likely due to the fact the process and the benefits it brings are subject to some misconceptions. The truth is, Zn-Ni coatings offer manufacturers valuable options for meeting ever-increasing regulatory, warranty, and performance requirements that affect their products.



Large cylinders rack-plated with zinc-nickel and hexavalent chromate have a slightly iridescent appearance, thanks to the chromate.

New regulations, for example, are encouraging more auto, truck, and small-engine designers to consider it more seriously. It has also been adopted widely by the aerospace industry and is increasingly being used to protect heavy construction and agricultural equipment, as well as components and devices of all kinds that are exposed to environments that lead to excessive corrosion.

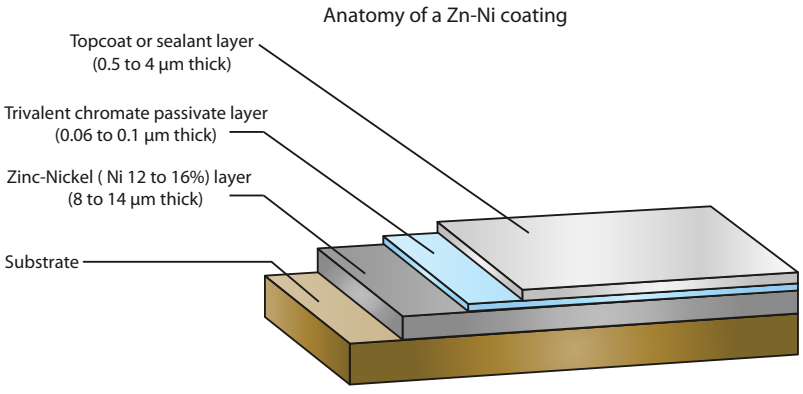
Here's a look at the nature and benefits of Zn-Ni electroplated coatings, and how they benefit real-world applications.

BENEFITS OF Zn-Ni COATINGS

Zn-Ni alloy coatings (usually composed of approximately 85% zinc and 15% nickel) are electroplated on carbon steel as a protective coating in a process similar to the way zinc coatings are applied. Zn-Ni coatings typically consist of 8 to 14 μm layer of 12 to 16% nickel alloy next to the substrate topped by a 0.06 to 0.15 μm trivalent passivate layer and a 0.5 to 4.0 μm top coat layer.

There the similarities end: Zn-Ni alloy coating significantly exceeds the protection offered by other coatings in three main areas:

- It offers greater corrosion protection.
- It provides more wear resistance in moving parts
- It limits thermal stress to parts subjected to higher operating temperatures.



This image shows a cross-section (not to scale) of a typical Zn-Ni coating. The three layers of coating consist of a layer of Zn-Ni alloy, covered by a layer of chromate, with a topcoat or sealant on top.

In the electroplating process, Zn-Ni coatings also have good throwing power (the ability to plate in recessed areas on parts with a complex shapes) to better coat blind holes and recessed areas.

Here is a brief summary of its benefits:

Corrosion protection: As a true alloy, Zn-Ni coatings are proven to provide two to three times more corrosion-resistant protection than zinc-only coatings. Furthermore, the crystal structures of Zn-Ni deposits are a uniform single structure that creates a thin, consistent protective layer across the entire surface being coated. Zn–Ni coatings provide corrosion resistance equal to or greater than cadmium coatings and they eliminate the risk of carcinogenic exposure that creates a concern for people working with cadmium-coated components.

Aluminum substrate parts have become more popular for automotive components. Due to aluminum's differing electropotential when in contact with steel, aluminum parts are subject to attack by galvanic corrosion. Fortunately, accelerated corrosion tests show that Zn-Ni coating also protects against this galvanic-induced corrosion.

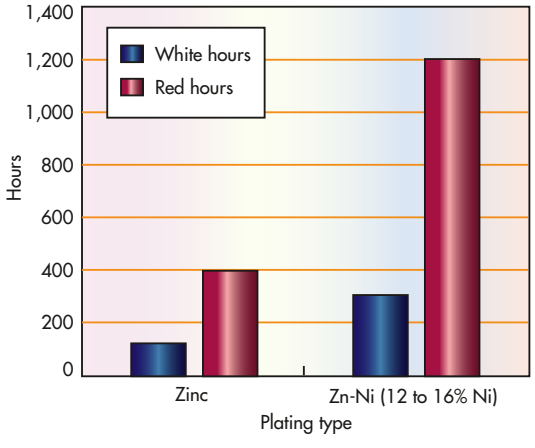
Increased wear resistance: A hard, thin-film Zn-Ni coating has a consistently smooth finish that increases wear resistance both through its hardness and by producing a surface that virtually eliminates irregularities, reducing both friction and opportunities for abrasion. On the Vickers hardness scale, parts coated with Zn-Ni reach 450, compared to less than 150 for zinc-coated parts.

Thermal stress relief: Zn-Ni coatings provide added protection against thermal stress. As a result of regulatory requirements, today's automotive engines, for example, are smaller and tend to run at higher operating temperature. This creates thermal stresses on other components within the engine compartment, and Zn-Ni coatings have been found to reduce the effect of that stress. Tests show, for example, that components coated with Zn-Ni retain their corrosion resistance despite exposure to thermal stresses in temperatures up to 200°C, as opposed to zinc-coated parts, which resist thermal stresses up to only 120°C without losing corrosion resistance.

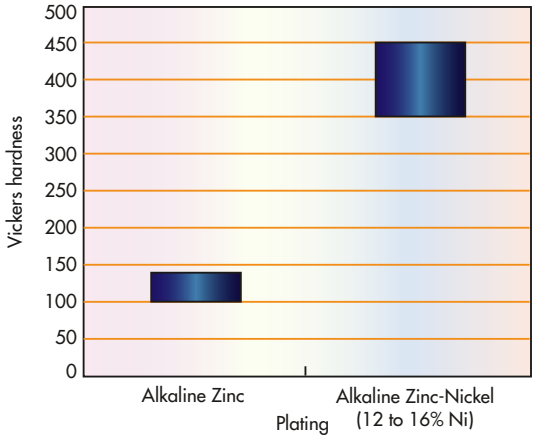
These laboratory tests reveal that Zn-Ni coating offers a unique set of qualities not found in other electroplated or traditionally applied coatings. Experience has shown that these qualities play a significant part in extending the life cycle of equipment and structures.

The smooth, hard, consistent surface finish of the coatings means they continue to provide excellent corrosion protection even after being formed or bent after coating. They also provide an excellent base for subsequent painting or powder-coated finishes.

Comparing ZN-Ni and ZN coatings on corrosion resistance (Neutral Salt Spray (ASTM B117)



Comparing ZN-Ni and ZN coatings on hardness



White hours represent the time it took to corrode the plating. (Zinc degrades into a white rust.) Red hours represent the time it took to corrode the substrate, which usually forms red rust.

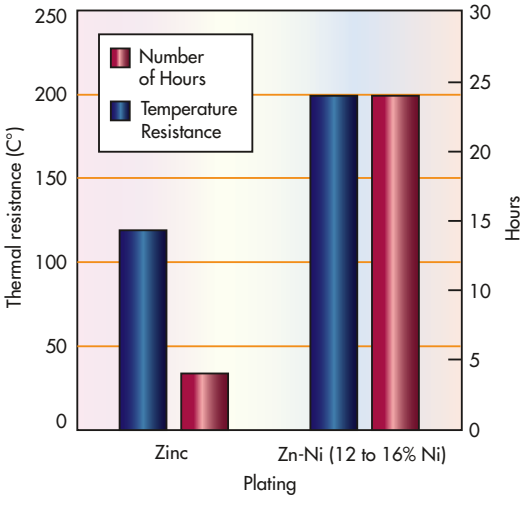
> "Automotive manufacturers and their suppliers have also taken advantage of a Zn-Ni coating's ability to increase wear resistance, a critical factor in extending the working life of parts that experience constant wear stress, yet must perform successfully, such as brake calipers."

SUCCESS WITH ZN-NI COATINGS

Zn-Ni coatings can provide a much higher degree of substrate protection, which means they can resist the stresses that inevitably shorten the working life of everything from equipment with moving parts to buildings and infrastructure. Some industries, including automotive and aerospace, have already widely adopted these coatings. Others, such as manufacturers of construction and agricultural equipment and electrical transmission structures, are beginning to take advantage of them to protect the value of their products. Agricultural and construction equipment is continually exposed to weather and often to corrosive fertilizers, herbicides, and road chemicals. These are large, expensive pieces of equipment that often sit for long periods yet need to be ready to jump into action without unexpected maintenance.

Zn-Ni coatings are ideal for applications where corrosion protection is essential, from automotive, agricultural, and construction equipment to electrical transmission equipment, as well as bolts and fasteners on bridges and other structures exposed to weather. In SAE J2334 Cyclic Corrosion tests, a much more stringent test than a simple salt test, parts coated with Zn-Ni outperform zinc coated parts by a factor of four. This level of protection on bolts securing a bridge girder could extend the life of that critical part by a factor of years.

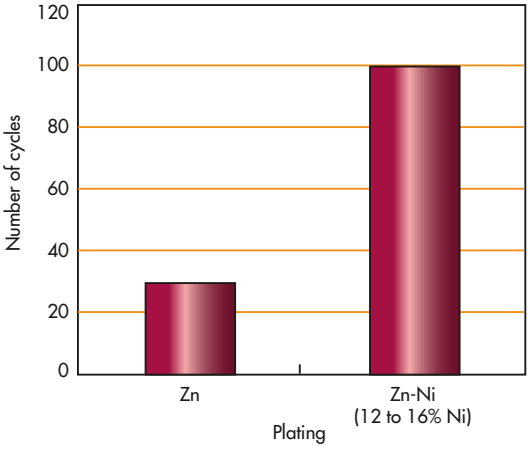
Comparing ZN-Ni and ZN coatings on thermal resistance while maintaining corrosion performance



As European and American regulators require longer life for vehicles, Zn-Ni provides a significant advantage for manufacturers by protecting parts from corrosion. Similarly, as aging infrastructure is replaced or repaired, the use of these coatings on fasteners and other structural elements helps ensure longer life for those structures.

Automotive manufacturers and their component suppliers have been pioneers in adopting Zn-Ni coatings. They have begun applying them to the undersides of hoods and other engine-compartment structures to protect them from the heat, as mentioned earlier. They also coat fasteners used in wheel wells and other exposed areas of vehicles requiring increased abrasion and corrosion protection. This extends the life and appearance of those parts and reduces warranty claims. This is a significant benefit as warranties continue to cover vehicles for longer and longer periods.

Comparing ZN-Ni and ZN coatings on cyclic corrosion performance (SAE J2334)



Automotive manufacturers and their suppliers have also taken advantage of a Zn-Ni coating's ability to increase wear resistance, a critical factor in extending the working life of parts that experience constant wear stress, yet must perform successfully, such as brake calipers.

Zn-Ni electroplated carbon steel can also be used to replace more expensive materials used to fight corrosion. In many industries, machinery manufacturers have turned to stainless steel to increase corrosion resistance. Carbon steel with a Zn-Ni coating performs as well, can reduce the weight of components, and helps in controlling costs.

Similarly, in aerospace applications where manufacturers have used cadmium coatings on landing gears, fasteners, and fittings for critical corrosion protection, Zn-Ni coatings provide the same level of protection or more while eliminating concerns about carcinogenic exposure and meeting longer warranty requirements.

WHERE NOT TO USE ZN-NI COATINGS

Although Zn-Ni coatings are valuable and successful in overcoming many challenges, they may not be the answer for some applications. For example, metal components not exposed to excessive wear and corrosion, or thermal stresses do not need the added protection this high-performance coating provides. In many cases where less protection is needed, there are other, lower-cost coatings that will do the job.

However, though the No. 1 advantage of Zn-Ni coatings is enhanced protection against damaging corrosion, even parts not exposed to weather, moisture, chemicals, or other corrosive forces benefit from the coating's other properties. It is wise, therefore, that

These bolts were barrel-plated with Zn-Ni and trivalent chromate.

designers carefully evaluate their requirements for a finish and the level of protection needed when making a decision.

Those evaluations should also weigh economic considerations. For example, parts that will see the stresses Zn-Ni protects against but which can be easily and cheaply replaced, or non-critical applications, as well as parts not expected to have extended functionality may not be good candidates.

In another case, highway guardrails are continually subject to the corrosive challenges of harsh weather, road salt, and damage to their protective coatings by the occasional collision. But given their replacement value, traditional hot-dipped galvanizing is probably still the most cost-effective way of protecting them. That's because a thicker galvanized layer can be applied at a lower cost because the rails have no critical dimensions.

Complex stamped parts were rack-plated with Zn-Ni and trivalent chromate.

On the other hand, moving parts within machines that are not exposed to strong causes of corrosion might not seem to be candidates for a higher-cost coating. But those parts are also subject to wear and possibly heat stresses. It might be justification for electroplating them with Zn-Ni to give them a thin, smooth, hard coating that protects against such forces, maxi-

mizing their productive lives and minimizing system downtime needed to replace them. The decision in such cases turns on the critical importance of the part to the machinery and the importance to the company of avoiding downtime and keeping production running. The cost to the company of a downed line while waiting for a replacement can quickly justify the expense of a coating.

Factors companies need to consider when making these decisions might also include the stress level the part faces and how easy it is to replace without stopping the line for a lengthy time.

GROWTH AREAS FOR ZN-NI

Corrosion is a concern for all structures or components exposed to weather. It shortens the functional life of critical components and their failures can take an entire structure or machine out of use. That need for protection is probably the primary driver of future growth potential for Zn-Ni coatings.

For example, these protective coatings are beginning to be used on electrical power-transmission line components at risk for weather-induced corrosion. These components are essential to the power grid and the public's continuing access to power. The use of these coatings will therefore inevitably increase as their role in reducing failures is better understood.

There is a growing use of the coating for fasteners on bridges and other structures exposed to weather, road salt, and other chemicals. As the current national focus on restoring the infrastructure translates into actual projects, there will be opportunities for Zn-Ni coatings to dramatically extend the working life of those structures.

Small engine and structural components for lawn, garden, and snow-removal equipment are also exposed to both weather and corrosive snow melt and garden fertilizer chemicals and can also benefit from ZN-Ni's protection.

Railroad rolling stock and rail-bed components are exposed not only to weather but also to corrosive chemical cargo that contacts railcars and can spill onto the rail bed. Ships and watercraft face similar challenges.

The installation of solar panels continues to grow rapidly and their roof-mounting hardware includes metal frames and supports that require protection.

Clearly, as designers and manufacturers become more familiar and comfortable with Zn-Ni alloy coating and the benefits it offers, application opportunities will continue to grow.

> “There is a growing use of Zn-Ni coating for fasteners on bridges and other structures exposed to weather, road salt, and other chemicals. As the current national focus on restoring the infrastructure translates into actual projects, there will be opportunities for Zn-Ni coatings to dramatically extend the working life of those structures.”

MISCONCEPTIONS ABOUT Zn-Ni ALLOY COATINGS

Misconceptions surrounding Zn-Ni alloy coating have likely limited its use across a wide range of industries. Even when engineers and designers explore the technology and view test results such as those in this article, concerns about two areas in particular may prevent them from using them:

- The cost of Zn-Ni coating can be as much as five times that of other electroplated coatings.
- Controlling the Zn-Ni electroplating is difficult and can add significantly to a project’s cost.

In fact, the cost of zinc-nickel coating, measured over the life of a coated component and factoring in the value of that extended life, is not significantly more than that of other electroplated coatings. It is this “value vs. cost” equation that successful users of Zn-Ni alloy coatings have found more accurate.

And controlling the process requires only standard operating procedures and practices that are no more onerous than those used for other electroplating processes.

Engineers and designers may be concerned that this higher-quality coating may require more time-consuming and specialized preparation of parts to be coated. In fact, the Zn-Ni alloy coating process itself, and prepping parts for it, are similar to those for electroplated zinc coatings.

Our two companies—Gatto Industrial Platers and Dipsol of America—have been intimately involved for 20 years as collaborators in multiple successful applications of this technology. We have seen the benefits it has brought to companies by extending the working life of the coated pieces and the systems they were part of. It will continue to be adopted across an increasing number of industries. md

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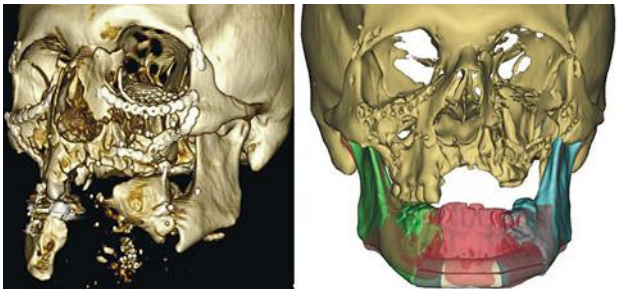
CARLOS M. GONZALEZ | Technology Editor

Expanding the Medical View with 3D CAD

The world of computer-aided design and simulations is evolving to a more realistic model, which has industries beyond engineering taking advantage of its capabilities.

When we think about simulation here at *Machine Design*, we usually dwell on testing parts for static or dynamic stress analysis. For engineers, simulation is a check system for the parts we produce, and on how well our mechanical component can endure a stress, deflection, or repeated cycle movement.

However, the simulation landscape is expanding and encroaching into newer technologies. The field of medicine, for example, is integrating computer-aided design (CAD), modeling, and simulation to help doctors perform medical procedures. These CAD models and simulation are now essential to ensure proper surgery, recreation of models for training purposes, and prediction of how organs will perform.



The planning process prior to surgery involves taking CT and MRI scans to accurately model the patient's features. Modeling is then done using CAD to develop the plan for surgery and reconstructive features using either 3D-printed material, plastic, or metal. *(Courtesy of Dr. Derek Steinbacher)*

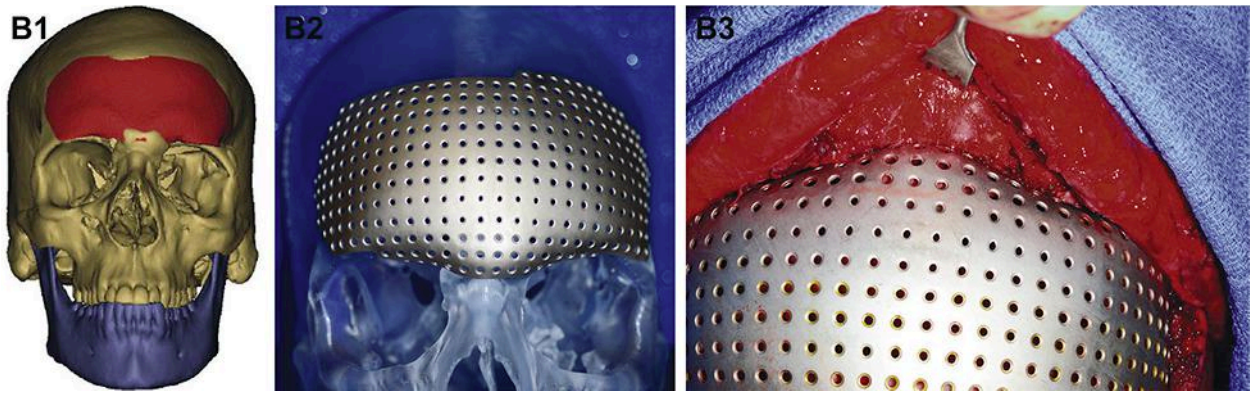
SURGICAL ADVANCES USING CAD MODELING

Dr. Derek Steinbacher is an expert on the use of virtual surgical planning in bone and soft-tissue analysis and procedures. Traditionally, surgical planning has been used on just bone manipulation, due to the modeling software not being able to accurately depict soft materials like cloth or skin. However, the software is now powerful enough to not only perform computer tomography (CT) based soft-tissue analysis, but goes beyond to three-dimensional digital photogrammetry to predict the fine details of soft-tissue dynamics for both pre- and post-operative settings.

Speaking with Dr. Steinbacher, he lists the many uses of CAD in surgery: "For the skeleton/bony movements, we can plan manipulations, osteotomies, resections, and reconstruction of the bone in space. Beginning first digitally/virtually, and then with 3D-printed splints or guides, help us with the bone cuts or positions, and printed plates or implants can be used intraoperatively for fixation or for parts of the reconstructions."

The essential steps for surgical planning with computer-aided design are analysis, planning, virtual surgery, implant design/production, and post-operative analysis. The first step of analysis is to understand the diagnosis and develop the solution. The initial data is a tomographic scan with the appropriate parameters. The raw CT data is converted to structure triangulation language format for digital modeling purposes. The linear, angular, and volumetric measurements are the overlays of normal anatomy. The doctors use the data to quantitatively understand the pre-operative state of the patient's structure.

Virtual surgery comes from the tomographic data. For example, defect reconstruction surgery is tried virtually first with appropriate size/contour material. A mirror image of the contralateral side guides the reconstruction surgery in a unilateral defect. The average anatomical overlay indicates the requirements of reconstruction. The magnitude and spatial positioning of the reconstructive surgery depends on present structures, quantitative parameters, and relationships to nearby anatomical intact structures. The pre-planning also



This image shows how pre-planning with CAD models occurs in bone skull operations. Image B1 is the three-dimensional plan performed using digital moldable "clay." The material is shaped to fill the defect with the appropriate size, shape, and contour. B2 and B3 illustrate how the custom-fabricated milled titanium mesh offers protection and aesthetic function. *(Courtesy of Dr. Derek Steinbacher)*

takes into account factors of overcorrection, growth, and relapse. With the endpoints established, they initially perform the surgery digitally.

Using the CAD and simulation tools, the doctor attempts several different methods and strategies to determine the most optimal approach. The approaches consider comprehensive anatomical examination of the reconstruction, new location of repositioned bone (including the position of nearby vasculature/nerve features), and recognition of unanticipated consequences, collisions, and problems long before performing the actual procedure.

Designs for the treatment guides and implants occur once the virtual surgical planning is chosen. Fabricated biocompatible implants and splints use the digital information and the solution derived from the virtual surgery. These include multiple materials such as biocompatible/sterilization plastic, titanium, and additive-manufacturing materials like stereolithography, selective laser sintering, and direct metal laser sintering.

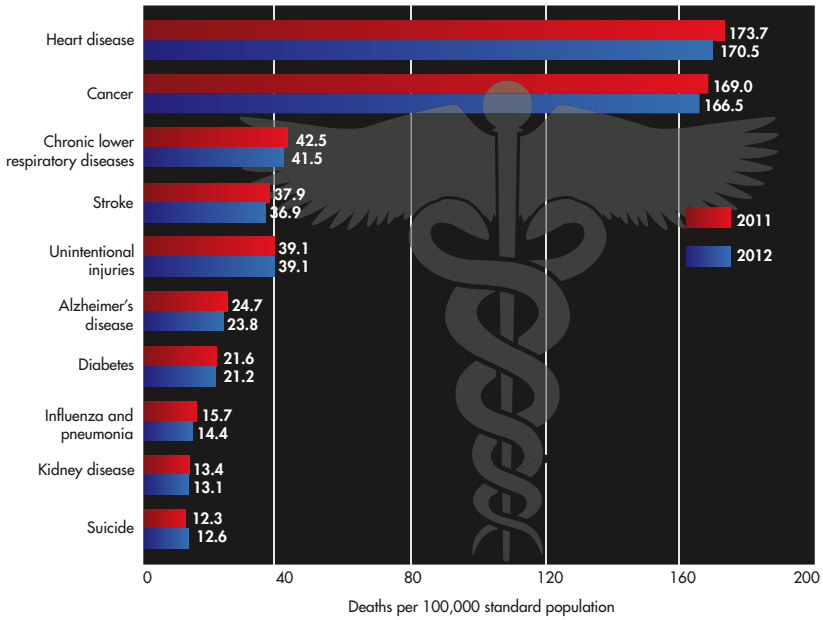
Only a small percentage of doctors use CAD for pre-operational analysis, though the benefits are clear. "The surgeon still needs a proper understanding and treatment plan—the computer and CAD cannot generate this. But if the plan is

appropriate, then the use of 3D planning and CAD/CAM will help ensure the surgeon is as close as possible to achieving his/her desired result [and it limits or eliminates the number of intraoperative variables]," says Steinbacher.

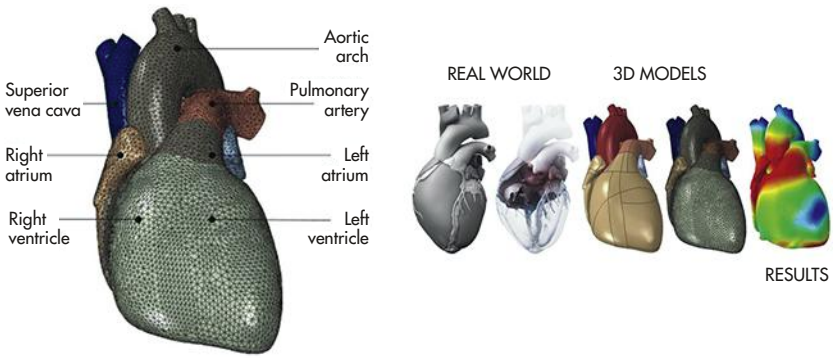
FUTURE INNOVATIONS FOR CAD IN MEDICINE

When it comes to using advanced engineering tools in surgery, 3D printing is already a common tool in medicine. According to Dr. Steinbacher, "we print [3D] items to use intraoperatively—temporary guides/splints to use intraoperatively for positioning and then removal, and permanent implants, plates, etc. can be printed to complete the reconstruction." When it comes to virtual or augmented reality, Dr. Steinbacher reports that "Google Glass and Oculus Rift have been reported, but not in the mainstream in surgery yet."

However, we do not have to wait long for virtual simulation to have a larger impact on medicine. Simulia and Dassault Systèmes are using simulation to help recreate the human heart. The



The leading cause of death in 2011 and 2012 was heart disease. It's for this reason (among others) that the Living Heart Project was founded. *(Courtesy of Simulia)*



The Living Heart Project's goal is to provide accurate models of the heart for different areas of study. The models include a solid model, a finite-element model, a muscle-fiber model, and a fluid model. *(Courtesy of Simulia)*

Living Heart Project (LHP) is a joint effort led by cardiovascular researchers, educators, medical device developers, regulatory agencies, and practicing cardiologists to develop accurate, personalized digital heart models. The five-year project started in 2014. The purpose of these models is to advance the training of future physicians, develop better medical devices, improve testing and clinical diagnosis, and assist in the future of regulatory science.

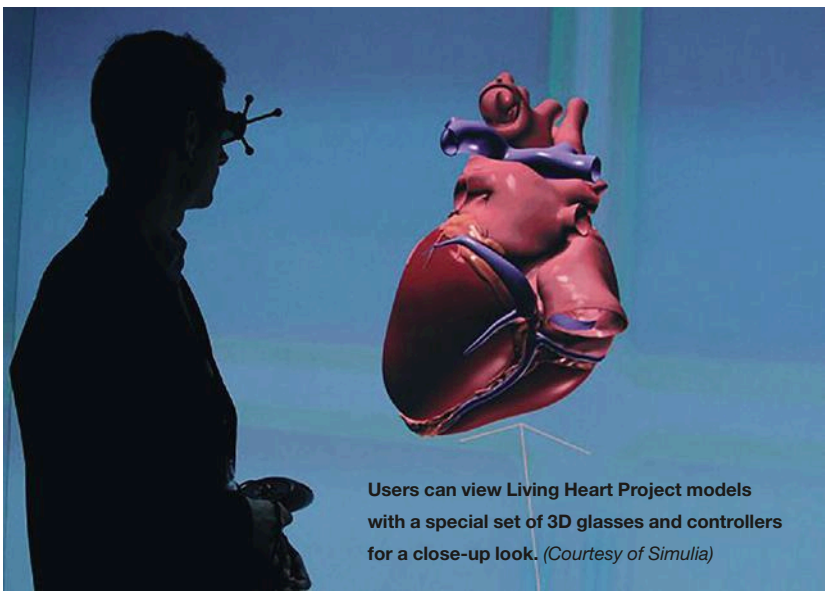
The LHP team utilizes Simulia Abaqus finite-element analysis as the primary software engine to create the virtual heart. Using data obtained from the CT and magnetic resonance imaging (MRI), the software creates an entire functioning heart including its four chambers (left and right ventricles and atria) and four valves (tricuspid, mitral, pulmonary, and aortic). Prior models only include a subset of the heart anatomy.

The team at LHP is able to create a more complex model. Taking into account a greater range of factors, they can model the interactions between electrical stimulation and mechanical contraction of muscle tissue. Irregularities between those factors may be the precursors to heart attacks or other heart dysfunctions.

The project develops a full of package models for different studies, including a solid model, a finite-element model, a muscle-fiber model, and a fluid model. The muscle-fiber model accounts for the muscle sheets and fibers. The finite-element model simulates the mechanics of the heart, including the dynamic electrical behavior. Lastly, the fluid model provides insights into the flow, pressure, and other blood characteristics in the heart. The models are able to be manipulated via an augmented-reality headset and controllers. With these interface tools, physicians and researchers can interact with the different models.

TRAINING WITH CAD AND 3D-PRINTED MODELS

The most promising use case of CAD models is for training purposes. Dr. Saleem Abdulrauf, leading neurosurgeon-in-chief from St. Louis University Hospital, has found a prime test-case scenario for CAD-assisted medical training. Dr. Abdulrauf, who wants to tackle the complicated procedures of brain aneurysm surgery, explains, "I personally perform a lot of brain-aneurysm surgeries. It is a complex operation given the number of anatomical issues that we are dealing with under



Users can view Living Heart Project models with a special set of 3D glasses and controllers for a close-up look. *(Courtesy of Simulia)*

the microscope. I knew if there was a way of simulating those complications before the operation using the same tools and under the same microscope, we'd have a higher positive impact on the procedure outcome for the patient."

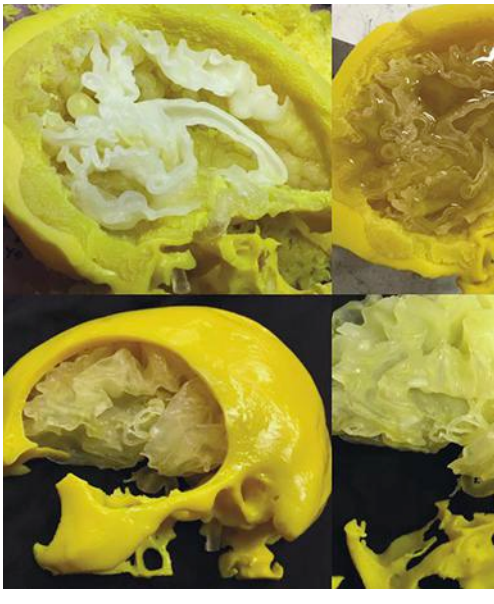
His solution is to create an accurate high-resolution mapping of the patient's brain into a 3D CAD model, similar to how the Living Heart Project creates models of the heart via CT and MRI scans. They create the model in real time from a current patient suffering from an aneurysm. The method would need to be quick and efficient, as the model would be a one-off part unique to each patient.

Stratasys Direct Manufacturing was chosen as the partner company to create polyjet brain models from the scans. Stratasys, working with St. Louis University, decided on PolyJet Rigid VeroYellow for the skull material and TangoPlus material with a durometer of Shore 27A for the brain. Within the 3D-printed brain was a version of the aneurysm.

By using these models, Dr. Abdulrauf is able to practice the surgery before performing the actual operation. According to Dr. Abdulrauf, "having the 3D-printed model here has a very positive impact on the procedure results. The model has helped to identify and overcome surgical challenges, like optimum access to the aneurysm or the depth and angle of the approach, before surgery begins."

With initial positive results, Dr. Abdulrauf is performing a two-arm study where resident neurosurgeons practice on either a cadaver brain or a 3D-printed brain prior to performing

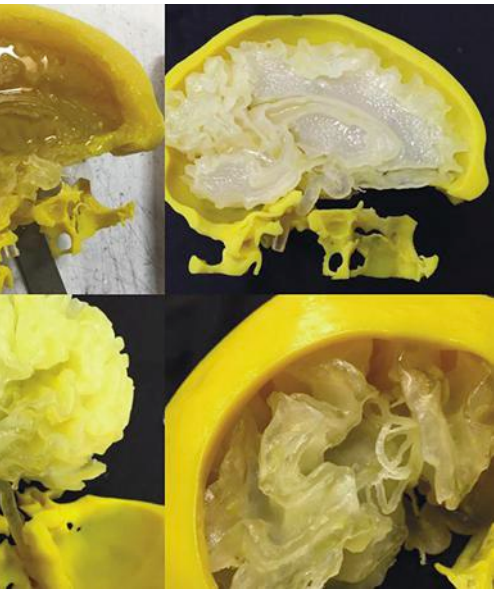
St. Louis University Hospital and Stratasys, using 3D printers from the latter, developed these 3D-printed brains. Surgeons use the models to practice brain-aneurysm surgery. *(Courtesy of www.todaysmedicaldevelopments.com)*



actual brain-aneurysm operations. The accessors of the operations will not know which model the neurosurgeon practiced on prior to the actual surgery. This study will allow them to evaluate if practicing on realistic 3D CAD printed models enhanced the results of the surgery, and help quantify the use of them in pre-surgical planning.

The world of computer-aided design is becoming more realistic with every technological step forward. As predicted by Dr. Steinbacher, the future of CAD, simulation, and virtual reality can provide "more accurate simulations; we wish to depict and predict how our surgical interventions will change the patient's outcome and aesthetics (or reconstructed) anatomy accurately." As we progress in creating more and more real-world-like models, the applications will expand not just for engineering, but into a range of other fields as well. md

Prior to operating on a patient's brain, Dr. Abdulrauf from St. Louis University Hospital, wants to see if practicing on a 3D-printed model would improve results and create less invasive surgery. *(Courtesy of www.todaysmedicaldevelopments.com)*



JEFF KERNS | Technology Editor

4 Common Production-Line Problems: How Can Modern Motors Help?

The evolving motor market is experiencing an upswing in servomotors, modular design, connectivity, and safety features.

The trends impacting today's motors and drives are the same as those affecting other manufacturing equipment. One example is the desire for modular products that facilitate integration with existing production lines or are easy to upgrade/replace over time. Customers also demand efficiency. This often means drivers that can handle more axes, motors that deliver more torque and speed, and both doing so in a smaller package.

Another major concern is maintaining safety as production lines increase power and speed of operation. Furthermore, advanced automation and the Industrial Internet of Things (IIoT) are increasing the need for connectivity.

This article examines these changes in the motors and drives market. Specifically, it looks at how four trends are influencing design, connectivity, and safety decisions.

Sinochron motor design offers advantages in continuous duty applications without an encoder. Applications can include powering of conveying equipment, escalators, spooling machines, compressors, and traction drive units. ABM Drives' Sinochron is one example of how continuous motors are competing on efficiency and cost levels (saving up to 35% in energy cost).

1. ELIMINATING LINE CHANGEOVERS

Shutting down a line to change tools or products is costly. Traditional alternating-current (ac) or direct-current (dc) motors can limit features like indexing or handling parts with multiple different sizes on a single line. Modern production lines are increasingly using advanced automation and robotics that benefit from knowing the position or phase of motors.

The servos or stepper motors in robotics can reduce the need for changeovers and advanced equipment downstream. For example, a robotic arm and machine vision can work together to pick-and-place parts on a conveyor belt in a specific orientation, or separate them based on size or the specific product.

This new information is uniting production lines. Previously, one section of a production line might have driven product to the end of an assembly line, while another, say, packaged

the products in boxes. Adding more data communication and control by using servo and stepper motors can reduce hardware and unite a segmented production line.

According to *PR Newswire* and *MarketsandMarkets.com*, advanced automation and energy-efficient standards has led to growth for servomotors and drives. The market is expected to rise from $10.26 billion in 2015 to $10.43 billion in 2018. And *Globe Newswire* says it will reach $15.92 billion by 2022. Advanced automation and robotics are the primary drivers of growth in the servo- and stepper-motor market, which in turn is leading to smaller, more powerful motors and enhanced drivers.

Servomotors and stepper motors are more expensive than ac and dc motors. Their usage has steadily increased, however, thanks to the benefits that come from advanced automation in applications for indexing or position control. Typically, continuous or free-running motors have specific applications; therefore, servo and stepper motors are unlikely to replace them completely. Overall, each motor has its own applications.

"While motor types are application-driven, reduced cost and added features have servomotors turning up in new places," says John Kowal, director of business development for B&R Industrial Automation. "As servos are reducing in price, something as complex as a packaging line may switch to servos to index, tuck flaps, and seal packages. This increases the axes, makes the line more flexible, reduces labor, and reduces change over time. These benefits will outweigh any difference in cost these motors might have. The driver in reducing the cost of servomotors is processing and modularity."

2. REPLACING CUSTOM MOTORS

Many OEMs offer modular designs, which enable them to cost-effectively produce semi-custom servo and stepper motors. In addition, high-speed communication buses make it possible for control systems to handle more axes in an efficient manner. Drivers and feedback devices can further hone a motor. Drivers and software will allow a few motors to satisfy a range of applications.

"Designers have found putting everything on one control platform is the most efficient way to design their code," says Jim Wiley, product manager for servo and stepper drives at Parker Hannifin Corp. "Having flexibility and being able to pick the motors and power size needed, while cramming more electronics in smaller boxes to get more axes in one cabinet, is an important design decision for OEMs."

Weight and temperature in the Cyber dynamic line was reduced by 25% by optimizing the magnetic circuit. This design cuts down on eddy-current losses and limits magnetic saturations

There are many design aspects to motors, which can make them difficult to mass-produce. The ability to mix and match standard frames, stators, and rotors with other components offers a balance between cost-effective manufacturing and customization. To streamline and keep manufacturing lean, some companies have automated material handling that will collect materials as they are ordered. With enterprise resource-planning software, the material handler can move the most-ordered parts closer to the drop-off point, quickening acquisition of materials and helping regulate inventory. The end result is you get your motors and replacements faster.

Parts may have to be replaced or upgraded before a component has met its lifecycle. Expectations are for a platform to last for 20 to 25 years. With such a long time span, the ability to easily modify the part has obvious benefits. If a standard motor stops working, it will be faster to replace than a custom version.

It is important to know the motors in the equipment you're buying so that you can anticipate lead times if one needs to be replaced. If an application requires a highly customized motor and there are long lead times, it may be beneficial to have an extra one in inventory or invest in predictive maintenance features. For example, harsh environments often wreak havoc on small, fragile servomotors. This creates a high total cost of ownership, not only due to replacement costs, but also from loss of revenue when production lines are down.

Keeping a production line up and running is more important than ever as manufacturers continually look to improve production-line run times. Reducing downtime can seriously impact profit margins on fast production lines. On this front, the market is currently abuzz about the IIoT. Being able to obtain more data about motors, speed, torque, position, temperature, etc., can improve a motor's lifecycle while reducing errors and downtime. Many companies are trying to justify the cost of new IIoT equipment, though, because it can be hard to monetize this data.

3. MILES OF CABLE AND SLOW PRODUCTIONS LINES

Feedback from the motor to the driver, along with reduction of cable, keeps production lines competitive. Feedback improves performance and resolution while providing more information. In the past, protocols in this space have been proprietary and specific to manufacturers, but open protocols like EnDat, BiSS, and Hiperface are becoming more popular because they offer more flexibility and choices. Advanced platforms, which increase the amount of data transmitted and data-transfer speed, are better at sorting out noise. This has made it possible to reduce the number of cables.

Parker's MPP (MaxPlusPlus) potted stators improve heat transfer for better thermal efficiency, resulting in increased torque at the motor shaft. Using Hiperface DSL feedback reduces complexity—there's only one cable connection between drive and motor.

In fact, if communication isn't diminished, customers are now demanding a single cable. Having less cables reduces installation time and cost while keeping or even adding features. At the center of this trend are communication protocols. You don't want to be locked into a single feedback or communication protocol type, so look for drive manufacturers that offer multiple protocols. This gives designers the option to use the protocol with which they are comfortable, or the protocol that works best for a specific application.

"Currently, fieldbuses such as CANopen, Profibus, and DeviceNet are used for various applications. But what has emerged from those different communications as the wave of the now and future is communication based on Ethernet," says Parker Hannifin's Wiley. "The hardware is cost-effective and it is in everything. It has become a matter of taking Ethernet hardware and finding a way to fulfill the real-time requirements needed in motion-control and servo-drive applications."

EtherCAT, Profinet, Ethernet IP, and Powerlink are the most common way of communicating from your control to your drive. They all enable high-speed real-time communication while increasing the amount of information that can be passed from the drive up to the control system.

"Ten to fifteen years ago, drive manufacturers would use communication protocols as an add-on or afterthought," says Wiley. "Today, it is important to design the servo-drive platform around these communication protocols. If you design with this in mind first, you can achieve the performance and cost structure that will help you be competitive."

CANopen is one of the high-level communication buses that can work well for motor control. This protocol was developed for embedded networking. In one example, Crouzet Motors offers a CANopen communication bus on its dc brushless motors. Depending on the application, it is possible to control up to 127 motors with a single, shielded two-wire cable. "The CANopen system is a very robust system, ideally suited to motion control, controlling the motor's position, speed, torque, etc.," says Robert Derringer, director of marketing at Crouzet Motors.

By relying on communication protocols, the control units on some motors also can handle multiple safety inputs. In the event of a failure, additional safety inputs can lock the motor power-stage control. This cuts the power supply to the motor windings, sending the motor into a type of freewheel mode. This action does not have to go through the microcontroller, thereby ensuring a high level of safety.

The CANopen dc brushless motor from Crouzet Motors lets a single cable run from one motor to the next; the master can address each of the motors separately to control a movement, make an adjustment, or run diagnostics. The image shows the CANopen motor with and without a gearbox. This specific gearbox achieves a 27 to 1 ratio. The CANopen interface permits data to be transmitted at speeds up to 125 kbaud up to a distance of 550 yards. Extending this distance is possible (up to three miles) by reducing the speed at which data is transferred.

Has anyone in your factory hit the E-stop, and in turn made you have to calibrate your motors before starting production again? Often, the encoder that sends the motor feedback to the drive is responsible for this occurrence.

4. DON'T TOUCH THE E-STOP!

Has anyone in your factory hit the E-stop, and in turn made you have to calibrate your motors before starting production again? Often, the encoder that sends the motor feedback to the drive is responsible for this occurrence. Absolute encoders are popular because they track the motors' specific position or phase. Power to a motor with an absolute encoder can be shut off and will subsequently start right where it stopped.

An incremental encoder, on the other hand, will only measure what direction and how far the motor traveled. Therefore, incremental encoders need to be calibrated, which takes time, or given a position to restart. If an emergency stop or light curtain is engaged, a motor with an incremental encoder cannot simply resume operation. While emergency stops and light curtains are important for worker safety, stopping production can be costly. This has led to a greater array of intelligent drive solutions.

Today, you hear more and more about functional safety. This approach doesn't just cut power from the motor; it also brings about more intelligent solutions. Functional safety offers different modes of operation, such as safe stop, safe speed, safe position, etc., that allow a machine to shut down, slow down, or limit where it travels. These are important design constraints applied by the programmer, and they must follow standards while keeping production moving and enhancing employee safety.

Some encoders have started offering additional mountings, reducing the risk of the encoder coming loose. A robust connection is more important than ever now that feedback information has become so critical to production and safety. While encoders may sound basic, knowing if your motors have an absolute or incremental encoder will be crucial if the motor is occasionally turned off, an emergency stop is engaged, or power is lost for any reason.

B&R Industrial Automation came out with a compact, IP65-protection-rated ACOPOSmotor that offers an intelligent safety encoder. With the EnDat 2.2 communication protocol, a securely mounted encoder, and compact size, this motor falls in line with many of the trends seen in industry.

As the speed of production lines increases, it is important to maintain worker safety while minimizing downtime. A desire for more safety features and greater use of advanced automation and robotics will continue to strengthen the servo and stepper motor market. The market will be led by motors with higher-level communication protocols and absolute encoders that offer more motor feedback. Overall, the motor and driver markets are driven by customer demands. Manufacturers that can get more torque, speed, and data in a smaller package for less cost will be more successful. md

CHIP McDANIEL | Technical Marketing, AutomationDirect, *www.automationdirect.com*

A Primer on Sensors for Machine Automation

Sensors are critical for converting physical properties into discrete and analog signals, letting machine automation systems do their tasks reliably and consistently.

Machines need sensors and transmitters to operate reliably and consistently. All it takes is a small drop in air pressure or a slight jam to cause a machine to crash; these sorts of problems can often be detected before they lead to bigger issues.

Here's a look at the top 10 physical properties detected by machine automation sensors and transmitters—temperature, pressure, flow, level, current, voltage, presence, position, distance, and speed—and one or more common applications for each property.

HOW HOT IS IT?

In machine automation, monitoring and controlling temperature is often essential, and there are many temperature switches or transmitters that can make these measurements.

Temperature sensors and transmitters come in a variety of types and configurations to fit a wide range of machine automation applications. *(Courtesy of AutomationDirect)*

Temperature switches work well in overtemperature, set and reset hysteresis, and dual-temperature high and high-high temperature applications. In these last two types of applications, temperature measurement methods provide increased reliability where exceeding a temperature must be avoided, such as in boilers, compressors, and large motors. Switches are also suitable for simple temperature control.

For more complex temperature monitoring and control, thermocouples and RTDs connected to temperature transmitters provide more granular feedback to close the control loop.

Thermocouples are good choices for measuring temperature, especially if the distance from the thermocouple to the controller is less than 100 ft. Thermocouples come in a wide variety of types, fit into small areas, have wide temperature ranges, and provide fast responses.

However, temperature sensors' millivolt signals are sensitive to electrical noise, require matching extension wires, and are not as linear or accurate as a two-, three-, or four-wire RTDs. The millivolt signals are also not scaled, so the PLC must do this calculation.

When distance and electrical noise are a concern, temperature transmitters should connect the thermocouples to the PLCs.

SENSOR OR TRANSMITTER: WHAT'S THE DIFFERENCE?

PEOPLE INVOLVED IN the machine automation industry commonly use the terms "sensor" and "transmitter" interchangeably. In this article, a sensor or switch is a device measuring or detecting a discrete, on-off condition. Position, temperature, and pressure switches are examples. Transmitters, on the other hand, measure continuous values and convert them proportionally to a common electrical signal level such as 4 to 20 mA, 0 to 10Vdc, or a digital fieldbus signal. Transmitters are typically analog output devices (such as a temperature transmitter with a 4 to 20mA output), although pulse counting (e.g., reading and sending the speed of a motor) might be done using discrete signals, analog signals, or a combination of the two. Sensors with fieldbus outputs represent a third case, where analog information is captured and then transmitted in a digital form.

These sensors or transmitters connect to PLCs, data loggers, HMIs, SCADA systems, and/or the IIoT. In machine automation, sensor and transmitter outputs typically become discrete and analog inputs, respectively, to a PLC.

Temperature transmitters convert millivolt input signals from thermocouples or RTDs to 4 to 20mA analog outputs or digital fieldbus signals. Temperature transmitters are commonly used in machine processes, tanks, and ovens. Their scaled analog outputs ease integration to PLCs and simplify calibration with their pre-configured temperature ranges and other configuration capabilities.

UNDER PRESSURE

Every machine with a pneumatic air preparation subsystem should have a digital pressure switch, preferably with a display to show its status. The switch sends its output to the PLC, which is essential because it needs to know there is enough air pressure available before starting a cycle. Some machines work well at 60 psig, while others require 90 psig to meet cycle time requirements. This makes an adjustable range and lockable keypad important features for pressure switches.

A discrete signal from a digital pressure switch typically tells the PLC the pressure is sufficient. If more information is required, there are devices to provide both discrete and analog outputs, as well as local indication of pressure. These devices provide pressure values with reasonable accuracy, and often include air/gas process control options.

Some pressure switches can be set locally using mechanical dials or hex keys to set the pressure level at which they will activate. Pressure switches with set and reset adjustments can provide simple control with hysteresis for a compressor or pump. Pressure switches can also provide overpressure or pressure-sufficient signals in pneumatic and engine monitoring systems, presses, and machine tools.

If more granular pressure indications are needed, pressure transmitters can generate readings over a wide range. Pressure transmitters can also detect leaks or gas, as well as monitor compressors or the vacuum levels in suction cups that are part of pick-and-place devices.

Some applications require differential pressure transmitters to measure low positive, negative, and bi-directional differential pressures. These include monitors for HVAC duct static pressure or air filters, building or chamber pressurization, clean rooms, fume hoods, air flow measurement, and draft pressures in furnaces, ovens, and dryers.

CHECK THE FLOW

Flow indicators are often used to confirm flow of a gas or liquid using a paddle wheel or floating ball. Flow switches

typically use spring-supported pistons lifted by a flowing medium, with the piston position detected by an inductive sensor. The spring lets these devices, which can also be used as check valves, be mounted horizontally or vertically.

Flow switches usually provide fast responses and precise, adjustable set points. The set point can be easily specified and locked with a setting screw or rotating dial to simplify machine setup.

A simple, discrete indication of flow is often needed for machine tool coolant, HVAC, and cooling water monitoring for processes such as injection molding. In these applications, the flow must be present and above a set point, but the actual flow is not monitored. When actual flow needs to be monitored, a flow transmitter is used.

In these applications, flow transmitters can monitor liquid media and provide analog or digital fieldbus outputs proportional to flow rates. There are many different ways to measure flow, but flow sensing based on differential pressure ensures fast response times and precise measurements.

DON'T OVERFILL

Float level switches are low-cost, general-purpose devices for single-point monitoring of liquid levels in a variety of applications. They are available made from materials compatible with many types of liquids, a wide temperature range, and various pressure capabilities. They can be top- or side-mounted, and submerged or suspended. These mounting options, along with shock and vibration resistance, ensure reliable operation.

Digital pressure switches, such as these AutomationDirect ProSense versions, provide an analog output proportional to pressure, along with a local indication of pressure. *(Courtesy of AutomationDirect)*

Discrete tank level indication is a popular application. If a tank has threaded ports at low-, full-, and high-level positions, float switches are a simple way to determine when a liquid reaches each of these three measurement points. A level switch can also be used as a backup up or safety level sensor to detect high-high overflow levels, and works well in pump monitoring to detect when there is enough liquid at a pump intake to prevent cavitation.

If actual tank level needs to be measured or monitored, level transmitters are required. Some level transmitters are submersible and continuously measure liquid levels by sensing hydrostatic pressures created by the weight of liquid—and hence, its height above the sensor—which then sends a 4 to 20 mA or digital fieldbus output signal. In addition to monitoring liquid levels, these transmitters work well in dewatering applications, in addition to controlling pumps and slurry tank liquid levels. For non-contact applications, such as measuring the level of a glue pot or tank full of paint, ultrasonic level transmitters can handle the task.

CURRENT'S FLOWING

A current switch consists of a current transformer or Hall Effect sensor, signal conditioner, and limit alarm in a single package. An ac or dc current switch provides proof of operation via its discrete output, and can also provide an accurate and dependable indication of overcurrent conditions.

AC current switches can detect jams or overloads on conveyors. They also work well detecting the on/off status of lighting and heating circuits. A dc current switch, on the other hand, can monitor welder status, power-supply overcurrents, and battery pack readiness.

A current transmitter extends the capability of a current switch by measuring an actual ac current, true RMS current, or dc current. Specific applications for true RMS current transmitters include monitoring VFD controlled loads and accurately measuring phase angle- or burst-fired, time-proportioned SCR controlled loads. True RMS current measurement can also accurately measure power supply or ballast input power.

DC current transmitters can work in many applications, including monitoring battery bank charging and load current and heater loads.

POWER ON

In some applications, voltage switches using simple resistor-based voltage divider circuits to sense voltages at PLC inputs

are a good choice. Voltage transmitters work well when there is a need to sense an ac or dc voltage and provide a proportional 4 to 20mA analog or digital fieldbus output to a PLC.

There is a lot of overlap in ac and dc voltage transmitter applications, such as detecting below normal or brownout voltage conditions to prevent overheating motors. In ac systems, switches or transmitters identify phase-loss conditions by detecting lower or missing voltage in one or more phases of a three-phase motor circuit. Both ac and dc voltage transducers can look for overvoltages associated with regenerative systems to identify and avoid issues with the motor drive or detect voltage conditions that may stress or damage devices.

Current switches are used to detect on-off conditions, while current transmitters are used to provide a continuous reading of current level. *(Courtesy of AutomationDirect)*

PRESENCE SENSING

A variety of sensors detect parts on machines or conveyor lines, and there is a lot of commonality in these presence sensors for different applications. Common presence sensors include photoelectric, inductive, capacitive, and ultrasonic versions. There are some key factors to consider, as one type of sensor may work better than others in an application.

Photoelectric sensors probably have the widest range of applications, including detecting pallets on conveyors and parts' presence in a nest. They have significant capabilities in detecting parts, products, and even marks on printed material. Many of them also have long-range capabilities and can detect small positional changes.

Inductive sensors, or inductive proximity switches, detect metal objects at close ranges (up to 1.5 in., typically). Ferrous metals have the longest detection ranges, but aluminum and copper can also be detected at ranges of about 1 in. reduced ranges. Common applications include sensing actua-

tor end-of-travel and detecting metal parts. Inductive proximity switches' low costs make them the best choice for sensing an actuator at its extended, retracted, or home position, and detecting pallets or metal.

Capacitive sensors can see through cardboard, plastic, and paper and be used to detect liquid. With adjustments, they also detect parts submerged in a liquid. Depending on how they are adjusted, capacitive sensors can also detect liquids such as oil, water, and chemicals, as well as with solids like sand, grains, and powders. They also see through tank walls and opaque bottles to detect fill levels.

Ultrasonic proximity sensors emit sound impulses, measure the elapsed times for the echoes to return, and then determine the distance of the reflecting target from the sensor. Ultrasonic sensors detect a wide range of materials, including metal, wood, plastic, glass, and liquids. They are not affected by object color, transparency, or reflectance.

Other sensors to consider include contrast print-mark sensors for packaging lines, beverage and bottling lines, paper and printing machinery, and ceramics printing. Another is a U-shaped through-beam fork sensor (slot sensor) that mechanically aligns the transmitter and receiver to simplify installation. And finally, magnetic proximity sensors that detect magnet targets may work for other applications.

These presence sensors from AutomationDirect use photoelectric, inductive, capacitive, and ultrasonic technologies for applications in a wide variety of industrial environments. *(Courtesy of AutomationDirect)*

GETTING IN POSITION

There are several ways to detect positon, often with presence sensors, as already discussed. For sensing part positions, a photoelectric sensor with accompanying software can tell if a part is fully seated. It detects small changes in position and can be mounted to confirm a position.

Inductive proximity switches or capacitive sensors are commonly used to detect actuator positions. However, accurate position sensing over a full range of travel requires an encoder or sometimes a more rugged resolver.

Encoders, sometimes connected to transmitters, are the preferred method of detecting linear and rotary positions—in addition to velocity and direction—of a motor shaft or other rotating component or assembly. They work in all types of motion sensing applications including machine tooling, semiconductor positioning, and multi-axis positioning. Incremental encoders measure positions relative to a start position (and may require a "homing" routine, depending on the application), while absolute encoders are referenced to a fixed position, and "know" their position at all times, including when powering up.

For linear applications, encoders attach to a motor, rotary shaft, or surface-driven wheel and generate a pulse train output in a variety of signal configurations. In some high-accuracy applications, a linear encoder, which includes a scale and sensor, converts the linear scale position into an analog or a fieldbus signal.

DETECTING DISTANCE

Programmable photoelectric sensors can determine rough distances and so act as a "within range" detector. Programmable functions in the sensor let it detect targets at an approximate distance.

Some photoelectric sensors also serve as distance transmitters, outputting a 0 to10 Vdc signal to indicate a measurement range or distance. A class 1 or 2 laser is needed in diffuse and retro-reflective (transit time) laser-based distance sensors.

Mini-rectangular plastic, retroreflective photoelectric sensors from AutomationDirect have reliable sensing ranges of 4 m, making them a good fit for detecting the presence of boxes on a conveyor. *(Courtesy of AutomationDirect)*

These transmitters can detect distances ranging from 5 mm or less to 10 m or more. With short-range laser distance sensors, resolutions are less than 8 µm. At distances over 10 m, resolution is not as good, but still enough for most machine automation purposes.

Applications for photoelectric distance sensors include determining if a part is seated in a fixture and measuring part height, diameter, or thickness. In longer-range applications, they can measure gantry position, or the droop in a web of material in an accumulator.

SPEED SENSING

Encoders and resolvers are readily available for sensing speed and position. Speed detection and zero-speed sensing can be added to most rotating shafts using either a Hall Effect, inductive, or photoelectric sensor. The sensor is able to see ferrous gears and sprockets with many teeth or holes, or detect a single magnet or target once per revolution. Sensor output is typically a digital pulse train suitable for monitoring via a PLC's high-speed counter input.

Speed switches are widely used in machine automation to monitor rotating shafts where turning too quickly or slowly damages the machine or creates process problems. Stopping machines if they run too fast is a common use. Safety-rated zero-speed switches are important in machine safety applications where all components must be stopped before removing power for a safe shutdown.

Digital-to-analog converters can change speed pulses into a current or voltage output that can be read by an analog PLC input. This value can then be used to close the loop for applications where precise control of motor speed is essential.

There are an abundant number of types and versions of switches and transmitters for measuring a wide range of physical properties in machine automation applications. Wiring their discrete, analog, or digital fieldbus outputs to PLC inputs helps bring a machine to life by providing it with continuous operating information. There is significant overlap between switches and transmitters, but in general switches should be used if they meet the application requirements because they are simpler, less expensive, and smaller than transmitters. They are also less expensive to connect to PLCs, requiring only a discrete input as opposed to an analog or fieldbus input. Transmitters are available for more complex applications, and can be used to solve a wide variety of measurement problems and to close control loops. md

What's the Difference?

(Continued from page 25)

by fluid entering the valve at any working port. The pressure is always applied to two equal opposing areas. As a result, the pressure cannot move the spool because they are cancelled out. Spool valves can shift either manually, electrically, mechanically, pneumatically, or hydraulically with the same force, independent of the operating pressure inside the valve.

Low-force solenoids can be used in conjunction with spool valves, due to their easiness of movement via mechanical friction and light springs. As mentioned before, spool valves are able to be used in vacuum operations. They can also be employed in high and low pressures as selector valves. Moreover, they can be used to lock pressure downstream.

Disadvantages

The metal-to-metal slide fittings can result in fluid bypassing the seal, which as mentioned earlier, results in leakage. The actuator will lose position if outside force is applied. This creates inefficiencies in the form of wasted energy and heat. To help reduce bypass, spool valves typically have land overlap, but this results in a delay prior to fluid flow. The delay is small—only a few milliseconds—but may cause a problem if the cycles are very fast and/or if there are several valve shifts per cycle.

A time delay also occurs if the spool shifts back to the end of its stroke. The spool valve moves more than it needs to for the required flow. As a result, it takes up more time shifting back to center or to the opposite flow path. When several valves are involved, this significantly slows down the cycle time.

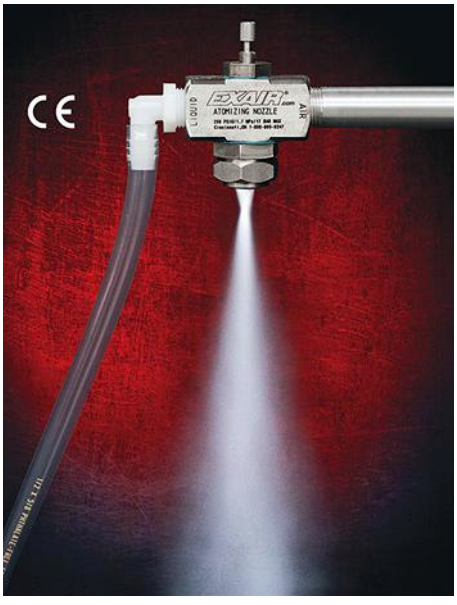
Using stroke limiters helps eliminate the delay, but the more common approach is to increase the pump size. Even though you achieve a higher energy input and faster actuator movement by installing a larger pump, it can add shock and heat to the system. Another disadvantage of spool valves is that open crossover occurs when all of the ports are momentarily open to flow during the actuation.

HOW TO CHOOSE THE RIGHT VALVE FOR THE JOB

The *table* below is a valve selection aid. Both spool and poppet valves come with advantages and disadvantages, but the one that best fits your application will depend on your operating conditions. One must consider, for example, if low leakage values and dual pressure operation with vacuum and ejector pulse are your design priorities. Or if you are more concerned with high operating pressures, some leakage may be allowable. Better understanding of your operating conditions will help guide you to choose the right valve for the job. md

	Piston spool valve (seal on piston)	Piston spool valve with cartridge principle	Conventional poppet valve (pressure-dependent)
Relationship between valve size and flow	++	+++	+
High operating pressures up to 16 bar	Not available	+++	++
Vacuum operation	++/+++*	+++	++
Reverse operation	++	+++	Not available
Resistance to "polluted air"	++	++	+++
Low leakage values	++	+++	+++
Switching time	++	++	+++
Lubricant compatibility[3]	+	+	+++

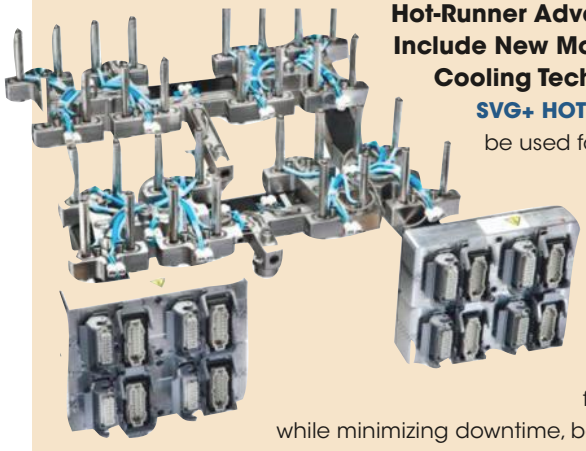
+++ = Excellent ++ = Good + = Satisfactory * = Depending on the structural design



Atomizing Nozzles Target Cooling, Coating Apps

THE 1/2 NPT siphon-fed atomizing spray nozzle can atomize a variety of fluids in a round spray pattern. It features a corrosion-resistant type 303SS nozzle that draws liquid into the airstream and mixes it internally while providing up to 24 in. of suction height. Liquid can be easily adjusted with the valve. Liquid flow can reach up to 68 gallons per hour in a 6-in. diameter round pattern. A patented no-drip version is also available to conserve liquids. They could be used to coat, cool, treat, and paint a variety of products using compressed air and liquids with a viscosity of up to 300 centipoise. Atomizing nozzles also offer an efficient way to evenly cool hot items in automated processes. They are also commonly used with light oils, rust inhibitors, chemicals, paints, and dyes. They are available with 1/4 and 1/2 NPT connections, and in a variety of spray-pattern sizes and shapes. All models are adjustable, and have an available mounting bracket.

EXAIR CORP., (800) 903-9247, *www.exair.com*



Hot-Runner Advancements Include New Modular Actuators, Cooling Technology

SVG+ HOT RUNNER SYSTEMS can be used for sequential molding of large parts. With no requirement for cooling lines or plates, they offer easy setup. Monitoring and diagnostics tools from outside the machine facilitate troubleshooting while minimizing downtime, boosting reliability, and producing less scrap. Users can easily upgrade to activeGate technology for lower operating costs and improved quality with Class A part surface finishes. The hot-runner system also can be used to produce molded parts with complex geometries and high-dimensional stability in less time. The integrated SynCool3 system provides indirect cooling of the actuators without the need for separate cooling lines.

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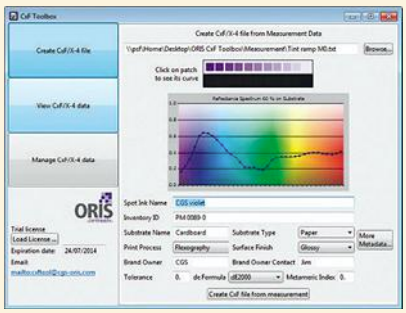

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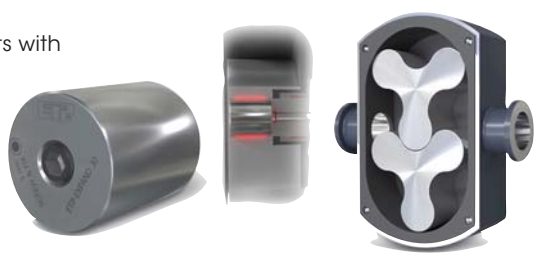

Surge Protectors Target Various Electronics Apps

THE SURGE-TRAP TYPE 1 STXR series of surge-protection devices feature a small, single-piece design requiring no assembly. With line- or load-installation flexibility, the devices can be used for protection in branch panels or in individual equipment. It can be installed on the machine or at the main panel to protect equipment from power spikes and surges that would cause downtime or damage. Available in 120-600 Vac models, it has a 200 kA short-circuit current rating. The devices are ideal for use in ANSI/UL Type 1 or 2 SPD installations including ac distribution, power supplies, drive protection, fire alarms, and control panels. The STXR series also provides up to seven modes of protection. Additional features include an LED status indicator, ¾-inch knockouts with 3-ft. leads for easy installation, and a NEMA 4X enclosure for outdoor or indoor use. An optional mounting bracket is available for surface mount applications.

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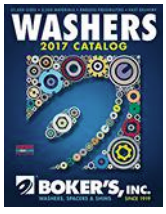

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BRADFORD L. GOLDENSE | Contributing Technical Expert

The 5 Risks of Product Development

Risk assessment and mitigation in corporations is a highly complex topic. And rarely are the answers exact, no matter how much effort is expended to assess the types and levels of risk. Perhaps that is why so few corporations do a good job at it.

A recent column in *Industry Week* indicates that only 39% of corporations can quantify their risk. Within the enterprise, myriad daily internal decisions affect risk. External risks are no less challenging, with political, economic, regulatory, weather, and competitive risks becoming more common since the age of globalization. Perhaps today's external risk can best be described as "VUCA," a term first coined by the U.S. Army for Volatility, Uncertainty, Complexity, and Ambiguity.

With regard to product development risk, there is good news and bad news. The good news is that it is a smaller subject than corporate risk. The bad news is that half or more of corporate risk emanates from strategic product development risk.

Strategic Product Development Risk: *HBR* studied the major categories of corporate risk: Industry, Technology, Brand, Competitor, Customer, Project, and Stagnation. It looked at how specific risks could affect a company's bottom line (specifically, the percentage of earnings that could be at risk). In the first four of these categories, R&D and product development could have as much as a 40% to 70% effect. In the latter three categories, it is on the order of a 20% effect. No company function, department, or activity imparts more risk to corporate earnings than R&D and product development.

Product Portfolio Risk: For the past 15 years, ever since the technology boom of the late 1990s petered out, there has been a nearly steady decline in portfolio risk. Today, funding for risky innovation projects is down 80% from the last quarter of the 20th Century. Those monies have been channeled into incremental products and extensions, keeping pace with compliance and regulatory requirements. Recently, the U.S. government forecast a return to greater than 3% GDP rates. With anticipated reductions in regulations under the new administration, combined with easier access to credit, one can expect more risky projects to be undertaken in the years ahead. Yes, that is good (even great) news for product developers. But there are now almost two generations of managers with little experience in handling portfolios full of high-risk projects. And many product developers have also become a bit rusty in achieving stretch products. Therefore, portfolio risk will be even higher going forward because experience and familiarity also need to be regained.

Technical Risk: Introducing new technologies too quickly can put companies ahead of the market and, as a result, products flop or have slow starts. Being late is just as risky. Markets now come and go quickly. Assuming market windows have been correctly gauged, and enabling new technologies have been introduced early enough into the pipeline to provide enough development time to achieve commercial volumes, managing the execution of technology readiness becomes paramount. Specific technical risks vary greatly by domain and discipline, but they all share one thing in common: The goal is to make money from them. Technology roadmaps identify when a technology is to be available, but do not help to assure it will be available on time.

Supply Chain Risk: Without delving into detail on this giant body of knowledge, but staying consistent with the earlier late 1900s vs. today benchmarks, the supply-chain impact on new product designs has now tripled. It is not uncommon to see 70% or more of product costs come from suppliers these days, versus 5 to 20% in the late 1900s. For better or worse, supply chain risk is a key risk for product and portfolio development.

Talent Risk: CAD systems and design automation do not invent or innovate products—people do. Some 50% to 70% of R&D spending goes to pay the people that do so. Unless the right quantity of the right people with the right skills and motivations are in place, projects will not be on time and roadmaps will not be realized. The risk of having a ready and able workforce is the linchpin of all other risks. Talent risk assessment is still in its infancy. md

BRADFORD L. GOLDENSE is founder and president of Goldense Group, Inc. (GGI; www.goldensegroupinc.com), a consulting, market research, and education firm focused on business and technology management strategies and practices for product creation, development, and commercialization.

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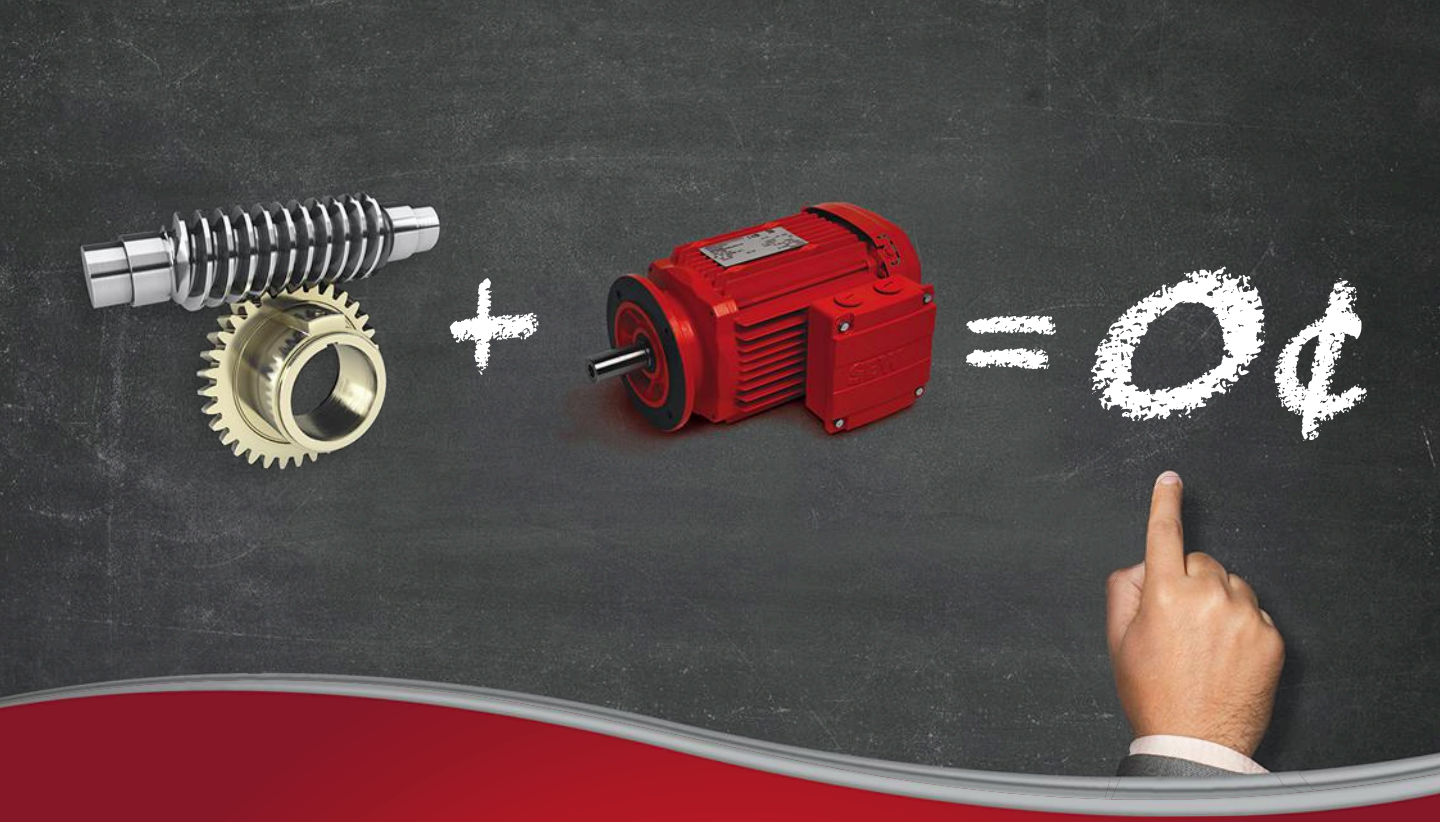

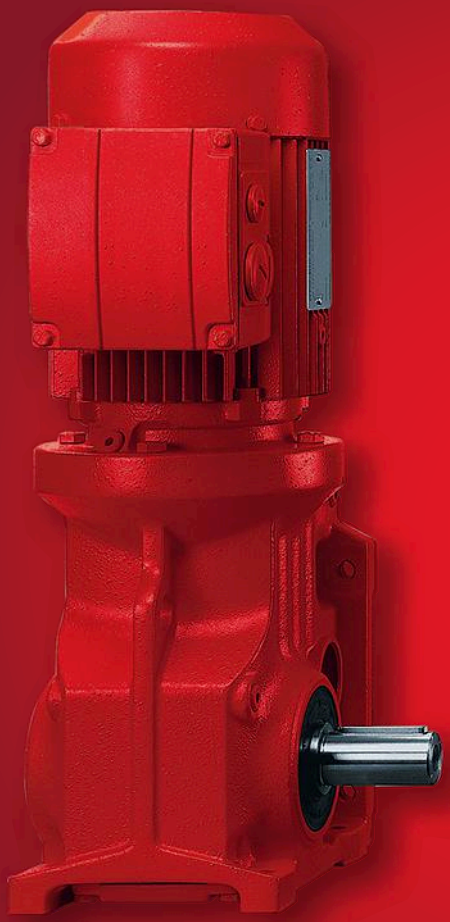

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