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Machine Design (ISSN 0024-9114) is published monthly by Penton Media, Inc., 9800 Metcalf Ave., Overland Park, KS 66212.
Paid subscriptions include issues 1-12. Rates: U.S.: $139/year; $199/two years. Canada/Mexico: $159/year; $239/two years; All other countries: $199/year; $299/two years. Cost for back issues are U.S. $10.00 per copy plus tax, Canada $15.00 per issue plus tax, and Int'l $20.00 per issue. OEM Handbook and Supplier Directory, $50.00 plus tax. Prepaid subscription: Penton Media (Machine Design), P.O. Box 2100, Skokie IL 60076-7800. Periodicals postage paid at Kansas City, MO and additional mailing offices.

Can GST #R126431964. Canadian Post Publications Mail Agreement No.40612608. Canada return address: IMEX Global Solutions, P.O. Box 25542, London, Ont., N6C 6B2.
Digital subscription rates: U.S.: $69/year. Canada/Mexico: $79/year. All other countries: $99/year. Print/Digital combo subscription rates: U.S.: $174/year; $249/two years. Canada/Mexico: $199/year; $299/two years; All other countries: $249/year; $374/two years.
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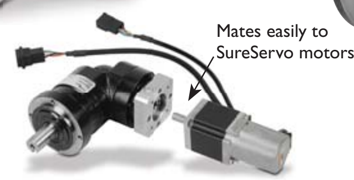

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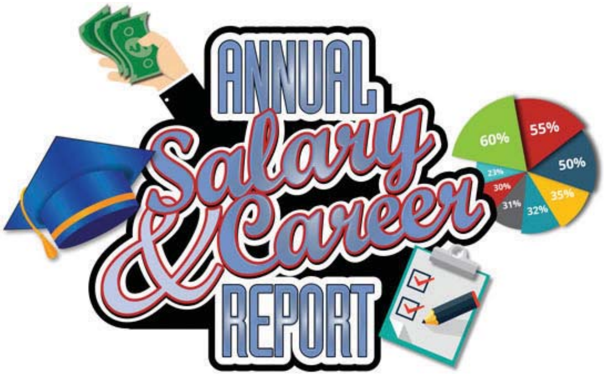

2016 MACHINE DESIGN SALARY SURVEY & CAREER REPORT: FIVE YEARS OF ENGINEERING THOUGHTS & OPINIONS

http://machinedesign.com/learning-resources/2016-machine-design-salary-career-report-five-years-engineering-thoughts-and-opin

Since 2012, when *Machine Design* published its first salary and career report, we have seen an increase of salary growth for engineers. On the other hand, the percentage of new engineers has decreased during the same timeframe, and as a whole they're getting older.

WHAT'S THE DIFFERENCE BETWEEN THORIUM AND URANIUM NUCLEAR REACTORS?

http://machinedesign.com/whats-difference-between/whats-difference-between-thorium-and-uranium-nuclear-reactors

The short answer to the question asked above is that uranium-fueled reactors can be built right away, but they use fuel inefficiently. Thorium-fueled reactors, on the other hand, are fuel-efficient, almost perfectly so, but that comes at the end of a three-phase process, with the first phase shared by thorium and uranium fuel. *(Image courtesy of Thinkstock)*

HOW TO SPECIFY FIBER OPTIC SENSORS

http://machinedesign.com/sensors/how-specify-fiber-optic-sensors

Sensing part presence in machines, in fixtures, and on conveyors is an important component of industrial automation. Error-proofing assembly and controlling sequence based on presence or absence of a part is often required. In many cases, one can't just assume the part is where it should be or the nest is empty as expected, so a presence sensor must be used for verification.

THE ROAD TO SMART MANUFACTURING

http://machinedesign.com/iot/road-smart-manufacturing

Numerous initiatives have been put into motion around the world to fundamentally transform manufacturing as we know it. Though the initiatives go by different names—from the Smart Manufacturing Leadership Coalition and Industrie 4.0 in the West, to Made in China 2025 and Manufacturing Innovation 3.0 in the East—they share a common pursuit: smart manufacturing.

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Editorial

JEFF KERNS | Technology Editor
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Science and Art, Two Worlds Apart

How can education bring together two fields that have been traditionally treated as polar opposites?

In the United States, the recent presidential debates covered topics like healthcare, retirement, education, and military involvement on foreign soil. While the economy seems to be the underlying tone or root cause of many of today's problems, I wonder what will happen in the bigger picture over time. If those who are more educated are doing better than those who aren't, why is college still such a cost-prohibitive investment or so difficult to obtain? Even if you look at our bloated, broken education system for younger Americans (high school and lower), it seems that, while we are spending more money, we are cutting programs like shop class and music.

People complain that the classroom hasn't changed in over 100 years. Meanwhile, inner-city schools obtain new smart projection screens that cost thousands of dollars. Perhaps more interesting are the schools that use an abacus to teach students, who end up outperforming most students around the world. Technology is only successful when applied correctly. So where does technology fit in schools? Perhaps in the machine shops and art programs that many schools are cutting.

As a carpenter-turned-engineer, I have used about all of the math I learned in high school in tinkering and building. As I started engineering school, I realized that I didn't have to tinker or guess as much if I used higher levels of math. School formats do not need to change the blackboard or desks. They need to change the mind.

With young students teeming with energy, we need programs like shop and art. Even if these programs are still in the curriculum, they often fail to demonstrate the science behind, say, the frequency of music, the material science of art class, or the trigonometry of shop. Imagine how much math and science you could teach young students in a wood shop with a few hand tools. After a semester, they might understand math better. In addition, students would inherently learn about jointing, adhesives, art, and be able to show off their actions with tangible goods. Instead of sitting in desks and chairs to learn, students should *build* the desks and chairs.

The question, "why do I need to know this?" would not come up if students learned through hands-on application. Whether it be music, art, or shop, students could learn to answer their own questions through tinkering. We can't solve problems in any industry unless we first teach the next generation how to be problem solvers. We can't build a future if the next generation doesn't know how to build. Education and technology are not talking points, they are answers to the problem of history repeating itself. md

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NOVEMBER 2016

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News

FESTO EXPANDING in the U.S. and Bringing Back Vocational Education

The company's recently opened new plant in Mason, Ohio is also a new educational model for the skilled labor force.

Festo recently opened the doors on its brand-new Regional Service Center (RSC) in the center of Ohio, located in the town of Mason and serving the North American market, including Canada and Mexico. With the new center, 70% of Festo's North American customers will only be a 10-hour truck drive away. Festo recently opened its doors for a tour of the facility to highlight how it is bringing the Industrial Internet of Things (IIoT) to the North America region and how it plans to develop a higher skilled labor force.

From Festo's newly established logistics and assembly plant in North America, 70% of customers can be supplied with automation products in a 10-hour truck-drive. *(Photo: Festo)*

FESTO AND IIOT IN NORTH AMERICA

The investment Festo is making in the United States and Americas region is due to the growing manufacturing market. According to Carlos Miranda, cluster lead of the Americas, the potential market for Festo in the Americas is a projected $3 billion. This includes not just the United States and Canada, but also Mexico and South America. Mexico is becoming an important hub for North American car manufacturing. Richard Huss, president of Festo Corp USA, said that automation is key to the rise of manufacturing in the states. It is becoming more expensive to assemble overseas with countries like China rising in cost and with the help of automation, manufacturing is rising in the Americas.

The RSC in Mason will serve has a hub for the United States, Mexico, and Canada for Festo products. The facility has a storage capacity of 65,000 bins and is completely automated. The Witron company implemented the automation used inside the warehouse to prepare products for delivery. Witron designed how the bins are stored, retrieved, and delivered to each of the picking stations. The 10-aisle automated storage retrieval system has 73,000 bin locations and is designed for a variety of tote sizes. A conveyor system delivers the bins to the picking stations. Each picking station, besides having an integrated computer system, has a pick-by-light system and integrated weight scale to ensure a high pick quality. Each workstation can pick up to four customer orders at the same time. The light flashes over the correct bin per order and the scale measures the bin ensuring the correct number of pieces per shipment.

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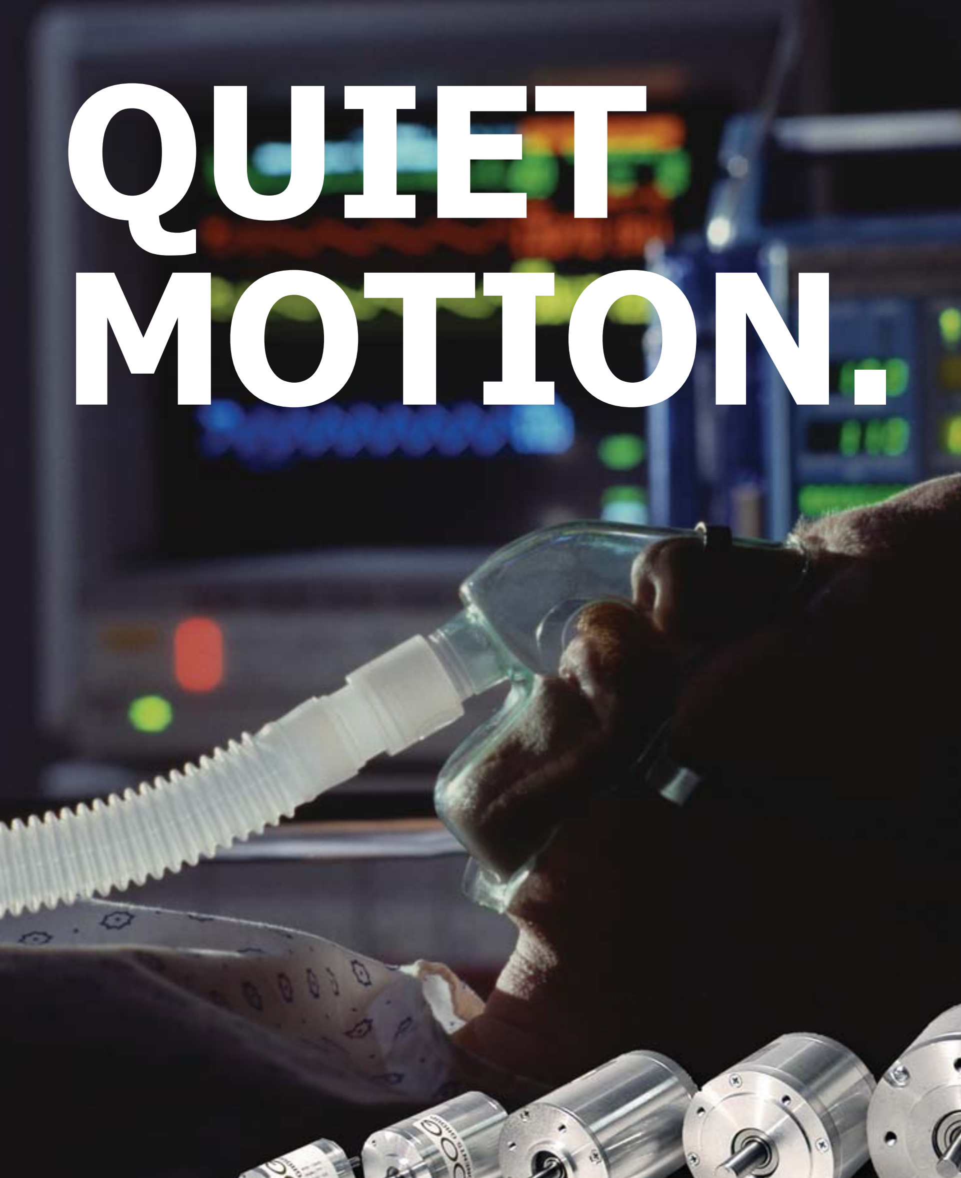

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The automated warehouse system enables the processing of large order volumes. With storage capacity of 65,000 bins and the high performance picking and packing stations the system enables Festo to pick and pack more than 1,000 items per hour. *(Photo: Festo)*

The bin is then transported back on the conveyor to packaging and shipping. The system makes it possible to pack up to 10,000 order lines without any errors.

The facility is also the assembly site for many customized parts. The RSC integrates assembly into the warehouse, providing direct access to components. This helps minimize the wait time for customers to receive parts by cutting down on additional supply chains. The customizable products assembled at the RSC include: pressure switches, custom cylinders, valve terminals, cylinder/valve combinations, valve manifolds, semi-rotary drives with ball valve, and sensor boxes.

DIDACTIC LEARNING

To help push manufacturing in the Americas, the need of a highly skilled labor force will be essential. According to American Manufacturing, in 2011, an estimated 600,000 manufacturing jobs went unfilled in the United States. Manufacturers could not find enough workers with the science, technology, engineering, and math (STEM) disciplines necessary to work in advanced manufacturing environments. By 2025, there will be over 3.4 million manufacturing jobs available and fewer than half of those openings will be filled due to the shortage of skilled labor fource.

Festo is tackling this problem through Festo Didactic. For more than 40 years, Festo Didactic has prepared students in North America for complex industrial environment jobs by simulating smart factories in high schools and college classrooms. The students receive hands-on learning on how to build and operate IIoT-related equipment. In Mason at the RSC, Festo is taking it one step further with their Mechatronics Apprenticeship Program to equip today's workforce with the necessary skill set and help recruit more young people to manufacturing.

(continued on page 15)

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Students in the Mechatronics Apprenticeship Program learn through a hands-on experience on how to operate modern IIoT-related equipment. *(Photo: Festo)*

(continued from page 12)

In Germany, 1.5 million apprenticeships are given to youth and it results in a low 7% youth unemployment rate. In the United States, the youth unemployment rate is 17% and only 358,000 apprenticeships are given to young students. Festo Didactic created the Mechatronics Apprenticeship Program in partnership with Sinclair Community College in Mason. The manufacturing partners are TechSolve, and employer partners are Art Metal Group, Clippard Instruments, Festo Automation, MQ Automation, and Nestlé. The two-year program helps train young students for careers as maintenance technicians, automation specialists, service technicians, and manufacturing technicians.

Each apprentice will earn an associate's degree in mechatronics from Sinclair Community College. Based off the German apprenticeship model, apprentices spend one day each week in educational classes at the college, one day using and learning how to operate modern IIoT equipment at the new Festo Learning Center in Mason, and three days working and training at their respective employers. Scott Markland, vice president for regional genters at Sinclair Community College, says , "We heard loud and clear from small, medium, and large manufacturers in our area that they have a skills gap and it is challenging to find young people who are interested in manufacturing. At the same time, [employers] have a workforce that is moving toward retirement, so the talent pipeline is a big concern." With the help of Festo Didactic and the Mechatronics Apprenticeship program, that talent gap will start to close. ■

PHASE-OUT OF HFC COOLANTS EXPECTED to Reduce Global Warming by 0.5 °C

AT A UNITED Nations meeting in Kigali, Rwanda last month, delegates from 197 countries settled negotiations to phase out heat-trapping hydrofluorocarbons (HFCs) used in refrigeration and cooling applications. The agreements are part of the Kigali Amendment to the Montreal Protocol, which was created in 1987 to eliminate ozone-depleting chlorofluorocarbons (CFCs).

While HFCs do not actively deplete the ozone like CFCs, they trap more than 1000 times the amount of heat per unit than CO2, making them significant contributors to the effects of global warming, from rising sea levels to bleached coral reefs. The UN Environment Program reports that HFC emissions are increasing by 10% each year, but by setting deadlines for individual countries to phase out 19 gases in the HFC family, the UN expects temperature rises projected for 2050 to decrease by 0.5 °C.

The amendment is a product of seven years of negotiations. While the plan originally set out to freeze all production of HFCs by 2021, India expressed concerns that pressure to switch to alternative coolants at such an early date would harm its economy. Between

(continued on page 18)

MIT ACHIEVES RECORD PRESSURE for Nuclear Fusion

A TEAM OF scientists from the University of California, Lawrence Livermore National Labs (LLNL), Massachusetts Institute of Technology (MIT), and other institutions have presented a metamaterial that exhibits minimal thermal shrinking when exposed to temperatures as high as 540°F. Although it is made of two thermally expanding materials, the metamaterial's star-shaped unit cells feature a mechanical design that promotes negative thermal expansion (NTE) when heat is applied. The results are published in the *Physical Review Letters Journal.* The research was conducted under a 5-year Defense Sciences Offices program funded by DARPA.

While structures for heat-shrinking metamaterials have been proposed before, the necessary tools to build them did not always exist. But now that we are in the age of 3D printing micro-fabrication techniques, scientists are equipped to create individual unit cells with virtually any design, and exact dimensions can be read from a computational model.

The product created and designed in this project is classified as a metamaterial because its ingredients act separately to induce a behavior that would not occur naturally. The legs or trusses of each star-shaped unit cell are made of polymer and copper/polymer-composites with different thermal expansion rates. The scientists can control the extent of shrinking for the entire metamaterial by altering the relative lengths of each beam and their stiffness through their computer model.

Each star-shaped unit cell is made up of tetrahedral pyramids that point inward. The base of each tetrahedral does not contain beams around its perimeter; rather, the beams lie diagonally to form a cross with a node at the center of the base. This node is connected to the inner legs of the cells, which are made of the quick-to-expand polymer. The legs that make up the base of the tetrahedrals are a stiffer copper/polymer composite.

As the inner legs expand, they pull upward on the node of the tetrahedral base. At temperatures approaching 540°F, the inner legs pull the node inward so that the diagonal beams buckle. This causes the star-shaped unit cells to close in on themselves, and as the inner beams continue to expand, the metamaterial continues to contract. The overall shrinkage is 0.06%.

The scientists are still optimizing their model to reduce all shrinking to zero under intense heat so that the material could be used for chips in computing and electronics, dental fillings, calking, and other applications that may need to withstand high-heat cycling. ■


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Phase-Out of HFC Coolants

(continued from page 15)

the higher cost of alternative coolants, the cost of redesigning systems, and providing new training for maintenance personnel, India would fall behind the rest of the world in the HVAC sector. So India demanded a ten-year extension to its freeze date.

In the end, developed countries including the U.S. and EU agreed to begin phasing out production of HFCs by 2019. Developing countries including China, Brazil, and countries in Africa plan to freeze HFC consumption by 2024. Other developing countries including India, Pakistan and Gulf states will freeze consumption by 2028. And some African countries are aiming to phase out HFCs faster than required due to the current climate situation.

The amendment is legally binding, so that countries have to adhere to the rules, goals, and guidelines that they set to ensure they cut down on HFCs as soon as possible. And since the amendment targets a single group of greenhouse gases, countries were able to set goals based on their resources and outlooks for industrial, residential, commercial, and automotive markets. At the next Meeting of Parties in Montreal in 2017, participating countries will provide an update on their financial plans to effectively reduce HFC emissions, and delegates will discuss grants and programs for research and development of affordable alternatives to HFCs. ■

Alternative	Global Warming Potential (GWP)	Properties to be addressed	Commercial availability
Hydrocarbons	3-5	Flammable	Immediate
CO_2 (R744)	1	High pressure	Immediate
Ammonia (NH3, R717)	1	Toxic	Immediate
Water (R718)	1	No risks	Immediate
R32 (an HFC)	675	Mildly flammable	Immediate
HFOs	4-9	Mildly flammable	Immediate/Short-term
R32-HFO blends	200-400	Mildly flammable	Mid-term

This table, from the European Commission (EC) of current alternatives to HFCs, includes the Global Warming Potential for each substance, which is a figure of merit that is generally in the thousands for HFCs.

FUJITSU DEVELOPS BETTER MEMORY CAPACITY for Deep Neural Learning Networks

DEEP NEURAL LEARNING (DNL) technologies have become an advanced tool for computers to identify the content in images, decipher audio recordings, and analyze other complex inputs. A DNL network consists of thousands of layers of nodes. Each node processes individual content from the input and generates a few interpretations that are sent to other nodes in a subsequent layer for further processing. This continues throughout the layers.

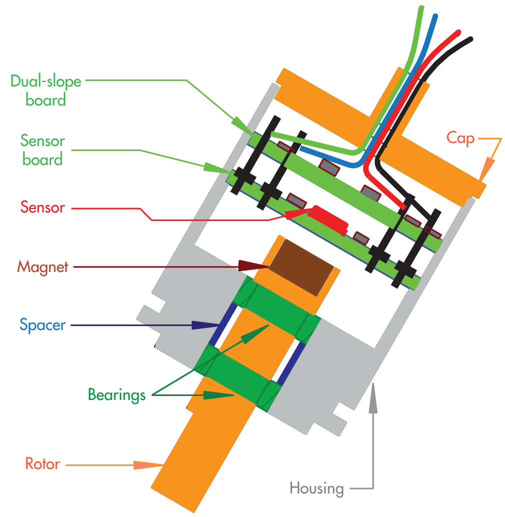
After an input has been processed through the network, the output is compared to a desired output and the computer generates an error reading. This error is fed back through the network, so that the each interpretation by a single node can be weighted. Based on the error, some interpretations are more heavily considered for the final output. There may be thousands of iterations for this process until the input is interpreted with a minimal error. This is how the machine learns.

Graphical processing units (GPUs) are generally used for DNL because of their memory capacity in parallel processing. The GPU must be able to remember weights and data associated with each error reading in every layer. When more layers are added, the processing speed of the GPU decreases because it needs to concentrate more of its power on memory. Conversely, central processing units (CPUs) are used more in serial processing, where data is interpreted one node at a time and processed through single strings of nodes. They can operate much faster, since they do not require as much memory as the node layers in a GPU.

With the introduction of a new memory system, Fujitsu announces development of a GPU that enables more layers in a DNL network without compromising its speed. Adding more layers will improve the overall accuracy and learning capacity of the GPU. At each layer, the GPU will compare the weights of nodal connections to a "weight error" calculated at the end of each iteration and will simultaneously compare the data stored at each layer to the "data error" calculated by the GPU. By subtracting the errors from the existing weights and data, the GPU can actually delete excess data and weights stored at each layer. This frees up more memory space so that they GPU can operate faster, storing only data that is necessary.

The new memory system is tested in the Caffe open source deep learning framework software. Evaluations used AlexNet and VGGNet, which is common in DNL research initiatives. Fujitsu reports that it reduced memory usage by 40% with the new system, nearly doubling the learning capacity and speed of the DNL network. The company plans to release the technology in March 2017 for use in its Human Centric AI Zinrai. ■

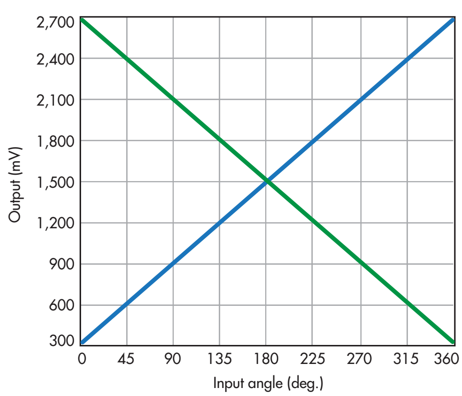
Hall Sensor Measures 360 Deg. of Rotation



ENGINEERS WHO WANT to measure and control rotating antennas, fluid flow direction, or a robotic arm joint can now use a Two-Pi hallpot angle sensor from Elweco Inc. (www.halpot.net), Painesville, Ohio, to measure the angular rotation of a shaft or joint. The sensor can measure angles up to 360 deg. and motion at up to 5,000 rpm, and the response is linear with the rotation. The sensor generates two simultaneous linear responses with opposite slopes, thus letting engineers choose the preferred direction of rotation and then use either slope. The device relies on non-contacting magnetic Hall effect sensors, so there are no moving parts to wear out.

The sensors do not require any additional hardware to obtain or decode the linear measurement or control signals, which means no software is also unnecessary. Because the sensor supplies signals for two slopes, engineers can insert the device directly in the system and have the desired slope— again, without adding hardware.

The sensor uses two ABEC Class-5 ball bearings on each rotor shaft for the servo-mount design, and anodized aluminum bearings are used on the threaded journal potentiometer-mount types. The sensor comes in three different mounting configurations in standard sizes and shapes, so no special mounting hardware is required for adding it into most new or existing systems.

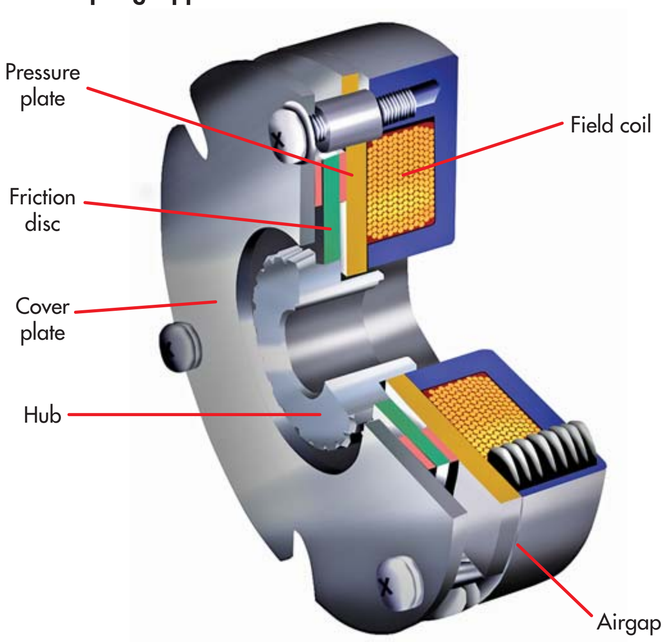


This graph shows the two simultaneous signals the device generated by the devices as the sensor perceives rotation. With a positive and negative slope for either direction of rotation available, users can choose the slope best suited to their applications.

The device is powered by 4.5 to 5.5 Vdc at 12 ma, and unregulated power supplies are acceptable. The output signals range from 300 to 2,700 mV. It works in temperatures from –-20° to 85°C and relative humidity from 0 to 95%. md

Are Holding Brakes Shrinking?

Spring-Applied Brakes for Servos and Robotics



AS TODAY'S EQUIPMENT moves toward miniaturization, there is a call for smaller, lighter spring-applied brakes that deliver the same holding torque. Ogura's (ogura-clutch.com) MTNB/TNB series brakes answer that call. Whereas a traditional 2-Nm brake has a width of 30 mm, the newest thin series brake has the same torque at a width of only 10 mm. A special coil design allows for high torque in a smaller body.

HOW THEY WORK: Spring-Applied Brakes for Servo Motors and Robotics

The fundamental purpose of a power off brake is to stop or hold a load. The most common are spring-applied brakes. When power is off or lost, the brake is engaged.

Power off condition: Coil is de-energized→The coil/field assembly is fixed and kept from rotating. The internal springs inside the brake forces the pressure plate up against a friction disc. The friction, created by squeezing the disc, keeps the shaft from rotating.

Power on condition: Coil is energized→The electric current causes the coil to become an electromagnet. Magnetic attraction pulls the pressure plate towards the coil; as it does, it compresses the springs creating an airgap between the pressure plate and friction disc. This allows the plate to move freely and the shaft to rotate.

These brakes will hold a load or provide for emergency stopping when power is released, or else lost to a servo motor. Some models have a manual release option. 24 V dc and 90 V dc are common, but other voltages are available. Designs can be as small as 18 mm in diameter, while larger designs are used on elevators and escalators. However, the most common applications are for robotic and servo motors for production, automation, and medical equipment. md

Bring Innovation Front and Center for the Next Technology Wave

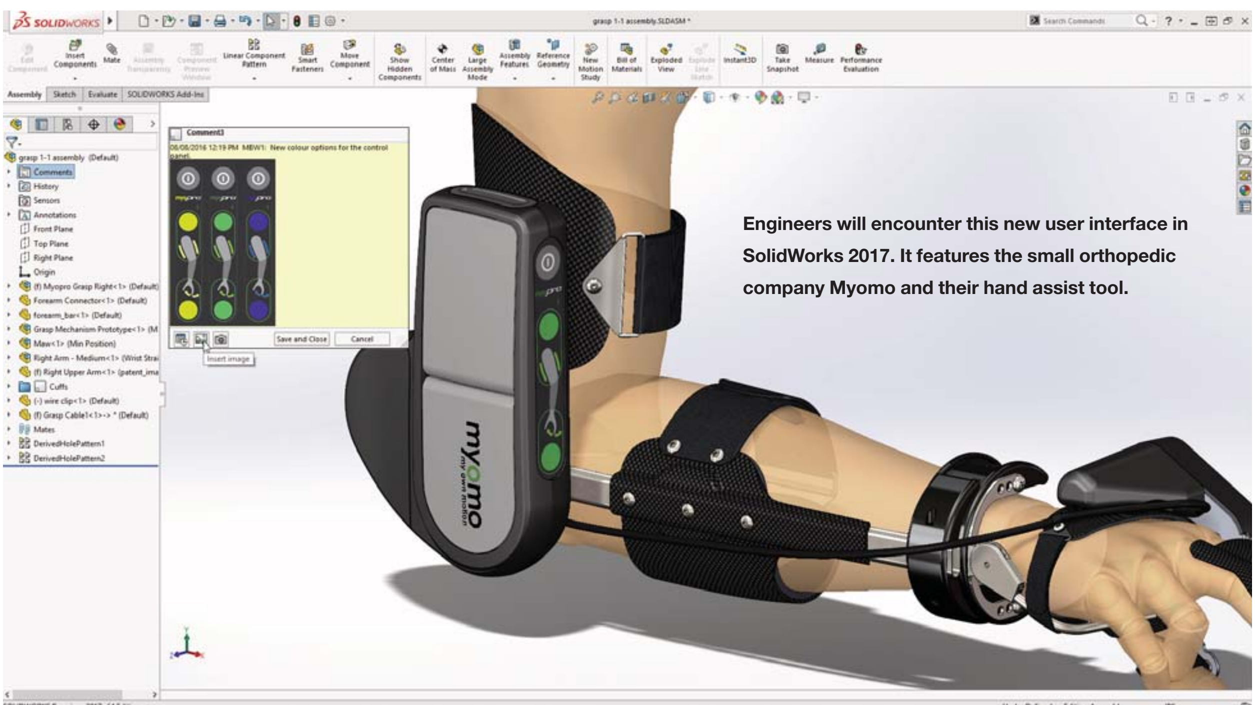
***Machine Design* sat down with Dassault Systemes' SolidWorks CEO Gian Paolo Bassi to talk about the future of the SolidWorks 2017 platform and innovation overall.**

Interview by CARLOS M. GONZALEZ

At the SolidWorks 2017 Launch Day, I had an opportunity to talk with Gian Paolo Bassi, CEO, Dassault Systemes SolidWorks (www.solidworks.com). We discussed the new launch of the software that not only provides customers with a SolidWorks version that is five times faster than 2016, but includes new online services through MySolidWorks.com. This provides engineers access to an online platform that connects them to manufacturers, additive manufacturing services, and part distributors to help them create their products.

Please tell me a little about yourself and your history with SolidWorks.

My journey started when I got my degree in mechanical engineering in 1984. I founded a startup straight out of the University of Bologna, Italy, to work on parametric 3D CAD. I worked on 3D software for several years and developed a strong background in research and development. In 1994, I moved to the United States and was working with Computer Vision. I continued to develop startup companies when I moved to Silicon Valley and later partnered with



Engineers will encounter this new user interface in SolidWorks 2017. It features the small orthopedic company Myomo and their hand assist tool.

Dassault Systèmes. The companies I helped found were focused on innovation, new products, and ultimately became part of the CATIA portfolio in the early 2000s.

Afterward, I started consultant work on architecture projects. Dassault Systèmes acquired my consulting firm and made me vice president of research and development in 2011. In 2015, I was offered the position of CEO. I still retain my title of VP of R&D, which is very typical of Dassault Systèmes. It is a very strong technology-oriented company and the heads of their brands come from strong engineering backgrounds. This helps bring Dassault Systèmes to the forefront of research and innovation for CAD, CAM, and PLM. It is very rewarding to work for Dassault Systèmes because the company is motivated by strategic decisions and long invested plans of, for example, 10 years.

At the SolidWorks 2017 press conference, we heard the phrase "democratizing innovation" quite a bit. Can you explain what that means?

It means to organize our products into dedicated solutions. We are pursuing this strategy that, for example, includes solutions for interconnected devices, design to manufacturing for highly integrated shops, and engineering consulting services. To be more innovative, we need to bring the power of the people and collaboration into the equation.

This is why we are evolving to platform-thinking, because it is only with the platform that you can bring together products and technology with people and the marketplace. You need the platform if you want to store and analyze big data. The technology used to analyze big data is high end and very expensive. If you make it part of the platform, then it becomes more available.

Making the search capabilities part of your software, for example, brings the high end and sophisticated technology to everyone. This is now available in SolidWorks 2017 with a low price-point entry to all users. Design optimization is one tool we want to make available to all engineers, and we do so by integrating it into the platform.

Platform services also require cloud services. Is SolidWorks offering cloud services along with their license?

We are a one-stop shop. Dassault Systèmes owns the infrastructure for cloud services. We are invested with Outscale Cloud service, which provides our cloud backbone. Dassault Systèmes is able to provide the entire solution, including hosting, which is very important.

For some industries, you cannot afford not knowing where your data is located. We own the servers, so we can tell you geographically the location of your data. Our customers have complete access to those servers and do not need to store anything locally, since everything is in the cloud. And many of these cloud services are included in the maintenance fees of their desktop products. When you purchase your SolidWorks seed, you own it forever.

Your maintenance fees provide you with regular updates and the cloud services that include, for instance, collaboration services and 3D part supply search services. The 3D part supply search gives you the ability to search for a component, where it is in stock, the price, delivery time, performance, etc.

Do you feel that the new SolidWorks Platform will compete against the rise of independent startup CAD platforms that have developed in recent years?

Yes, but I do not think there are that many in the market, per se. Those services are more focused on offering CAD in a browser, which is interesting to do. But that is only one part of what can happen if you have a fully connected platform solution. For example, this concept of a marketplace where people can sell their production or supply services is a unique ability.

Manufacturing is a difficult world and while we expect competition to arise, we do not see many entering the community the same way as we plan to for a while. We have a large spectrum of customers, and many come from "mom and pop shops" or small companies, which is still a very important aspect of engineering. The Myomo orthopedic hand assist tool comes from a company of only 60 people. Markforged, another small company, is the first company to introduce a 3D printer with carbon-fiber capability. Both are our customers and highly innovative. We do not have to confuse size with innovation.

New to SolidWorks is Xdesign (coming later in 2017), a design-optimization tool in which the computer offers design solutions. How can this help engineers, and is there a danger that this may lead to poor design solutions?

The idea is to free up the imagination of the engineer. Xdesign will suggest geometry based on stress and strain optimization algorithms to create the best design. We envision the machine telling you that this part is optimized from a statistical point of view, and now you as the engineer have to turn it into an industrial part. An engineer would then verify the part through their manufacturing experience and training.

What the computer cannot do is invent the product. It can tell you the optimal form, fit, shape, and function around your idea, and with our new platform, it helps create that idea in the most possible and affordable way. The greatest inventors are the people that come from any trade.

SolidWorks is very involved with the education of future engineers. What do you offer engineering students?

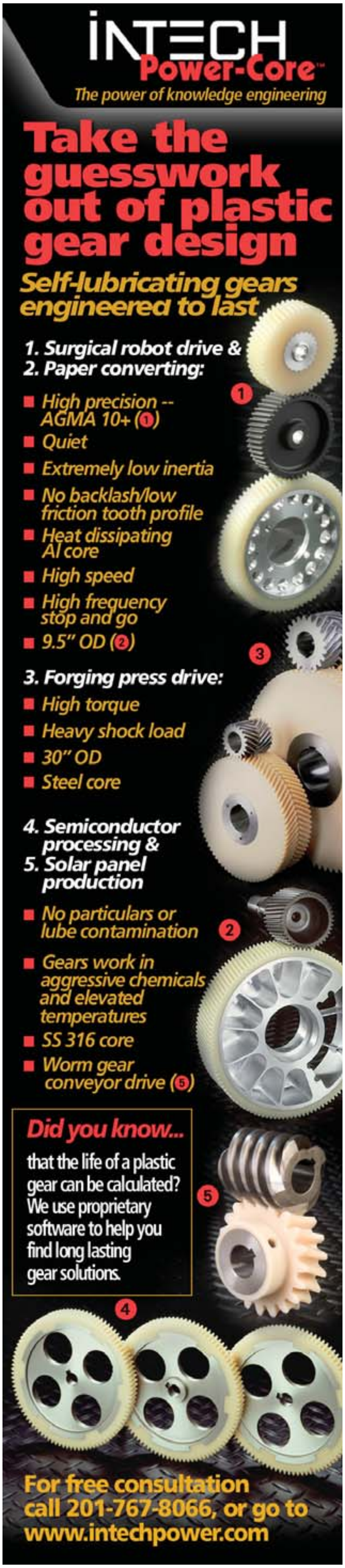
We have a very rich and deep education program. Today, 82% of the top

> Manufacturing is a difficult world and while we expect competition to arise, we do not see many entering the community the same way as we plan to for a while."

educational institutions in the world are standardized in SolidWorks for the engineering studies and research departments. Most students entering school now, or the engineering competitions such as the DARPA Challenge, Formula SAE, or Mini Baja, use SolidWorks to design their robots or vehicles.

Our education line does more than just offer our software platform at a discount price. We also assist in creating the curriculum, supporting the schools with installation and upgrade, and providing the teaching materials. We provide all of the tools necessary to make the class successful. We offer certification as well in SolidWorks so that students graduate not only with a degree, but are certified in SolidWorks. This is essential for them to find a job.

In fact, our strategy is to be even more pervasive in education by offering CAD modeling to kids. Our program "Apps for Kids" helps to teach young kids on how to use 3D modeling, because we need more children, especially young girls, to go into engineering. The value is not just giving them the software for free, but in developing them into better engineers by engaging in their curriculum and their projects. md



STEPHEN MRAZ | Technology Editor
stephen.mraz@penton.com

What's the Difference Between ASTM Rubber Types and Classes?

Reading through this quick review of loading classes and failure theories can help enhance the efficiency and safety of your designs.

Material experts at the American Society for Testing and Materials (ASTM) have codified the type and class designations for rubber in its standard, ASTM D 2000. The type designation, a single alphanumeric consisting of a letter from A through J, indicates the rubber's temperature resistance. It is determined by subjecting the rubber to an ASTM-defined test. In the test, researchers determine the highest temperature the rubber can be held at 70 hours and change its tensile strength by no more than 30% and lose 50% or less of its hardness or less. This is the rubber's service temperature. The letters A through K cover the range from 70° to 300°C.

The class designation, another single alphanumeric, divides rubbers into categories based on how much they resist swelling. To determine this, researchers immerse the rubber in IRM No.903 oil for 70 hours. The oil is kept at the rubber's service temperature. However, the maximum oil temperature is 150°C. Any hotter and the oil is unstable. The researchers than measure how much the rubber sample swelled. Swelling is then given as a percent of the original size. The values for the A to K Class designations range from 140% to 10%.

Type and class are often written together to identify broad groups of rubbers by performance. For example, AK identifies a rubber that can be used continuously at 70°C and it will not swell more than 10% when immersed in the ASTM reference oil.

TYPE AND CLASS REQUIREMENTS FOR RUBBERS

Type	Service Temperature (°C)	Class	Max. Volume Swell (%)
A	70	A	No requirement
B	100	B	140
C	125	C	120
D	150	D	100
E	175	E	80
F	200	F	60
G	275	G	40
H	250	H	30
J	275	J	20
K	300	K	10

TYPE AND CLASS OF SPECIFIC RUBBERS

Type/Class	Examples
AA	Natural rubber, Styrene butadiene, Butyl, Ethylene propylene, Polybutadiene, Polyisoprene
AK	Polysulfide
BA	Ethylene propylene, Styrene butadiene (high temperature), Butyl
BC	Chloroprene
BE	Chloroprene
BF	Nitrile
BG	Nitrile, Urethane
BK	Polysulfide, Nitrile
CA	Ethylene propylene
CE	Chlorosulfonated polyethylene
CH	Nitrile, Epichlorohydin
DA	Ethylene propylene
DF	Polyacrylate (butyl-acrylate type)
DH	Polyacrylate
FC	Silicone (high strength)
FE	Silicone
FK	Fluorinated silicone
GE	Silicone
HK	Fluorinated rubbers

Distribution

VICTORIA FRAZA KICKHAM | Distribution Editor

Connected Cars Spell Opportunity for Manufacturing, Distribution

The auto market continues to drive business for supply chain companies, as rapid growth in connected-car production continues through 2020.

The connected-car market continues to be a boon to supply chain companies, as a recent survey by Gartner points to rapid growth in the market over the next five years. Production of new automobiles equipped with data connectivity is expected to increase 150%, reaching 12.4 million this year and rising to 61 million in 2020, according to Gartner.

This is good news to electronic components manufacturers and distributors, many of which point to the automotive marketplace as a bright spot in an otherwise murky economy. In a mid-year business outlook report this summer, electronic components distributors listed automotive and Internet of Things applications as two of the greatest business opportunities now and into 2017.

A "connected car," as defined by Gartner, is capable of bidirectional wireless communication with an external network to deliver digital content and services, transmit telemetry data from the vehicle, enable remote monitoring and control, or manage in-vehicle systems.

"The connected vehicle is the foundation for fundamental opportunities and disruptions in the automotive industry and many other vertical industries," says James Hines, research director at Gartner. "Connected vehicles will continue to generate new product and service innovations, create new companies, enable new value propositions and business models, and introduce the new era of smart mobility, in which the focus of the automotive industry shifts from individual car ownership to a more service-centric view of personal mobility."

He went on to explain that connected-car technology is an opportunity for automakers to generate post-sale profits through sales of additional services and feature upgrades, as

CONNECTED CAR PRODUCTION BY CONNECTIVITY MODE, WORLDWIDE (THOUSANDS)						
	2015	2016	2017	2018	2019	2020
Embedded	2,174	4,914	11,097	21,394	33,928	42,949
Tethered	4,681	7,519	9,971	12,374	14,995	17,994
Total	6,855	12,433	21,068	33,768	48,923	60,943

Source: Gartner (September 2016)

well as enhance brand loyalty through a more personalized customer experience. It also will spur innovations in adjacent businesses, such as insurance, car rentals, car- and ride-sharing services, and electric vehicle charging, the company said.

"As cars become more automated, they are being equipped with an increasing array of sensing technologies, including cameras and radar systems," Hines explains. "Many automobiles will use image detection as the primary means to identify and classify objects in the vicinity of the vehicle so they can provide more sophisticated responses and even have autonomous control."

The projected growth underscores the changing automotive landscape, which is marked by a need for deeper integration of electronic content. Gartner also points out that in order to become more automated, automobiles will need 5% more embedded processing functions, year over year, from 2016 through 2020.

CHIP DEMAND RISES

Other recent statistics echo the growth Gartner projects. In another report out this fall, IC Insights underscored strength in the connected cars market with its projection for semiconductor sales to the IoT market. Although IC Insights trimmed back its overall semiconductor forecast for IoT systems, it pointed to the automotive sector as a strong point, with semiconductor sales for automotive IoT applications experiencing considerable growth in 2016, and through 2019.

Overall semiconductor sales for IoT system functions are now expected to reach $29.6 billion in 2019 compared to the previous projection of $31.1 billion in the same time period—due mainly to lower projections for smart cities applications, the researcher said.

Semiconductor sales for connected cars will see the most dramatic growth this year. For 2016, IC Insights says revenues of IoT semiconductors used in connected-cities applications are expected to rise 15% to about $11.4 billion while the connected vehicle category is projected to climb 66% to $787 million this year. ■

CARLOS M. GONZALEZ | Technology Editor

Advanced Robotic Systems: The Manufacturing Labor Force of Tomorrow

Advanced and collaborative robots are answering the call of a diminishing manufacturing labor force.

The automation industry is seeing a shift in its labor force. As many current workers get ready to retire, a younger workforce has yet to arrive to take its place. In response to this shortfall, the advanced robotic market has grown significantly. Advanced robotic systems and collaborative robots are taking center stage at a time when manufacturing industries need them the most.

LABOR WOES AND THE FUTURE OF ROBOTS

As reported by Deloitte.com and the Manufacturing Institute, the United States will face a labor shortage of 3.5 million workers in the years leading up to 2025. It is predicted that 2 million of those jobs will most likely go unfilled due to the skills gap. The current workforce is close to retirement; by 2025, 2.7 million professionals will exit the manufacturing workforce.

According to Jennifer McNelly, president of the Manufacturing Institute, the challenge will "only grow as the demographics of our workforce evolve with retirements, new technological advances requiring a higher level of training and certification, and our K-12 education system,

Baxter and Sawyer are the friendly collaborative robots, or cobots, from Rethink Robotics. They not only perform physical tasks, but are self-learning and continuous improvement equipment for the manufacturing line. *(Image courtesy of the Rethink Robotics Inc.)*

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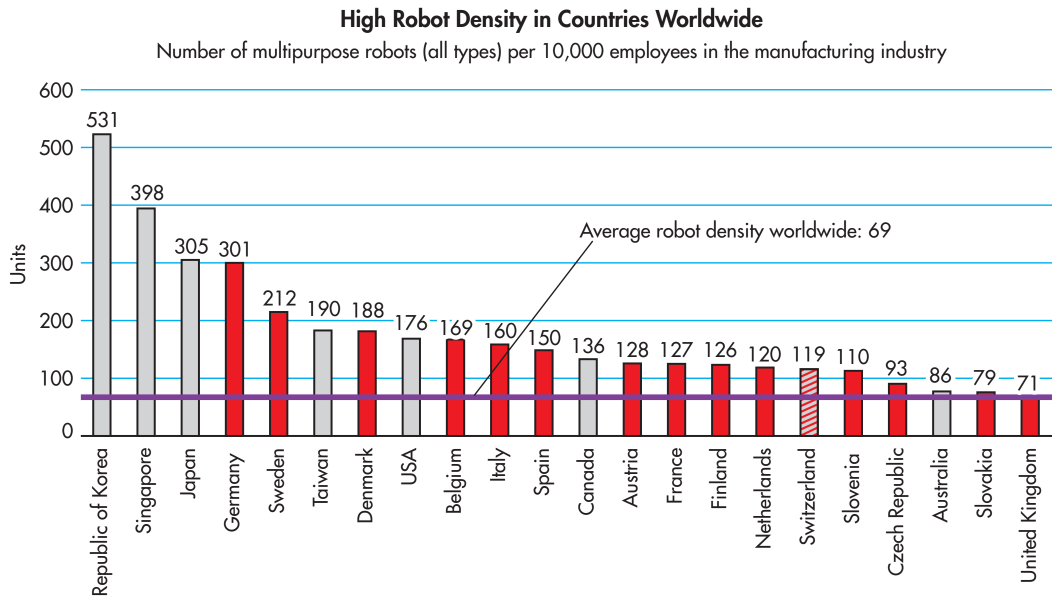

The graph above highlights the number of multipurpose industrial robots in the manufacturing industry. The leading manufacturing countries in the world are all above the average density of 69 robot units. *(Image courtesy of the International Federation of Robotics)*

which continues to lack the necessary focus on STEM education."

This future labor shortage does, however, present an opportunity for robotic systems. The use of industrial robots has been around for the last four decades. These are mostly large robotic arms programmed to lift heavy objects, weld, paint, and perform other stationary tasks. Simpler and mundane tasks (e.g., taking out the trash) are performed by manual labor. This is primarily because of the inexpensiveness of manual labor compared to buying and installing robotic systems as well as the capabilities and safety of those robots.

ROBOTS AT WORK

Advances in robotics—especially collaborative robots, robotic safety, and a faster return of investment—have increased the use of robots. According to a 2015 study from the Boston Consulting Group, the current percent of industries installing advanced robots are around 2% to 3% annually. They predict that this will increase to 10% annually by 2025.

In certain industries, the use of robots for manual labor may see a jump of 40% or more. The price of hardware and software is projected to decrease by more than 20% within the same timeframe. The performance of robots is expected to increase around 5% each year.

The study conducted by the Boston Consulting Group analyzed 21 industries in the world's 25 leading manufacturing export economies. This accounts for more than 90% of the global trade in goods. By analyzing five common robot setups for investment, cost, and performance, they developed a future industry view of more than 2,600 robot-industry-country combinations and their likelihood of adoption by the industry. Their predictions are:

- By 2025, robots will perform 25% of all labor tasks. This is due to improvements in performance and reduction in costs.
- The United States, along with Canada, Japan, South Korea, and the United Kingdom will be leading the way in robot adoption.
- The four industries leading the charge are computer and electronic products; electrical equipment and appliances; transportation equipment; and machinery. They will account for 75% of all robotic installations till 2025.
- Due to a wider adoption of robots, especially for small manufacturers, worker output will increase by 30%.
- Labor cost is expected to decrease 18% to 25% in countries like the United States, China, Germany, and Japan.
- Leading countries in robot adoption will see an improvement in national cost competitiveness. For example, South Korea will see a 6% point improvement relative to the United States by 2025 if all other factors stay the same; driving up their manufacturing output. High-cost countries like Russia and Brazil will see their relative cost competitiveness decrease.
- Manufacturing tasks will become more complex with the adoption of more robots. Low-cost laborers will be required to master new skills and work in conjunction


THE POWER OF
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with the robots in order to succeed, and to continue working in the advanced manufacturing plants.

THE RISING ROLE OF ROBOTS

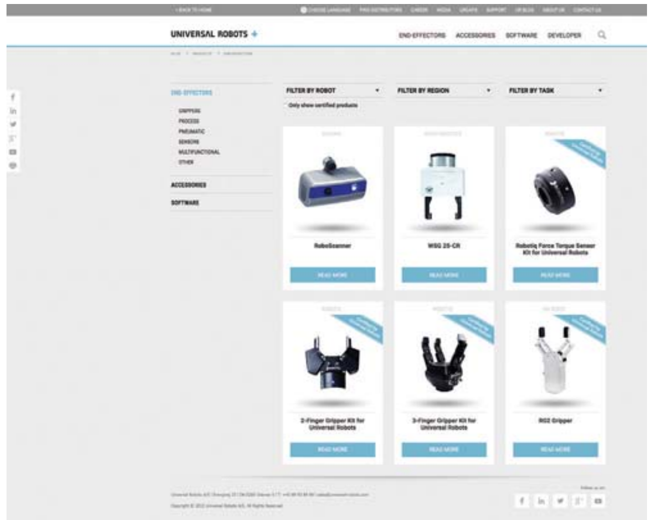
As previously mentioned, 25% of all labor tasks will be completed by robotic systems. Leading the charge are collaborative robots, or cobots. In September, the International Federation of Robotics released the World Robotics Report 2016. The report predicts that between 2017 to 2019, sales of industrial robots will increase by 13% and that human-robot collaboration will have a breakthrough period. This enables humans and robots to work side-by-side safely without fences, increasing production, efficiency, and quality.

Jim Lawton, chief product and marketing officer for Rethink Robotics, has highlighted the importance of cobots in the engineering workplace. Lawton describes two types of labor: tasks that people are well-suited for, which involves critical thinking, dexterity, flexibility, and other qualities unique to humans; and labor tasks that are menial and repetitive.

> "By 2025, robots will perform 25% of all labor tasks. This is due to improvements in performance and reduction in costs." —Boston Consulting Group

The latter category includes pick-and-place, sorting, and simple filtering jobs that—whether due to space, safety, or high cost—are performed by people rather than robots. "The person became the plug, meaning that they would take on the task of what the traditional robot could not do," says Lawton. This is where cobots come into play. "The average age of a person in manufacturing is 58 years old," he adds. The younger workers entering the market are not looking to perform these labor-intensive and menial tasks.

The benefits provided by cobots are high because they are easy to deploy, offer safe working conditions, and are easy to repurpose. Many small companies have short product lifecycles or have several tasks to be completed. In large companies, like a car manufacturing plant, robotic arms are stationary.



Universal Robots have turned their UR product line into a one-stop shop for robotic equipment. Along with purchasing a robotic arm, one can acquire end-effectors, sensors, and software to provide a complete robotic system. *(Image courtesy of Universal Robots)*

According to Lawton, 65% of all robots are used in the automotive industry.

Cobots are easy to move from job to job and reprogrammable to suit the current needs of the facility. The user can simply add more logic and use it in conjunction with IoT sensors, data, and analytics. Baxter and Sawyer from Rethink Robotics use vision systems to implement analytic learning. The improvement process is done autonomously.

The cobots' learning capabilities move manufacturing lines from a reaction to prediction. The cobots learn and manipulate the line to help production efficiency. As Lawton noted, these robots "need to be a PC with arms."

Several companies are focusing on cobots. Universal Robots has long been a collaborative robot company with

The MiR100 is an autonomous robotic assistant that can traverse any floorplan, such as a manufacturing plant or hospital floor, for the purposes of delivering goods and equipment. The cobot has built-in sensors for guidance and an access point for web-browser interface control. *(Image courtesy of MiR)*

its UR robot arm series. These robots can be used right next to the operator without the need for safety cages or light curtains. Now the firm is introducing its Universal Robots+ online store. It allows users to not only select their robot, but also end-effectors and accessories they want to use in conjunction with the robot.

Universal Robots is providing a one-stop solution with parts and accessories that are guaranteed to work with the robotic arm. An example would be the line of parts from Robotiq. The company offers end-effectors, mounted cameras, and force-torque sensors that can help detect, scan, and move a part in place.

Not all cobots are robotic arms. The MiR100 is a multipurpose, self-automated, in-house transportation unit. The benefit of this robot is its ability to transport supplies over any floor layout on its own. The cobot's present main targets are industrial sites and hospitals, both of which require transport of parts and medication.

To prepare for the new role robotics will play in manufacturing, industries need to understand the global landscape. They will need a clear understanding of the trends in robot adoption, including the price point and the performance capabilities, and how these factors will change in relation to the total cost of labor.

The MiR100 learns the plant floor by scanning the layout into the robot's computer. The cobot can plan a route now knowing the floorplan. On-board sensors help it avoid people and obstacles, and can execute a re-plan route if necessary. The MiR100 is Cat 3 performance level safe.

The MiR100 also has its own access point, which allows users to pull a web-browser interface for full access control. According to Ed Mullen, MiR's vice president of sales for North America, one can operate an entire fleet of MiR100s. They work in tandem, and specific orders can be issued to dispatch the closest robot for a task.

HOW TO INTEGRATE ROBOTIC ENHANCEMENTS

The world is getting ready to embrace robots and cobots. Jeff Burnstein, president of the Association for Advancing Automation (A3), recently testified in front of the U.S. House of Representatives' Energy and Commerce Committee about the state of advanced robotics. Burnstein spoke to the Subcommittee on Commerce, Manufacturing and Trade about how robots will be disruptive technology for many industries across the United States.

In an interview with *Machine Design*, Burnstein highlighted the automation advances of advanced robotics, including improved productivity, speed and flexibility of production, predictive maintenance, less downtime, Internet of Things (IoT) implementation with sensors, data collection, and increasing the manufacturing industry.

Burnstein also acknowledged that because of robotic automation, many companies have been able to keep manufacturing within the U.S. instead of looking abroad for production services. Last March, A3 released Technical Specification 15066 (TS15066), a guideline for cobots.

Specifically, TS15066 highlights the design of collaborative robot systems, including such important aspects as:

- Definition of a collaborative robotic system.
- Important characteristics of the safety-related control system for collaborative operation.
- Identification of factors to be considered in the design of a collaborative robot system.
- Built-in safety-related systems that can be used effectively in a collaborative operation, along with requirements for their effective use.
- Steps in implementing a collaborative application.
- Guidance on maximum allowable speeds and minimum protective distances, as well the formula for determining the protective separation distance.
- Data to help determine threshold limit values for power and force-limiting to avoid pain or discomfort on the part of the human operator.

To prepare for the new role robotics will play in manufacturing, industries need to understand the global landscape. They will need a clear understanding of the trends in robot adoption, including the price point and the performance capabilities, and how these factors will change in relation to the total cost of labor. These companies will also have to know how to benchmark the competition and be aware of how their competitors are handling robotic integration.

Companies will be required to stay current with technological advances. If a firm is considering investing in robots and see that new gripping features or flexibility, they may choose to hold off on investing until the right moment. Lastly, they will need to prep the workforce and the organization. They should also take into account how the labor force will need to change in the next decade.

Workers will be required to learn more complex tasks. Skills such as programming, automation implementation, and experience with robotic systems will become crucial. These employees will be sought out as adoption grows. Companies should also start to adapt their facilities for robotic systems. This includes upgrading existing networks (power and data) and adjusting handling and operation procedures. Organizations could also start to train their existing or incoming workforce by providing certification in future robotic systems. md

AVOIDING WORKPLACE HAZARDS THROUGH ERGONOMICS

SOME TECHNOLOGY AND robots are keeping employees in the workplace by improving productivity, reducing cost, and increasing safety. Looking at the cost of the production/cost ratio, the Bureau of Labor Statistics reported that in 2012, injuries caused by jobs that involved lifting, pushing, pulling, holding, and repetitive motions accounted for 28.4% of workplace injuries that cost $16.94 billion. These injuries and costs are driving the need for automation and robotics to reduce injury from tedious, monotonous, or dangerous jobs.

Companies such as Strong Arm are working on soft exoskeletons to promote ergonomics and reduce injuries, while ReWalk, Cyberdyne, and Lockheed Martin are a few of the companies that have designed and prototyped active or hard exoskeletons. Exoskeletons could prevent debilitating lifting injuries or help decrease rehabilitation time. In addition, standards are reducing a robot's operating speeds so it can operate safely with employees without a cage.

Called collaborative robots, companies such as Universal Robot, Fanuc, and others are removing safety cages to let workers work side-by-side with robots to help relieve stress from repetitive or tedious motions. Collaborative robots may not only reduce the cost associated with injury, but also alleviate an employee from monotonous work to focus on more complex tasks.

Meanwhile, the Industrial Internet of Things (IIoT) and modern robotics are spreading automation by offering more low-volume and flexible solutions that previously may not have made economic sense. This can help reduce the amount of workers, and time workers spend in the field or hazardous environments. For example, autonomous robots that are self-driving can roam in a set area with a sensor package. This helps keep a worker out of the way of danger while gathering valuable information.

"Also, today's U.S. workers want jobs that are more interesting, safe, and offer opportunities for advancement," says Jeff Burnstein, president of the Association for Advancing Automation (A3). "Tedious, manual jobs tend to have high turnover, which drives up costs for recruiting and training, while workers who stay in those positions can drag down productivity with low morale. Robots are the ideal replacement for these repetitive, low-wage positions, and allow companies to move employees into more appealing, career-oriented positions." *—Jeff Kerns*

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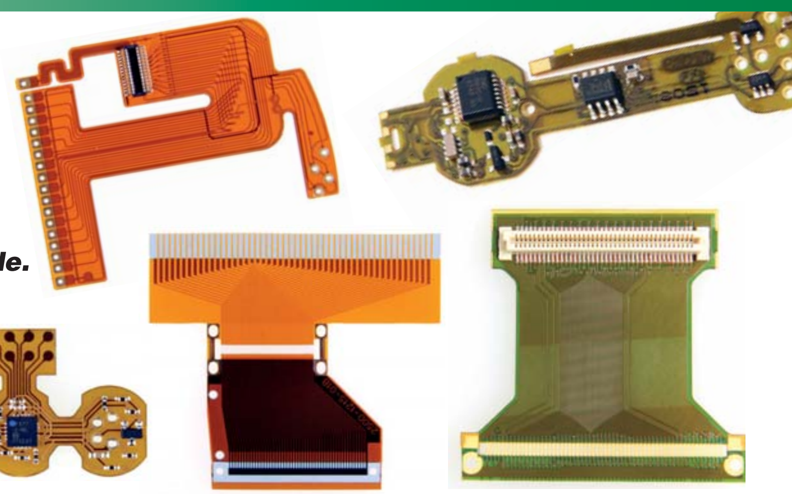

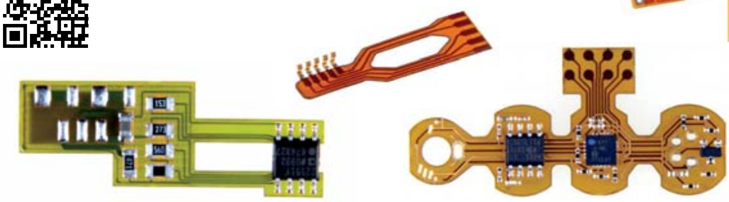

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PETER NACHTWEY | Delta Computer Systems, Inc.

Tips for Smooth, Precise Hydraulic Motion Control

Learn how to control hydraulic motion systems by adjusting second derivative gain.

Controlling hydraulic motion with precision involves understanding the fundamental difference between servo motors and hydraulic actuators. Electric motors generally respond linearly to control inputs and can be referred to as "first-order systems." Simple PI and PID control algorithms can provide precise control of first-order systems, and typical electronic motion controllers or even PLCs implementing simple P, PI, or PID algorithms can easily handle the task.

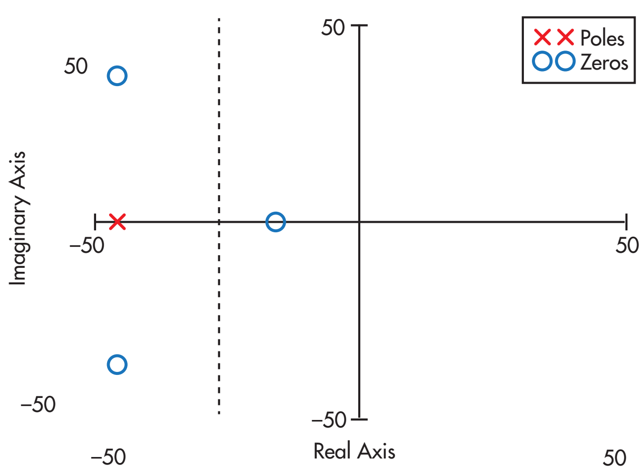
Some hydraulic systems, on the other hand, must deal with the effects of the compressibility of the hydraulic fluid medium, which can be modeled as a mass between two springs, where the piston and the load are the mass and the oil on either side of the piston is the springs. With such systems, simple P only, PI or PID controls often exhibit performance limitations due to the natural frequency and damping factor of the hydraulic/mechanical design. For such systems, called "second-order systems," algorithms that employ second derivative gains are often needed.

PLACING POLES AND ZEROS

The technical rationale for these conclusions can be explained using traditional control theory. Control engineers plot poles and zero points on a two-dimensional plane, called the s-plane, according to the behavior of the system's transfer function (the function representing the relationship between the control outputs of a system to its inputs). In a physical system, poles are caused by devices that store energy. A motor-driven system has one pole in the open-loop velocity-transfer function, because kinetic energy is stored in the motor and load. A hydraulic system has two poles, with one pole corresponding to kinetic energy being stored in the piston, rod, and load and a second pole corresponding to the potential energy of the oil under pressure. Oscillations in hydraulic systems are due to energy being transferred back and forth between kinetic energy and potential energy.

It should be noted that when integrating a velocity-transfer function into a position-transfer function (meaning that both velocity and position of the actuator are being controlled), an extra integrator is added to the open-loop system. And yet another pole is added when using the integrator gain in an electrohydraulic motion controller.

PID with 2nd Derivative Gain Poles and Zeros



The four closed-loop poles using PID control plus a second derivative gain (two poles overlap) can be moved to the left to avoid oscillations and increase the operating frequency of the system.

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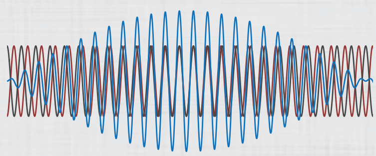

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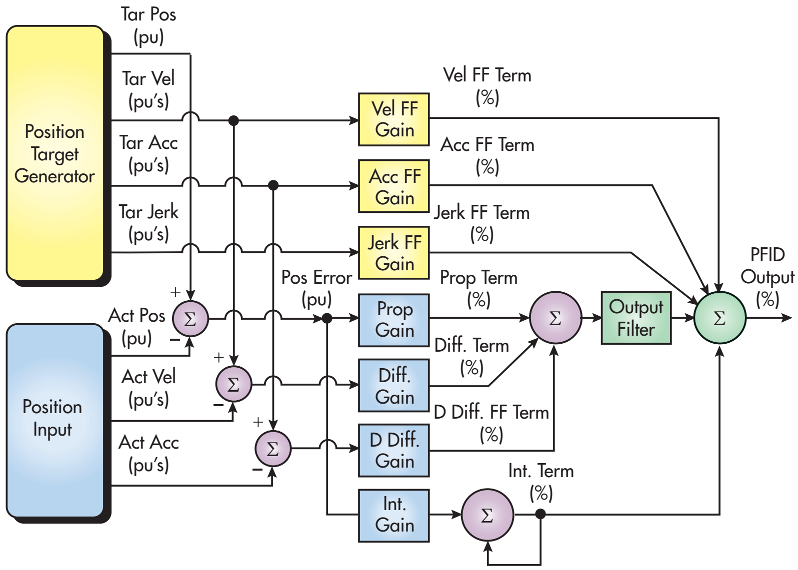


The closed-loop control diagram of a second-order system, incorporating a second derivative gain (D Diff. Gain) along with feed-forward gains for velocity, acceleration, and jerk.

For optimal control, the closed-loop control algorithm implemented by the motion controller should include one gain term for every pole in the closed-loop system. The positions of the closed-loop poles on the plot determine how fast the error between the target and actual motion will approach zero. Providing adequate damping to ensure that the system does not oscillate involves placing poles on the s-plane's negative axis and as far away from zero as possible. Because of the relative simplicity of the transfer functions that govern PID or PI control, there are limitations in setting the parameter gains to specify where the poles can be safely placed.

If the hydraulic system is relatively stiff, simple PID control may provide adequate system performance and stability. On the other hand, some of the more challenging hydraulic systems are underdamped (i.e., could be prone to oscillations) and it is impossible to control the motion by adjusting PID gains alone, even by applying predictive elements such as feed-forward gains. For these systems, a higher-order derivative

gain often needs to be added to provide necessary electronic damping. For control engineers, adding a second-derivative control term to the transfer function allows placing the system poles at any desired location on the s-plane. This enables the engineer to get around any stability and performance limitations due to the system's hydraulic and mechanical design.

When four gains are used, which correspond to an integrator, proportional, derivative, and second-derivative gain in the control-loop equation, it is possible to place the closed-loop system poles just about anywhere within reason, but the goal is to move them to the left half of the s-plane and keep them close to the negative real axis to minimize oscillations.

DESIGN CHALLENGES

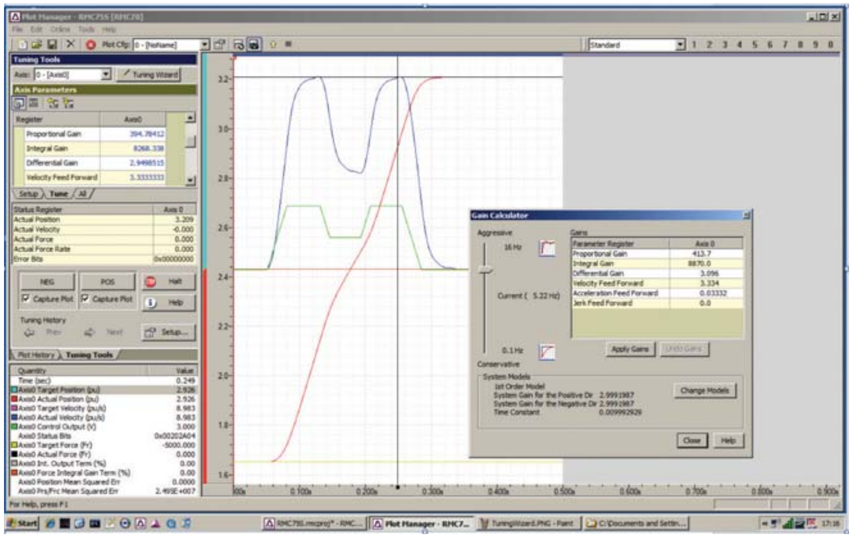
There are some design challenges to overcome when using the second-derivative gain term in the closed-loop algorithm, however. One is the need to have smooth motion profiles where the jerk (i.e., the rate of change of the acceleration) changes smoothly in order to set the value of the jerk feed forward. (Feed forwards are predictive terms that are added to the control-loop equation to help the actual motion profile converge more quickly on the target motion than can be accomplished by the P, I, D, and second-order D terms alone.)

Another design challenge is that some system conditions can make using the double derivative gain problematic. For example, if the feedback lacks precision or there is sampling jitter or noise in the feedback signal, undesired and unpredictable fluctuations in the measured system acceleration can occur. The system designer should select transducers and wire the system so as to minimize these problems.

A third challenge is how to tune a second-order system; there are several ways this can be done. One way is by creating a mathematical model of the system to be controlled and then computing what the controller gains need to be in order to properly control the system.

How do you get the information to use in constructing system models? The more common approach is to create the model from the information available for the different parts in the system and how they are put together. This math-intensive method requires a very experienced control person to accomplish. It usually requires having good specifications for most if not all of the components. The component information is often hard to obtain because manufacturers do not usually supply all the information that is necessary. Therefore, the values of key system parameters are typically not calculated during the system design process. Calculating or estimating a system's natural frequency and damping factor is complex and can only be estimated empirically.

A much easier way to get a model is to do system identification. This involves exciting the real system (or a simulated one) with a step change in the control signal to the valve and recording how the system responds to the control input. The



An example of an automated tuning tool is the Tuning Wizard, provided by Delta Computer Systems for use with its RMC product family. The Tuning Wizard, using plots of the motion of system generated by Delta's Plot Manager in the RMCTools software, generates a mathematical model of the system. The Gain Calculator then computes and the user positions a slider bar to pick from a range of appropriate gain combinations for the system. The Gain Calculator stays open, making it easy to move the motion axis back-and-forth to try out various sets of gains.

model constants are modified using trial and error until the model's response mimics the actual system's response. There are functions and mathematical techniques that can quickly find the best values for the model in order to minimize the error between the model and the actual system.

USING A TUNING TOOL

A still easier and more modern way to set the controller gains is to use a motion controller that is supported by an automated system identification and tuning tool provided by the controller manufacturer. An example of this method is to use plots of the motion of the system being tuned to generate a mathematical model of the system. Then, based on the model, the software tool picks a range of appropriate gain combinations for the system. If a certain set of gains is not acceptable (e.g., the system responds too quickly or not quickly enough), the user can adjust the model to calculate a new set of gains.

CONCLUSION

In short, the second derivative gain allows the limitations due to hydraulic and mechanical design to be overcome. If the hydraulic motion controller being used for a particular application is only capable of implementing a simple PID control algorithm for closed-loop control, the response or bandwidth of the system will be limited by the system's damping factor and natural frequency.

While increasing the system's natural frequency can be accomplished by increasing the diameter of the cylinder, this can result in extra costs for a bigger valve and a more capable hydraulic power unit in addition to the extra cost of the cylinder. Increasing the damping factor can be accomplished by adding friction or leakage to the system. Both of these steps increase operating costs and waste energy. It is far more efficient to select a motion controller that can provide second-order control, compensating for most limitations of the physical design. md

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How to Pick and Install the Correct Pneumatic Actuator

Contemplating an actuator for your pneumatic linear-motion system? Here are some tips on how to select the best one for the job.

Many industrial applications require practical and complex linear-motion systems during daily operation. No matter how complicated the system, its cost and practicality are two of the most important aspects to consider when looking at pneumatic systems and actuators. Pneumatic actuators, commonly referred to simply as air cylinders, help transfer power to useful output systems to conduct a variety of tasks.

ACTUATOR STYLE: ROD VS. RODLESS

There are two basic types of pneumatic actuator: rod and rodless style. Though rod-style actuators are the most common, many of the same selection criteria pertain to both. Rod-style actuators come in several design types and standards, which can be important to the user because the envelope dimension of a cylinder is typically consistent throughout. Most cylinder designs will adhere to a standard set forth by organizations such as the National Fluid Power Association (NFPA) or International Standards Organization (ISO).

These compact-style actuators can be beneficial when space limitations become a main concern.

Rod-style actuators include:

- Round repairable – No design standard
- Round non-repairable – No design standard
- Round design – Metric ISO, repairable
- Compact design – Metric ISO/non-ISO, repairable
- Tie-rod design – NFPA interchangeable industrial type, inch and non-NFPA, repairable
- Tie-rod design – Non-NFPA, repairable
- Tie-rod design – Metric ISO, repairable
- Profile design – Metric ISO, repairable
- Round design – Metric ISO, repairable
- Slide and gantry design

Rodless-type actuators are also available in different design styles. A large benefit of the rodless-type actuator is that it saves up to 50% of weight and space when compared with the rod style. The downside to rodless-style actuators is that they are limited when it comes to mounting.

Rodless-style actuators include:

- Single profile barrel and cartridge design – Inch and metric
- Single profile barrel and cartridge with external bearing rail design – Inch and metric
- Magnetically coupled single barrel design – Metric
- Magnetically coupled external guide design – Metric

Several important factors should be taken into account when selecting the correct actuator for the application. Once the designer completes the application assessment, selecting the proper cylinder is much easier as the actuator successfully performs its intended functions. Most cylinder manufacturers

offer online configurators that can assist in the selection process. However, inputting the proper information is something that should be considered because of how the cylinder is sized.

SELECTING A CYLINDER

It is necessary to know the following design parameters before selecting a cylinder. This checklist presents considerations to weigh when contemplating an actuator:

- Analyze the application
  - *Will this be cylinder be new or replacement? If replacing, why did the actuator fail?*
- Force required
  - *How much force will be required for extension and retraction?*
- Actuator stroke
- Actuator speed
- Are there space constraints?
  - *If yes, it might be a good idea to consider compact rodless actuators.*
- Air pressure available
  - *It is advisable not to size the actuator based on the pressure provided, but 85%-90% of that value is a safety factor.*
- Mounting angle of actuator
- Mounting style
  - *Fixed or pivot?*
  - *Once that is determined, the appropriate mounting can be selected.*
- Required life of the actuator
  - *Repairable vs. non-repairable*
- Will cushions or bumpers be required?
  - *This is based on the load and speed that the actuator will encounter.*
- Is the actuator subject to side load?
  - *If yes, how much force is the side loading?*
- Long-stroke actuators may require internal "stop tube" or trunnion mounting that provides additional bearing support.
- Environment
  - *Special paint or stainless-steel construction may be required.*
- Sensing piston-rod position (head, cap end, or both; entire piston travel); the actuator will need to be manufactured with a magnetic ring on the piston.
- Are multiple fixed positions needed?
  - *If yes, multiple fixed positions can be obtained.*

If you are the application designer or maintenance person responsible for sizing, selecting, or replacing the actuator, then answers to these questions will ensure the correct actuator is selected for the application. If it is simply an actuator replacement, then the question that needs to be asked is: "Did the actuator provide reasonable life for the particular application, or did it require service or replacement sooner than expected?"

Rod-style actuators, like the one seen above, are the most common type of actuator. They come in many standard configurations.

If reasonable life was achieved, then a simple repair or like replacement based on cost should continue to be successful. However, if the actuator is not delivering the life expectancy, then it is probably the wrong actuator for the application.

A worn cylinder can provide information as to a possible cause of failure. For example, a warn rod bearing on one side or broken rod end threads would indicate side loading. Therefore, a different mounting style or guided actuator would be a more appropriate solution.

Proper filtration should be used to maximize seal life. When using inline lubricators, make sure the oil is compatible with the seal material. Keep in mind that some synthetic oils are not compatible, so mineral-based oil should be considered.

Many designers are looking for lighter-weight actuators than heavy steel-constructed actuators. If that is the case, an aluminum profile actuator is a good alternative, as it can still operate in demanding applications.

Properly adjusted cushions at the head (rod end) and cap (blind end) can extend the life of not only the actuator, but also the machine framework, by reducing shock in demanding applications where speed and load are a major factor. Manufacturers have computer programs that can aid in determining if the internal cushions are adequate to dissipate the energy, and if not, it may require mounting shock absorbers on the machine frame.

Long-stroke actuators that require pivot mounting should consider either intermediate trunnion mounts that can be positioned anywhere along the actuator's barrel, or head trunnion mounts to shorten the fulcrum point of the actuator mount and the load attached to the end of the rod. Some long-stroke applications may need a trunnion mount as well as an internal stop tube for additional internal bearing support.

BENEFIT SUMMARY

Rodless actuators offer a reduced weight and smaller overall profile compared to the rod-style actuator. The rodless-style actuator has the added benefit of guide bearing to counteract offset loads. A disadvantage would be the fixed mounting or lack of pivot. However, with some modification, its mounting plate could be made to pivot.

Most rodless cylinders, regardless of manufacture, have a slight leak path due to the piston/cartridge assembly. As a result, they are not the best for load holding applications. Air-bellow actuators are a good option for applications that require a low profile plus high force capability with the ability to arc to the required position.

Air actuators can be a cost-effective way to achieve the desired force or work, with the key being proper sizing and reducing the air pressure required to perform that work. Often times, only one direction of travel is performing the work and the return direction is idle. Therefore, dual pressure adds to the efficiency of the system. md

Rodless actuators offer the benefits of reduced weight and a smaller profile. They also have the ability to counteract offset loads.

JAMES STROUD | Global Product Manager, Southco, Concordville, PA
www.southco.com

How to Get the Best Rotary Latches

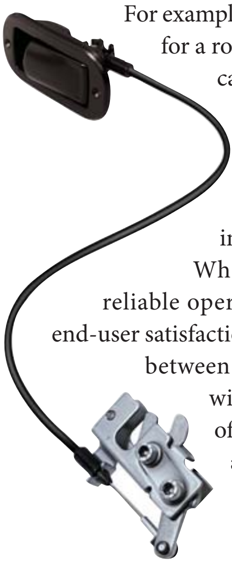
There are only three main components to a rotary latching system, but understanding each of them—and how they work together—is key to a successful latch.

In any mechanical system, the best components will only deliver optimum performance if they are designed to work together and are properly connected. Nowhere is this better exemplified than in the area of rotary latches.

Rotary latches provide an effective and reliable means of remotely opening interior and exterior doors, compartments, hoods, and other compartments. They combine security with push-to-close convenience.

Typically, a rotary latching system consists of three main elements: the rotary latch itself, the actuator (the interface with user), and the cable which connects these two components. For example, one of the most common everyday uses for a rotary latch is to remotely open the hood of car. In that application, a mechanical lever (the actuator) is activated from the driver's seat. It connects via a routed cable to the latch in the hood. By pulling the lever, the rotary latch is triggered, allowing the hood to be opened remotely.

What ultimately governs the effective and reliable operation, maintenance requirements, and end-user satisfaction of the latch is the level of compatibility between these three elements. Any compromise will ultimately result in poor performance of the latch. Therefore, with several options available, the design engineer should choose all latch elements from a proven supplier whenever possible.



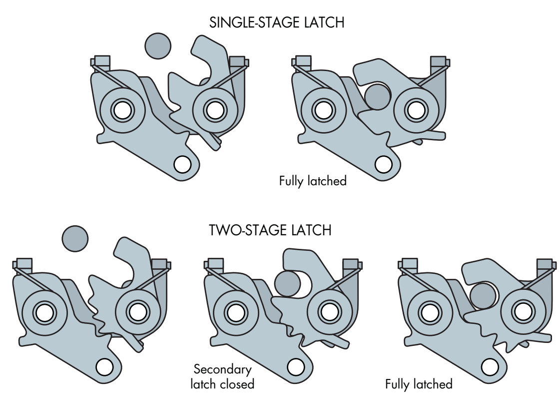
A rotary latch system consists of an actuator, the black plastic lever a person uses to activate the latch in the system shown, the cable that connects the actuator to the latch, and the latch itself.

THE LATCH

Choosing the appropriate rotary latch is crucial because it acts as the heart of the system. The primary deciding factor in any application should be based on the size or strength of the latch required. For example, it might take a stronger latch to open doors on a large piece of off-highway equipment, whereas a light-duty, compact latch would be well suited for opening hidden storage compartments on a luxury yacht.

Rotary latches come in a variety of sizes and strengths and can meet most application's needs.

Another consideration when choosing the latch is deciding whether the application is best served by a single or two-stage latch. A two-stage latch is recommended if greater assurance the possibility of "false" latching is required, and prevents the possibility of a door accidentally opening or not completely closing. One of the most common examples of this are the latches in car doors. Even if a car door isn't closed all the way, it still latches and won't open, but it's still not completely closed and will rattle and vibrate. It takes an extra push to ensure the latch is completely engaged and the door is securely closed.



Single-state rotary latches provide a secure way of simply closing a door or panel. Two-stage latches provide increased security by adding secondary latching position which helps prevent false latching.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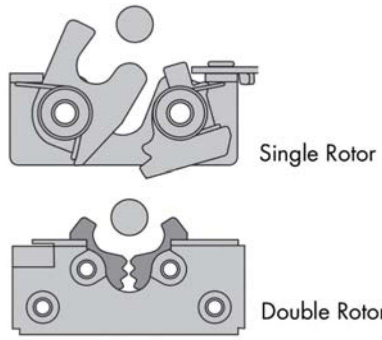
There are also a variety of latch options available that offer differing performance attributes. The choice will always to some extent be determined by whether the latch is to be used on a rigid or a flexible panel. Beyond that, some latches systems offer multiple triggering options, letting the rotary latch be easily configured and mounted without having to change the overall design of the application.

Another important feature to consider when choosing a rotary latch is whether a single or double rotor is required. Most rotary latches are single rotor, with only one rotor engaging the striker. Double rotor latches however, tolerate misalignments and offer even greater strength than single rotor versions, allowing them to withstand higher working loads. Additionally, rotary solutions can have a built-in bumper that traps the striker between a rubber bumper and the rotor. This eliminates noise and vibration caused by normal operation.



Double latch rotors tolerate a greater level of misalignment and offer greater strength than single-latch rotors, letting the double-rotor version withstand higher workloads.

Rotary latches with multiple triggering options, such as this R410 Dual Trigger series from Southco, give designers several points of actuation, allowing the latch to be triggered by two independent actuators.

THE ACTUATOR

As the only visible part of the mechanism, actuators serve as a "touchpoint" or interface between users and the latching mechanism. Although the actuator's functionality is undeniably important, the overall "feel" of it can create a powerful impression on users.

Depending on the needs of the application, the actuator also provides enhanced strength and security, as well as good ergonomic design.

Selecting the appropriate actuator generally depends on whether it will be used inside or outside the application. For interior applications, finger pull/paddle actuators or push buttons are most commonly used, as they provide a flush surface. Another popular option is a simple, economical T-handle, which allows for an increased level of ergonomics in triggering the system.

Actuators can be made of a broad variety of materials, including plastics and zinc or aluminum die cast. Plastics are the most economical choice, but zinc or aluminum may be preferred due to strength considerations and the perceived quality of a metal product.

For exterior actuation, other specification considerations come into play. These include the desired level of security, the need for a larger design to accommodate gloved hands, and available corrosion-resistant materials. The choice for actuators is also broad, ranging from flush, surface-mount, and push handles to push buttons. Almost all types of actuators can include multiple key code options.

For enhanced security in applications highly prone to theft or vandalism (such as construction equipment left overnight on a job site), designers can choose an electromechanical access device—e.g., a key fob connected to an internal electronic actuator. The key advantage provided by electromechanical devices is their ability to remotely

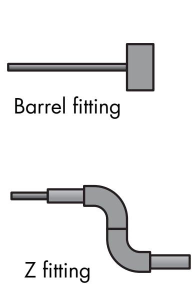
Depending on the needs of the application, the actuator also provides enhanced strength and security, as well as good ergonomic design.

control and monitor user credentials. They can also create a digital record of access; this can be used to demonstrate compliance with industry-accredited associations, similar to what CESAR, a UK-based organization, does for Datatag security markings.

THE CABLE

The cable should effectively transfer the mechanical input from the operator via the actuator to the rotary latch, allowing it to open as quickly and safely as possible. Engineers generally face a choice between bare and coated cables, which are commonly used in "line of sight" applications, such as where the actuation point needs to be located in an area separate from the actual rotary latch. For example, on an RV, there may be a need to install several, fairly wide panels down the side of the vehicle for storage. In this case, the actuator would be designed into the center of the panel for ergonomic advantage, while the rotary latches would be located on each edge of the panel to ensure secure closure against the frame.

Actuators, the parts people use to activate the latch, come in a variety of styles. Cable actuators often provide a convenient hand grips for opening the door or panel. Hidden electronic actuators can be triggered by a smartphone or keycard to pop open a door or panel.



Cables can connect to the latch with one of several possible end styles—one or more of which should suit the application. They include barrel, L, ball, Z, eyelet, and threaded fittings.

Many manufacturers offer a range of cable end fittings—barrel, L, Z, eyelet, ball fitting, and bare cable are among the most common.

Cables are usually coated with vinyl, which improves aesthetics and protects the cable itself. The cable should ideally be stainless steel, which combines corrosion resistance with strength and minimal stretch even after thousands of cycles. An acetal liner, which is integrated into the jacketed cable, lets it move and flex inside the jacket without wearing through during high cycle use. This ensures the cable runs smoothly and can turn through a bulkhead or around a curve.

End fitting options offer a high degree of flexibility and enables rotary systems to be easily added into existing designs where there may already be an actuator in place. Many manufacturers offer a range of cable end fittings—barrel, L, Z, eyelet, ball fitting, and bare cable are among the most common.

Barrel fittings are compact and easily attach to any actuator, while ball fittings can be attached to actuators as well as rotary latches. L fittings are designed specifically for rotary latches and must to be used with a retaining clip, which eliminates metal-on-metal contact. Z fittings, on the other hand, can be used without a retaining clip, but they do not offer a high level of vibration resistance. The eyelet fitting is designed to accommodate round hardware such as a cylindrical mounting pin. for applications where the cable will be threaded through a hole and have a set screw to tighten down on, bare cable is often the best option. md

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How to Pinpoint the Best Plain Bearing

Though "plain bearing" may sound simplistic, the name belies its complexity. Pay attention to these key factors when selecting a bearing.

Where there are moving parts, you'll often find bearings. The goal of a bearing, in short, is to affect the system as minimally as possible—absorb minimal energy, wear slowly, and cost as little as possible. Bearings come in many flavors. This article will focus on plain bearings, and five factors that will play a role in selecting the right one for an application.

The plain bearing has many names; often engineers will use plain, journal, sleeve, bushing, and slide bearings interchangeably. These types of bearings can be as simple as a tube of relatively soft material pressed into a hole as a guidepost, or used as a caster bearing (a metal sleeve with a wheel or ball inserted).

Processing will affect cost and must be considered during bearing selection. A flange may not sound complex, but it changes processing and therefore will affect cost. This is a benefit for different materials. Plastic, for example, can be relatively easy to process.

Sleeve-type bearings, which typically work in a rotating or sliding shaft application, are commonly known for linear motion almost as much as rotary motion, according to *Thomasnet.com*, a product sourcing and supplier platform. These bearings come in two types: a cylinder that mounts flush and only handles rotary loads, and a "flanged bearing" that helps a flange with axial loads.

Simply adding a feature, such as a flange, to your design can inflate cost. However, not adding a needed feature could lead to failure. That said, the first step to pinpointing the right plain bearing is to evaluate how and where it's used.

WHAT IS THE APPLICATION?

"The selection of journal bearings always begins with a thorough evaluation of the intended usage of the device containing the bearings," says Gary Rosengren, director of engineering at Tolomatic Inc., a company that must select the right journal bearing for its electric actuators. "Proper selections include an evaluation of environmental factors such as aggressive chemicals, contamination, high or low operating temperatures, and/or wash-down requirements that may be present in food and beverage applications. Each application will suggest specific materials for optimal performance. Further application evaluation should focus on the type of loading the journal bearing will be subjected to. High rotational speeds, high linear velocities, or the presence of impact loading will also have an influence on the materials used for journal bearings."

For example, high-speed applications such as centrifugal pumps, turbines, and compressor applications typically will not use ball bearings above 3600 rpm. This is one of the reasons why high-speed precision rotary equipment in the gas and oil industry uses plain bearings.

"After I have a conversation about how a bearing is going to be used, then I get into speeds, loads, tolerances, clearances, etc." says Nicole Lang, product manager at igus, a plain bearing manufacturer. "A particular importance in all applications is the relationship between pressure and velocity (pV)."

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KNOW YOUR PV VALUE

The pV value—the pressure (p) multiplied by the speed of operation (V)—measures the ability of the bearing material to accommodate the temperature limit generated by the frictional energy during operation. The pV value alone is only one-half of what is needed to achieve a stable temperature limit. Therefore, the solution pV will be multiplied by two for a design pV value before comparing with a material's pV rating. Pressure is expressed as:

$p = F/LD$

where F = load/force; L = length; and D = diameter of journal.

The journal is the area of the shaft that operates inside the bearing. Journal speed would multiply pi with the given speed of the shaft (n) and the estimated diameter (D) divided by 60,000:

$V = \pi Dn/(60{,}000)$

"Plain bearings are rated at different speeds depending on which kind of material they are using, says Lang. "For iglide [Ed. note: an igus product line of plastic bearings] we will calculate speeds differently—in feet per minute not rpm. For example, a ½-in. bearing traveling at 2000 rpm is 262 fpm; the same bearing with a ¼-in. inner diameter traveling at 2000 rpm is 131 fpm. This can determine an accurate lifetime for bearings and can be convenient when you are working with many sizes of bearings."

> "Typically, for our plastic bearings, a running clearance will be around 0.002 to 0.004 inches. Housing bore and shaft tolerance will also have to be considered, and it is possible to have tighter clearances."
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After solving for bearing pressure and velocity, they are multiplied together to obtain the pV factor. Materials with a rating above the doubled pV factor—known as the design pV value—are applicable.

Bearing diameter is often limited by stress and deflection, so the length is specified to provide a suitable bearing pressure. A trial diameter is selected that will then determine a trial length based on a desired length-to-diameter (L/D) ratio. For a full-film hydrodynamic bearing (explained later in this article), a common range for a length-to-diameter ratio is 0.35 to 1.5.

While this basic pV value can reveal the applicability of certain materials, it is important to consider different conditions, or understand different conditions that might alter design. For example, if the material's pV rating is close to the calculated design pV value, thermal expansion of the selected materials will become increasingly important.

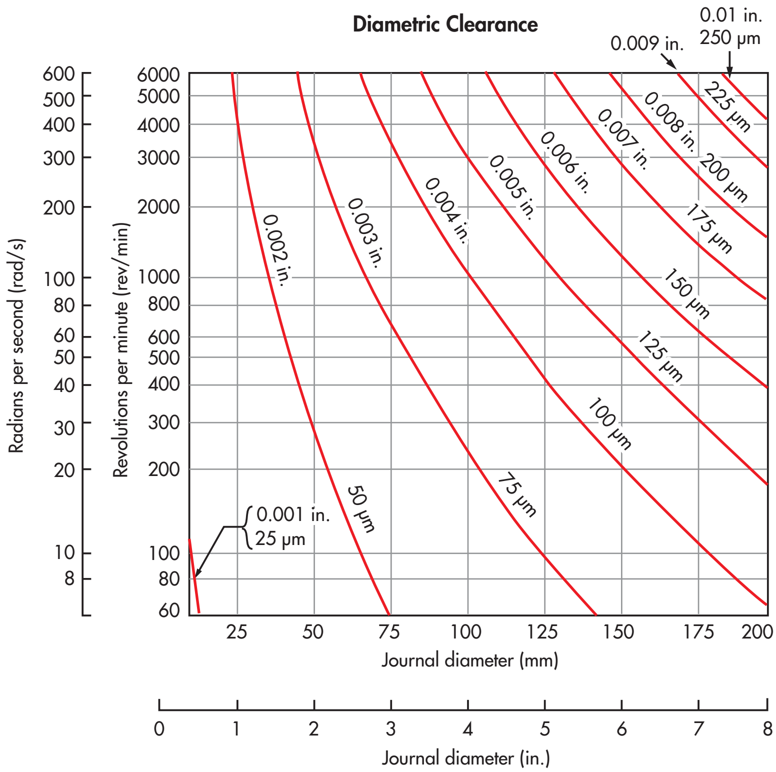
KNOW YOUR DIAMETRAL CLEARANCE

The coefficient of thermal expansion, precision of the machine, rotation speed, and the shaft's surface roughness all play a part to ensure the diametral clearance is satisfactory during operation. The minimum diametric clearance can be found from charts, or calculations.

"Typically, for our plastic bearings, a running clearance will be around 0.002 to 0.004 inches," says Lang. "Housing bore and shaft tolerance will also have to be considered, and it is possible to have tighter clearances."

Another guideline, referenced in *Machine Elements in Mechanical Design* by Robert L. Mott, is that clearance can be 0.001 to 0.002 times the bearing's diameter. Engineers might also want to ask about how swelling will affect clearances in plastic bearings in humid or underwater applications.

With the information gathered thus far, it is probably a good time to look for bearing manufacturers to talk about



This chart was originally published in the Plain Bearing Design Handbook in 1983, but is still a great resource today.

your application. Some online manufacturers offer online calculators that might suggest a material or even a product. However, with application information, a pV factor, and diametral clearance, you have enough information to start a conversation with someone in the field. Speaking with manufacturers will help inform you of new materials, and other material properties that are not covered, or only briefly covered, in this article. After considering the application and basic properties, the focus can shift to the material.

MATERIALS

In general, journal bearings are considered a sacrificial material, which means the material will be softer than the shaft. In addition, contamination can increase wear on a shaft. If the lubrication is insufficient in clearing contaminants, or it is a dry bearing application, having the contamination become embedded into a softer material can minimize wear. However, the softer the material, the more load and speed become a concern.

Babbitt material, named after metalsmith Isaac Babbitt, is a soft alloy normally made from lead or tin. Able to blend with other metals, such as copper, it is possible to tailor Babbitt materials for a specific application. Greater softness of a given material generally means that it will be more effective in terms of embeddability. Unfortunately, it also typically means the material has lower strength. Babbitt materials are often used as liners for steel or cast-iron housings, and are regularly used in engines for crankshafts.

Bronze is a blend, like Babbitt material. While metals like zinc and lead are added to reduce hardness, tin and aluminum can be added to improve the strength and hardness. Aluminum works well in pumps and aircraft applications, but due to poor embeddability, it needs to have continuous lubrication. Zinc is able to run without a continuous supply of lubrication—bearing grease is often used. While zinc protects well, it isn't very effective in corrosive environments like salt or sea water. Overall, bronze will handle loads from around 25,000 to 40,000 psi in oscillating, or rotary, applications.

Load and speed will be the main determining factors in material selection, particularly for Babbitt and bronze. For example, a Babbitted sleeve bearing with a 1-in. diameter, operating at 200 rpm, will have a load rating of 270 lbs. Under the same conditions, a bronze sleeve bearing is rated at 470 lbs.

Other considerations for materials are corrosive or wash-down environments. *Plastics* and *composite* bearings have advanced to the point where they often are a good solution for these types of environments. It can be difficult to characterize plastic and composite

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bearings due to blends, fillers, and reinforcing matrix materials. Different blends are able to perform well in corrosive, humid, and even in underwater applications.

Another benefit of plastic bearings is their higher modulus of elasticity that works well for vibration damping and shock loads. While strength is a concern, plastics can handle surface pressure of a few thousand psi with relative ease. "There are a few plastics that can handle over 20,000 psi," says igus' Lang. "Metal-backed bearings can even handle upwards of 29,000 psi, but generally plastic will be used in applications under 20,000 psi."

"A big benefit to using plastic bearings is that the fiber-reinforced material blends are tailored to specific application requirements, helping bearings stand up to shock and edge loads," continues Lang. "In addition, swapping metallic plastic bushings to composite plastic bushings can reduce weight by 25% or more."

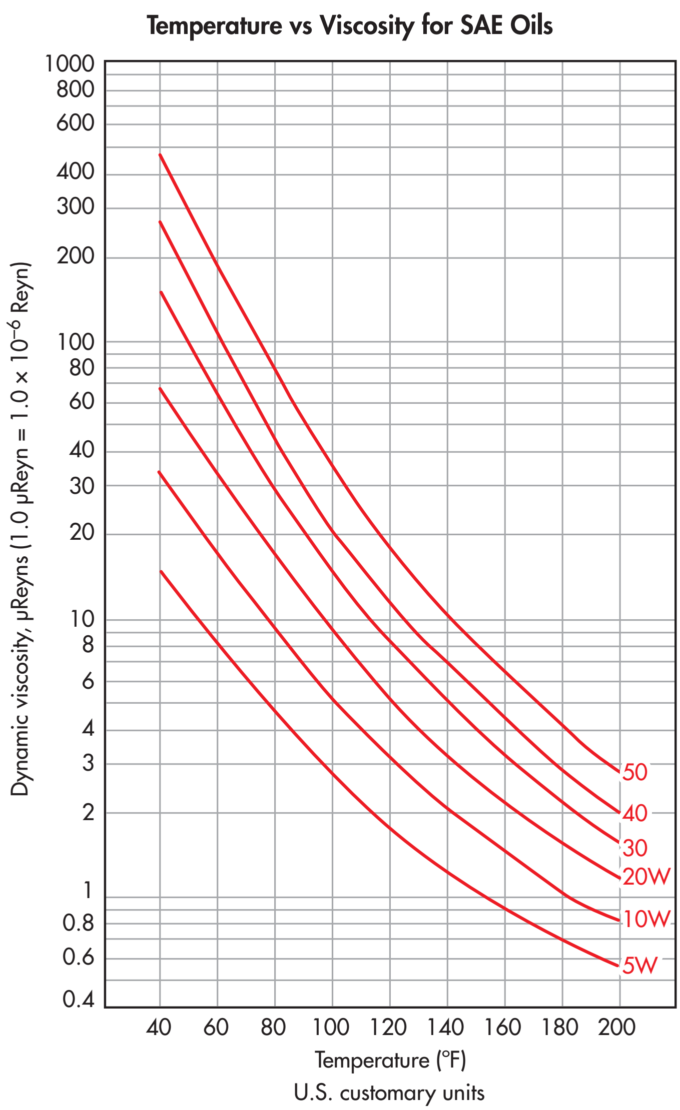
Plastics are generally cost-effective, easy to process, and can offer pre-impregnated (prepreg) polymers. Prepreg bronze bearings are also available and draw oil from the bearing as it warms up. At low speeds, or during a cold start, the prepreg oil may have dried or solidified. This increases coefficient of friction and wear during startup. Some plastics such as fluoropolymers offer a low coefficient of friction (0.05 to 0.15) and wear resistance without oil.

Like plastic, metal bearings can offer custom blends and prepreg options when using a *powdered-metallurgy* (PM) process. PM offers easy custom alloying and good dimensional tolerances. Lubrication is key in journal bearings. Many applications that don't use prepreg options employ *hydrodynamic lubrication*, whereby the shaft will ride on a layer of continuously flowing lubricant. Often speeds at least above a few hundred rpm are needed to pump oil and contaminants through the bearing.

LUBRICATION

One of the disadvantages of some plain bearings is the need for a continuous supply of lubricant. This could entail a pump, controls, piping, and other components that increase cost and complexity. *Hydrostatic* bearings offer an alternative with non-flowing lubrication that is often pressurized and held in with seals.

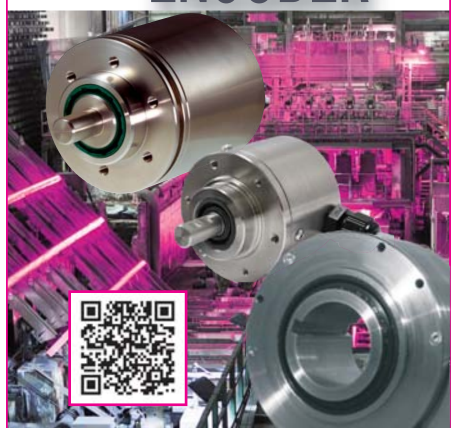
With the high levels of friction and temperature associated with journal bearings, hydrodynamic lubricant systems are able to control temperature of the lubricant, bearing, and shaft (some systems may include a heat exchanger or chiller for the oil). While hydrodynamic lubrication is common, the application and load is important. If the machine will experience a lot of starting and stopping, it's important to keep in mind that the shaft will rest on the bearing when stopped.



Operating temperature must be calculated into the viscosity to ensure proper lubrication and minimum film thickness.

Kinetic coefficient of friction between the materials will affect wear during startup.

Petroleum oils are often designed to operate around, or under, 160°F to combat oxidation. However, one of the biggest reasons for temperature control of lubricants concerns viscosity. *Dynamic viscosity* is imperative to bearing performance, and it changes with temperature. Viscosity is expressed in lb*s/in.[2] (knows as a Reyn, named after Osborne Reynold for his significant work in fluid flow) or Pa*s in SI units. Some engineers will express it in centipoise.



$1.0\ lb^*s/in^2 = 6895\ Pa^*s$
$1.0\ Pa^*s = 1000$ centipoise

The shaft's surface roughness, and the minimum film thickness, will also affect lubrication. An average *surface roughness* of 16 to 32 microinches is acceptable for good bearing quality. In general, the bearing's surface roughness should match the shaft. However, if the bearing material is softer than the shaft, the shaft will "wear in" the bearing. With some materials, especially plastic, this may be beneficial. The particles of the bearing that are ground off can fill valleys in the journal; essentially making the shaft smoother over time.

Hydrodynamic lubricated bearings are designed with a *minimum film thickness* that is affected by the surface roughness of the shaft. During standard operating conditions, the film of lubricant must ensure that no solid contact exists between the rotating shaft and bearing. Generally, a reduced surface roughness on the journal will reduce the minimum film thickness. However, the calculation for minimum film thickness does not account for the surface roughness. For ground journals, a common calculation only considers the journal's diameter:

$$h_o = 0.00025D$$

where D = journal diameter.

If anything during operation affects this minimum thickness, asperities on the journal and bearing will start to make contact and break. This will accelerate wear, as the asperities will aggregate if they aren't flushed out of the system with a consistent flow of lubricant. If the lubricant is going to be reused, and often is, a filtration process must be added into the system.

CONCLUSION

Overall, the simplicity, cost, ease of manufacturing, and ease of maintenance keeps plain bearings in use in a wide range of applications. "A couple of tips—split bearings are good for applications that need maintenance; and for high-strength plastic bearings, pay attention to press fit bearings and housing materials," says igus' Lang. "Strong plastics rated bearings to be press fit in a steel housing may push out aluminum housings. This might affect the final internal diameter of the bearing."

The article offers a few simple tips that online tools, calculators, or apps might not tell you. While a good start, they will not replace the advice obtained from talking to a manufacturer or other experts in the field when selecting a bearing for your application. md

RULES OF THUMB

WHAT SHOULD ENGINEERS be asking, or focusing on, when looking for the right bearings?

Nicole Lang, igus: The main question should be: "What is the most cost-effective bearing that will suit my application's specific requirements?" The requirements of the application at hand will really drive the selection process of a bearing.

Gary Rosengren, Tolomatic: Evaluate each application and select proper "size" bearings based on loading requirements. Evaluate each application and select proper "type" bearing based on load and cost objectives. Evaluate each application and select proper bearing "material" based on environmental requirements. Use good engineering practices to apply journal bearings and adhere to manufacturers suggestions regarding mounting tolerances.

"A couple of tips—split bearings are good for applications that need maintenance; and for high-strength plastic bearings, pay attention to press fit bearings and housing materials." —Nicole Lang, igus

CHRISTOF SALCHER | Product Manager, Test & Measurement, HBM

Energy-Saving Electrical Pumps Satisfy New DoE Standards

Using a variable-speed drive could reduce up to 50% of a pump's energy consumption.

The mechanical world is becoming increasingly electrical. The evidence is everywhere, from consumer goods, public transportation, elevators, escalators, and vehicles to various pumps, drives, and valves used in industrial equipment. In many industrial environments, electrical actuators are rapidly replacing hydraulic or pneumatic power sources.

Generally, electric actuators use a single-phase or more common three-phase electric motor with a gearbox to create the torque required for operating the moving elements. The actuators may be pumping liquids, such as water, pharmaceuticals, chemicals, oil, or natural gas, or merely driving a mechanical system. Such electrical motors sometimes consume a large amount of the total energy consumed by a system when in standby mode. This much wasted energy adds up, substantially increasing both the operating and maintenance costs of electrically actuated devices.

Three-phase drives are taking the place of mechanical actuators in many industrial applications.

Since 1997, there have been regulations in place that set minimum efficiency standards for general-purpose, three-phase motors rated as low 1 hp and as high as 200 hp. These regulations were updated in 2010, when the *Energy Independence and Security Act* of 2007 (EISA) went into effect.

This legislation raised the minimum efficiency levels of the motors covered by the earlier legislation. It also extended the regulations to electric motors up to 500 hp, as defined in the National Electrical Manufacturer's Association (NEMA) Standard MG 1-2011.

The U.S. Department of Energy (DoE) recently released new efficiency standards for commercial and industrial pumps that are based on efficiency levels negotiated by manufacturers, efficiency advocates, and other stakeholders. In addition to establishing the first-ever national efficiency standards for pumps, the final rule also provides a mechanism for energy-efficiency programs to incentivize high-efficiency pump packages.

The new standards apply to clean water pumps between 1 and 200 hp, which are used for a wide variety of applications such as irrigation, circulation of hot and cold water in commercial buildings for heating and cooling, and pressure boosting in high-rise apartment buildings. The standards will require the least-efficient 25% of today's pumps market to be redesigned to improve efficiency and reduce energy losses.

Pumps meeting the new standards sold over 30 years would reduce electricity consumption by about 30 billion kilowatt-hours, which is equivalent to the annual electricity use of 2.8 million US households, and save customers $0.4 to 1.1 billion. The standards reflect efficiency levels that were agreed to by manufacturers, efficiency advocates, pump users, and utilities as part of a negotiated rulemaking, and build on standards established in the European Union.

The new standards are based on a metric that incorporates

The U.S. Department of Energy (DoE) recently released new efficiency standards for commercial and industrial pumps that are based on efficiency levels negotiated by manufacturers, efficiency advocates, and other stakeholders.

not just the power consumption of the pump itself, but also of the motor that drives the pump and any controls. In many pump applications, the required flow is variable. Oftentimes, this variable flow is achieved by opening and closing valves, which wastes a significant amount of energy.

A better option for variable-load applications is to control the pump with a variable-speed drive, which adjusts the pump output to only meet the required load. Overall, it can help reduce energy consumption by up to 50% or more.

The energy-saving benefits of variable-speed drives are captured in the new metric, such that a pump with a variable-speed drive will have a significantly better rating than a constant-speed pump. The new ratings for pumps will arm customers with more information when making purchasing decisions, and provides a mechanism for utilities and other efficiency program administrators to incentivize high-efficiency pump packages.

The regulations cover all drives sold in the U.S. and motors installed in machinery imported for sale. Canada and Mexico have similar regulations.

In addition to these regulations, the DoE has what's called the "Small Motor Rule." This rule applies to general-purpose two-digit NEMA frame (and IEC equivalents), single- and three-phase, 1/4- through 3-hp motors in open enclosures. This regulation went into effect on April 9, 2015. NEMA has published a white paper to help manufacturers and users interpret this rule and meet the requirements.

THE MEASUREMENT CHALLENGE

To accurately determine the efficiency of today's electrically driven systems, the measurement system being used must make both electrical voltage and current measurements, calculating electrical power. It must simultaneously measure torque and speed, calculating mechanical power or even flow and pressure, or calculating hydraulic power. Once the data-acquisition system makes the power calculation, the ratio determines power efficiency.

In addition to measuring power efficiency, you may also need to analyze power quality as part of your product design or system testing. Electrical actuators may cause voltage sags or excessive harmonic distortion.

When making power quality measurements, it is important that they are done with high accuracy and the best possible resolution. Many power analyzers available today typically make 16-bit measurements with an accuracy of 0.1%. This may be insufficient for some applications, but modern data-acquisition systems can provide much higher accuracy (typically 0.05%) at 24 bits of resolution.

These more accurate measurements can find problems in the design and testing phase, or in maintenance jobs. And because these data-acquisition systems also acquire sensor signals from torque, speed, displacement, flow, pressure, temperature, and humidity, it may be easier to determine the cause of a power-quality problem.

Another advantage of using a single data-acquisition system, in comparison to a collection of special-purpose instruments or handhelds, is that it saves time processing the test data. Many instruments are unable to stream and store raw signals. The raw data is helpful in analyzing the overall efficiency, load situations, and special conditions, or detect anomalies. Although some instruments have an option to interface with mechanical measurement devices, they can be expensive and lack seamless integration, thereby leaving the end user with a do-it-yourself task.


The QuantumX MX403B data-acquisition amplifier can measure l ow or high voltages at high electrical potential with CAT II or CAT III safety rating. This reduces the risks of working in high-voltage domains.

The low-voltage input can be used for current measurement with current clamps, resistive shunts, or burden resistors measuring low-current output from high-precision current transformers.

By adding additional QuantumX modules, even mechanical, hydraulics, or temperature quantities can be measured. The system is freely scalable.

The two most common ways to connect three-phase electric induction motors in industrial applications are the Y or star configuration and Delta configuration. In each of these configurations, there are three voltages (L1, L2, and L3) and three currents, all sinusoidal waveforms, each with a phase difference of 120°.

In the Y configuration, the voltage across the loads is equal to the line voltage, whereas in the delta configuration, the voltage across each load is instead line-to-line. In either case, the voltages and currents should be balanced. The line voltages should all be equal to one another and 120° out of phase with one another.

In the Y configuration, the return path for the current in a particular phase conductor is the other two phase conductors. When properly balanced, the neutral conductor carries little or no current, and in some systems may even be optional. Properly balancing the voltages and currents also helps to reduce vibrations.

To calculate the consumed electric power, the data-acquisition system has to measure the voltage and current of each phase. To do this, you'll need to setup a data-acquisition system with at least six channels—three to measure the phase voltages and three to measure the phase currents.

While you can connect the three voltages directly to the data-acquisition system, you may not be able to measure the current quite so directly. For this purpose, you can use current sensors,

CASE STUDY: MEASURING THE EFFICIENCY OF A PUMP'S THREE-PHASE MOTOR

For most industrial applications, engineers use three-phase motors. One reason for this is that a three-phase motor is typically 50% more efficient than a comparable single-phase motor.

Another reason to use three-phase motors is their ability to self-start. Single-phase induction motors have no starting torque, so you must provide an auxiliary means of starting them. Single-phase motors also vibrate more than three-phase motors. This can lead to premature failure of the motor or machine that it is powering.

Isolating the data-acquisition system from these hazardous voltages and their transients is important. Most inputs of data-acquisition systems are not isolated and may not save enough for the user. In addition, they may not able to handle transient voltages. Before using a modern instrument, one must look into its specs and measurement category according to the IEC 61010 standard. The measurement category and the accordingly listed voltage level describe the voltage range in which the user can safely measure.

Buying a data-acquisition system with a CAT II or CAT III safety rating reduces the risks of working in these high-voltage domains. For example, the QuantumX data-acquisition system from HBM can measure low voltages (±10 V) or high voltages (±1000 V) at high electrical potential.

United States Postal Service

Statement of Ownership, Management, and Circulation **(Requester Publications Only)**

1. Publication Title: Machine Design
2. Publication Number: 323-980
3. Filing Date: 9-19-16
4. Issue of Frequency: Monthly
5. Number of Issues Published Annually: 12
6. Annual Subscription Price: Free to Qualified
7. Complete Mailing Address of Known Office of Publication (Not Printer): Penton, Media, Inc., 9800 Metcalf Ave., Overland Park, Johnson County, KS 66212-2216 — Contact Person: Debbie Brady, Telephone: 216-931-9882
8. Complete Mailing Address of Headquarters or General Business Office of Publisher (Not Printer): Penton Media, Inc. ,1166 Avenue of the Americas New York, NY 10036
9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor - Publisher: Paul Miller, Penton Media, Inc., 1166 Avenue of the Americas, New York, NY 10036; Editor: Nancy K Friedrich, Penton Media, Inc., 1166 Avenue of the Americas, New York, NY 10036; Managing Editor: ,
10. Owner - Full name and complete mailing address: Penton Media, Inc., 1166 Avenue of the Americas, New York, NY 10036; Penton Business Media Holdings, Inc. (owns 100% of the stock of Penton Media, Inc.), 1166 Avenue of the Americas, New York, NY 10036
11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages or Other Securities: None
12. Tax Status (For completion by nonprofit organizations authorized to mail at nonprofit rates) (Check one) The purpose, function, and nonprofit status of this organization and the exempt status for federal income tax purposes: N/A
13. Publication Title: Machine Design

14. Issue Date for Circulation Data: August 2016 15. Extent and Nature of Circulation	Average No. Copies Each Issue During Preceding 12 Months	No. Copies of Single Issue Published Nearest to Filing Date
a. Total Number of Copies (Net press run)	62,228	62,450
b. Legitimate Paid and/or Requested Distribution (By Mail and Outside the Mail)		
(1) Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	58,717	58,974
(2) In-County Paid/Requested Mail Subscriptions stated on PS Form 3541. (Include direct written request from recipient, telemarketing and Internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	0	0
(3) Sales Through Dealers and Carriers, Street Vendors, Counter Sales, and Other Paid or Requested Distribution Outside USPS®	1,172	1,118
(4) Requested Copies Distributed by Other Mail Classes Through the USPS (e.g. First-Class Mail®)	0	0
c. Total Paid and/or Requested Distribution (Sum of 15b (1), (2), (3), and (4))	59,889	60,092
d. Nonrequested Distribution (By Mail and Outside the Mail)		
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e. Total Nonrequested Distribution (Sum of 15d (1), (2), (3), and (4))	1,821	1,923
f. Total Distribution (Sum of 15c and 15e)	61,710	62,015
g. Copies not Distributed	517	435
h. Total (Sum of 15f and g)	62,228	62,450
i. Percent Paid and/or Requested Circulation (15c divided by 15f times 100)	97.05%	96.90%
16 Electronic Copy Circulation		
a. Requested and Paid Electronic Copies	-	-
b. Total Requested and Paid Print Copies (Line 15c)+ Requested/Paid Electronic Copies (Line 16a)	59,889	60,092
c. Total Requested Copy Distribution Distribution(Line 15f) + Requested/Paid Electronic Copies (Line 16a)	61,710	62,015
d. Percent Paid an/dor Requested Circulaltion (Both Print & Electronic Copies) (16b diveded by 16c x 100)	97.05%	96.90%

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18 Debbie Brady, Manager, User Marketing — Date 9/19/16

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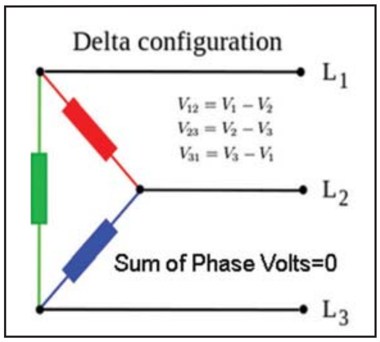
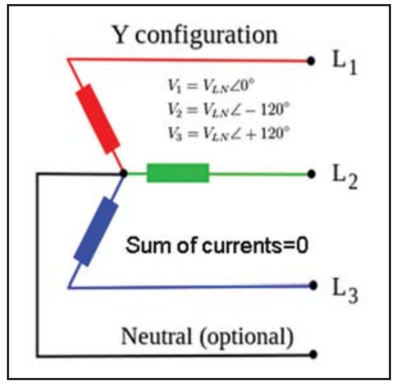


The Y configuration is a common method for connecting three-phase networks in industrial applications.



Connecting a three-phase network in an industrial application can also be accomplished using the Delta configuration.

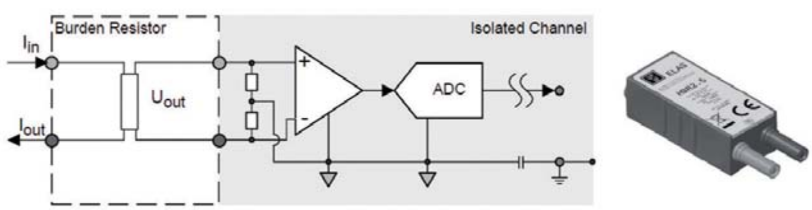
such as current clamps or resistive shunts, and read an output voltage. Another option is to use current transformers to lower the current and measure the voltage with a burden resistor plugged into the MX403B.

ADDING SENSORS

When using inductive sensors, be sure to compensate for any phase error or voltage attenuation as part of the measurement calibration process. The data can be found in the sensor datasheet. If, however, this information is not present, it is easy to determine these values. All you have to do is measure the current through a resistive load using the selected sensor and determine the phase shift.

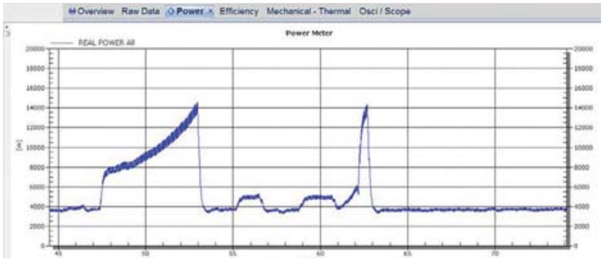
You can then use this value when measuring the motor's power consumption. This ensures that the measured voltages and currents have the appropriate phase relationship and the power measurement is accurate. Making this calculation is very easy to do with a data-acquisition system, and as a result, you are able to choose a current sensor that has the appropriate size, accuracy, bandwidth, and frequency range.

With accurate voltage and current measurements, you can then calculate the rms voltage and current as well as the power factor. The power factor is a measure of how much the current leads or lags the applied voltage. Mathematically, the power factor is the cosine of phase angle between the voltage and current during the measurement process. The ac power consumed, also known as active power, is the product of the rms voltage, rms current, and power factor.



Current measurement can be performed using a burden resistor.

Some of the applied power is reflected back (or lost) due to energy stored in the load, or due to a nonlinear load that distorts the wave shape of the current drawn from the source. This is called reactive power. A motor with a low power factor draws more current than a motor with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the system. As such, electric motors with a high power factor are more desirable than motors with a low power factor.

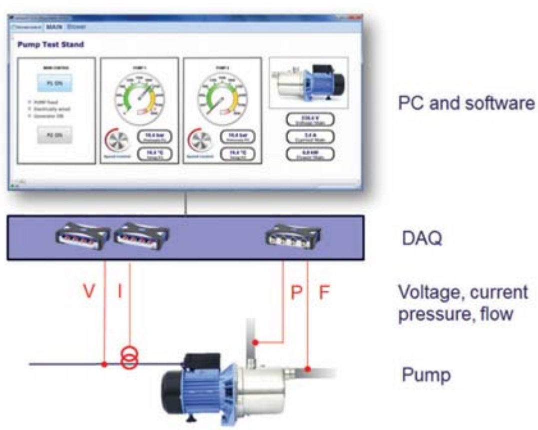


This display shows how active power varies with time during an efficiency test. When correlated with mechanical measurements, users can determine whether the spikes are the result of normal operation or caused by a fault.

Modulating the phase and amplitude of applied voltage to the motor makes it possible to minimize the contribution of reactive power, which, in turn, creates a much more energy-efficient system. A variable-frequency drive or inverter-based drive can make that happen. It simply takes a sine-wave input and load feedback from the motor, which then outputs a pulse-width-modulated sinusoidal waveform instead of a smooth sine wave. The motor basically sees this as a sine wave with a ripple, and because motor windings are inductive, will filter out any high-frequency component. This type of closed-loop control allows the motors to operate much more efficiently.

Some data-acquisition system provides an easy-to-use approach for measuring the efficiency of electrical motors and other electrically actuated systems. Connectivity is simply plug-and-play with provided adapters, and data can be acquired immediately with no programming needed. Data-acquisition systems are able to provide accuracies up to 0.05% and resolution up to 24 bits. They can acquire data up to 100 k samples/s, and stream the acquired raw data to a computer for online analysis.

Data-acquisition systems can help troubleshooting by defining custom triggers. For example, a user may set a trigger to take measurements when a system that normally consumes 500 W suddenly spikes to over 1,000 W. Because the system measures both electrical input power and mechanical output power, the user has the data needed to figure out what caused the electrical spike.



To measure the power input to a three-phase motor, you need six channels—three to measure the voltage and three to measure the current.

In addition, the software is capable of performing a fast Fourier transform (FFT) on the raw data, which can determine harmonics of the signal. Voltage harmonics are mostly caused by current harmonics triggered by nonlinear loads.

Making power-efficiency measurements will not only help you comply with DoE mandates, but also help in creating an efficient electric motor. By analyzing and calculating your system under typical load and operating conditions, you can determine your system's average power consumption and when power consumption peaks, and subsequently take the appropriate steps to reduce that consumption. md

CHRISTOF SALCHER studied electrical engineering and information technology, graduating from Technical University of Munich, Germany in 1999. Soon after, he worked as an engineering consultant for dSPACE, and in 2004, Christof joined MAGNA Electronics as a team manager. Since 2007, he has worked as international product manager in the test-and-measurement domain, specifying and designing its product QuantumX—a universal data-acquisition system for in-field and lab testing of systems and complete vehicles under development.

KASHYAP VYAS | Engineer, Hi-Tech CADD Services
www.hitechcaddservices.com

DFM and Sheet Metal

Engineers can turn out sheet-metal designs that are both highly functional and easy to make by following Design for Manufacturing principles.

Engineers designing sheet-metal enclosures and assemblies often end up redesigning them so they can be manufactured. In fact, research suggests that manufacturers spend 30% to 50% of their time fixing errors and almost 24% of those errors are related to manufacturability. The reason behind these preventable engineering errors is usually the wide gap between how sheet-metal parts are designed in CAD systems and how they are actually fabricated on the shop floor. Many engineers developing 3D models for sheet-metal products are unaware of the fabrication tools used to form the part or product, and instead design models for an "ideal" world.

In the ideal world, everything is perfect. Tolerances and allowances are exact, and there's no need to add any feature or change the design to accommodate the shop floor or real-world material behavior. But the truth is, numerous factors including chamfers at the edges, collars near hole, and spaces between drilled holes matter in the sheet metal world.

This gap between the ideal and real-world sheet-metal design usually proves costly. The overflowing engineering change orders (ECOs), fixing the design errors, and sending revisions back to the shop floor turns into a vicious cycle, one that is often difficult to break.

Closing this gap is critical. Fortunately, it's possible if companies and engineers adopt a Design for Manufacturability (DFM) strategy. With DFM, designers can consider important manufacturability factors while developing sheet- metal designs. This reduces the possibility of errors and ECOs, and fills the void between ideal and real world. A DFM strategy focuses on simplifying designs and reducing the parts counts. It suggests standardizing parts so they can be used over and over in different applications. DFM also provides insights on developing designs that are easier to manufacture.

DFM TIPS FOR SHEET METAL

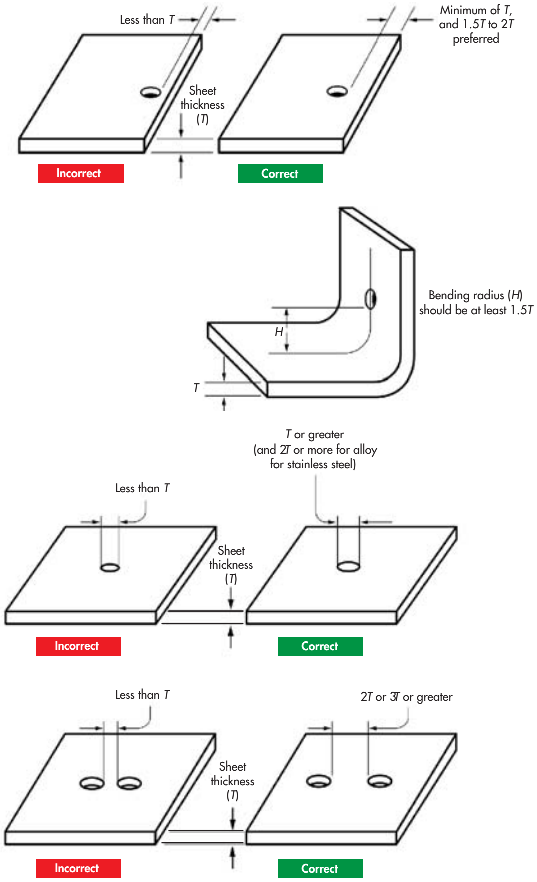
In a sheet-metal design, specifying hole sizes, locations, and their alignment is critical. It is always better to specify hole diameters that are greater than the sheet's thickness *(T)*. Hole diameters less than the sheet thickness result in higher punch loading, longer burnish in the holes, and excessive burr. It also leads to slug-pulling when withdrawing the punch, which ultimately affects the life of both punch and metal sheet. Spacing between holes also matters. It should be at least two times the sheet thickness *(2T)*, if not more. Distance between holes ensures strength of the metal and prevents holes from deforming during the bending or forming processes.

THE GAP BETWEEN THE IDEAL AND REAL WORLDS OF SHEET METAL DESIGN

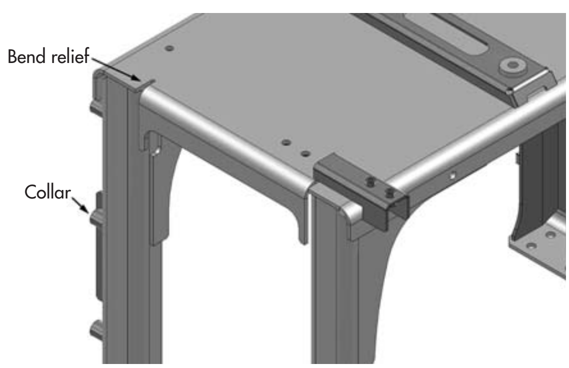
Ideal World	leads to Real World
Specify exact hole diameters, spacing, and tolerance values.	Holes expand in high-temperature applications, causing the spacing to misalign and the fasteners to loosen.
Specify hole diameter, spacing, and tolerances without considering allowances.	Actual design varies after bending and this leads to misalignments.
No need for beads, embossing, or coining.	Less strength in the design and it's unable to maintain flatness.
No need for ribs, collars, or chamfers.	Pierced areas will have less stiffness which increases the spring-back effect and could lead to tears in the metal.
Providing lugs without understanding grain structure of the blank.	If lugs are parallel to the grain structure, it will lead to crack formation.

In cases where holes must be near the edge, the minimum space between the edge and holes should be at least the sheet thickness *(T)*. Also, spaces between pierced holes and bends should accommodate the bend radius *(H)* and be far enough from the bend. Usually, the preferred distance between holes and a bend is 1.5 times the sheet thickness plus the bend radius ($1.5T+H$). Supplying 3D models without considering these factors increases the chance of change orders from the factory floor.

It is common to receive designs for sheet-metal parts with modeling mistakes regarding bends and fillets, especially when several vendors are involved. This can lead to formed parts looking different than the models they are based on.



Engineers designing sheet-metal parts should understand the importance of bend relief and how it helps avoid torn metal and that features like beads and flanges serve specific purposes. They reduce the spring-back effect and add stiffness to the final part or product. (Spring-back is the unwanted tendency of sheet metal to retain or go back to its original flat form after the forming process.) Features such as collars near pierced areas also serve a purpose. They strengthen the metal and let it withstand higher loads. Neglecting these features not only invites ECOs and extends fabrication times, it also significantly increases material scrap.

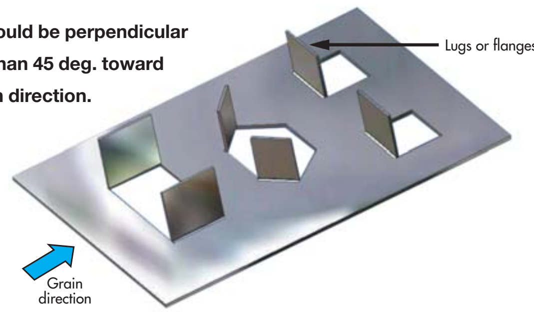


Bend relief and collars near pierced areas strengthen sheet-metal parts.

Grain structure in the metal sheet is critical for avoiding cracks in sheet-metal parts with lugs or tabs that are cut on three sides and bent in or out. Other components are often mounted or clamped to them. The engineer modeling the part needs to understand the grain structure of the metal coil that will be used. Lugs formed parallel to the grain direction usually tend to form cracks.

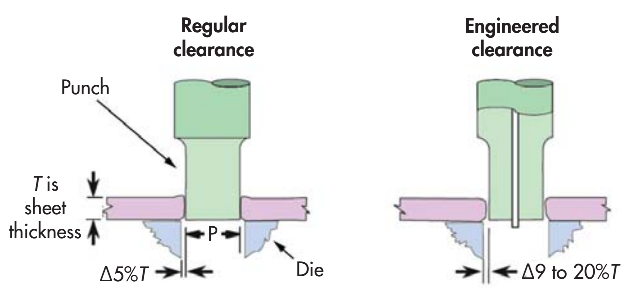
There might be instances in some complex product designs when this rule of thumb might not apply. Still, the recommended practice is to form lugs perpendicular or at an angle less than 45 deg. towards the grain direction. It is likely that an engineer would be unaware of this factor while developing the model. Communicating with the fabricator is key.

Lugs should be perpendicular or less than 45 deg. toward the grain direction.



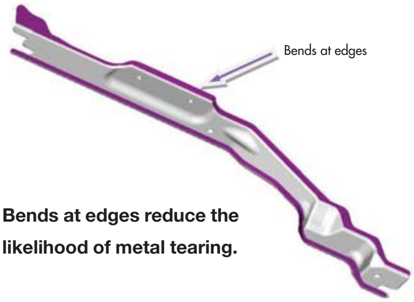
Designers often deal in the ideal world when specifying tolerance values. However, in the real world, numerous factors affect tolerances. For example, the part's function or feature, as well as the material type, temper, and thickness affect tolerance specifications. Moreover, engineers must consider the fabrication process that will convert the sheet metal into a part and the die accuracy and its wear during the punching operation to ensure tolerances are accurate.

From the fabricator's point of view, the punch-to-die clearance is critical because small clearances lead to increased burr height and slug pulling, and wears out the punch prematurely. In such cases, the engineer's tight tolerances increase manufacturing cost.

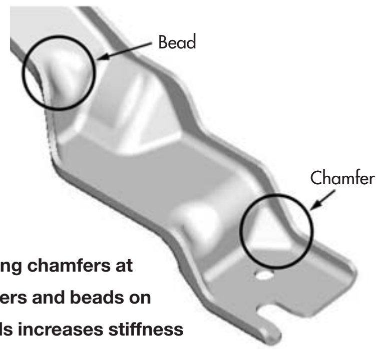


Regular clearance is an exact clearance between die and the punch and is used, but it prematurely wears out the punching too. Engineered clearance, which is slightly larger than the regular clearance is preferred because it extends the punch life. Although holes punched with engineered clearance have slightly bigger diameters, damage to the punch is greatly reduced.

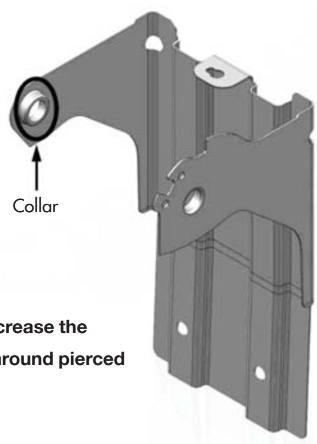
Here are some other sheet-metal DFM features:



Bends at edges reduce the likelihood of metal tearing.



Putting chamfers at corners and beads on bends increases stiffness and reduces the spring-back effect.



Collars increase the stiffness around pierced areas.

Coining and embossing around flared holes improves a part's strength and its ability to maintain its flatness.

BENEFITS OF DFM

Designers and engineers who adhere to the DFM guidelines strive for sheet-metal products with minimal part counts that are relatively easy to produce and assemble. The products are also less expensive and the possibilities of errors and rework are reduced.

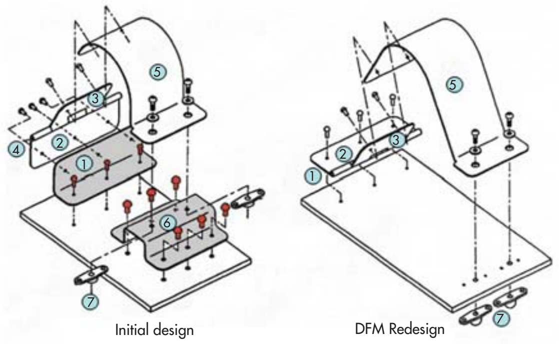
Minimizing part count: Part counts can be shrunk by incorporating the functions of two or more parts into a single part. To do this, designers must ask themselves the following questions:

- Do the parts move relative to each other?
- Do the parts need electrical or thermal insulation?
- Do the parts need to be made of different materials?
- Does combining the parts interfere with assembly of other parts?
- Will combining parts complicate maintenance?

If the answer to all of these questions is 'No,' then a single part may perform several functions. This concept of theoretical minimum number of parts was first proposed by Boothroyd (1982) and is widely practiced by engineers and manufacturers across the globe. Through this approach, Dell Computer Corp. saved an estimated $15 million by redesigning a computer chassis so it could be used in several lines of PCs. And the part count went down by 50% and assembly time decreased by 32%.

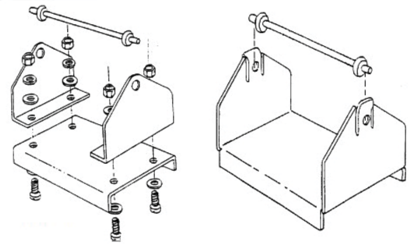
Ease of assembly: This is a critical consideration for sheet-metal products. Engineers should strive to develop parts that insert into one another easily and intuitively and always with the proper orientation. Self-locking features contribute to short assembly times and lower parts counts.

Usually, it is a good practice to design the first part large and wide to ensure the stability and then assemble smaller parts on top of it. It is also a good practice to design parts in such a way that they can be assembled from one direction, rather than multiple directions, which extends assembly times further.



Ease of manufacturing: Engineers should know the manufacturing capabilities available to them and the limitations of those capabilities. This means designers should understand the processes, as well as the materials compatible with them and their production volumes. Here are some other assembly-related DFM tips:

- Use near-net shapes for molded parts to reduce machining and processing.
- Simplify fixturing by providing large mounting surfaces and parallel clamping surfaces.
- Prevent parts from breaking easily by not giving them sharp corners or points.
- Thin walls, webs, deep pockets and deep holes should be avoided so parts will withstand clamping and machining without distorting.
- Engineers should know what standard cutters, drill-bit sizes, and other tools are available in the shop before designing sheet-metal parts.
- Avoid unnecessary features as they slow production and increase machining times and cost.



- Original design
- 24 parts
- 8 Different parts
- Several manufacturing and assembly processes

- DFM Redesign
- 2 parts
- 2 manufacturing processes
- 1 assembly step

It is common for large fabrication units to outsource design to engineering service providers so they can focus on core activities. However, selecting the right partner helps avoid further widening of the gap between the ideal and real worlds. Work with partners willing to collaborate, interested in knowing more about manufacturing processes, and involved in developing sheet metal products. Look for firms that have past experience of successful projects and the needed resources before handing over a design task. This will ensure that ECOs are few and the product is brought to market faster. md

Electrical Connectors Are Compatible with Thick Panel Boxes

THE RD24 connectors feature plastic hex nuts for compatibility with thicker panel boxes, and reduce the need for mounting screw holes. They are available in 4- and 7-pin configurations, and rated at a maximum 16 A per contact for transferring up to 400 V. The screw-terminated connectors are fitted with gold-plated contacts for an IP67 rating to withstand harsh industrial environments. A cap lanyard can be attached directly to the housing body of the connector.
BINDER-USA, (805) 437-9925, *www.Binder-USA.com*

Slotless Gear Motors Offer a Variety of Sensing Capabilities

THESE 42-mm slotless brushless gear motors have 24-and 48-V ratings with a 2-pole design. They provide a power output of over 800 W and come in a compact 21-ounce package. The 10.875-ratio planetary gearbox and all-surface hardened gears contain needle bearings and ball bearings on the stainless-steel output shaft. Hall-sensor and sensorless versions are available, along with optional temperature sensors and a variety of windings. The slotless design enables high efficiency and power density with zero-cog, linear torque behavior for servo applications.
KOFORD ENGINEERING LLC, *www.koford.com*

Capacitor Power-Backup Systems Approach 1-Hour Energy Release

ULTRA CAPACITOR DC UPS (uninterruptible power supply) power-backup systems are optimized for seamless switchover during power outages and interruptions, peak power demand, or power dips and sags. They are a good alternative to batteries, eliminating the risk of leaking toxic chemicals. They enable fast microcontroller-based charging and discharging, an extended energy release of up to 55 minutes, and an output of up to 10,000 W. Available with 12- and 24-V dc output voltages, and output currents between 3 to 40 A, they are resistant to shock and vibration and come in a compact convection-cooled metal housing for extreme conditions. They can operate in climate ranging from –40° to 65°C, and can be DIN-rail mounted.
ALTECH CORP., (908) 806-9400, *www.altechcorp.com*

Miniature Ball Screws Target Sensitive Fluid-Release Apps

MINIATURE BALL screws from the optiSLITE series deliver low-friction torque for smoother running and quick servo response. A finishing process that removes microscopic peaks on the shaft raceway enables smoother running screws. Available with shaft diameters as small as 5 mm and pitch down to 1 mm, they come in standard lengths and nut designs.
STEINMEYER INC., infoUSA@steinmeyer.com

Motorized Impeller Minimizes Vibrations

THE XR Motorized Impeller suits applications dealing with space limitations. Speed can be controlled across a wide range for precise cooling. A ball-bearing motor reduces vibrations, and the motor and impeller are located in the air stream for more efficient cooling. Available with a 115- and 230-V single-phase motor, it has air-moving capacity up to 1,175 cfm. It can be used for supply or exhaust applications.

CONTINENTAL FAN INC., (800) 779-4021, *www.continentalfan.com*

Wall-Mount Power Adapters Include Overload Protections

THE TXM25 series of 25-W wall-mount power adapters meet 2 MOPP levels, are approved to Class II medical standards, and comply with standards for home healthcare environments. They accept a full range of ac inputs from 80 to 275 V ac. The output voltage is factory preset between 3 to 55 V. It has short-circuit and overload protections with a maximum enclosure leakage current of 100 μA at 240 V ac, 60 Hz.

TRUMPOWER, (408) 988-6616, *www.trumpower.com*

Surface-Mount Fasteners Facilitate PCB Design

PEM REELFAST surface-mount fasteners include threaded or unthreaded nuts and standoffs, captive panel screws (spring-loaded or standard), and R'ANGLE types that provide strong reusable threads at right angles to boards. All are supplied on tape and reel that is compatible with existing SMT automated installation equipment. They mount in the same manner and at the same time as other surface-mount components prior to the automated reflow solder process.

PENN ENGINEERING, (800) 237-4736, *www.pemnet.com*

Membrane Dryer Replaces Refrigerated Dryers to Save Space, Electricity

THE AMD-035 SuperStar Membrane Dryer provides clean, dry compressed air in automotive applications. The equipment is useful for replacing refrigerated dryers that may be too large or require too much electricity. It lowers the dew point by venting water vapor to the surrounding air. The product can be used to lower dew-point temperatures more than 20°F, suiting it for spray-booth applications. A pre-filtration system includes a high-efficiency coalescing filter to assure contaminant- and particle-free air. A standard automatic float drain allows discharge of moisture from the extractor and dryer while preventing any system air loss.

LA-MAN CORP., (800) 348-2463, *www.laman.com*

Gas Monitor Ensures Safety in Hydrogen-Cooled Generators

THE XTC601 analyzes moisture and oxygen in hydrogen-cooled generators to monitor systems that are supposed to be cooled with pure hydrogen. It is designed with three phase profiles to cover all gas-analysis requirements. At normal operation, it provides continuous, online measurements of the atmosphere within the generator to ensure H_2 purity. When the machine is purging H_2 with CO_2, it indicates when all H_2 has left the system. When the machine is purging CO_2 with air, it enters the phase that ensures the atmosphere is safe for engineers to work. Operators are able to switch between three calibration maps via an human-machine interface (HMI) or input from the plant control system. A non-depleting sensor helps improve its lifespan, and no parts need to be replaced.


Image courtesy of Siemens AG

MICHELL INSTRUMENTS, *www.michell.com/us*

Chargers Are Compatible with Lead-Acid and Li-Ion Batteries

THE RC900 and RC1200 chargers can be used to charge lead-acid and lithium-ion batteries. Providing 900 and 1200 W of dc output power, they are available in 36- and 48-V models. RC Series chargers use controller-area-network (CAN bus) communications, and are designed for use in battery-powered scrubbers, sweepers, and burnishers. They are IP66-rated for ingress protection against dirt and fluids. The chargers are resistant to vibration, shock, and temperature extremes.

DELTA-Q TECHNOLOGIES, (604) 327-8244, *www.delta-q.com*

Wand Probe Enables Seamless UV and Blue-Light Curing

THE X1-1-RCH-116-4 UV and blue-light LED curing radiometer maintains stability in high-temperature environments with intense UV-flooding and spot-curing. It features a horizontally constructed photodetector assembly that keeps the photodetector out of the hot zone. The RCH-116-4 "wand" style detector consists of a RADIN radiation integrator coupled to a stainless-steel rigid tube housing. A quartz light guide pipes the light signal to a detector capsule that houses the photosensor/filter assembly. RADIN not only provides a cosine-corrected spatial response, but works with the light-guide and remote detector for signal attenuation and thermal isolation. Because it is not subjected to direct irradiation, the detector assembly reduces aging and saturation effects, and allows the RCH detector to operate in temperatures up to 1000°C with peaks up to 2000°C. The radiometer includes the meter, detector, USB cable, calibration certificate, and carrying case. Optional S-X1 software is available.

GIGAHERTZ-OPTIK INC., (978) 462-1818, *www.gigahertz-optik.com*

Motor Controllers Attach Directly to Motor

THE ACSI integrated servo motor for single-axis applications incorporates the drive and controller in the servo-motor design to save space on the machine by eliminating the drive box. It can be used to replace pneumatic cylinders and automate other axes of motion. The ACSI servo-motor control works with most proprietary electric actuators and can create linear motion in millimeters or inches via a USB or Ethernet port. It can be controlled from a PLC or master controller as well. Available in NEMA 23 and 34 sizes, the ACSI also supports rotary axes and third-party actuator control. When ordered with an actuator, the ACSI controller will come mounted the motor, configured for the actuator, and fully tested before shipping.

TOLOMATIC, (800) 328-2174, *www.tolomatic.com*

Rotary Stages Target Large-Bundle Power-Transmission Apps

SERVOBELT ROTARY STAGES offer two through-hole configurations and are available with 50-, 100-, or 200-mm center openings. Large through-hole stages accommodate large bundles of power in pneumatic, signal, and laser and optical systems. Standard-sized models with 16- or 25-mm through holes are more economical when fewer utilities need to pass through the center of the stage. Designed for NEMA 23 and 34 motors, the rotary stages offer speeds up to 1,000 rpm and continuous torque up to 6.6 N-m. Coupled with Renishaw ring encoders or tape scales for partial rotation, they provide resolution down to 0.16 arc-sec. They support continuous-rotation and variable-indexing applications, and come with robust, "lubed-for-life" bearings. They may incorporate large full-duplex, angular-contact bearings for excess load capacity that translates into longer bearing life.

BELL EVERMAN, (877) 737-8698, *www.electromate.com*

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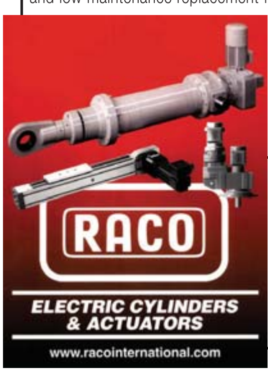

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MD 12/16 ISSUE PREVIEW

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Sensors Are Essential To Be IIoT- and IoT-Competitive

It has become clear to many this past year that the predictions of the speed at which the Industrial Internet of Things (IIoT) and Internet of Things (IoT) will develop will prove truer than not in the decade ahead. Hmmm. Ten years. 2026. If your company's time-to-market for new products is two to three years, then it has somewhere between three and five development cycles to assure that it does not fall behind.

In this column, we look at a narrow slice of one part of the IIoT and IoT challenge. Big Data, neural networks, smart machines, and artificial intelligence all require "source data." In short, a great amount of the IoT discussion comes down to sensors.

Sensors of all types and sizes will be needed to generate the source data upon which the IoT's intelligence will largely be built. Companies that make the most progress in the next 10 years in embedding and augmenting their hardware and electronics with data gathering and generating capabilities will likely be the market leaders in the following decade.

There are three primary ways to "sensorize" products. Companies can surround their products with third-party sensing capabilities, an adjacent appended approach. Companies can retrofit products through value engineering and sustaining activities, a partially integrated approach. Or, companies can modify their product architecture today so that all new products will be "IIoT-ready" at launch, a fully integrated approach. IIoT-ready doesn't mean fully sensored-up. It means that what is available today is already on-board and the product design facilitates the addition of new capabilities as they come down the pike.

Companies should take inventory of all the current and future sensors likely to exist. What exists today is perhaps a tenth of what is coming. A robust literature search will do the job to establish an inventory. For example, MEMS technology is here (and shrinking rapidly) and new "printed sensors" will soon be commercially available. Printed sensors take up almost no room, but still need designs that provide for them. Then examine the architecture(s) of company product lines and develop a systematic blueprint or roadmap of how product designs should change to incorporate sensors. Unless companies get in front of this, they will experience a slew of engineering change orders starting in a few years as customers force companies to "sensorize" their products. The room to skate around that issue exists today, but will soon be gone.

To make the point, *Global Purchasing (www.globalpurchasing.com)*, *Machine Design*'s sister website, published IHS data showing that the average sensor density in biometric devices will rise from 1.4 to 4.1 sensors per product by 2019. Of course, this extrapolates across products and industries. The train is on the tracks. We should already be systematically architecting all new products for the IoT, and the same for retrofitting. Examining both challenges together will likely make it easier and less expensive in terms of product and development costs.

Let's now assume companies have developed "sensor-enabled product architectures." Doesn't this have tremendous implications for the product development process? At the beginning of the process, during definition, not only will "portfolio-fit" and "roadmap-fit" checks be necessary but also an "IoT-fit." At project approval, every plan will need "sensor modules" that manifest in project Gantt charts and may even change the way bills of materials are structured. Throughout the design process, just about every design and quality review will need additional checklist items. Test suites will have to be overhauled, and they will become greatly expanded. Beta testing with customers will yield new surprises. At launch, the marketplace will comment not only on the product but also on its readiness for the IoT. There is much work to be done to "IoT-ize" the product development process.

The architectural relationships between the manufacturing-process sensors, the product being manufactured, and how data gets from the product's sensors into the network are major subjects for another day.

Three to five product cycles is not a lot of time. Will your company's products be IIoT- and IoT-ready, or will it be retrofitting in 2026? md


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