machine design

BY ENGINEERS FOR ENGINEERS

OCTOBER 2016
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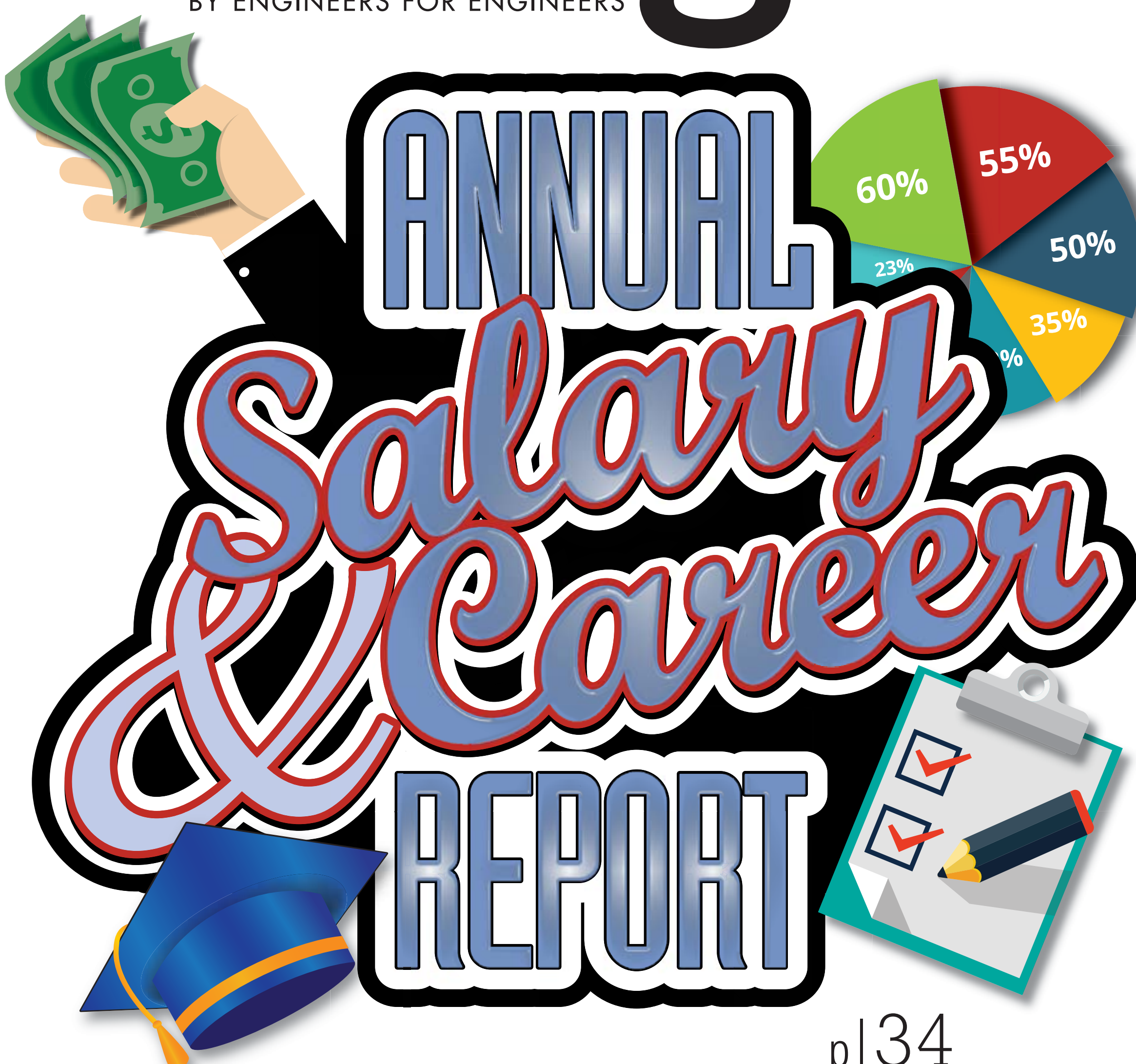

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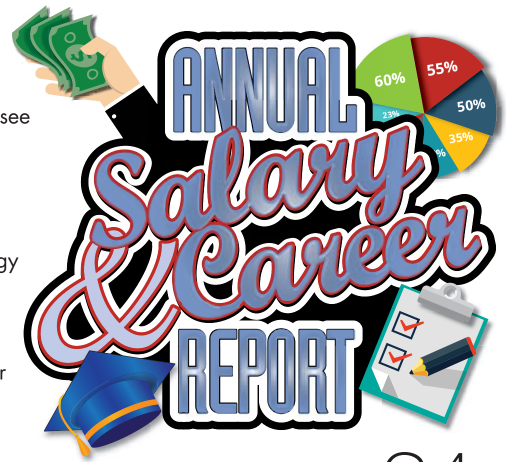

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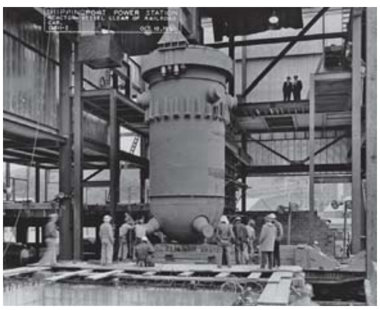

50

60

DEPARTMENTS

COLUMNS

66

ON THE COVER: Illustration by Tony Vitolo.

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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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A "HUMAN-CENTRIC" APPROACH TO DESIGN

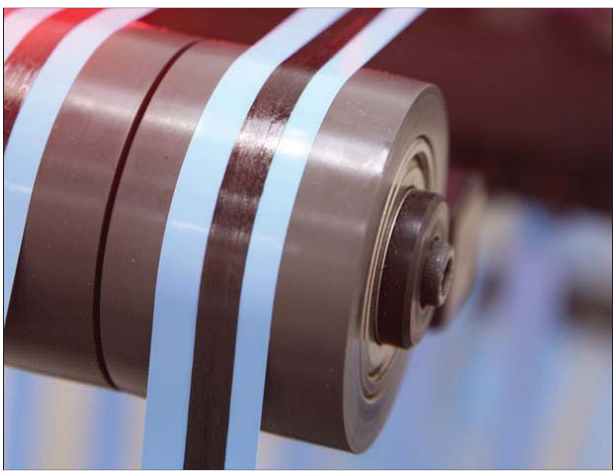
http://machinedesign.com/blog/taking-human-centric-approach-design

In his latest blog, Tech Editor Jeff Kerns argues that Today's engineers have to move beyond "user-friendliness" as they forge creative paths to human-centric designs. *(Image courtesy of Thinkstock)*

WORKING WITH SHEET METAL

http://machinedesign.com/metals/following-dfm-guidelines-working-sheet-metal

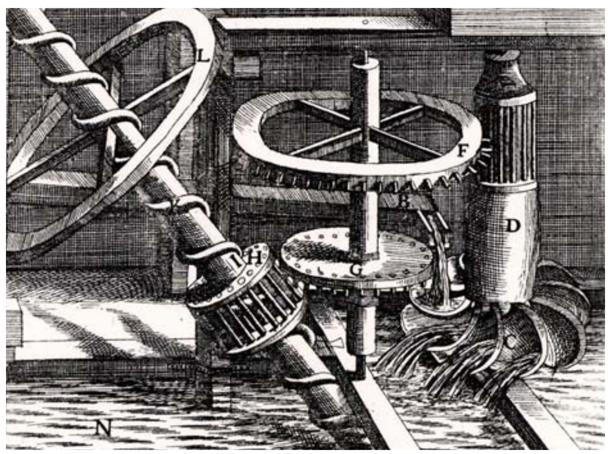
Engineers can turn out sheet-metal designs that are both highly functional and easy to make by following Design for Manufacturing principles. *(Image courtesy of Thinkstock)*



CAN PLASTICS REPLACE METAL?

http://machinedesign.com/materials/replacing-metal-plastic

While plastics can certainly make parts lighter and stronger, that may be just the tip of the iceberg.



A GALLERY OF PERPETUAL MOTION MACHINES

http://machinedesign.com/technologies/engineering-dead-ends-gallery-perpetual-motion-machines

Perpetual motion machines can do work indefinitely with zero energy input. If one existed, it could turn a wheel or raise water, thereby generating energy without needing fuel of any kind—a useful device. Here, we present a collection from the past of various schemes put forth as perpetual motion machines. *(Image courtesy of Thinkstock)*

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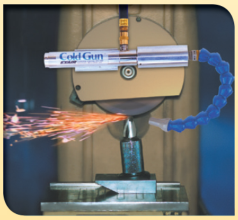

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Editorial

CARLOS M. GONZALEZ | Technology Editor
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Is Engineering Employment in Danger or Is It Being Redefined?

The tracking of engineering hires might need to reflect the change in engineering job roles.

In this year's Salary and Career Report, we captured some impressive numbers for engineering salaries. According to our survey, since 2014 our readers have seen an 11.5% increase in their salaries and the average salary for 2016 is very close to $100,000. Our report comes hand in hand with the fact that our engineers are getting older. The average age of the engineer is now 53 and we're seeing a steady decline in the number of engineers 35 and younger. In talking with some of our readers, they believe that engineers are not finding jobs in the U.S. and that more work is being outsourced to contract firms in the United States or in other countries. However, different labor reports point to another cause, which may be the redefining of engineering job titles.

For the traditional engineering professions, the growth is expected to be slow for the next few years. The Bureau of Labor Statistics (BLS) reports that there will be 3% growth from 2014 to 2024. This will add 67,200 new jobs in the engineering sector—lower than the expected average growth rate for all occupations, which is around 7% for 2014 to 2024. If broken out to individual professions, aerospace engineers will see a 2% decline, mechanical engineers will see a 5% increase, and petroleum engineers will see a 10% increase. Little to no change is expected for electrical and industrial engineers. These predictions are based on the traditional definitions of the engineering professions. The BLS notes that the slowdown in growth can be partially attributed to the decline in drafting and technician occupations due to the improvements in technology. The increase of design software and digital equipment has redefined job titles.

Independent job reports have a more promising outlook on the engineering job market. Kelly Services, an outsourcing and consulting service, has predicted an 11% increase overall for engineers. They conclude that nearly 249,000 jobs will become available by 2023. The majority of these jobs will go to civil and mechanical engineers, but leaning toward the infrastructure, oil & gas, renewable energy, medical devices, automotive, and aerospace industries.

I believe we are in a time of flux for many of the engineering professions. Technology has caused many of these niche professions to meld. A mechanical engineer in today's engineering world needs to be concerned as much with electrical and computer technology as they are with their own jobs. The BLS reports are based on how we have typically defined engineering roles, yet other reports indicate that new roles are being created and that perhaps engineers coming out of college now need to focus on applying for these new roles. We also should be tracking how many engineers are hired into nontraditional jobs and revisit what we consider an "engineering profession" to be. md

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OCTOBER 2016

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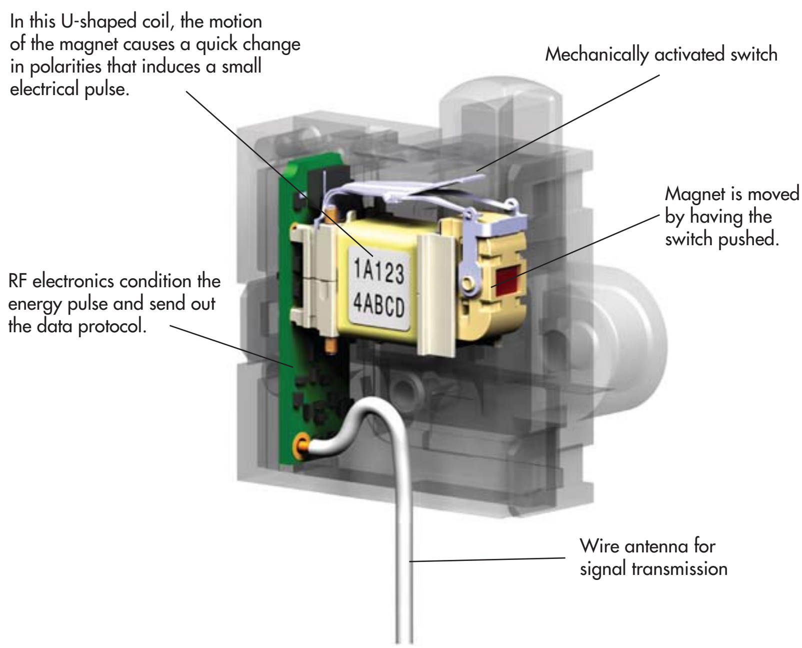
Wireless, Energy-Harvesting Switches Transmit Data More Than 900 Ft.

THE AFIS ROCKER and snap switches from Cherry Industrial Products *(cherryswitches.com)*, which will become ZF in 2017, need no wires for power or to deliver data signals. These truly wireless devices instead harvest energy from the act of a technician or manager pushing the rocker or snap switch. Activating the switch moves a magnet and that motion affects an electromagnetic generator, letting it create an electrical impulse. The impulse is temporarily stored before being converted into a predefined voltage supply by a voltage converter. This provides all of the voltage needed for the switch's RF electronics to send a radio message containing all user data via an antenna.

The switches operate on 868 MHz and 915 MHz, sending up to three data "telegrams" 984 ft. in open areas or 98 ft. inside buildings. Users can transmit information as a proprietary, customer-specific protocol or with RF standards such as KNX-RF or ZigBee. An available receiver can be used to pick up signals from serval switches.

The switches operate in temperatures from –40° to 185°F, with the rocker switch having a life of at least 100,000 operations and the snap switch lasting at least 1,000,000 operations. The switches are also sealed to have an IP40 rating.

For companies new to wireless switches, the firm makes an Energy Harvesting Evaluation Kit that fully demonstrates the technology and lets technicians test its behavior, measuring signal strength and range. The kit includes an energy-harvesting switch, wireless snap switch and rocker switch, receiver, USB cable, antenna bushing, and manual. md



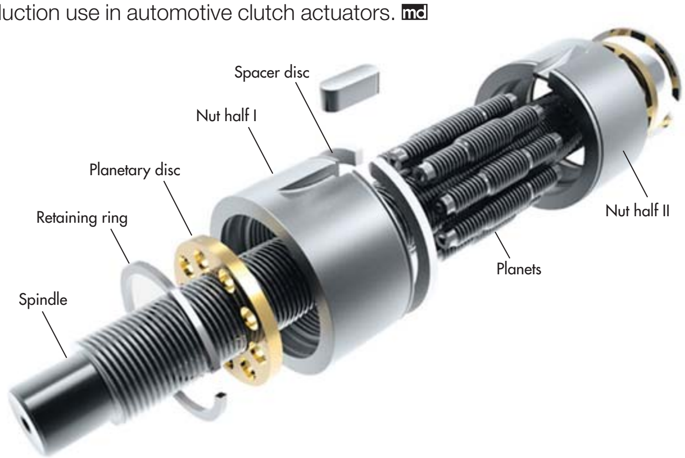
Creating Larger Forces with Differential Roller Screws

POWER DENSITY IS one of the primary reasons why design engineers and manufacturers rely on hydraulics when they want their machines to move something. Hydraulic systems offer very high force density in a compact, relatively economical design. But inherent drawbacks to hydraulics are leading design engineers and manufacturers to consider an electromechanical system as an alternative to its hydraulic counterpart. One way to do this is by replacing the hydraulic cylinder with an actuator and screw driven by an electric motor.

The roller screw's ability to generate two to five times the force of an equivalent ball screw makes it an excellent replacement for a hydraulic system. However, due to the precise grinding tolerances needed to achieve the load-sharing properties, roller screws can be expensive. To address this issue, Schaeffler *(www.schaeffler.com)* recently developed the PWG differential roller screw, which offers the high forces of a traditional roller screw at a price point closer to that of a ball screw.

The key to the PWG's affordability is Schaeffler's ability to manufacture its spindle and planet gears by forming (rolling), rather than undergo the time-consuming and expensive grinding process typically used to manufacture traditional roller screws.

Schaeffler's PWG is characterized by very high power density. The PWG's large number of contact points between the planets and spindle enable it to achieve very high axial load-carrying capacity. Applications for the PWG include power tools, sheet-metal bending machines, locking cylinders for plastic-injection-molding machines, and riveting and cutting devices. The PWG is currently in volume-production use in automotive clutch actuators. md



Schaeffler's PWG differential roller screw—whose spindle and planets are manufactured using forming, instead of traditional grinding, methods—is characterized by a very high power density. *(Image courtesy of Schaeffler)*

News

DASSAULT SYSTÈMES
Launches SolidWorks 2017

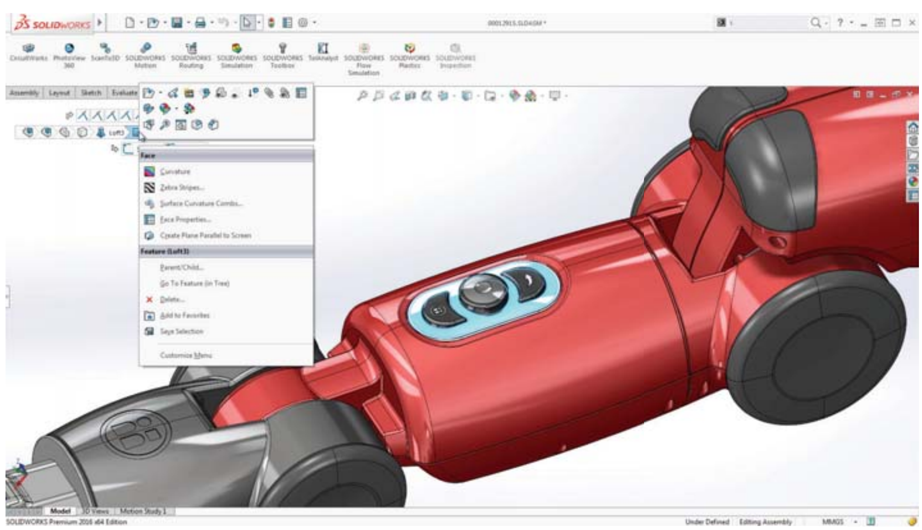
More than 250 enhanced CAD features have been added to the latest version of Dassault Systèmes' (DS) 3D CAD (computer-aided design) software, SolidWorks, which garners over 3.1 million users. Driven by Beta-program user feedback, new features in SOLIDWORKS 2017 are designed to streamline design processes across multidisciplinary teams, and strengthen relationships with customers, vendors, and suppliers for improved product time-to-market.

SolidWorks 2017 includes tools that enable access to a wide variety of CAD parts. It is available through a desktop version, and customers can gain access to online services through MySolidWorks.com. It enables designers to upload CAD models to the internet as eDrawings, and its 3D Interconnect feature removes barriers to third-party data. 3D Interconnect reads neutral and native CAD data, converting it to base parts that can be integrated into assemblies. Product data can also be made available through Android and iOS mobile apps to improve collaboration across teams and with customers and vendors.

Partnerships with major manufacturers give users access to multiple supplier inventories, including ones for electrical components. Teams can directly calculate the cost of entire assemblies and determine the availability of modular parts. Users can ultimately submit their design to manufacturers to predict manufacturability. DS also announces improvements in SolidWorks PCB, powered by Altium, for designing printed circuit boards (PCB) that comply with the mechanical design.

New chamfer, fillet, and advanced hole-specification tools facilitate changes to existing parts. For example, fillets can be replaced with chamfers in existing parts, and pre-saved specifications can be added to previous hole definitions. Constructing stepped holes is faster than it is in previous versions, and surfacing features like wrap, drag and drop, emboss, deboss, and 3D curve have been improved to generate surface characteristics on complex 3D geometry. A magnetic-mates feature lets users better organize complex assemblies by setting up connection points for drag-and-drop mating and easy repositioning.

SolidWorks Simulation includes design-verification tools that identify stress "hot spots" and analyze part performance based on user-defined parameters. As part of the analysis, it may recommend alternative designs, such as chamfers rather than sharp corners in high-stress regions, to improve the strength of the part. All analyses are communicated in the RealView bar on the screen. In addition to linear-static analysis, Simulation can also perform non-linear or dynamic analysis. ■



SolidWorks 2017 enables designers to upload CAD models to the internet as eDrawings, and its 3D Interconnect feature removes barriers to third-party data.

CATALYST DATABASE STREAMLINES Testing of Fuel-Cell Reaction

SCIENTISTS AT STANFORD and the Department of Energy's SLAC National Accelerator Lab reveal a new catalyst that can be used to drive faster oxygen-evolution reactions (OER) in fuel cells and other light-driven renewable energy sources. The catalyst is highlighted for its low levels of iridium—one of the rarest metals on Earth, along with its ability to drive OER at rates 100 times faster than IrOx and ruthenium oxide (RuOx) systems commonly used in acidic fuel-cell environments. Results from the experiment were published in the journal *Science*.

Using a catalyst database called SUNCAT, the team simulated various catalysts' behavior when deriving diatomic oxygen from water in the presence of light. A partnership between SLAC and Stanford, databases like SUNCAT enable scientists to tweak the structure and molecular constituents of a catalyst to figure out which ones will achieve the desired reaction rates. Various student and research groups add catalyst simulations to the SUNCAT database on a regular basis.

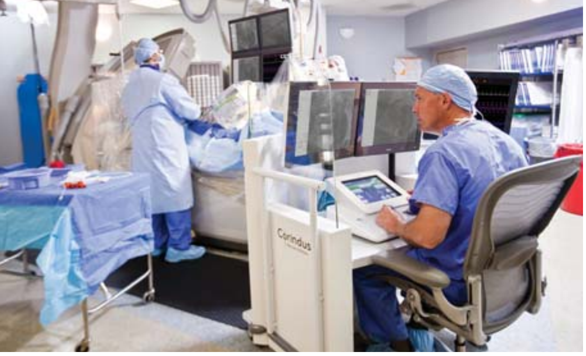
After running tests with SUNCAT, SLAC Staff Scientist Yasuyuki Hikita and SLAC/Stanford Professor Harold Hwang chose to test the behavior of a strontium iridium oxide catalyst in the lab. They placed the catalyst on the surface of an undisclosed material and immersed in an acidic fluid used in fuel cells to measure its ability to drive OER.

THE RESULTS

The strontium iridium oxide catalyst worked better than expected due to a corrosion process at the surface of a material. "Surfaces can be very dynamic," says Thomas Jaramillo, an associate professor at SLAC and Stanford and deputy director of the SUNCAT Center for Interface Science and Catalysis. "But in this case the catalyst changes in a way that gives you excellent performance in acid. This is unusual, because under these conditions most materials are either poor catalysts or they completely fall apart."

Over the first two hours, the speed of OER increased exponentially as a corrosion process stripped strontium atoms from the catalyst and left IrO at the surface. In the end, the film of iridium oxide was just a few atomic layers thick, but much more active than the original material.

But the scientists are still unclear as to how the IrO molecules arrange themselves to improve the OER rate after corrosion. To further understand the surface reaction, the team will observe the catalyst with X-ray beams at SLAC's Stanford Synchrotron Radiation Lightsource, a DOE Office of Science User Facility. This will enable them to observe the reaction up close. ■



CorPath PCI robots from Corindus can improve the health of surgeons as well as performing steady-handed surgery on their patients.

VASCULAR-INTERVENTION ROBOTS SPARE

Surgeons from Radiation, Back Problems

BEING A VASCULAR surgeon in a catheter lab is strenuous work. After a person has a heart attack, they may undergo non-invasive surgery called percutaneous coronary intervention (PCI), where a surgeon inserts a catheter containing a stent through a small incision and guides it through an artery or vein until it reaches the part with plaque buildup. Then the stent is expanded via a balloon or other mechanism to widen the vessel for better blood flow, and the surgeon pulls the catheter out. PCI is guided through X-ray imaging so that the surgeon can see what he or she is doing inside the body.

But chronic exposure to X-ray radiation has been linked to health problems in catheter surgeons. To combat this, surgeons wear lead bibs to prevent ionizing radiation from penetrating their cells. But wearing this heavy radiation armor can cause other problems like chronic back pain and spinal injury, especially when surgeons lean over their patient for hours during meticulous surgery.

Hospitals across the country are employing CorPath PCI robots from Corindus to improve the health of their surgeons and perform steady-handed surgery on their patients. Released in January, CorPath is the first robot to be cleared for PCI by the FDA. The CorPath bedside units are controlled by surgeons in a room protected from radiation, called the Intervention Cockpit. The surgeon uses joystick and touch-screen controls to guide the catheter to the damaged artery or vein.

First, the CorPath system can use X-ray imaging to measure the clot for the correct balloon stent to be inserted. When positioning the stent at the clot, the catheter can be moved in the vessel with a resolution of 1 mm. The bedside unit includes a motor on the robot arm's wrist for precise positioning and another drive to adjust the height. A one-use cassette contains the drives that feed the catheter into the patient at the proper angles. They have an open-architecture design so that surgeons can interchange a wide variety of tools and guidewires with diameters as large as 0.36 mm (0.014 in.) ■

IN PERSON WITH "OLLI," Your New Autonomous Vehicle Valet

THIS YEAR AT the International Manufacturing and Technology Show (IMTS) 2016, Local Motors had a hit on its hands with Olli, the company's new autonomous vehicle made up of 3D-printed parts. IMTS had set up the bottom portion of the North Building to be a track for Olli to ride around and show off its autonomous skill.

For purposes of the show and due to the lack of GPS inside the building, the drive was semiautonomous. This means that the vehicle was driven once around its route and then programmed to repeat the same route. The ride was smooth, handling turns and the obstacles placed in its path with ease. Inside the vehicle there was space for six people seated and plenty of standing room left for car-pooling trips. The vehicle maintained a low speed and personally it was a comfortable ride. You forget that no one is at the helm of the vehicle. Once outside of the vehicle, it went on its next run and I stepped into the path of the vehicle. It stopped automatically, waited for me to clear the path, and slowly started driving again until it reached its top programmed speed.

Adam Kress, director of public relations for Local Motors, described to us their future plans for Olli. They plan to introduce it into dense urban areas. This could be from major cities like Chicago or New York, to college campuses and amusement parks. With the technology built into Olli, one could call upon Olli to pick them up. An integrated mobile app can be used to call Olli and track its current location. The vehicle has built-in GPS that can be used for it to travel from point A to point B. Using LIDAR technology along with short- and long-range sensors, Olli can navigate its surroundings. Inside and outside cameras transmit video back to a security location to monitor the conditions inside and outside. Olli is made of an aluminum chassis with carbon-fiber body panels, along with several 3D-printed parts, including the wheel wells, fenders, and interior kick panels. The pilot programs for Olli are set to launch at the University of Las Vegas, Maimi-Dade County, Washington D.C., and Denmark.

Olli is made of an aluminum chassis with carbon-fiber body panels, along with several 3D-printed parts, including the wheel wells, fenders, and interior kick panels.

This is not Local Motors' first time in the spotlight at IMTS. Back in 2012, the company unveiled the Rally Fighter, which was built right on the floor of IMTS. This highlighted the strength of its micro-factories and being able to build efficiently. In 2014, it showcased Strati, a 3D-printed car. Using 3D printing techniques and additive manufacturing, Local Motors was able to construct an entire vehicle in under 48 hours. Then in 2015, it built the world's first 3D-printed highway-capable concept vehicle, the LM3D Swim. Building on top of the frame of a BMW i3, the interior and exterior are 3D printed. The vehicle itself is also 100% electric, rear-wheel drive, automatic single-speed transmission, with a range of 100 miles, and a top speed of 50 mph. Entering the fray of American car manufacturing is a challenge. Considering all the heavy players in the field, Local Motors is pushing the envelope embracing the emerging technologies of today like 3D printing and self-driving vehicles. ■

Paving the Way to an IoT World

To get an idea of how IoT is growing within the U.S. and around the world, *Machine Design* talked with Marissa K. Tucker, product marketing manager for Controls and HMI at Parker Hannifin's Electromechanical and Drives Division.

Interview by STEPHEN J. MRAZ

What is your definition of IoT?

In essence, the Internet of Things, or IoT, is just a network of physical devices, whether they are embedded with electronics or software or any sort of sensors that collect data and simply share it with other devices. Those really are the fundamentals of IoT. So you can easily make the argument that Parker—and, in fact, a lot of companies—have been doing that for decades.

The new thing and the excitement about IoT, and why it's kind of coming to the forefront now, is that people are starting to take the concept from individual machines and really starting to share data between machines—which, again, is technology that's been around and been used for decades. But even more exciting is that companies are starting to realize they can now group entire factories together.

How did the IoT get started?

It started about 20 years ago when engineers discovered they could control systems using Ethernet rather than through command signal, and bus-based networks started to overcome the traditional controlled networks. So all of a sudden, factories had to collect a lot more data from all of the sub-devices within a single machine so that managers could make better decisions based upon that. In addition, companies learned they could share information with other systems. And there are still a lot of systems out there that aren't even doing any of this.

Why do we need IoT?

If companies can really get their machines inside their factories communicating with each other, then they can get them to communicating directly with their enterprise-resource-planning (ERP) manufacturing execution systems (MES), and then to whatever global network they have as an enterprise. All of a sudden, we're getting closer and closer to a fully automated factory that not only takes orders, compares what's needed to what materials are in stock, and order additional parts as needed.

The automated factory can also schedule automatically and retool as necessary, using optimized algorithms. And all of this can be done without human intervention.

Of course, if any maintenance is needed—if there is any human maintenance required—the machine can simply contact the human, in theory, before even an error or maintenance issue arises. So, we're inching ever closer to the self-managed factory. And that's always been the goal and promise of manufacturing, since Ford back in the day with efficiency. But there are still a thousand steps to get there.

Describe the differences between IoT, the Industrial Internet of Things (IIoT), and Industry 4.0.

The terms are used interchangeably in this industry, but slight differences exist between them. IoT usually includes consumer-based products and devices. IIoT, the Industrial Internet of Things, concerns manufacturing companies. And Industry 4.0, which some people use interchangeably with IIoT, is a German-defined knowledge strategy. It's defined by the German government, which promotes and subsidizes IIoT, or just the general computerization of automation. And it's called Industry 4.0 because they really see that the interconnectedness of the factory as basically the fourth Industrial Revolution.

Who will benefit—and will anyone lose out—because of IoT?

There will be some losers in the short term. But in the long term, everyone wins. The entities poised to win early are the large manufacturers with the capital to invest in the new technologies. And, in fact, they have been investing in this for a very, very long time. These larger companies already have had manufacturing systems that communicate with each other and with databases for a long time. They also know that the cost of building and implementing these networks can be ridiculously high.

What contributes to the costs?

For instance, every factory line is made up of five or six individual machines, and each packaging line is made up of five or six individual machines, and they can all be from different manufacturers. So, to get all of those machines talking with each other, you have to invest a considerable amount of money to get an integrator. The companies then have to standardize communications and data formats between machines, and that takes another huge upfront investment.

Companies also have to be careful. For example, some manufacturers tried standardizing their packaging lines by having all of the machines use the same controller. Many soon realized that standardizing on one controller gives the controller manufacturer a lot of power to increase prices and the cost of support, especially when a company is in a downtime situation.

Is there a way around some of these costs?

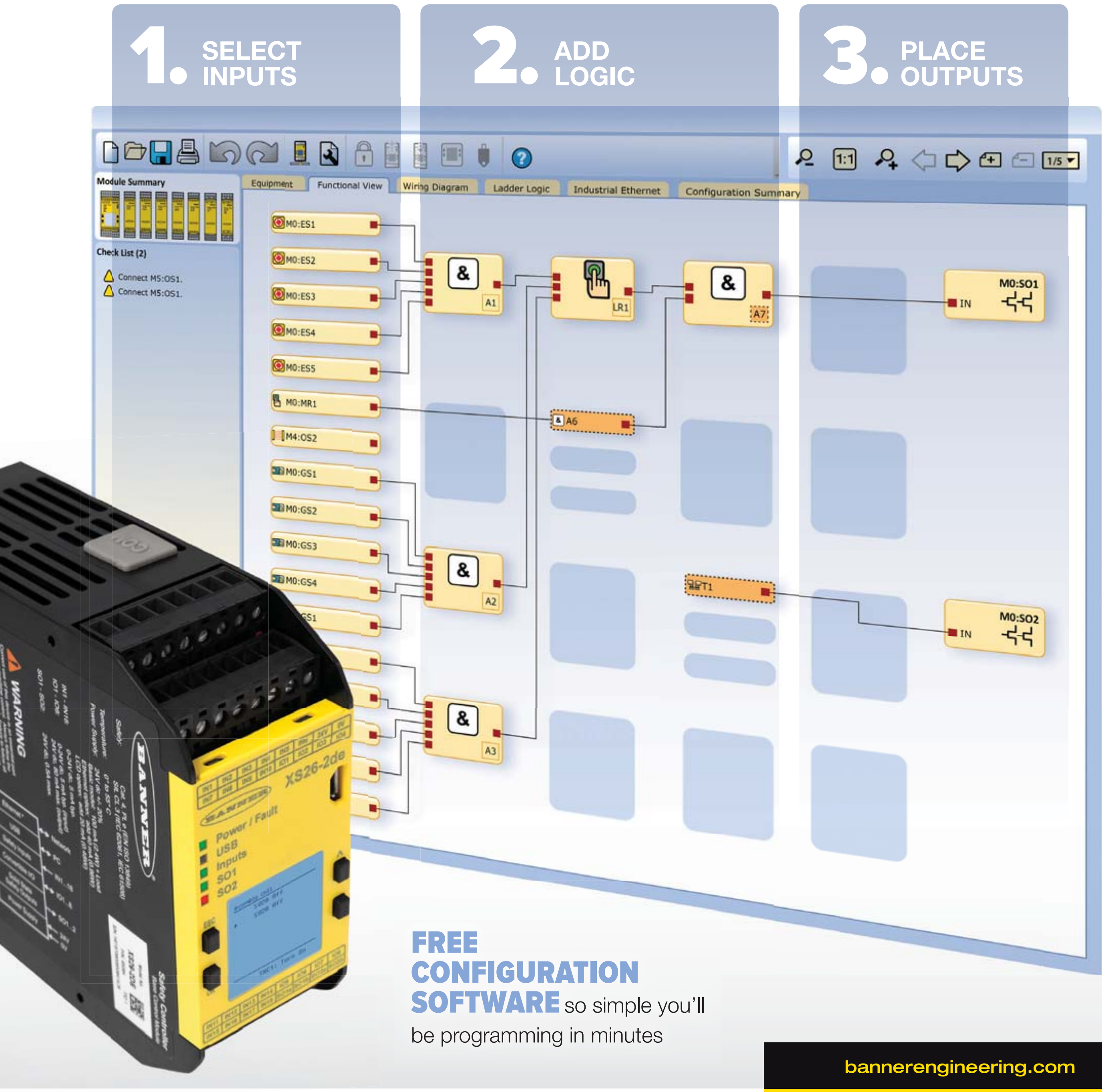
Some of these large manufacturers have learned from their mistakes and they've created new standards. A good example is PackML (Packaging Machine Language). Armed with that standard, a company can go to any machine builder and tell them to use whatever components they want, as long as the finished machine gives the company access to a specific type of data on all of its machines. In that way, the company can become more interconnected, and it's a lot less expensive to integrate and to communicate.

So larger, better-capitalized firms hold the upper hand when it comes to IoT?

In the short term, companies who could afford to invest in IoT machinery are going to be the ones who benefit from IoT and move faster and closer to the true self-managing factories. But small and medium manufacturers will also benefit from standardization and advances in technology.

The trick for these small- and medium-sized manufacturers is that a lot of them still don't even have the base foundation. There are still a lot of machines on factory floors because managers just wanted the lowest prices. Many of these brand-new machines cannot communicate in even the simplest terms with other machines; they're just discrete logic-handling PLCs. These small- and medium-sized manufacturers have to be using intelligent devices. That's really the foundational layer.

SCALABLE SAFETY MADE SIMPLE.



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Are there any countries that seem much further advanced toward a more complete realization of IoT than others?

Some facets of Germany are a little ahead of where the U.S. is, but that's because the government subsidizes a lot of medium-sized manufacturers to jump ahead. We don't have the same system within the U.S., but we're pretty much at the same level right now.

What's the biggest stumbling block on the road to IoT?

Across the board, the biggest stumbling block is what's in your factory right now. In most factories, there is going a combination of new and old machines. Some might have been built there in the 1980s, but they are still going strong. Updating them for IoT or replacing them, however, will be expensive. Some firms will have new machines they just purchased or relatively new machines that they retrofitted recently. So there's going to be a huge variation in what companies have in their factories.

Another stumbling block is that some people define IoT as it being built around a network or cloud of external servers that will not be owned by individual manufacturers, but managed by someone else. If that is the case, it will be a long wait until IoT is fully in gear, because the manufacturers I talked to are not comfortable with storing and using data from the cloud or external servers. If you let IoT be based around a network owned and inside a company, you can still carry out many of the same tasks possible with external servers and everything hooked into the internet.

So where should companies start on the road to IoT?

The most important task for factory managers to do right now is to survey the machines in their factories, because that's limitation. For example, if you have machines with discrete logic that cannot communicate with anything else in the factory, step one is figuring out how you're going to get those machines to talk with others without completely replacing it—an incredibly expensive proposition.

Fortunately, there are already intermediate products out there to help customers connect the machines that are not interconnected. For example there are HMIs that have web-publishing capabilities that will let machines communicate using a wide variety of different drivers.

Companies should not be upgrading for the sake of upgrading, and I fear that's what a lot of companies are doing right now. Instead, they should upgrade with a purpose, and the purpose is to get just the right data to all of the places that need it. So first they need to answer the question: What process, either an enterprise or a manufacturing process, could be improved by the collection and use of more data? That's where you first start: Do things that make sense for your company.

What about security? Is that a concern?

We are far from perfect when it comes to security, and that's why a lot of manufacturers are choosing not to put their information on servers they don't own, because they lose the control over that data. And with the IoT, people are talking about putting much, if not all, of the company's intellectual property in the web.

To get all of the talked-about IoT benefits, manufacturers need to convince customers to put their devices on my cloud and let me use their data. That's not going to happen significantly within the next five to 10 years, because most manufacturers I talk to won't put their information on the cloud in the first place. So although manufacturers want all that sharing to happen, I'm not convinced that's what users want to happen. I'm not convinced they're sold on the benefits yet, and I think the reason is because we don't know what that data is, what it might lead to, and who exactly will have access to it.

Are standards necessary for IoT to grow faster?

There are two ways to go about standardizing an industry or technology: The government can mandate it, or you can see what happens naturally. It would be a lot quicker if someone with a gavel came around who said, "Okay, everyone will use this standard," but we're making good progress letting the free market do what it does best.

If we, as manufacturers, simply listen to the needs of what our OEM machine builders need and what their customers' needs are, we'll develop IoT very, very quickly. But we have to be listening and open to that kind of the change when the market is demanding standards from us, and telling us what those standards should be. md

JEFF KERNS | Technology Editor
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What's the Difference Between Failure Theories?

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

Calculating stress can be a relatively easy task; you may even remember it from school. However, it's much more difficult to determine all possible loading situations that cause stress. For this article, we'll look at loading class, how it affects failure theory, and how that will change the factor of safety.

Note that this article provides an overview of design basics for those seeking general knowledge or an introduction to loading analysis. It does not attempt to cover all of the complexities of a loading analysis.

LOAD CLASS

In general, the difference between loadings that will dictate if a design is safe will be whether it's static or dynamic. While the stress is calculated, it is generally proportional to the loads. But the stress analysis is only as good as the quality of the information about the loading situations. This is broken into moving and stationary components and load type.

There are other classes, but these are the most common. Determining the class can be difficult when considering unplanned loads—something impacting the object, another component breaking and thereby putting extraneous loads on an object, wear generating higher vibration loading, etc. Unplanned loads might change the loading class, too.

For example, in the midst of a quick assessment, someone could make a mistake and classify a bridge as a Class 1 load. However, once you consider the winds and traffic that act on the bridge, it would be considered a Class 2 load.[1]

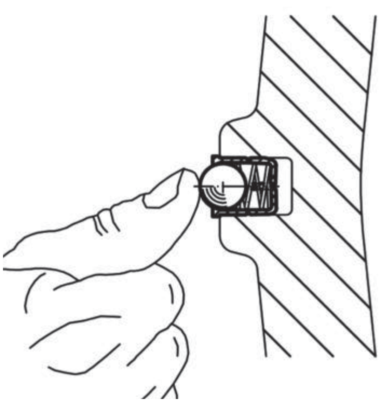
The difference between materials that will determine if a design is safe is whether they are ductile or brittle. The ductility of a material could alter the stresses considered in a design. For example, stress concentrations can be ignored for ductile material under a static load.

Ductile material—having more than 5% elongation before breaking[1]— causes local yielding that reduces stress concentrations caused by geometric discontinuities. Brittle materials, on the other hand—those with less than 5% elongation before breaking, and a difficult-to-define yield point[1]—will need to include stress concentration with the calculated stress. There are exceptions, such as cast materials where inherent stress-raisers in the materials are so high, geometric discontinuities will have little additional effect.[1]

MOVING AND STATIONARY COMPONENTS AND LOAD TYPE

	Static/constant Load	Dynamic/time-varying Load
Stationary elements	Class 1	Class 2
Moving elements	Class 3	Class 4

Source: *Machine Elements in Mechanical Design,* Robert L. Mott



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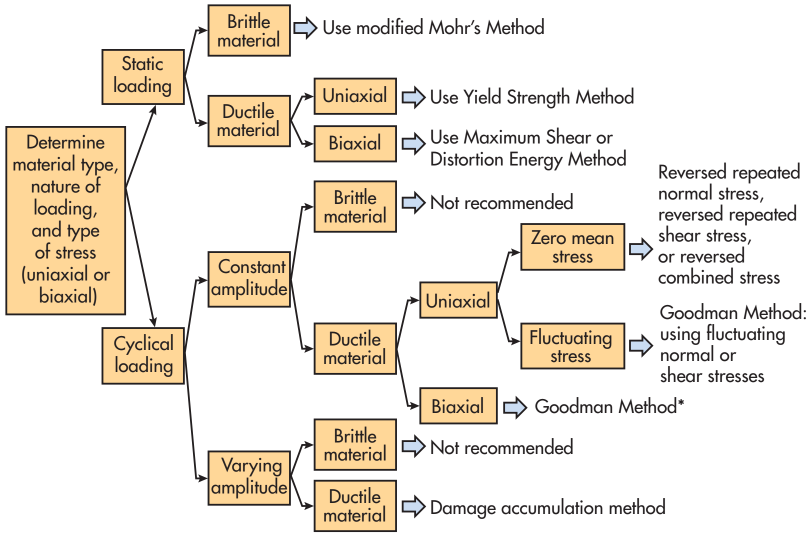
FAILURE METHODS

Differentiating between loading and material properties will help to reveal the types of stress. Obtaining this information is the first in a series of steps that will lead a designer to use the correct failure theory. Such a theory isolates the conditions in which a material for a specific application will fail. This prediction is the allowable stress, and it should be less than the actual stress.

In the decision tree *(Fig. 1)*, different situations will lead to the correct failure theory.

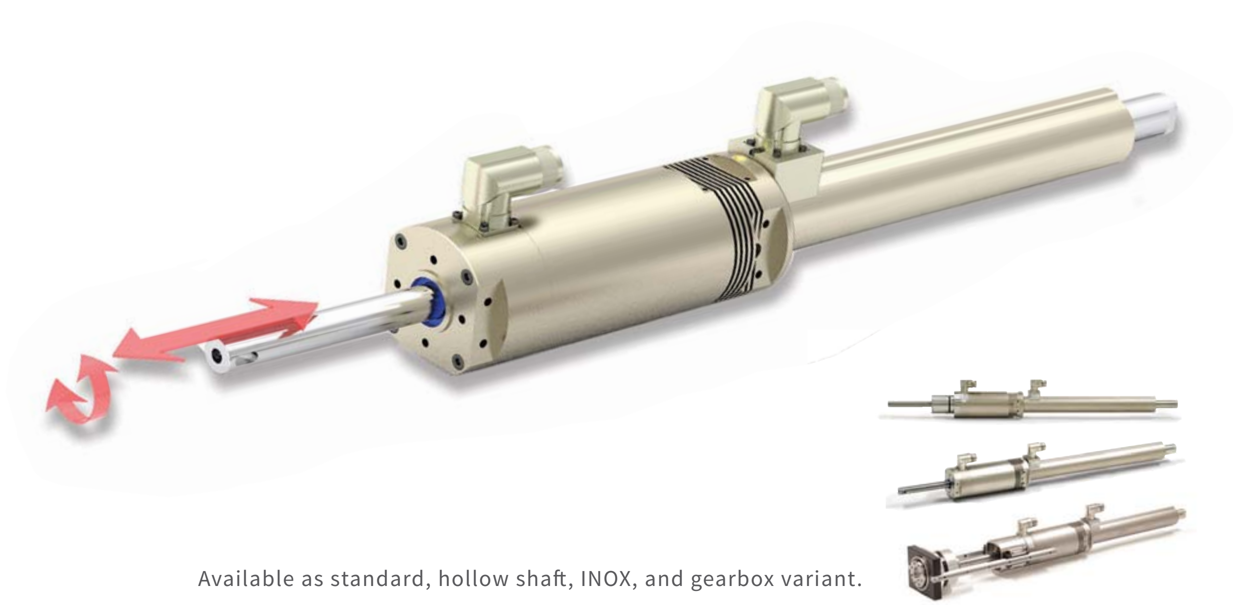
Failure theories cannot be compared side-by-side unless the same situations exist. Load, ductility of material, and stress types dictate the difference between failure theories.

Figure 2 shows the stresses that can be covered by static loading situations. Notice how a design must be less conservative (cover a larger area of stress) when dealing with brittle material—the line between Coulomb-Mohr's versus modified Mohr's. In addition, for uneven (materials that are stronger in compression than tension), using one of these methods over the normal-stress theory can allow for a more efficient design.



*Instead of using the normal and shear stresses, the biaxial stress will have two approaches. Both approaches will use the Goodman equation and Mohr's circle to find combined stresses. The difference will be what stresses are calculated. The first approach uses the maximum mean shear stress and alternating stress from Mohr's circle in the Goodman equation. The second approach uses Mohr's circle to find the maximum and minimum principle stresses, then uses von Mises to solve for the mean and alternating components to be used in the Goodman equation.

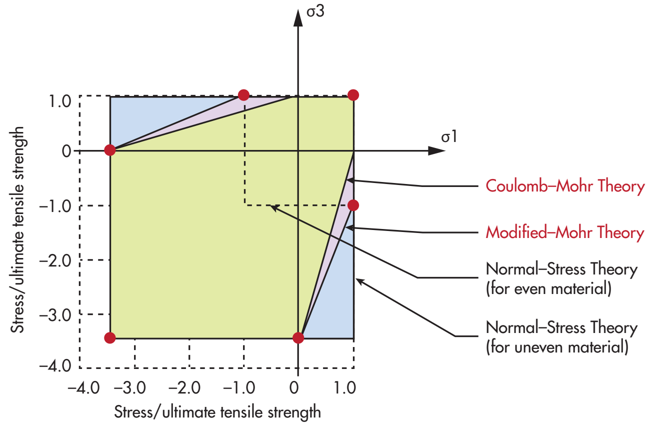
1. "Logic diagram for visualizing methods of design analysis," taken from p. 194 of *"Machine Elements in Mechanical Design,"* fourth edition.



What's the Difference?

The principle stresses calculated by the failure theory (represented in *Fig. 2* as σ^1 and σ^3) must fall within the area covered by the theory selected, not the opposite way around. Do not select the failure theory that covers the area with the stresses. This is because the different theories represent the behavior of the materials under that loading scenario.

Using the wrong loading, stress, or failure theory might lead to an inefficient design. This can lead to over-designing or using excessive material that leads to consuming more weight, resources, etc., which can give the competition an edge. However, overdesigning is the best-case scenario. The other option might lead to a design that is waiting for a catastrophic failure.



2. Note that the positive sides of the axes are tension and the negative sides are compression.

One common comparable example of a failure theory that does have the same loading situations involves the distortion energy method (DEM) and maximum shear stress. They will both work for biaxial and ductile material under a static load.

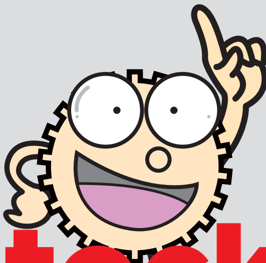
If a customer asks for a design to be more conservative, or to use the maximum stress theory, the engineer must know the failure theory used by the software. Otherwise, it will be necessary to generate calculation by hand, spread sheet, or a MathCAD-type program.

Both theories are able to use Mohr's circle to calculate information needed for maximum shear stress and DEM graphically.

FACTOR OF SAFETY

While the DEM generates an acceptable factor of safety (FoS), it is important to know the source of that information. Using published strengths of materials may sound safe (independent of the failure theory), but published properties could be the average or median value of where failures occurred. Designing to a published value, however perfect, could therefore yield a large number of failed components. md

Editor's Note: For more on FoS, please see the expanded version of this article at MachineDesign.com.



VICTORIA FRAZA KICKHAM | Distribution Editor

Final DFARS Rule Improves Anti-Counterfeit Efforts

The Final Defense Federal Acquisition Regulation Supplement further clarifies procedures for sourcing electronic parts and emphasizes authorized sources.

Electronics industry representatives were praising new efforts to clarify certain government anti-counterfeiting provisions over the summer, as a final Defense Federal Acquisition Regulation Supplement (DFARS) was released. The U.S. Department of Defense published its final DFARS addressing required sources of electronic parts for defense contractors and subcontractors in August, addressing issues surrounding terminology, traceability, and flow-down requirements, among others.

The final rule emphasizes a preference for purchasing parts from original manufacturers or their authorized sources, and leaves the onus on contractors when it comes to identifying and buying from trusted suppliers.

The rule clarifies provisions outlined in the National Defense Authorization Acts of 2012 and 2015, which issued new guidelines for government contractors that procure electronic parts—essentially telling them what they need to do to detect and keep counterfeit parts out of the defense supply chain. The newest update addresses key issues identified by the authorized electronic components industry: it clarifies definitions of the term “supplier,” establishes traceability requirements for contractors, and notes

that flow-down requirements do not apply to the original component manufacturer.

The Electronic Components Industry Association (ECIA), which represents component manufacturers and their authorized distributors, was among the authorized channel sources weighing in on the final rule. ECIA participated in the industry comment process regarding the rules, suggesting changes in key areas: use and definition of the terms "authorized dealer" and "trusted supplier;"; procurement policy; traceability; and flow-down requirements. ECIA's COO and general counsel Robin Gray said he was satisfied with the final rule, and the association pointed to the following changes specifically in a statement issued in early August:

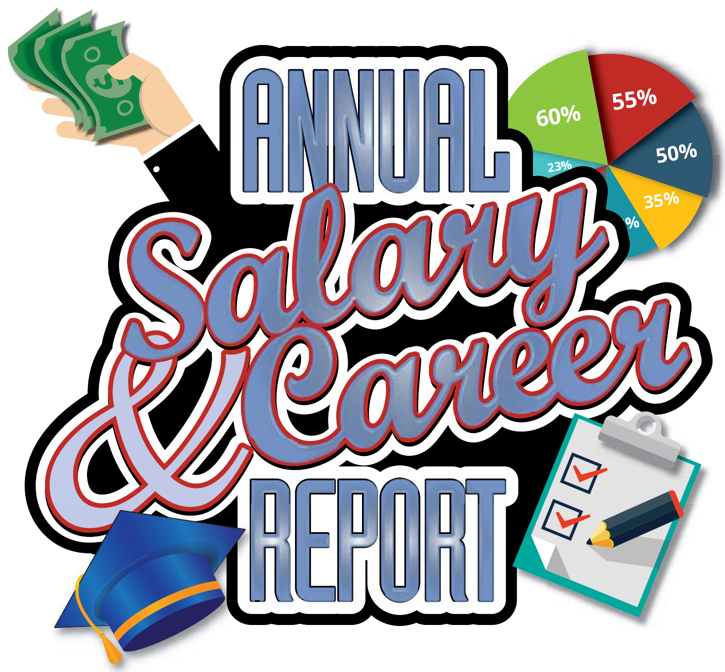
The term "authorized dealer" was deleted and replaced with the term "authorized supplier." Authorized supplier means a supplier, distributor, or an aftermarket manufacturer with a contractual arrangement with, or express written authority of, the original manufacturer or current design activity to buy, stock, repackage, sell, or distribute the part.

The term "trusted supplier" was deleted and replaced with the term "contractor-approved supplier." Contractor-approved supplier means a supplier that does not have a contractual agreement with the original component manufacturer for a transaction, but has been identified as trustworthy by a contractor or subcontractor.

The rule establishes a strict, three-tiered approach to the procurement of electronics parts; it provides that the contractor is responsible for inspection, testing and authentication if the contractor cannot establish traceability from the original manufacturer for a specific part; and it clarifies that the flow-down requirements do not apply to the original component manufacturer.

The counterfeit component problem continues to be a key issue across the electronics supply channel, especially among buyers at manufacturing organizations. In a recent Global Purchasing survey of more than 700 purchasing professionals, 34% listed counterfeit components as one of the major issues that "keep them up at night," and 47% said that keeping up with government regulations surrounding anti-counterfeit efforts is one of their major workforce challenges. Those with management titles were more likely to list counterfeit issues as a concern (36%) than those who identified themselves as buyers (25%). Executive-level buyers—vice presidents of purchasing and chief procurement officers, for example—expressed the most concern about quality/counterfeit parts (40%).

The questions about quality and counterfeit parts were part of Global Purchasing's annual Salary & Career Survey; results will be published online in October, at *www.globalpurchasing.com.* ■



Five Years of Engineering Thoughts and Opinions

With this 5th edition of our Salary and Career Report, we look back to see how the engineering profession has changed.

Since 2012, our survey has seen an increase of salary growth for engineers. According to our Salary and Career Report, from 2012 to 2014, the average salary was around $90,000 a year. In 2015, the salary jumped to $98,000 a year. This is promising for the engineering community as 56.6% of engineers responded that they expect their salary to increase in 2016. Over the last five years, engineers have been satisfied to extremely satisfied with their work, averaging a satisfaction rate of 90%. They also feel challenged at work over the last five years with 56% answering they are sufficiently challenged and 35% saying they feel somewhat challenged.

These trends of salary and job satisfaction are encouraging for the engineering profession. However, the average age of engineers is pushing more to the right. In the last five years, the percentage of new engineers has decreased and engineers as a whole are getting older. For engineers under 25, the percentage is below 1% for 2016. Engineers between the ages 30 to 39 comprised as high as 11% in 2013 of the engineering community and have declined to 8% in 2016. The same goes for other age ranges. The 40 to 49 age group has decline from 21% in 2012 to 15% in 2016. Engineers from 50 to 54 were at 20% in 2012 and dropped to 15% in 2016. The older age ranges have seen the most increase. Ages 55 and older have increased from 45% in 2012 to 59% in 2016.

PROFILE OF A TYPICAL ENGINEER

According to the 2016 survey, the majority of our readers are white males and 74% of our readers are age 50 and older. A little more than half work as a design & development engineer at 58%. This percentage is a bit down from last year (61.7% in 2015). Engineering and operational management comprise 19.3% of current principal job functions. These engineers have the job title of chief, senior, executive, or lead engineer. At least 55% of our readers work 40 to 50 hours a week.

OUTLOOK ON NEW TECHNOLOGY AND STANDARDS

Developments in technology and the changing environment have led to the rise of new standards. 52% of engineers said that standards and regulations have become more stringent over the last year. When asked about their opinions on the evolution of new standards, 63% said that it will cause companies to cheat when designing their products and only 32% agreed that they should be more stringent on software or hardware products. Overall, engineers felt that the new green initiatives and new efficiency energy standards would not affect design and manufacturing process or job security. One engineer's response elegantly stated that "Standards are always evolving and changing. As soon as one standard is adopted, work begins on the next release. It helps to provide a level playing field for all manufactures. In general, product safety is paramount. Without such standards some manufactures could/would cut corners resulting in product safety issues, and poor product performance."

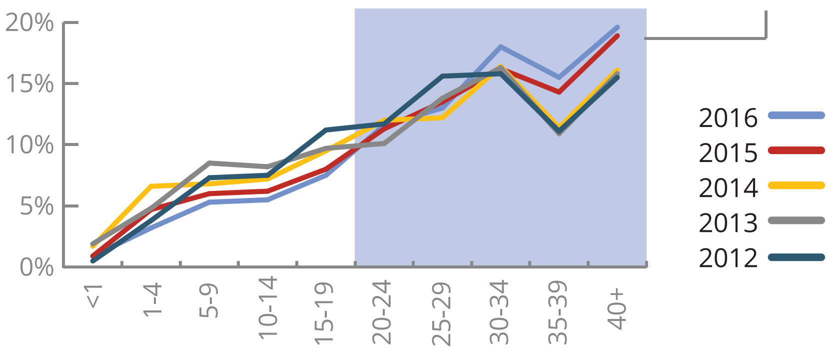
THE FUTURE OF ENGINEERING

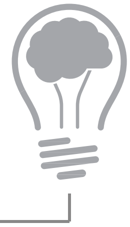
The future of engineering is still bright in the eyes of many current engineers. Over the last five years this view point has not changed as a strong 91% would recommend engineering as profession. When asked how they feel the engineering field is changing, one engineer spoke to our the fields of engineering are merging. "The lines are currently blurring between mechanical and electrical engineer. Increasingly we are specifying electrical components required to accomplish motion. It is becoming important to have a basic understanding of the limitations of control systems and their impact on the mechanical systems being designed." As the world of IoT continues to expand, we will see more of how the engineering worlds combine. md

—Carlos Gonzalez, Technical Editor

THE TYPICAL ENGINEER

YoY - Years in the Profession

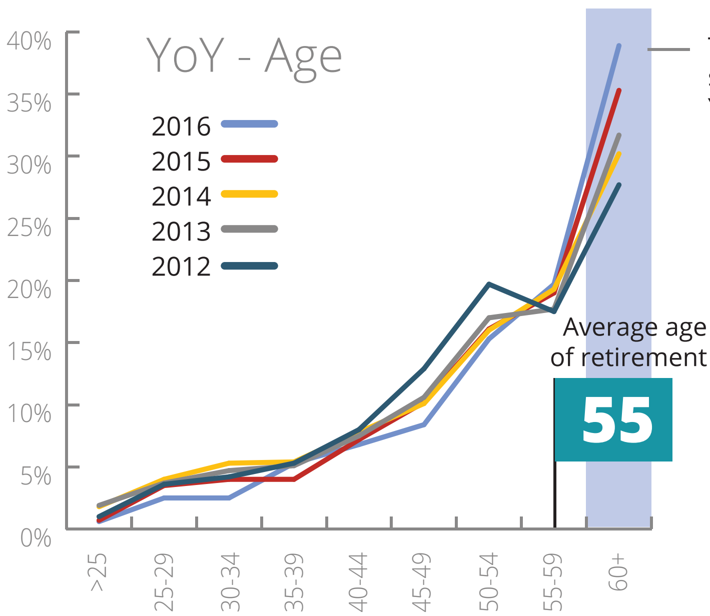




In 2016

77%

of engineers have
20+ years of experience



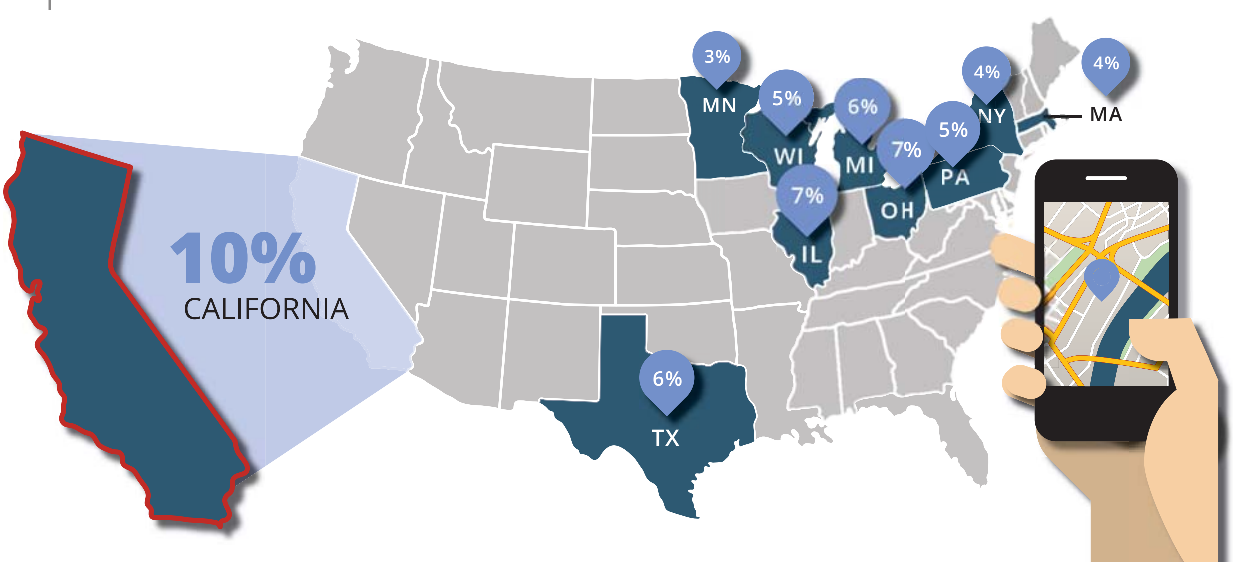
Those 60+ are steadily increasing YoY

Certification

Which of the following certifications do you have?

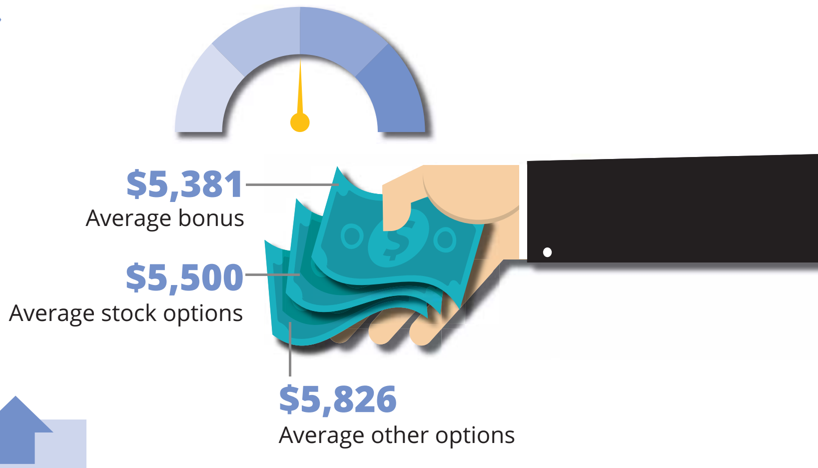
Professional Engineer	**42.6%**
Certified Drafter	**15.5%**
Certified Engineering Technician	**14%**
Six Sigma by Institute of Industrial Engineers	**8.4%**
Senior Member of the Institute of Electrical and Electronics Engineers	**5.2%**

Top Work Locations in 2016



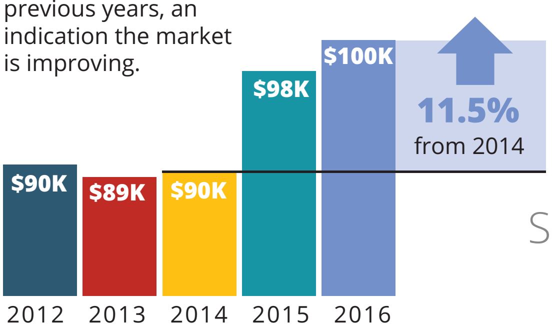
Average Salary in 2016

$99,933



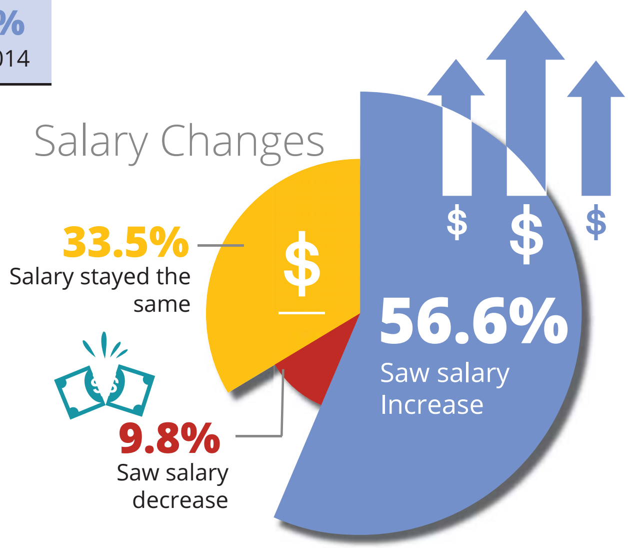
YoY - Average Salaries

Seeing a large jump in average salary as compared to previous years, an indication the market is improving.



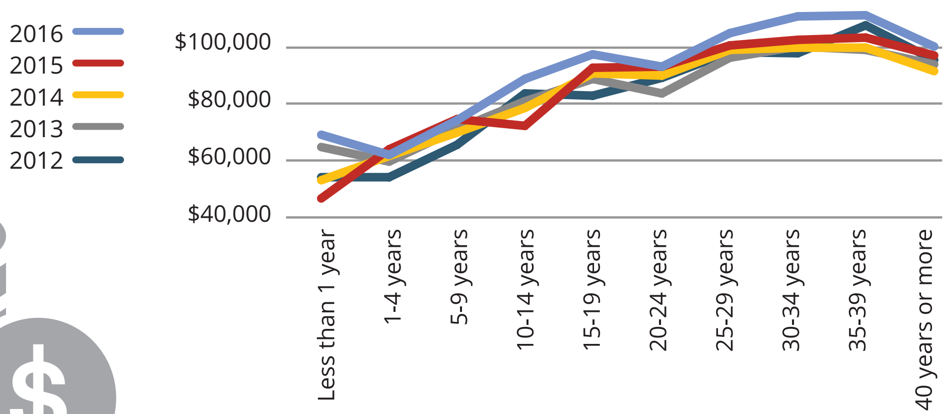
Since 2012, the value of $1 has risen to $1.05, which is a cumulative rate of inflation of 4.8%. The increasing rate of the average engineer's salary surpassed that rate, jumping 10.7% from 2012.

Salary Changes



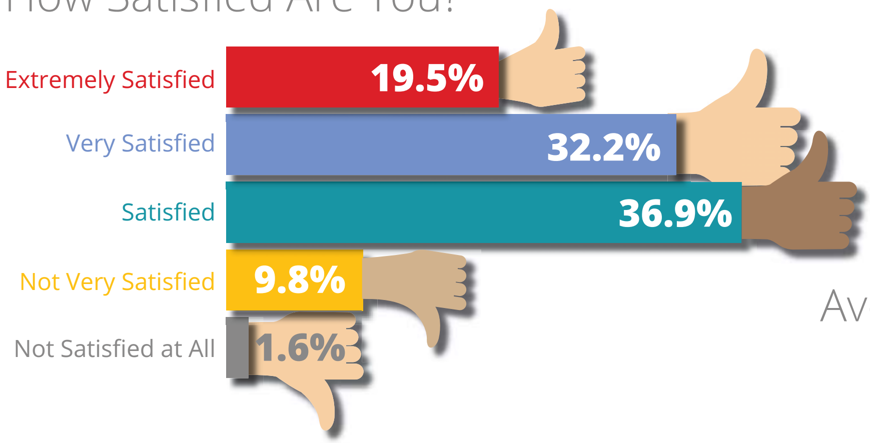
YoY - Salary by Experience

Salary trends closely YoY for past five years – with compensation generally rising with experience. Again, **seeing highest values in 2016.**

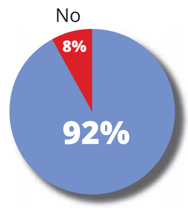


JOB SATISFACTION

How Satisfied Are You?



Recommend Engineering



Average Hours per Week

40.8

Down 1.2 hours from 2012

Reasons Engineers Would Leave the Profession

36% Try something different

31% Pursue other opportunities

26% Do something more fulfilling

25% Make more money

Feeling Challenged

58% Sufficiently challenged

33% Somewhat challenged

Most Important Factors in Job Satisfaction

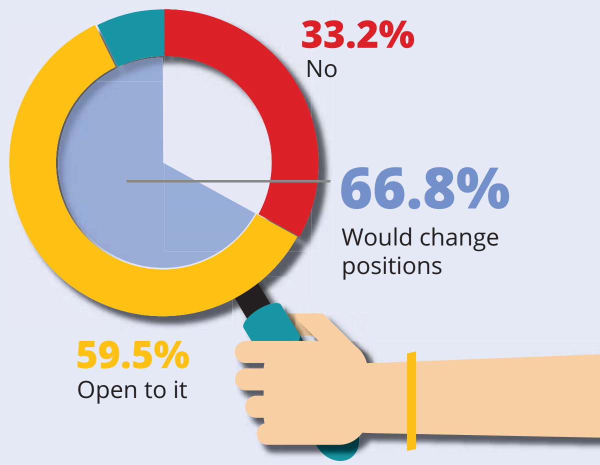
Challenges
The challenges that accompany the design of new products

Research
Researching potential design solutions

Benefits Society
Opportunity to design products that can benefit society

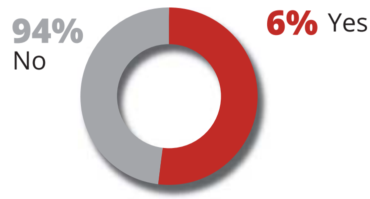
EMPLOYMENT OUTLOOK

Actively Seeking a New Position

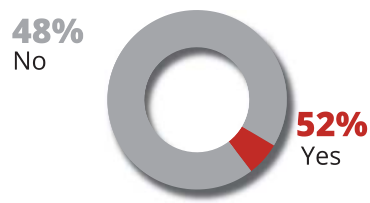


ANNUAL Salary & Career REPORT

Planning to Outsource?



Currently Outsourcing?



CONCERNS

Top Concerns at Work

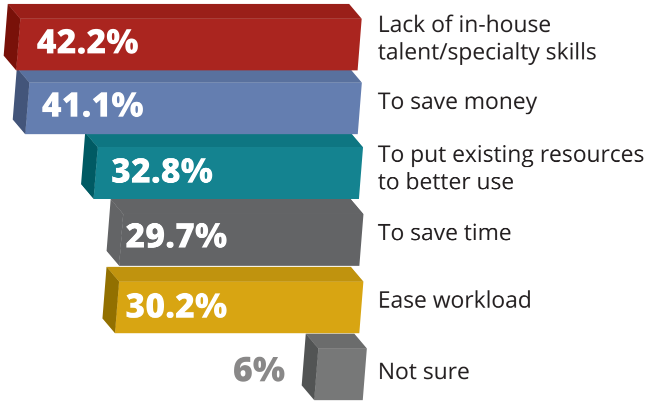
Resources **Time** **Funding**

Insufficient people resources to get the job done	6.77
Time-to-market pressures	6.41
Finding resources for my designs	6.3
Inability to adequately test product designs	6.17
Insufficient funding for my design projects	6.14
Having to compromise my design approaches	6.04
Competitive market pressures	5.86
Lack of design management direction	5.78
Politics at work	5.42
Shrinking product life cycles	5.24
Management is taking company in wrong direction	4.85
Second sourcing for the components specified	4.76
Seniority issues	3.86

ANNUAL Salary & Career REPORT

OUTSOURCING

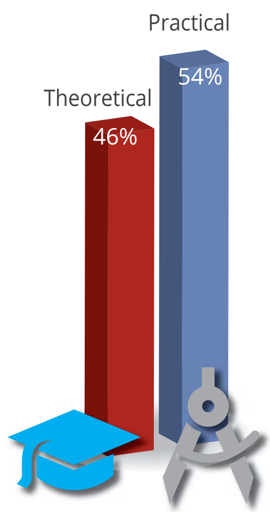
Reasons for Outsourcing



Work Being Outsourced

Design	50.8
Manufacturing/assembly	38.7
Software engineering/development	32.3
CAD/CAE	34.3
Drafting	28.2
R&D	17.7
Design verification	16.7
PCB layout	14.2
Software verification/test	10.3
Final test	10.1
Incoming inspection	3.8

Educational training (theoretical vs. practical)

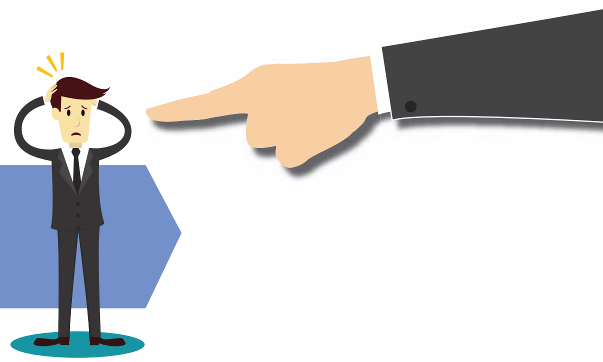


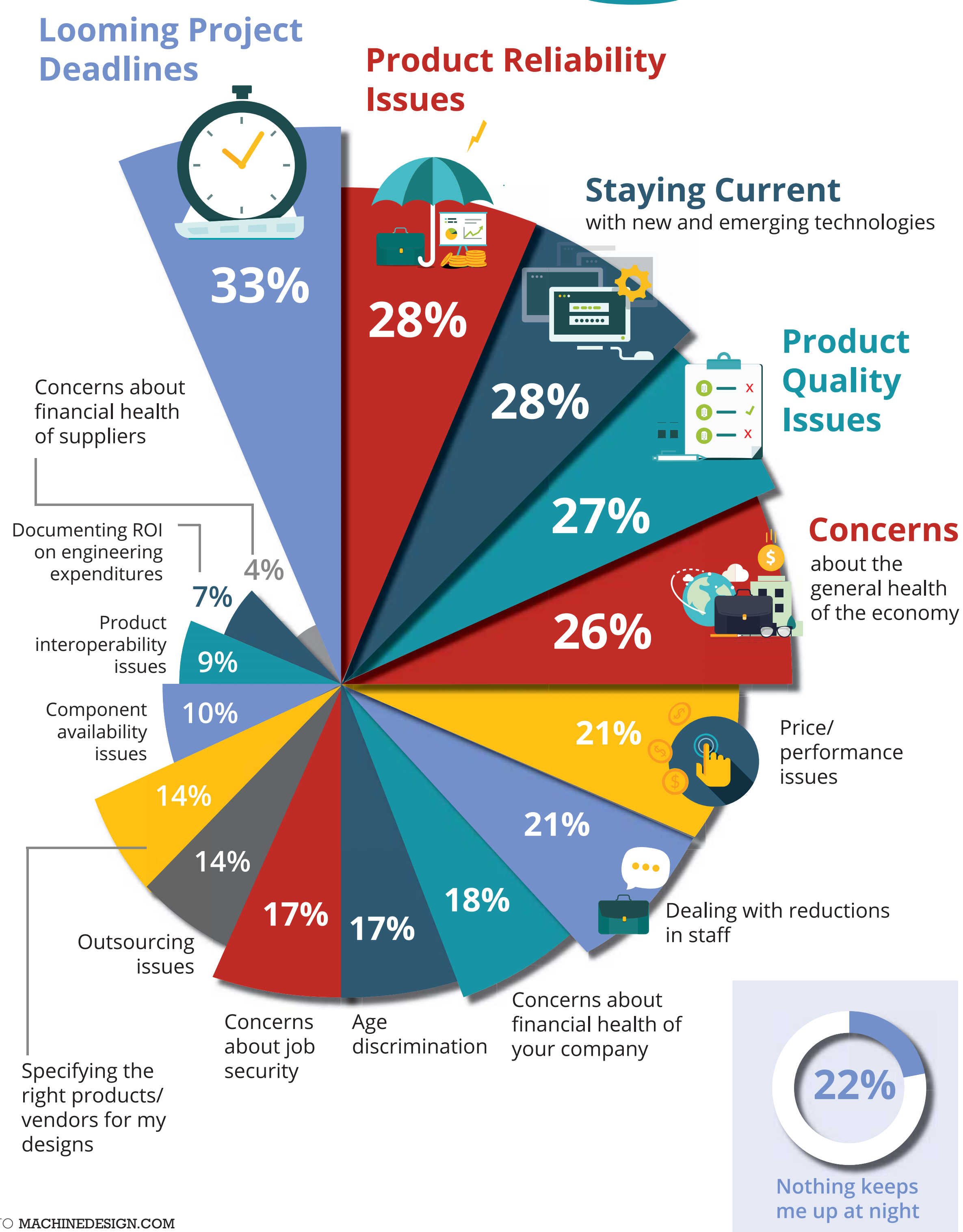
An engineer's thoughts: What percentage of your engineering knowledge is theoretical vs. practical?

"I think engineering education should be more practical and hands-on… working with industry on real world projects. I learned more about practical design and engineering during my internship than in the university classroom. If university professors came from industry instead of lifelong academia, more practical knowledge could be passed along… reducing the time needed to train new engineers fresh out of university."

2016

WHAT'S KEEPING ENGINEERS UP AT NIGHT?





My Company is...

16% Looking for engineers to help develop IoT products

36% Replacing older devices with interconnected devices

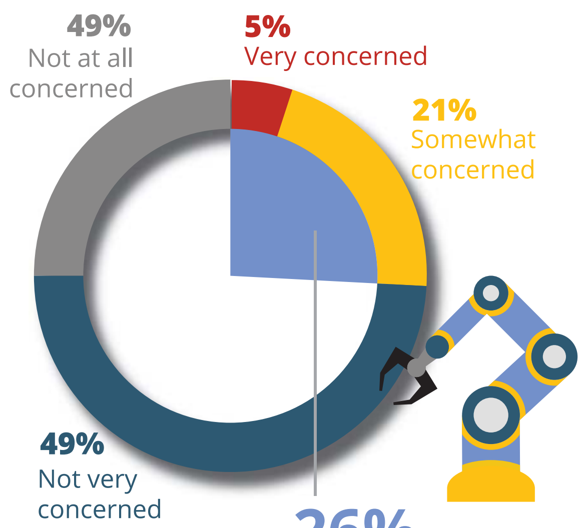
81% Upgrading computer security (firewalls, computer logins)

36% Using mobile devices for IoT data purposes (system failures, data collection)

12% Providing IoT systems training

Artificial Intelligence

How concerned are you that artificial intelligence will replace large amounts of people in the workforce?

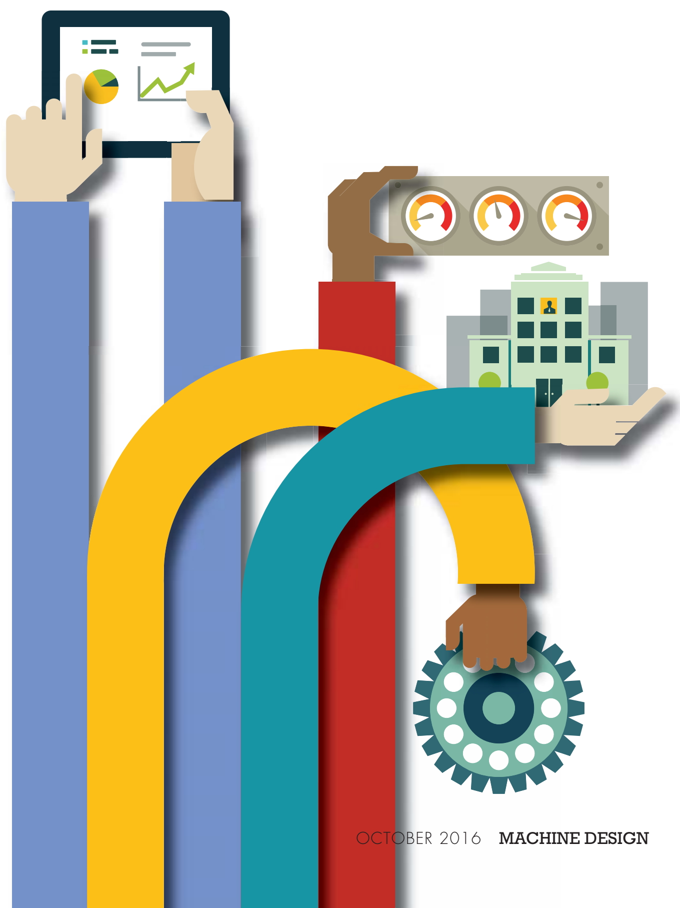


26% Are concerned about AI replacing them in the workforce

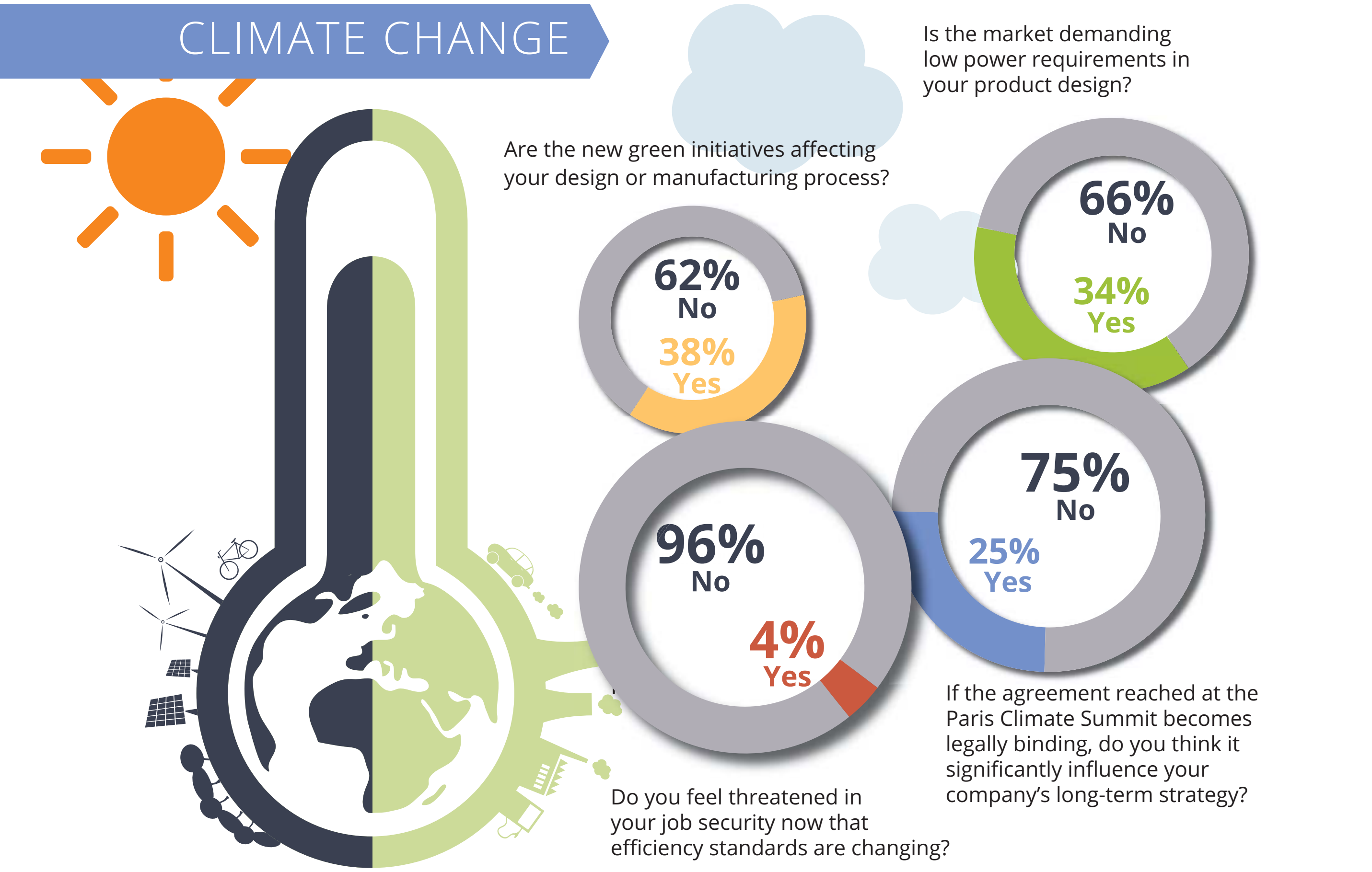
IoT Investing

How has your company invested in IoT systems upgrades?

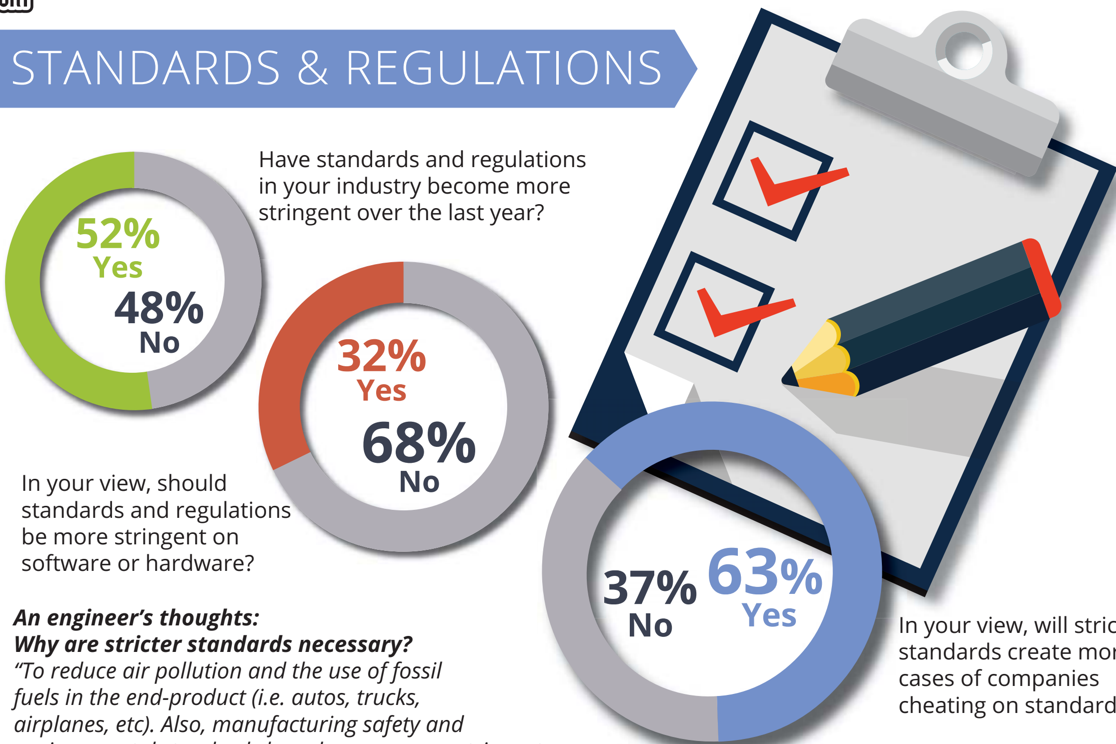
Wireless systems	64.7%
Mobile devices	40.9%
Ethernet	49.8%



CLIMATE CHANGE



STANDARDS & REGULATIONS



Have standards and regulations in your industry become more stringent over the last year?

In your view, should standards and regulations be more stringent on software or hardware?

In your view, will stricter standards create more cases of companies cheating on standards?

An engineer's thoughts:
Why are stricter standards necessary?
"To reduce air pollution and the use of fossil fuels in the end-product (i.e. autos, trucks, airplanes, etc). Also, manufacturing safety and environmental standards have become more stringent, and while making things more difficult this ultimately is a good thing."

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KIRK SORENSEN | Chief Technologist, Flibe Energy, Huntsville, AL
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Comparing Thorium and Uranium Nuclear Reactors

A three-phase plan to use thorium in a nuclear reactor could produce energy with less waste and more efficiently use the fuel as well.

What's the difference between thorium and uranium nuclear reactors? The short answer 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.

STARTING WITH URANIUM

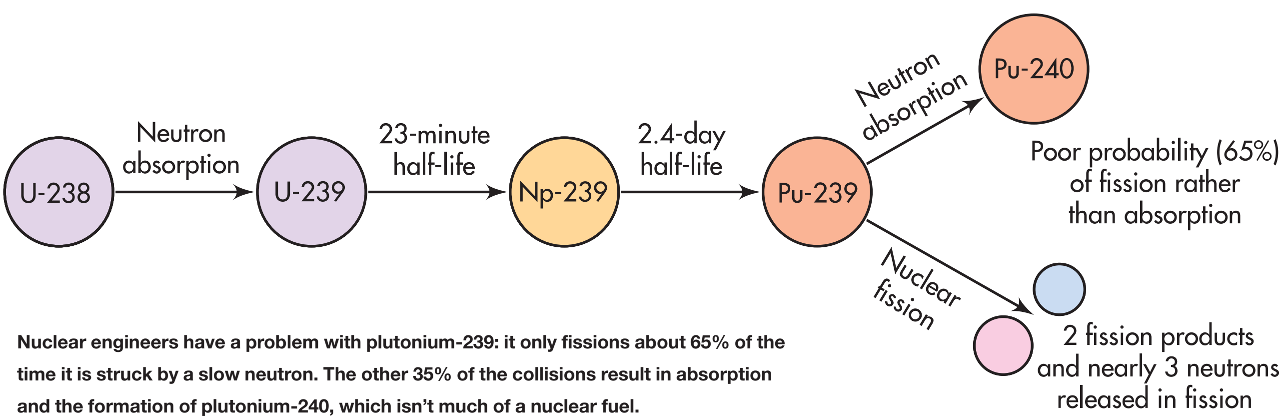
Uranium is the only element with a naturally occurring fissile isotope, meaning the isotope's nucleus splits into two smaller nuclei when struck by a neutron travelling at any speed. Few isotopes are fissile. But all thorium and nearly all uranium is fertile, meaning that when they absorb a neutron, they undergo a double-beta decay and become fissile materials.

This has both positive and negative implications.

99.3% of natural uranium is the isotope U-238, so its behavior in a reactor dominates the discussion of nuclear energy. Except in rare circumstances, U-238 won't fission when it absorbs a neutron, but it does decay on its own over a few days into Pu-239.

Essentially all natural thorium is the isotope Th-232, and it also does not fission when struck by a neutron (except under

Problem with Plutonium



Nuclear engineers have a problem with plutonium-239: it only fissions about 65% of the time it is struck by a slow neutron. The other 35% of the collisions result in absorption and the formation of plutonium-240, which isn't much of a nuclear fuel.

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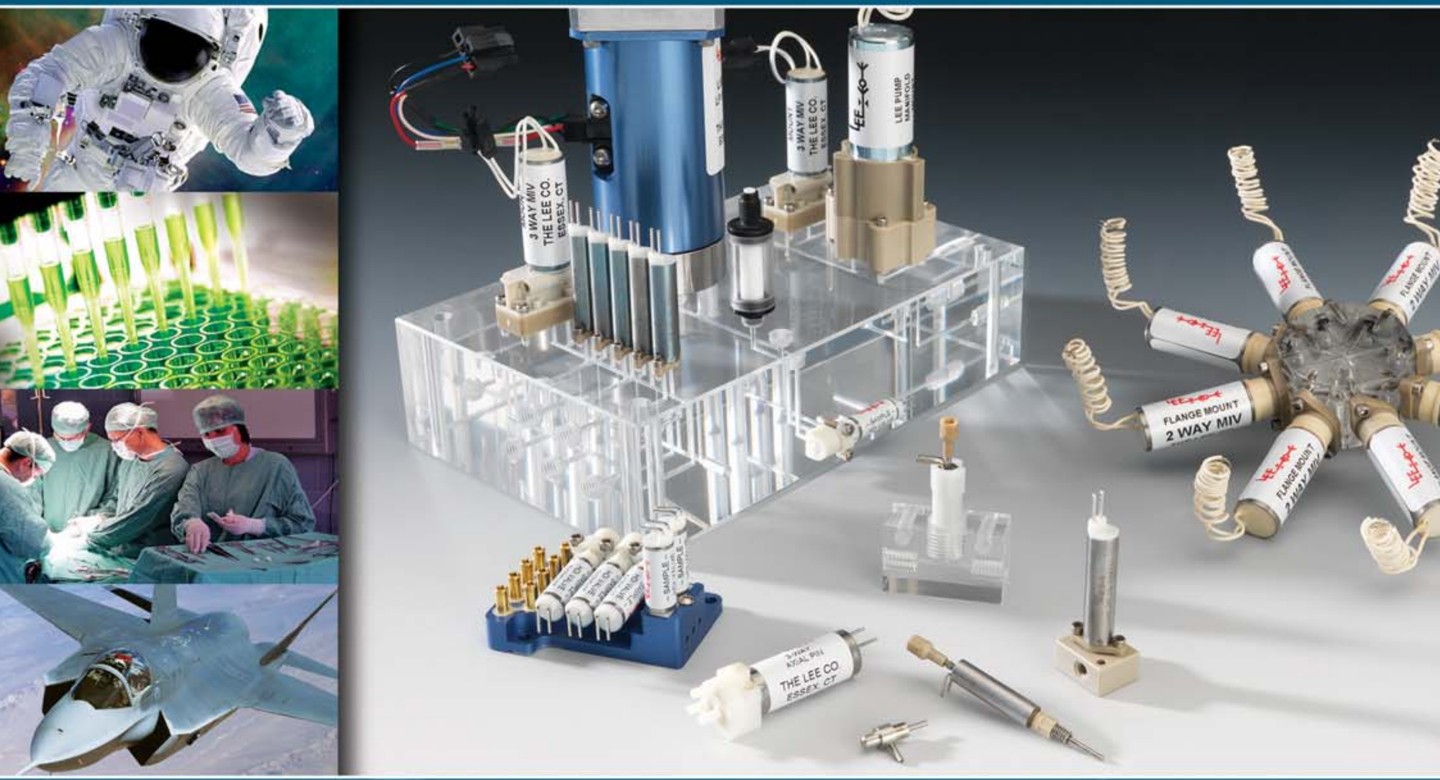

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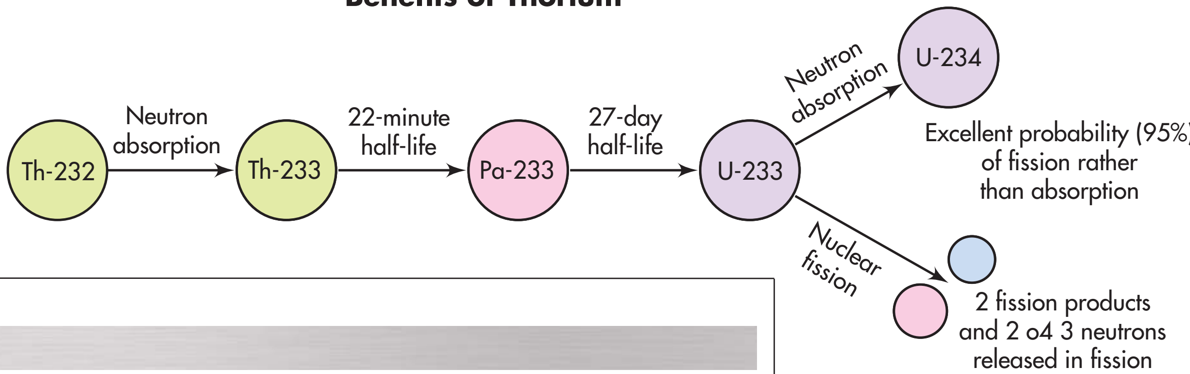
Benefits of Thorium



Uranium-233 has a high probability of undergoing fission when it is struck by a neutron of any energy, and fission releases enough neutrons to continue the conversion of thorium to new uranium-233. This lets thorium be consumed like a fuel in properly designed reactors.

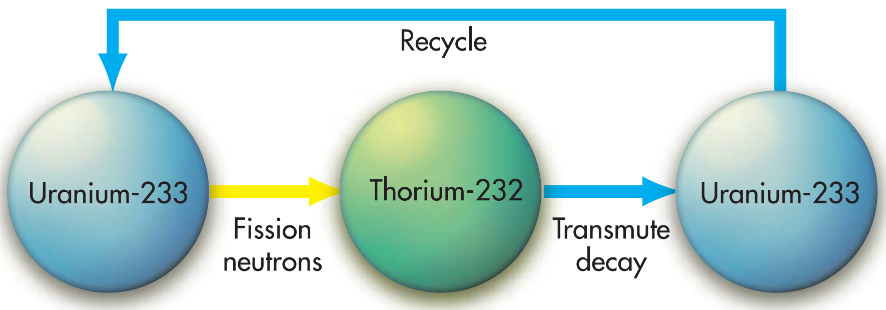
rare circumstances). After absorbing a neutron, it decays in about a month to U-233.

U-233 is special in that it will likely fission when struck by a neutron of any energy and release enough neutrons to continue converting thorium into new U-233. It acts a bit like a "nuclear catalyst," letting thorium be consumed like a fuel in properly designed thorium reactors.

If a thorium reactor is started with U-233 and it is frugal with its neutrons, the reactor can use thorium as a fuel and release essentially all of its energy. This is the main reason people have gotten excited about thorium reactors. Full energy release means no wasted fuel at the end, which eliminates the problem of long-lived nuclear waste. Of course, such a reactor must be efficient at the chemical recycling step, which is a strong reason why reactors that use liquid fluoride-salt mixtures are so attractive as thorium reactors. But the larger challenge is the need to start the reactor on uranium-233.

We simply don't have much uranium-233. It does not occur naturally and must be produced from thorium. But it's difficult for even well-designed thorium

Thorium can be sustainably consumed using Uranium-233.



reactors to produce much more U-233 than what they consume. A source of U-233 is needed, and that takes us back to uranium and plutonium.

ADDING PLUTONIUM

U-235 is the only naturally occurring fissile material, and so it was the starting point for developing nuclear energy. But it is rare: only 7 out of 1,000 uranium atoms are U-235.

In the earliest reactors, uranium was used at its natural isotopic composition: only 7 atoms out of a thousand. Later, enriching uranium so that the percentage of U-235 is higher let other coolants such as light water be used. But even in these reactors, U-238 outnumbers U-235 by 20 or 30 to one. So as these U-235 atoms fission, they produce neutrons that are absorbed in U-238 and form Pu-239.

But Pu-239 has a problem; it only fissions about 65% of the time it is struck by a slowed-down neutron. The other 35% of the collisions with slowed neutrons result in absorption and the formation of Pu-240, which isn't much of a nuclear fuel. And therein lies the real problem with uranium-plutonium fuels.

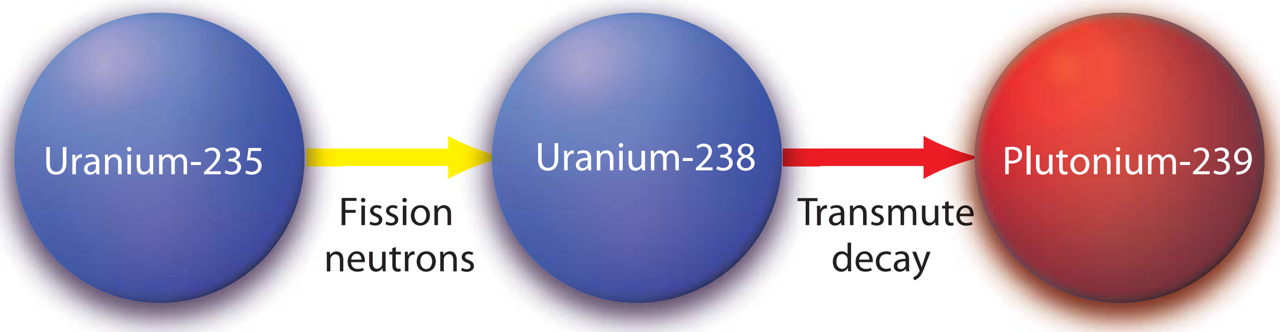
Because of Pu-239's one-out-of-three absorption problem, it can't make enough new Pu-239 to replace what was consumed. U-233 in thorium can do it, but Pu-239 in U-238 can't, at least not with slowed neutrons.

This is why today's reactors have to be regularly shut down to load in fresh fuel and take out some used fuel. They run too low on fuel to keep generating useful nuclear energy. Nuclear engineers call this a "loss of reactivity."

There are several other neutron-eating culprits in typical reactors: the light hydrogen that likes to absorb neutrons, the metallic cladding of the fuel tubes, and the fission products left over from the reaction. But the central problem is that Pu-239 eats one out of three slowed neutrons instead of fissioning and the reactor steadily runs out of fuel.

For 70 years governments, academics, and nuclear industrialists have championed one possible answer to this problem: When Pu-239 is struck by a fast neutron instead of a slow neutron, the probability it absorbs that neutron instead of fissioning goes way down. And because splitting Pu-239 creates two or three neutrons, there are enough neutrons to make more Pu-239 (from U-238) than was consumed. This is referred to as a "fast breeder reactor." Remember, the word "fast" has nothing to do with how quickly the reactor makes electricity or how quickly it creates new plutonium fuel. It only refers to the speed of neutrons in the reactor causing fission.

All of today's reactors intentionally use slow neutrons, and have materials such as water or graphite in their path to slow them down. Such materials need to be eliminated in the reactor if the goal is to ensure a lot of the neutrons are fast. That is why "fast" reactors use coolants such as sodium or



Uranium-fueled reactors consume uranium-235 and produce plutonium-239.

lead that are a lot heavier (on an atomic basis) than hydrogen or carbon. This limits the slowing down of neutrons (called neutron moderation) and keeps the neutrons fast, thus raising the likelihood the Pu-239 will fission rather than absorb a neutron.

But fast reactors are challenging machines. The favored coolant for these reactors, metallic liquid sodium, is highly reactive and will react not only with water and air, but with nearly anything that will accept an electron. And we live on a planet full of things ready to accept electrons. Using lead as a coolant solves this problem, but a more fundamental one persists: it is quite challenging to control a reactor whose neutrons are predominantly moving so fast.

Reactors that slow down their neutrons, which is just about every reactor, are straightforward to control because the process of slowing down neutrons builds in a variety of safety mechanisms. In water-cooled reactors, for example, if the water overheats, it expands so it's less dense and there's less of it there to slow neutrons, and the fission rate drops, so the water cools. Conversely, if it gets too cool, the water gets denser and the fission rate increases, heating the water. The use of water makes the reactor inherently self-controlling.

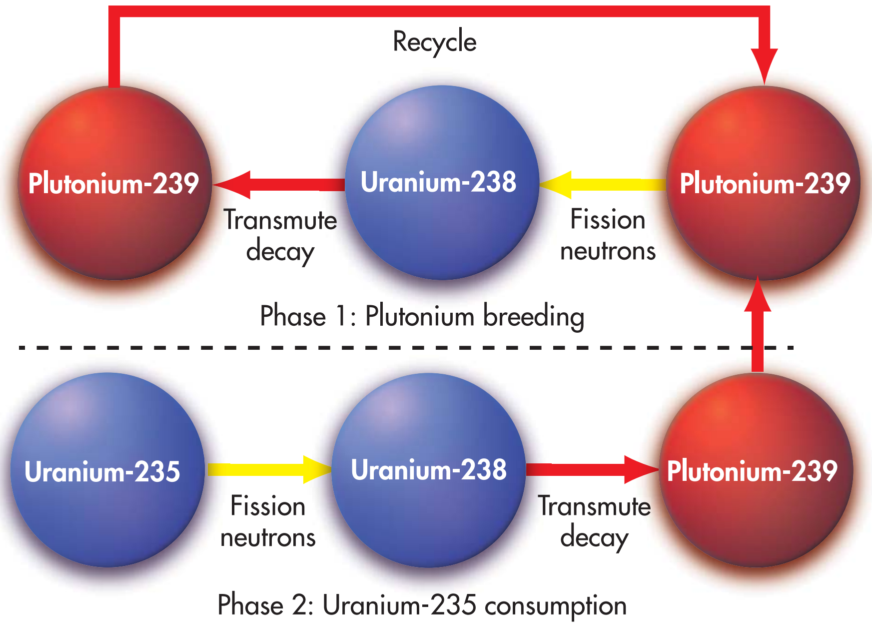
Fast reactors don't have this feature because they intentionally don't have a moderating material such as water or graphite, and that's because they're trying to keep Pu-239 from absorbing so many neutrons.

ENTER THORIUM

Because plutonium can't "catalyze" efficient consumption of uranium in reactors with slowed neutrons, and because fast neutron reactors have their own challenges and dangers, perhaps the answer is get the plutonium away from uranium altogether and consume it in the presence of thorium instead. The idea is to remove plutonium, which is chemically distinct from uranium, and let it fission in proximity to thorium. Then the neutrons it emits while fissioning are captured in thorium to create U-233.

This neatly solves several problems. It eliminates the plutonium produced in today's uranium-fueled reactors and it generates the U-233 needed to efficiently start future thorium-fueled reactors.

Plutonium fast breeder reactors



Plutonium fast-breeder reactors have been used for the past 70 years to generate power. When Pu-239 is struck by a fast neutron instead of a slowed neutron, the probability of it absorbing that neutron instead of fissioning goes down. And because splitting Pu-239 creates two or three neutrons, there's actually enough neutrons to make more Pu-239 from U-238 than was consumed

A three-phase plan was probably first proposed by Eugene Wigner at the University of Chicago in the fall of 1944. Actually building one has been the goal of India for over 50 years.

In the three-phase plan for efficiently using thorium, a uranium-fueled reactor consumes U-235 and as it fissions it generate neutrons that are absorbed in U-238 to create Pu-239. The Pu-239 is chemically extracted from the reactor and put into another reactor for the second phase.

The second phase consumes the Pu-239 through fission, releasing neutrons in the presence of thorium that generate U-233, which is also chemically distinct and separable. In the third phase, the U-233 is fissioned and releases neutrons in the presence of thorium, which absorbs the excess neutrons and creates enough U-233 to continue turning out energy (heat) as long as thorium is supplied.

Nearly all of the today's reactors are representatives of the first phase of this plan. They have been consuming uranium and generating plutonium for many decades now, and that spent nuclear fuel containing plutonium is generally viewed as a hazardous waste, or at the very least, an unappreciated byproduct. Plutonium fissioning in the presence of thorium generates the U-233 that is the bridge, or second phase, between the inefficient first phase and the sustainable, fuel-efficient third stage.

Only one reactor has ever been built that could qualify as a reactor representative of the third phase of the plan, and that was the final core of the Shippingport Atomic Power Station in Pennsylvania. The experiment was called the Light Water Breeder Reactor and involved using thorium/U-233 fuel in a repurposed pressurized water reactor. The experiment was a success and showed that just as much U-233 could be produced as was consumed.

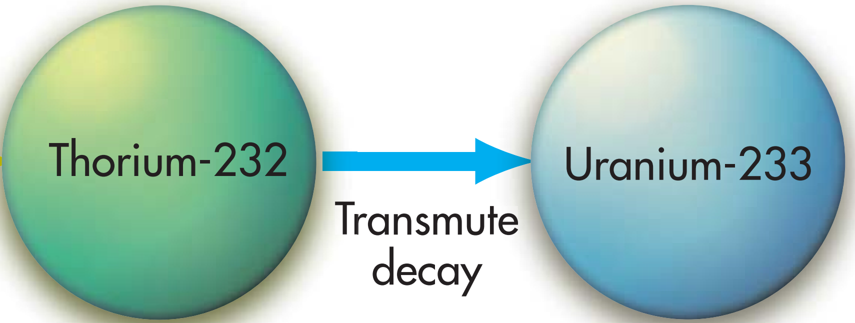
But the pressurized water reactor is not a likely candidate for a sustainable third-phase thorium reactor because the increased potential performance available from thorium can easily be lost on reactors that lose lots of neutrons.

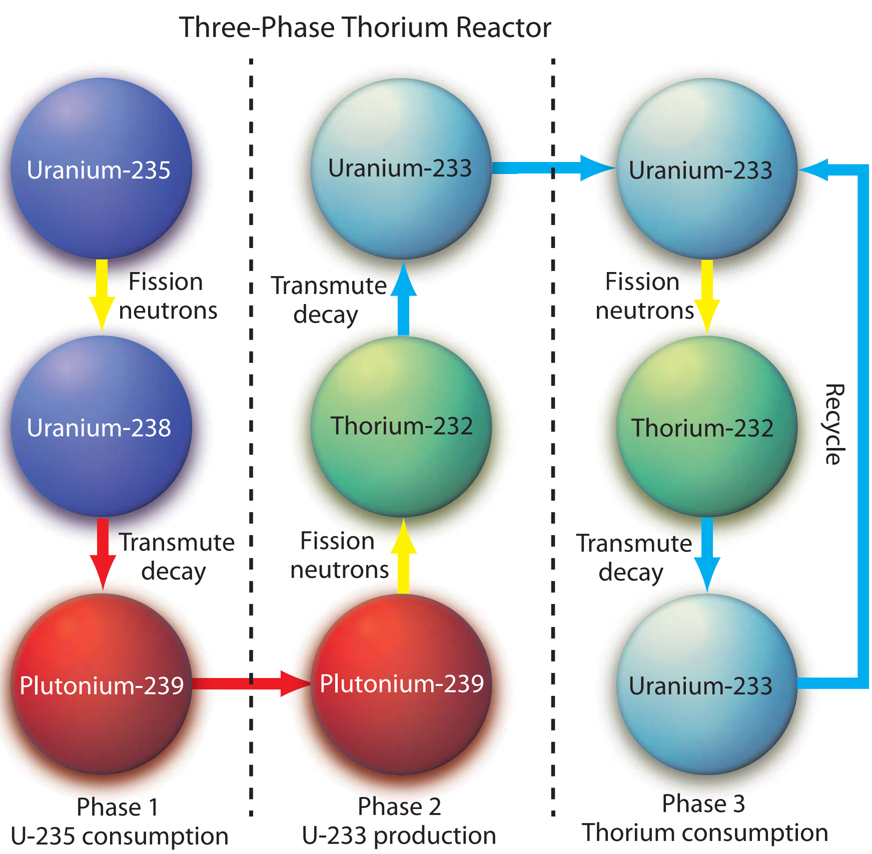
Today's light-water-cooled reactors lose many neutrons to the light hydrogen in the coolant water that is moderating the neutrons. They also lose neutrons to the fuel rod's metallic cladding and to the decay byproducts that build up

Plutonium-239 consumed in the presence of thorium produces uranium-233, which is phase two of the three-phase thorium reactor plan.

in the solid fuel pellet. If these losses exceed the margin of performance of the thorium fuel, the whole effort to use thorium could be for naught and one would have likely gotten less expensive fuel by just using uranium. The Shippingport experiment succeeded, but chemically recycling the fuel was never attempted.

Reactors that use liquid fluoride salts have far greater potential both for Phase 2 and 3. A particular mixture of fluoride salts, one with highly depleted lithium fluoride and beryllium fluoride, can serve as a suitable solvent while absorbing few neutrons. Using graphite (carbon) as the moderator would involve more material to slow neutrons, but would not absorb them nearly so much as light hydrogen.





The three-phase plan for thorium development begins with uranium consumption, but transitions to the sustainable use of thorium using uranium-233.

So what's the difference between uranium/plutonium and thorium-powered reactors? Uranium-fueled reactors are the first step in any attempt to use nuclear energy because only uranium has an isotope that fissions.

Graphite is also chemically compatible with fluoride salts, so metallic cladding can be eliminated along with its neutron losses. Thorium, uranium, and plutonium all form suitable fluoride salts that readily dissolve in the LiF-BeF2 mixture, and thorium and uranium can be easily separated from one another in fluoride form, an enormous improvement over today's ceramic (oxide) fuels.

So what's the difference between uranium/plutonium and thorium-powered reactors? Uranium-fueled reactors are the first step in any attempt to use nuclear energy because only uranium has an isotope that fissions. But releasing all the energy of uranium is difficult and

requires that uranium be transformed to plutonium and consumed through fission in a reactor with fast neutrons.

Thorium-fueled reactors are fuel-efficient as long as they operate using U-233 and chemically process their fuel at high efficiencies, a task liquid-fluoride reactors can handle. The need for U-233 persists, however, and splitting plutonium in liquid-fueled reactors containing thorium is the bridge between the two, permanently eliminating the plutonium from the first phase of nuclear energy while generating the U-233 needed for the next phase. In this way, the full potential of thorium can be harvested, and this would go a long way to improving the public acceptance of thorium technology. md

KIRK SORENSEN is co-founder, president and chief technologist at Flibe Energy, based in Huntsville, AL.

Construction on the Shippingport reactor in western Pennsylvania began in the 1950s. Here, the reactor's pressure vessel is being installed.

BETH PARKINSON | Market Development Manager, Rockwell Automation

The Road to Smart Manufacturing

The majority of manufacturers have yet to implement an IoT strategy in their operations—here's a guide to help in that quest.

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.

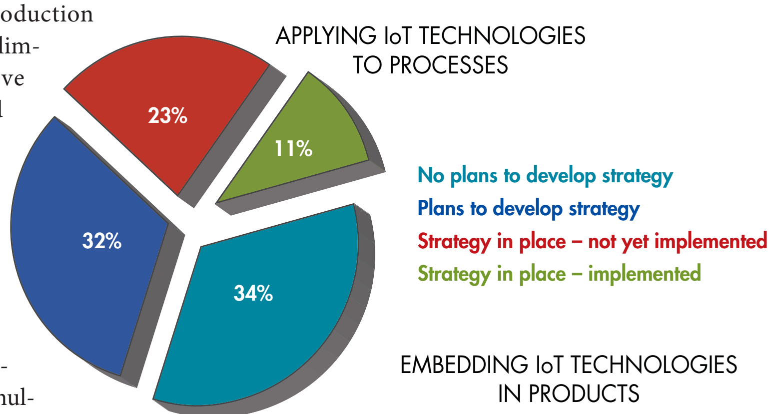
This global push for smart manufacturing is underway for good reason. By providing greater connectivity across a manufacturing enterprise and the ability to act on production intelligence, smart manufacturing offers nearly unlimited opportunities for manufacturers to improve their operations, create new value, and respond to challenges such as the skilled-labor shortage. Rockwell Automation approaches smart manufacturing via the Connected Enterprise, which is an infrastructure for Internet of Things (IoT) connected systems.

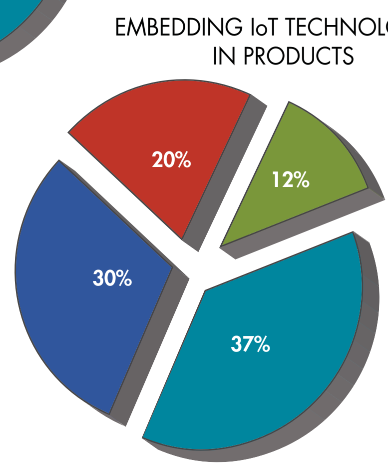
For example, manufacturers use embedded machinery intelligence to predict equipment failures and improve productivity. By using remote-access capabilities to monitor multiple machines simultaneously from a centralized location, they can better utilize labor. They are extending this greater connectivity and information sharing outside their production walls to better track and coordinate supply-chain activities. And through the use of contemporary cloud technologies, they are able to change business models and build new revenue streams.

However, while some forward-thinking manufacturers fully embrace smart manufacturing and are already reaping the benefits, most still have much work ahead of them. Case in point: Only 11% of manufacturers have implemented a strategy to apply IoT technologies to production processes, according to a recent survey by The MPI Group. Even worse, about half of manufacturers said they are still struggling with the basics of defining and implementing an IoT strategy.

BUILDING THE INFRASTRUCTURE

Adoption of key enabling technologies is an essential part of a smart-manufacturing approach. This includes leveraging the IoT, an ever-growing proliferation of connected smart devices, to better understand quality, efficiency, security, and safety. It also involves the strategic use of cloud computing, mobility, and data analytics.





This graph demonstrates the percentage of companies in the United States that have applied or implemented IoT solutions.

And while most manufacturers are not yet prepared to deploy smart-manufacturing technologies, they clearly see opportunities for using them. According to the MPI study, the top five objectives that manufacturers identified for incorporating the IoT into their operations are improved product quality, increased speed of operations, decreased manufacturing costs, improved maintenance and uptime, and improved information for business analytics.

Achieving these objectives requires an integrated architecture and a strategy for using smart-manufacturing technologies. Specifically, manufacturers must converge their Information Technology (IT) and Operations Technology (OT) systems into a single, unified network infrastructure. In addition, they must identify opportunities for using IoT technologies that enable seamless connectivity and information sharing across people, processes, and things.

At the same time, manufacturers also need to ensure they can efficiently manage their greater abundance of data in ways that helps them make better, faster business decisions. This includes using IoT device intelligence, cloud connectivity, and data analytics all together to help manage the large data sets required for balancing production activities based on upstream inventories and downstream demand. Manufacturers seeking to build and implement IoT connected systems in support of a smart-manufacturing deployment in their operations should focus on the following four core tactics:

1. INCREASING QUALITY AND PRODUCTIVITY

Quality-management and continuous-improvement programs can only do so much when the information they rely on is limited or not available in real time. Manufacturers use embedded machine or equipment intelligence to monitor virtually every product specification in real time, either from a customer or regulatory perspective. More than that, they use this intelligence to rapidly address product defects and variations as they happen, ensure quality goals are met, and improve customer satisfaction.

Better control and transparency of manufacturing processes via embedded intelligence also creates new opportunities to improve productivity. For example, operators on the plant floor are now analyzing real-time production data to uncover hidden inefficiencies and more quickly implement changes. At the supply-chain level, managers and logistics professionals use smart-manufacturing technologies to deliver critical information, such as forecasts and schedules to suppliers, while also monitoring delivery performances.

2. IMPROVING DECISION-MAKING

Better decision-making begins with working data capital. However, most manufacturers have older systems in place that will need to be updated for the next generation

The Allen-Bradley ControlLogix 5580 controller includes an embedded 1-Gb Ethernet port to support high-performance communications, I/O, and applications with up to 256 axes of motion.

of productivity. This involves reconciling their disparate OT data sources with their current IT systems, extracting the right data from smart-manufacturing technologies, and transforming that data into actionable information.

Manufacturers that have taken these steps and armed themselves with better information are using it to optimize their assets, improve their responsiveness to changing customer needs, refine work flows, and reduce inventory. More than that, they are gaining new strategic insights that help them understand their business in deeper ways, including:

- Identifying operational strengths and weaknesses
- Analyzing processes and planning improvement initiatives
- Designing and implementing better production systems
- Developing targeted training programs
- Establishing performance-management systems

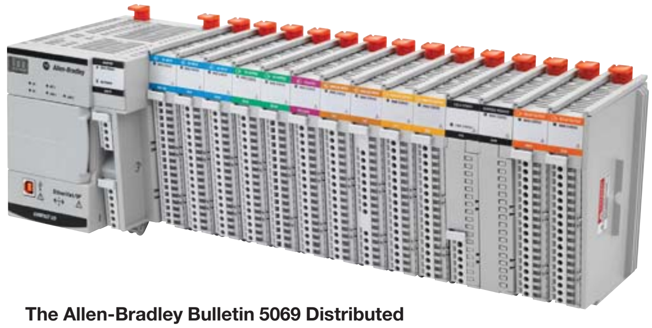
3. ESTABLISHING SAFE AND RELIABLE OPERATIONS

Achieving safe, compliant, and reliable operations is an ongoing concern for any manufacturer, and smart manufacturing opens up new opportunities for dealing with some of these age-old challenges. The most obvious opportunities will include replacing the obsolete and isolated automation systems that have exceeded their lifespans, are difficult to connect, and are no longer supported by their manufacturer. However, manufacturers also should define new requirements based on past performance in areas such as employee injuries, machinery downtime, and work stoppages.

From there, they can prioritize processes and equipment for redesign. They should consider using embedded intelligence to gather real-time data, including equipment status and exception-based reporting, that can be contextualized and delivered as role-based analytics in areas like quality, safety, compliance, energy usage, and downtime issues.

Different stakeholders, from quality and safety managers to operators and maintenance technicians, can use that information to optimize machine performance, manufacturing processes, compliance, and more. Manufacturers should also

The Rockwell Software Studio 5000 development environment helps engineers speed development of automation systems as they implement smart-manufacturing strategies.



The Allen-Bradley Bulletin 5069 Distributed Compact I/O system with two 1-Gb Ethernet ports can connect to as many as 31 modules without the need to expand.

make these processes collaborative, such as asking line workers about which smarter machine assets can provide more visibility and control of complex production processes.

4. SECURING THE INFRASTRUCTURE

Greater information availability and more connection points may introduce greater risk to manufacturing environments in the form of internal and external threats. Indeed, cyber attackers are now looking beyond corporate servers to target operations technologies, while decades-old devices and controls on the plant floor can be more susceptible to breaches through both malicious attacks and unintentional employee actions.

No single security technology or methodology will suffice in this complex threat landscape. Instead, manufacturers must employ a comprehensive, defense-in-depth approach that establishes security safeguards at different layers to stop threats on multiple fronts.

A robust and secure network infrastructure should be built on standard and unmodified Ethernet, which has become the industry preference for security purposes. It also should ensure technicians can securely manage software installations, patches, and upgrades for years to come, and incorporate strong security policies and procedures for everything from machine operations to bring your own device (BYOD).

BEGINNING THE JOURNEY

Smart manufacturing offers nearly unlimited potential, and it all begins with establishing an IoT connected system as the foundation for achieving greater connectivity and information sharing. Some of the most common questions that manufacturers are asking today as they prepare to build an IoT system are:

What continuous improvement processes can smart manufacturing help me with?

This will depend on a manufacturer's specific operations and business goals. But some good areas to start with include overall equipment effectiveness (OEE), product quality, downtime, scrap, worker safety, and energy consumption.

What business process transformation is going to provide me with a competitive advantage? And is smart manufacturing going to get me there?

Enterprise-wide connectivity can help manufacturers better coordinate operations across all levels to create more demand-driven operations. Asset intelligence also is able to transform maintenance approaches from reactive to predictive to help improve uptime. In addition, automated data collection and reporting can significantly save time compared to manual processes, especially in highly regulated industries.

What organizational changes are needed to facilitate smart manufacturing?

IT/OT convergence is essential, and a similar convergence must occur within the workforce. IT and operations personnel have historically worked separately from each other, but tighter collaboration will be needed moving forward. Manufacturers must bridge the gap between these two groups while equipping them with new skills for managing industrial networked technologies.

How do I measure the benefits?

The same working data capital used to monitor operations will help quantify benefits. Data can be historically viewed over set periods of time in key-performance-indicator (KPI) dashboards to measure OEE increases, quality improvements, scrap reduction, labor utilization, and more. Standardizing data collection and reporting can also help compare performance across sites.

Am I ready for an ongoing journey versus a one-time event?

Any journey into developing IoT connected systems should begin with a comprehensive assessment. With an eye on the manufacturer's current and future states, the assessment should cover the organization's network infrastructure, manufacturing environment, data and reporting capabilities, and security policies. In the end, this will help identify what can be upgraded and what needs replacing. md

The Allen-Bradley Kinetix 5700 servo drive can help machine builders reduce cabinet-space requirements by up to 70%, reduce wiring requirements by as much as 60%, and achieve easier configuration and commissioning.

ANDREW WAUGH | Sensor and Safety Components Product Manager, AutomationDirect

How to Specify Fiber-Optic Sensors

Fiber-optic sensors work well in tight spots and in applications with a high degree of electrical noise, but care must be taken when specifying these critical components.

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.

Many types of sensors are available, including inductive, magnetic, capacitive, and photoelectric. Each has its own strengths and weaknesses depending on the application. Photoelectric sensors, however, have the broadest offering of types and technologies, and the widest range of applications.

Photoelectric sensors come with a variety of light-emission types (infrared, visible red, laser Class 1 and 2), sensing technologies (diffuse, background suppression, reflective, through-beam), and housing configurations (photo eye or fiber optic). This article focuses on specifying and applying fiber-optic sensors, which offer advanced capabilities and configuration options, and are great for tight spots that are too small for a photo eye sensor.

FIBER-OPTIC TECHNOLOGY

Fiber-optic sensors, sometimes called fiber photoelectric sensors, include two devices that are typically specified separately: the amplifier, often called the electronics or fiber photoelectric amplifier; and the fiber-optic cable, which includes the optic sensor head and the fiber cable that transmits light to and from the amplifier.

The basic theory behind all photoelectric sensors is quite simple. Every photo eye has a light emitter producing the source signal and a receiver that looks for the source signal. Many different technologies exist for sensing and measuring the light transmitted to the receiver. For example, background suppression sensors look for the angle at which the light is returned, while standard photo eyes look for the amount of light, called excess gain, returned to the sensor. Other sensors monitor the time light takes to return, thus providing distance measurement.

Photo eyes house the emitter and receiver in either one optical sensor head, such as that used in diffuse and reflective units, or two optical sensor heads like those used in through-beam units. Fiber-optic sensors put all of the electronics in a single housing, with the optical heads for the emitter and receiver separated from and connected to the electronics housing via a fiber cable. The emitted and received light travels through these fiber cables, much like high-speed data in fiber-optic networks.

1. A variety of fiber optic amplifiers are available, with simple to advanced configuration options.

TABLE 1: SPECIFICATIONS OF FIBER-OPTIC ELECTRONICS
• Output NO/NC
• Output type – NPN or PNP
• Output configuration NPN/PNP/push-pull
• Connection – cable or quick disconnect
• OLED display
• Signal strength
• Filtering
• Pulse output
• On/off delay
• Adjustable measurement speed
• Sensitivity adjustment
• Teach – automatic or potentiometer

TABLE 2: FIBER CABLE CHOICES
• Optic cable selection – diffused or through-beam
• Plastic or glass fiber
• Optical head options
• Sensing range
• Fiber environmental ratings

One benefit to this segregation is that only the sensor head needs to be mounted on the machine. The integrated fiber-optic cable is routed and plugged into the amplifier, which can be mounted in a safe place (typically a control enclosure), protecting it from the often harsh manufacturing environment.

The variety of options available for both amplifiers and fiber-optic cables is vast. Amplifiers range from basic to advanced, and machine builders continue to demand more functions, including logic and communication capabilities.

FIBER-OPTIC SENSOR AMPS

Fiber-optic amplifiers range from those with basic electronics and plug-and-play functionality to models with fully configurable electronics *(Fig. 1)*. Some even have electronic units that can handle up to 15 fiber inputs in a manifold-like configuration. Output indication is highly desirable on fiber-optic electronics, as it shows whether the sensor is working properly, but other basic functions *(Table 1)* must be specified. The output format and connection to the amplifiers are important because they define the interface to the controller, and teaching the on and off setpoints is an integral part of amplifier configuration.

Output types can be set normally open or normally closed—as well as switching via sinking, sourcing, or push-pull. This allows the device to either sink or source the signal automatically, depending on how the circuit is wired. Electrical connection options are generally prewired with at least a two-meter length of cable, or a quick disconnect with a standard M8 or M12 multi-pin connector. Switch settings are programmed by dialing-in a potentiometer or digitally via pushbuttons.

Beyond the basics, advanced amplifier capabilities provide significant flexibility with features such as pulse outputs, on/off delays, and the ability to eliminate intermittent signals. These advanced electronics give machine builders the ability to drill down and adjust amplifier parameters as required by the application.

On/off delays are often desired to slow the reaction of the control system to changes in sensed parameters. In the case of intermittent signals, some applications present the sensor with spurious, short-term signals that aren't consistent with overall operating conditions. The ability to eliminate these signals at the sensor frees up the controller from this task.

Most all models will provide output-status LEDs, while some offer graduated displays to provide a coarse view of signal strength and output status. More advanced units have multiline OLED displays with customized diagnostics and programming.

Filtering is an option often needed with increased sampling rates, as it provides a more resilient measurement less susceptible to ambient conditions. This stronger signal, however, requires the unit to operate at slower switching frequencies. Pulse outputs allow for stretching of the input signal, which may help when the operating frequency is too fast for a PLC input. On/off delays give machine builders the ability to add timers when the output signal starts and stops.

Advanced units provide more programming options, such as sensitivity adjustments. Using these options, machine builders can teach the machine to sense part absence, part presence, or both—even with difficult materials such as glass. This teaching function reduces or eliminates the need for programming the controller to perform these functions. They can also program the output to switch off/on inside two switch points. By way of example: For part positioning, a switch could turn on at one position and off at another such as in a fill level signal for a pump application.

SEEING THE LIGHT WITH FIBER CABLE

Fiber-optic cables don't conduct electricity; instead they transmit light. They come in a variety of configurations with different material types and optic head styles *(Fig. 2)*. *Table 2* lists some of the decisions to be made when specifying fiber-optic cable.

Diffused fiber-optic cables have two leads to insert in the amplifier for the emitter and receiver light, with the two leads joined together near the single optical head. Through-beam fiber-optic cables are two separate, identical cables that are connected to the amplifier, each with their own optical head. One cable transmits the emitting light, and the other transmits the receiving light. A common mistake is only ordering one through-beam cable, as some suppliers may provide one piece per part number, while others package the required two cables.

Fiber materials are generally either plastic or glass. Plastic units are thinner, less expensive, and provide a tighter bending radius, while glass units tend to be more rugged and can handle higher operating temperatures. Plastic fibers can be cut to length with a special one-time cutter; glass fibers aren't able to be cut once received from the supplier. The fiber jacket material can also vary from a basic extruded plastic, on up to stainless-steel braiding to operate reliably in the toughest environments.

Optical-head selection is the most crucial part of fiber-optic sensor specification, because it greatly affects the detection of the small stationary or moving parts found in most applications. Head selection differs in how the

2. Options abound for fiber-optic cables and heads; making the proper selection depends heavily on application requirements.

emitter and receiver optics are oriented in angle and dispersion to the object to be detected. Heads can have rounded bundles of fiber to project a circular beam, or else spread out to form a horizontal, ribbon-like projection.

Round bundles in a diffuse head can be strictly bifurcated with all emitter fibers on one half and all receiver fibers on the other. This is common, but can provide a lag in reading a part moving perpendicular to the bifurcation line. Another option is to have the emitter and receiver fibers dispersed evenly in the head to produce a more homogenous beam. Homogenous fiber mixing gives equal exposure to sending and receiving light, and provides detection independent of part travel direction.

Sensing range for fiber optics will be impacted by the amplifier, fiber cable length, and type of optical head. Thus, it is usually difficult to determine an exact working range, but suppliers typically supply an estimate. Generally speaking, through beam has longer range than diffuse. The longer the fiber cable, the shorter the range, and advanced amplifiers usually have stronger emitting signals and longer ranges as well.

CONNECTING FIBER-OPTIC SENSORS

Use of distributed I/O and distributed smart devices has been increasing throughout machine automation, and fiber-optic sensors are no exception. Connecting multiple fiber-optic sensor cables to a single manifold of electronics has its advantages.

Fiber-optic amplifiers are typically single-channel standalone units. With slim housings and common DIN rail mounting, they can easily be sandwiched and stacked in a panel. One drawback may concern the routing of electrical connections for each single amplifier.

Another option is to use a fiber-optic manifold, which groups multiple fiber channels to one central control and electrical point *(Fig. 3)*. These fiber-optic manifolds typically

utilize an OLED display with menus to allow for programming of each fiber channel. Each fiber channel can be configured separately, such as setting light-on or dark-on, and switching hysteresis. This central control also enables grouping of outputs via basic AND/OR logic, which can reduce and simplify the output signal to the PLC.

APPLICATIONS AND ISSUES

Fiber optics work well, and are commonly used, in applications where significant electrical noise is generated by sources such as automated welding, variable frequency drives, and motors. Fiber cabling is immune to electrical noise, and the electronics can be mounted away from the noise in a shielded enclosure.

Another very common application is small part assembly. These operations tend to be fully automated,

3. Fiber-optic manifolds with expansion electronics simplify and reduce the number of wires to the machine controller by converting sensor signals to digital data, and combining signals logically if desired. Pictured is AutomationDirect's new three-channel OPT2042 fiber manifold, which is expandable to 15 channels. It accepts various plastic and glass fiber optics, and transmits and receives data via IO-Link to allow full 15-channel diagnostics on a single 4-pin connector. It can also be wired with two 8-pin M12 connectors to hardwire each channel if needed—for example, in applications where the controller doesn't support IO-Link.

Regardless of the application, machine builders must select the proper sensor technology. If fiber-optic sensors are used, amplifiers and fiber-optic heads must be carefully selected for the application to provide robust sensing performance.

and thus require multiple sensors to confirm part placement (seated) and assembly verification to confirm completion of an operation. Typically, the parts are moving in and out of a stage quickly on carriers or an indexing table. Because travel tolerance is minimal, precise measurement of position becomes essential.

A fiber-optic solution provides various options in head size, orientation, and light dispersion to allow the smallest and most accurate light focus for each application, regardless of the electrical housing size. With on-board logic, one channel of a two-channel sensor can confirm a part is in place to trigger an assembly action, while the other channel is able to confirm that assembly was completed.

A common issue in fiber-optic installations concerns excessive flexing of the fibers. Since the fiber cables are bundles of individual fibers, they typically feel quite pliable, allowing an installer to easily bend the fibers beyond their recommended maximum bend radius. This can cause irrecoverable plastic deformation of the fibers, which will reduce the light transmission or, in the worst case, sever it entirely. The maximum bend radius, listed with all fibers, varies depending on fiber material, bundle size, and fiber dispersion in the bundle—and it must be adhered to in all cases.

Regardless of the application, machine builders must select the proper sensor technology. If fiber-optic sensors are used, amplifiers and fiber-optic heads must be carefully selected for the application to provide robust sensing performance. md

ANDREW WAUGH is the product manager for sensor and safety products at AutomationDirect. He has more than 16 years of experience with machine sensor and safety devices used in packaging, assembly, material handling, and process control equipment.

Incremental Rotary Encoders Available for Two Logic Signals

THE ROD 620 and 630 models of incremental sealed rotary encoders target high loads and feature reinforced bearings with high axial and radial load capacity. A large shaft diameter of 15 mm and a solid-flange socket connection also enables connection in radial or axial directions. ROD 620 supplies electrical output with transistor-to-transistor logic (TTL), while ROD 630 employs high threshold logic (HTL) output signals. Both permit connection with many standard electronics. Multiple couplings are available for interfacing encoders with the rotating mechanism.
HEIDENHAIN, (847) 519-4213, *www.heidenhain.us*

Multi-Turn Encoders Feature Serial-Port Programming

THE AMR58 multi-turn absolute encoder features eight integrated electronic cam outputs. Sixteen programs with independent position presets may be stored in the Flash, and programmed via serial port, eliminating the need for PLCs and PC controllers. The modular bus cover enables various bus interfaces including Profibus and SSI. The cams generate ON/OFF phase electrical signals at set points to command synchronized repeated operations, and have an overall 20-bit multi-turn resolution (12-bit singleturn x 256 revolutions). Both connector and cable versions are available.
LIKA ELECTRONIC, *www.lika.it/eng/index.php*

Metal-Removing Fluids Cut Down on Water, Harmful Chemicals

QUAKERCOOL 700 and 7000 Series metal-removal fluids comprise six new formulations that reduce the use of hazardous materials like boron and formaldehyde. Improved emulsion characteristics reduce chemical consumption and water usage per part. In addition, the 680 VDA fast-drying process cleaner provides thin-film protection against corrosion.
QUAKER CHEMICAL, (610) 832-4000, *www.quakerchem.com*

High-Pressure Water Jet Cuts Thick Metals in Half the Time

LAYING CLAIM as the fastest waterjet pump currently available, the PRO-III 125hp Waterjet pump operates at 90,000 psi and cuts products twice as fast as conventional 60,000-psi 50-hp waterjet systems. Another pump in the series, the Streamline PRO-III 60hp, also operates at 90,000 psi. Featuring a newly patented metal-to-metal seal and a SUPRAlife metal canister for protecting UHP seals, the pumps can cut materials including metal, aluminum, steel, stainless steel, titanium, rubber, plastic, and glass. They can cut thick metals, perform intricate cutting with tight tolerances, and perform 5-axis three-dimensional cutting.

KMT WATERJET SYSTEMS INC., (417) 781-7778, *www.kmtwaterjet.com*

Turbine Hole-Drilling Solution Boosts Speed 10-Fold

THE HYBRIDCELL hole-drilling machine targets engine components in mission-critical aerospace and industrial gas-turbine applications. It leverages a MCS 500 Laser MicroJet machine to cut diffuser shapes in the coating layer and drill metering holes, and an EDBV3 electrical discharge machining (EDM) unit to drill deep through-holes. It can drill difficult "non-line of sight" holes, and has a complex data-transfer scheme to enable high-accuracy hole-drilling for producing complete components. The system is available through Makino's North American Single Source Technologies sales channel.
MAKINO, (888) 625-4664, *www.makino.com*

Bar Loader Enables Easy Pusher Switch-Out

THE TRACER Vs-105XL bar loader works with heavy bars with diameters up to 4.125 in. and up to 72 in. long. The magazine rack has a maximum capacity of 5 bars, and the patented external LED light provides a visual status of the pusher. It features a touchscreen HMI display to present automatic system settings, and a movable hand-held remote controller. The quick-change pusher can be changed manually without the need for any tools. A top-cut optical sensor measures each bar's length and automatically adjusts them. The standard rail-retract system allows the bar loader to move back and away from the CNC lathe at a 45-deg. angle for convenient spindle-liner changes and access to the machine's head-stock area for ease of maintenance. The PLC control comprises comprehensive data-bank software and interfaces with any CNC lathe.
CNC INDEXING & FEEDING TECHNOLOGIES, (513) 770-4200, *www.cncindexing.com*

White-Light Sensors Enhance Surface-Property Monitoring

DOTSCAN CHROMATIC white-light sensors are featured on the ACCURA multisensor coordinate measurement machines. In addition to saving measurement time, the DotScan sensors measure highly reflective freeform surfaces—e.g., metal components in knee implants—without the need for a contrast medium. They can be used to distinguish transparent lacquered surfaces from other underlying metallic layers. The sensors are available in three different measuring ranges (1, 3, and 10 mm,) and offer a maximum measuring angle of ±30 deg.

ZEISS, (800) 327-9735, *www.zeiss.com*

Lightweight Key-Bar Chuck Targets Milling and Turning Apps

THE DURO-TA XT key-bar chuck features detachable extended guideways to enable quick conversion between small and large workpieces for milling and turning machines. It is up to 75% lighter than competitive designs, and protects against dirt and dust. The direct mount on the base body provides high rigidity, and stability, and base plates are available for any machine table.

RÖHM PRODUCTS, (770) 963-8440, *www.rohm-products.com*

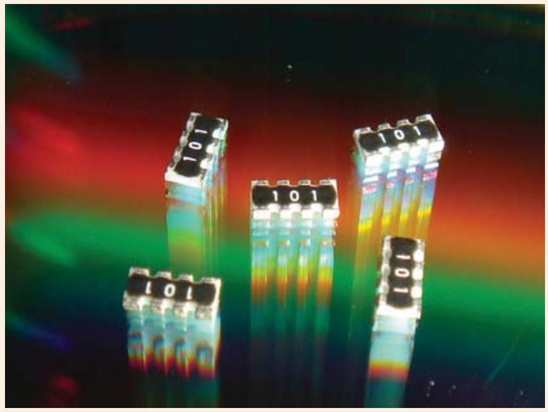
Lock-Out/Tag-Out Valves Prevent Unintentional System Startups

THE RLT series of lock-out/tag-out valves feature a 3-way, rotary-turn design. They can connect with a pneumatic cylinder's NPT ports or with manifold-interface items. Available in ¼-, ⅜-, and ½-inch inlet port sizes, they are manually operated and can be locked while in the exhaust position to prevent unintentional system start-ups. This also prohibits unexpected cycling due to any stored energy in the equipment's airline.

FABCO-AIR INC., (352) 373-3578, *www.fabco-air.com*

Electrical Connectors Target Process-Control Apps

SEALED M8 connectors in the M Series feature a screw-locking, waterproof design with an IP67 rating. Robust against vibration, liquids, dust, and other materials, they target process-control applications, and their plastic housing makes them resistant to chemicals commonly found in food and beverage splash areas. Contact pins are made of copper alloy with gold-over-nickel plating for mechanical stability, and the brass connector body and cable are overmolded for high strength and operating performance. They are offered in variations ranging from 3 to 4 contacts. With a rated current of 3 Amps and a rated voltage of 30V or 60V, they have an operating temperature of -40 to 85°C.
CHOGORI, (400) 081-6063, *www.chogori-tech.com*



Chip Resistors Meet Durability Standard by Automotive Electronics Council

WITH OPERATING temperatures ranging from -55 to 150°C, the RACF and RAVF Series of thick-film chip resistor arrays can survive high electrical and mechanical stresses, along with exposure to temperature cycling and humidity. They completed AEC-Q200 testing, which ensures passive-component durability in electronics that may experience electrostatic discharge, board flexure, and thermal shock. They are available in a wide range of resistance values with 1% and 5% tolerances.
STACKPOLE, (919) 850-9500, *www.seielect.com*

Dust Caps Robust to Hot and Cold Environments

SANTOPRENE DUST caps and plugs are available in 1-, 2-, and 3-in. sizes. Santoprene is a thermoplastic elastomer (TPE) made from a crosslink mixture of EPDM rubber and polypropylene—a combination that offers flexibility and durability consistent with natural rubber. It is environmentally age resistant in both hot and cold environments. With stainless-steel arms, pins, and rings, the caps are designed to keep the interiors of pipes and hoses clean, providing protection for mating adapters and couplers during transport. Caps and plugs are blue for easy identification.
BEE VALVE INC, (440) 366-0220, *www.beevalve.com*

Vapor-Phase Soldering System Minimizes Health-Hazard Fumes

THE 4040 Vapor Phase Soldering System for surface-mount technology offers an alternative to inline convection ovens with a near-zero risk of overheating. It achieves uniform soldering temperatures for long-term product reliability, and does not require complex ductwork or external venting since it generates minimal exhaust that is managed by any self-contained fume-extraction system. With a power rating lower than 3 KW, it features a multi-chamber design, an automatic board-handling system, and an illuminated processing chamber with a 14-in. viewing window. The fluid recovery system collects and filters condensate during cooldown. Cycle times range from 6 to 9 minutes and the 18 x 16-in. work holder allows batch soldering. Soldering programs are easy to create on the machine, and thermal profile data can be recorded, saved, and exported through the built-in SD card slot.

MANNCORP, (215) 830-1200, *www.manncorp.com*

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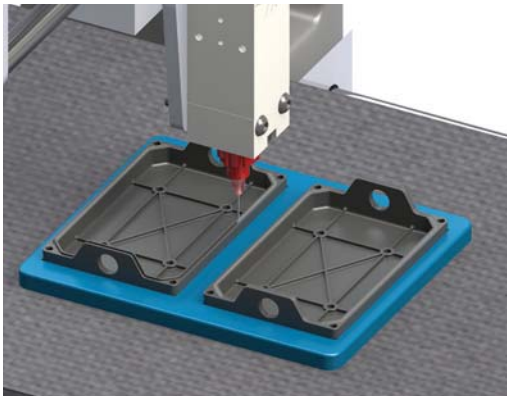
THE GH100 and GH101 hoses for high-percentage biodiesel blends and high-temperature oil applications are made of a polymer that resists degradation. Targeting high-temperature mobile applications, including trucks, buses, agriculture, and construction equipment and eco-friendly power vehicles, they are qualified for -40 to 150°C with B2, B5 and B20, -40 to 125°C with B100 biodiesels. With synthetic oils, such as those used in transmission oil-cooler applications, the hoses are qualified to -40 to 150°C, and intermittent temperatures up to 175°C. They are also offered with an abrasion-resistant fabric or rubber cover, and multiple fitting options.

EATON CORP., (440) 523-4400, *www.eaton.com*

Miniature Connector Ensures Uninterrupted Signal Transmission

THE FH53 Series miniature printed-circuit FPC connector targets portable electronics that require high-speed transmission from smart phones, cameras, notebooks, and tablets, to various medical devices. It employs a back-flip style actuator that minimizes the required mounting area. Weighing a mere 0.034 grams, it offers excellent impedance characteristics, and supports Embedded DisplayPort ver1.3 and MIPI D-PHY ver1.1 standards. A top-contact design employs a contact-retention spring for signal continuity, while the back-flip style actuator and bottom-contact provides a retention force of 9.9 N. The contact design also prevents against solder wicking and flux penetration. A metal lock mechanism allows for horizontal FPC insertion and withdrawal, and produces a clear tactile click upon insertion.

HIROSE ELECTRIC CO, (630) 282-6700, *www.hirose.com/us*



Curing Gasket Targets Heat-Sensitive Materials

THE GA-201 UV and visible light-curable FIP/CIP gasket can be used for sealing heat-sensitive substrates and is resistant to moisture and chemicals. It acts as a barrier to air, dust, noise, liquids, and gaseous substances, and can be used to seal plastic, glass, and metal enclosures, as well as plated surfaces. The gasket is soft, tack-free, and flexible.
DYMAX CORP., (860) 482-1010, *www.dymax.com*

Motion Controller Achieves 32-Axis Motion Capacity

THE RMC200 closed-loop electro-hydraulic motion controller offers closed-loop control of up to 32 motion axes, for complex motions in production lines, and in testing applications with a large number of sensor inputs. It leverages RMCTools software for setup, tuning, programming, and diagnostics through a graphical programming interface. In addition, the software contains a motion-plotting tool and a Tuning Wizard to automatically set control-loop gains. The RMC200 can synchronize the motion of multiple axes. It also has built-in support for controlling pressure and force, in addition to position, velocity, and acceleration. The controller can transition smoothly between these control modes.
DELTA COMPUTER SYSTEMS INC, (360) 254-8688, *www.deltamotion.com*

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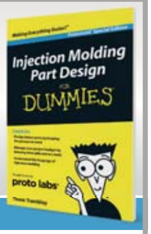

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Measuring Product Development Maturity

Since Carnegie Mellon University founded its Software Engineering Institute in the 1980s and introduced its "Capability Maturity Model (CMM)" process, maturity has been both a subject of study and practice around the world. While generally applicable to all engineering disciplines, it has been most widely applied and practiced in software engineering. To be selected as a supplier of defense and mission-critical systems, or as a supplier to the medical and other life-and-death industries, companies must be certified at a high level of maturity.

While I've been on board with this body of knowledge since its inception, I've always found it to be insufficient for really getting at the business of making money from investments in R&D. The CMM is a "project-level" or "product-level" definition of maturity.

In "Measuring Product Development Effectiveness" *(read the article on machinedesign.com)*, I described different business functions as being mature or immature. Now I will address maturity measurement from a business-level view for the currently immature functions of R&D and product development.

How many times have you heard managers say they have no idea if a product will actually sell once it is launched? How many times in your career have you heard management lament that their new product releases are not producing the intended revenues or profits? These comments are a direct statement about business-level process maturity. A company should—and eventually will—be able to predict revenues and profits from new products with certainty. It is just a matter of time. The realization of "big data" and "data analytics" in the years ahead will go a long way toward creating confidence and reliability regarding the outcomes of new product and portfolio plans.

John Trudel's "Tales From A Skunk Works" column in *Electronic Design* (*Machine Design's* sister publication) got me thinking about this years ago. In December 1993, Trudel cited improvement from 30% success in 1968 to 53% success in 1993. Over the past 25 years, most cross-industry studies show the same approximate success figures. Not much progress has been made. Yet, every year when management approves the plan for the year, they still expect close to 100% of their approved projects to be business successes. Go figure.

Of course, no company actually wants 100% success from new products. Think about it: If engineers and managers were directed to design to commercial certainty, they would immediately dumb-down all designs so that every development would launch and produce some revenues. Business-plan projections would shrink as risk, uncertainty, and attempted innovations were removed to create certainty.

Maturity = PREDICTABILITY

Achieving The Planned Pipeline Productivity

So, what then is business-level product development maturity? It is the ability to plan a portfolio of products and associated projects, and to know what the expected revenues and profits will be from the portfolio as a whole, within a few percentage points of plan. There has to be an allowable margin of error because the ability to predict competition and global economics is even less mature, and product developers can't be held responsible for that.

This definition of maturity provides the flexibility to differentiate across industries and for different company strategies within each industry. Innovators, about 5% of all companies, take big risks and expect low success rates. Technology and consumer product companies often fall into this category. The few successes, however, are usually giant revenue/profit producers. Companies with balanced portfolio strategies should expect success rates similar to those described by John Trudel. Fast-follower strategies should expect high success rates with less upside potential per product launched.

Focusing big data and analytics in the years ahead on quantifying expected year-over-year new product portfolio success rates would have tangible benefits. External Wall Street analysts are increasingly focused on the financial performance of new products. Companies that forecast well get treated well. Internal managers will be less inclined to overload the pipeline if they have confidence in the results they will get from a chosen set of products. md