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Automation's got Talent

STEM Programs Really Do Help Bring Rookie Engineers Into Machine Shops and Onto Factory Floors to Replace Retiring Veterans

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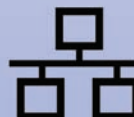
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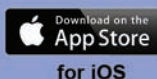
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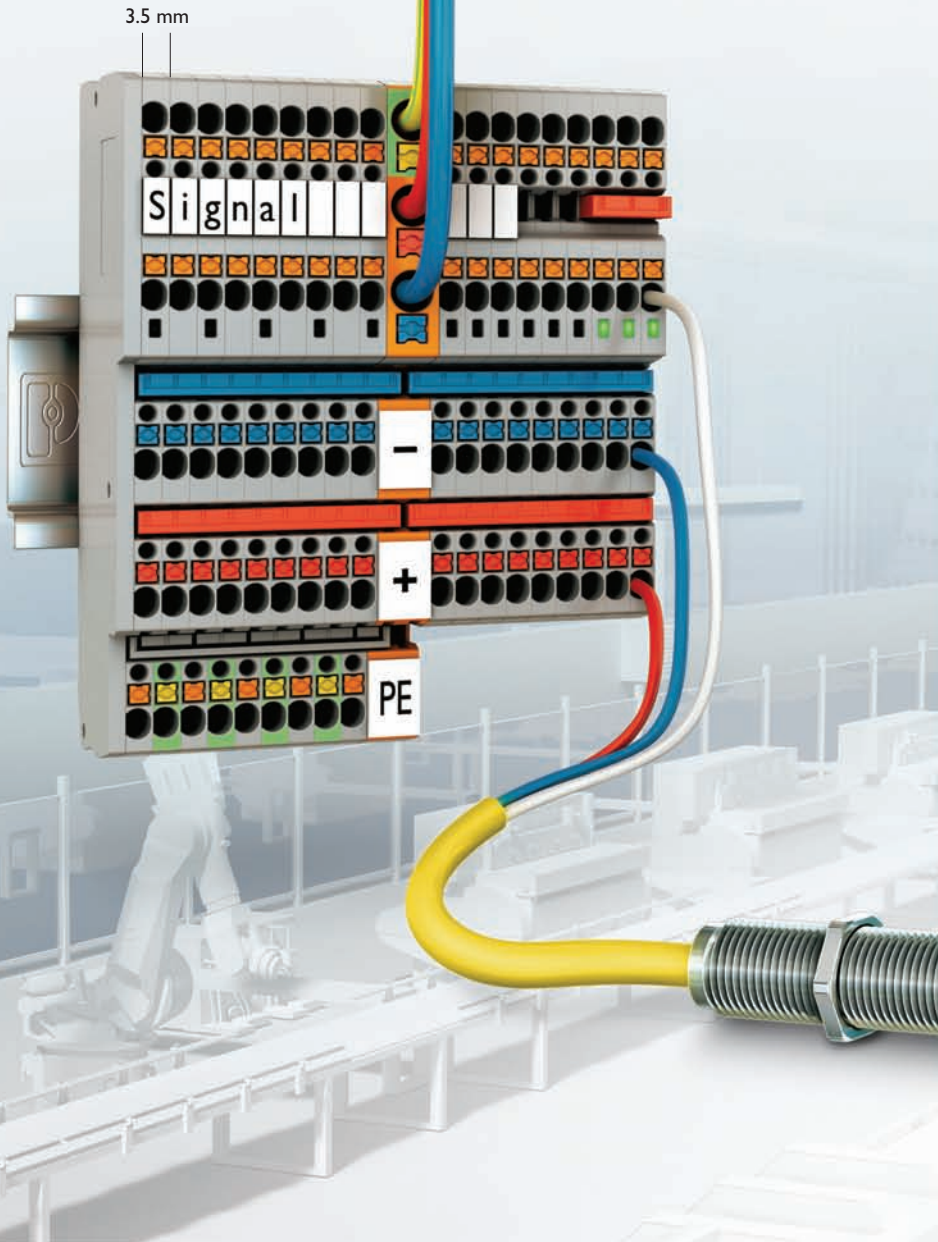


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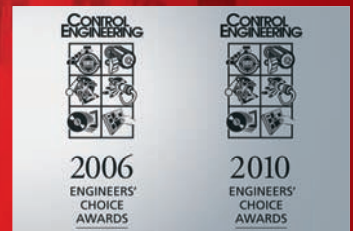
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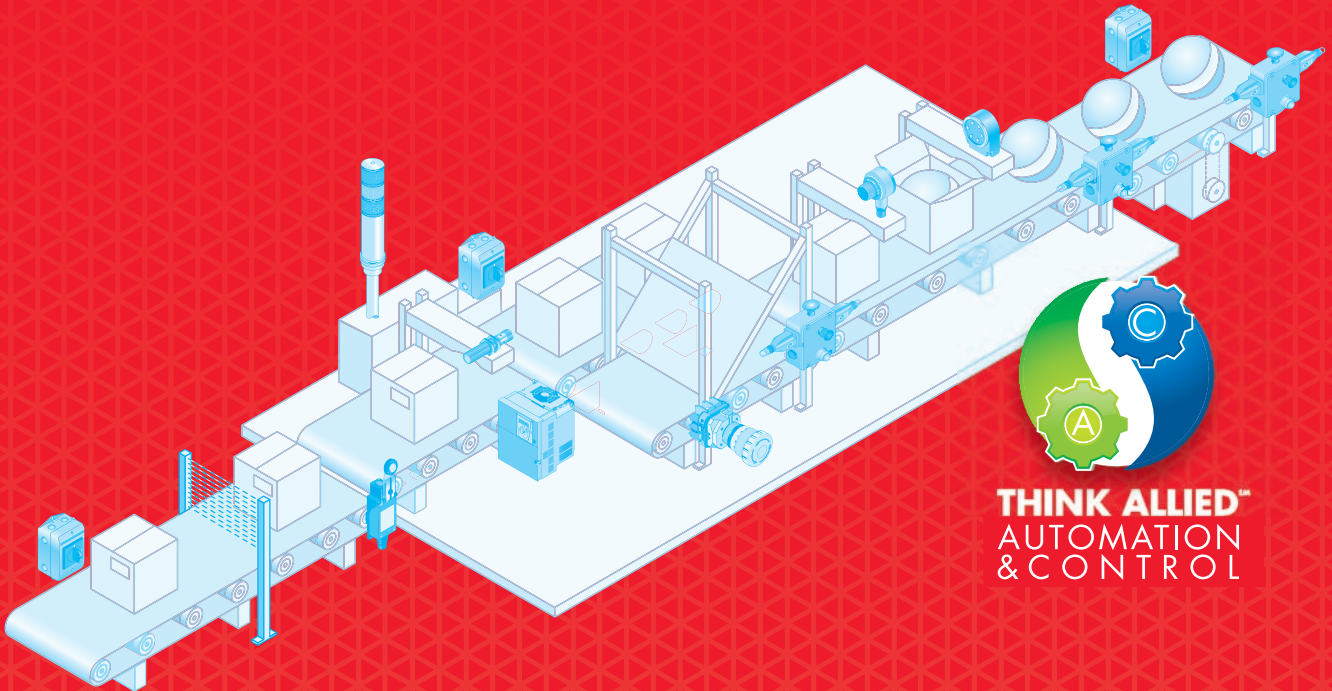
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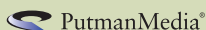
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Materials Handling, Conveyors	
& Conveying Equipment	1,868
Metalworking Machinery	3,553
Mining Machinery & Equipment	619
Oil & Gas Field Machinery & Equipment	1,191
Packaging Machinery	946
Paper Industries Machinery	351
Printing Trades Machinery & Equipment	508
Pumps & Pumping Equipment	778
Rolling Mill Machinery & Equipment	156
Semiconductor Manufacturing	
Machinery	1,406
Textile Machinery	233
Woodworking Machinery	273
Other Industries & Special Industrial	
Machinery & Equipment NEC	7975
TOTAL	40,020



Think Like an Operator

WHO WANTS TO be responsible for designing an HMI graphic that can lead to confusion, cause eye fatigue and cause operators to make serious mistakes? That's the key question posed in an HMI graphics design presentation at Rockwell Automation's RSTechED event in Orlando, Florida, last month.

Dave Board, a Rockwell commercial manager, shared his best practices on how to design effective HMI screens for plant operators, noting that good situation awareness for operators "means being aware of what is happening around you, understanding what the information means to you now, and understanding what that information means to you in the future. It also relates to the goals and objectives of a specific job or function."

Board said designers and engineers form a different mental model of the process in their heads than operators. "By understanding how operators select and use goals, designers better understand how information is perceived," he said. "Without understanding the user's goals on situation awareness, the information has no meaning."

Contrary to the wonderful, imaginative, animated, 3D color graphics available to designers today, Board makes it clear that they have no place in a best practices list for industrial operator displays.

"Use gray background, vessels and pipes in low-contrast grey," he said. "High-contrast color objects strain the eyes and cause fatigue. Warm colors, especially when flashing, draw the operators attention to them. Color should be used for abnormal conditions only." There should be little or no movement of objects that cause unnecessary distractions.

Board also is a big fan of analog status indicators. "The brain interprets analog more quickly than a number," he said. "We should provide a pointer to a scale, provide a clear indication of the normal working range, and clearly show upper and lower limits."

With an analog display, the operator easily can see where the value is, as well as what it is. And he can see rates of change easily.

"The key operating parameters should be trending on-screen and should not require the operator to click to show them," Board stated. "And radar plots are very good for easy monitoring of multiple, but related, variables."

■ **With an analog display, the operator easily can see where the value is as well as what it is.** ■

Board says low-level details of the plant should be accessed by clicking to them when needed. And the navigation should be as consistent as possible across displays.

Board gave high praise to several references as the basis of his presentation, and strongly recommended that session attendees read them. They are:

- *The High Performance HMI Handbook*, PAS, Bill Hollifield, Dana Oliver, Ian Nimmo and Eddie Habibi
- *Designing for Situation Awareness*, Mica R. Endsley and Debra G. Jones
- *Human Machine Interface Design: The Good, The Bad and The Ugly*, ICS Triplex, Paul Gruhn, PE

Joe Feeley

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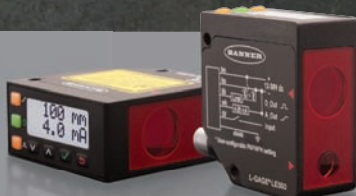
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The Kids Are All Right

I REALLY ENJOYED researching this month's "Automation's Got Talent" cover article on how science, technology, engineering and math (STEM) programs are beginning to produce the rookie engineers, technicians and operators needed to replace their veteran and rapidly retiring counterparts. It was especially refreshing to learn about the headway these programs are making because I've sat through at least a couple dozen presentations in recent years proclaiming the coming brain drain, but offering few suggestions on how solve it. I was beginning to get depressed because they made the problem sound unsolvable. As usual, panicky, doom-and-gloom talk is initially exciting, but ultimately it's cheap, empty and unhelpful.

Anyway, it was a true breath of fresh air to cover STEM efforts at some U.S. community colleges and high schools and even more gratifying to see the help they're getting from some machine builders who are hiring the graduates they need. These students, teachers and builders don't just know the brain drain can be solved—they're living examples of the solutions.

For instance, Sergio Garibay just graduated from the industrial engineering program at Purdue University Calumet (www.purduecal.edu) in Hammond, Indiana, but he's already been working for Morrison Container Handling Solutions (www.morrison-chs.com) in Glenwood, Illinois, for 11 months, and even helped his new company rethink its production layout in its new building. "The old building was three times bigger than the new one, but the equipment was pretty scattered, so there were many opportunities to be more efficient," Garibay, who also presented a senior project on the revamp during Purdue Calumet's Tech Day event in April, says, "So we did from/to calculation sheets in Excel, numbered each of our 22 machines, determined foot travel per day and came up with about 150 different designs. This allowed us to pick one with the best equipment positioning, optimum foot traffic and workflow and added room between the machines for better safety. The new layout is also successful because it's neater, cleaner and lets us bring in customers more easily."


Beyond immediate initiatives to educate and hire more engineers and operators, I was also encouraged that everyone and their brother seems to be involved in longer-term STEM programs for elementary, middle and high school students. In fact, FIRST Robotics and FIRST Tech Challenge now seem as almost as widespread as the Girl Scouts and Boy Scouts.

For example, Rick Folea, senior technical marketer at Automation Direct (www.automationdirect.com), reports his son, Chris, and 11 friends wanted to start a robotics club about eight or nine years ago in Forsyth County, Georgia, so they approached some local companies and organized a FIRST Robotics team. "We just started with his friends, and since then it's grown into an enormous, monster organization with 125 teams in FIRST Lego League, Vex Robotics and FIRST Robotics, as well as a STEM Academy program at Central Forsyth High School and an in-class Manufacturing Pathways program at South Forsyth High School," says Folea, who adds that local firms like Automation Direct, Siemens Industry and other have partnered with the teams and STEM programs. "It's even gone from being an extra-curricular activity to a co-curricular program that drives the kids' in-school interests because they want to learn to make their robots work better. In this county, our kids are getting a lot better chance to choose their professions. We're really living FIRST's mantra: 'This is the only competitive sport where every child can go pro.'"

**"We're really living FIRST's mantra:
'This is the only competitive sport where
every child can go pro.'"**

For instance, Folea adds that Chris learned Autodesk's donated AutoCAD design software as part of his FIRST Robotics experience, cranked out product animations at Automation Direct as part of a multiyear internship, and was recently hired by the company. "It's very gratifying to see kids excited about engineering. STEM has taken it from an activity that was thought of as yucky and dirty to become what the cool kids are doing. I'm told there are even some kids picking STEM teams over sports."

So all the rookie engineers are getting ready, and some may be headed your way. Maybe you can help them along if you're not doing it already.

Finally, in the "Safety is Elemental" cover article in the May 2014 issue of CONTROL DESIGN, the vertical "Comments" column at the right of Figure 1 incorrectly identified in its top two boxes the safety calculation tool for evaluating the safety of machine designs. The correct name is the Safety Evaluation Tool (SET) from Siemens Industry. The corrected chart is at www.controldesign.com/articles/2014/machine-safety-is-elemental-for-new-automated-systems. 



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Hydroforming Gets 21st-Century Makeover

Beckwood Press Uses Modern Controls, Hydraulics, Design Software and 3D Printed Tooling to Slash Part Development Time and Costs

EVERYONE NEEDS to update their skills now and again, and every machine eventually needs a revamp. However, it's rare for a 70-year-old technology to gain so many new capabilities that it can leapfrog present competition, and rarer still for a builder to be imaginative and flexible enough to pull off the design and construction of a whole new line of machines based on these innovations.

Still, that's exactly what Beckwood Press Co. (www.beckwood-press.com) has accomplished over the past few years with its Triform sheet hydroforming presses. Located in Fenton, Missouri, near St. Louis, the 38-year-old company builds hydraulic presses and automation systems, which are custom-made to meet the individual needs of its users.

"Beckwood was founded in 1976," says Ryan Pendleton, Beckwood's sales and marketing manager. "For years, we were exclusively a supplier of custom hydraulic presses and equipment. In the last decade, we've expanded our product offerings beyond custom hydraulic presses. Today, Beckwood customers benefit not only from our hydraulic press solutions, engineered for their specific application, but also from our line of Triform sheet hydroforming presses, stretch forming presses, forming simulation software, as well as a variety of automation offerings, including robotics and quick die-change equipment."

Applications for Beckwood's presses include forming, drawing, hot forming, compression molding, punching and blanking, stamping, powder compacting, straightening,



BECKWOOD PRESS

FINE FORMING

Beckwood Press' Triform sheet hydroforming press has 1,225 tons of lower punch force, 10,000 psi maximum chamber and a 25-inch diameter forming area. It uses two 125-hp motors, hydraulic pumps, is controlled by CNC and PLCs, and can achieve forming pressure control of $\pm 1\%$ of full scale and forming position control of ± 0.002 inches.

sheet hydroforming and more. Its customers range from multinational corporations to smaller manufacturers in industries that include aerospace and defense, oil, gas and energy, construction and off-road vehicles, agriculture, automotive and appliances.

"Our philosophy revolves around manufacturing high-quality, high-performance manufacturing solutions engineered to the needs of the specific customer," explains Pendleton. "Each Beckwood structure is put through a rigorous finite element analysis (FEA) and is designed for infinite life. Beckwood products are also subject to meticulous quality control procedures to ensure that each system is ready to perform when it hits the customer's floor."

Beckwood's focus on customization has been good news for its customers, who can routinely request and receive wider, deeper press designs and specialized functions. So when an Oklahoma-based aerospace

parts manufacturer got tired of fixing and adjusting its ancient Cincinnati hydroforming machine, it knew Beckwood could help it to develop a modern, more-capable version. The company partnered with Beckwood to design and build a prototype with modern controls and technology. It became the template for Beckwood's Triform Sheet Hydroforming line of presses.

Hydraulic hydroforming was invented in the late 1940s, and basically pumps hydraulic fluid into a "rubber" bladder at high pressure to force or draw sheet metal onto a tool to create desired shapes. These machines were made until the 1970s, and many of these aging presses are still in use today. Their main advantage is an ability to form parts using inexpensive tooling. This is because the diaphragm acts as a universal die half, conforming to any shape within the forming chamber. The process can also form parts consistently without wrinkling sheet metal or damaging its finish, which can

prevent a lot of wasted material and save a lot of time on post-production work.

However, these traditional machines typically required numerous screws to be adjusted to specific distances via a big cam on the front, so the machine's trip switches could make the right pressure changes at the right times during each cycle. In addition, these difficulties were compounded by the steel tooling forms used in traditional hydroforming, which cost thousands of dollars to machine, finish and maintain. Eventually, epoxy forms were developed and used, but they were also time-consuming and costly to mold, pour and produce.

To help customers like its user in Oklahoma, Beckwood completed and launched its Triform machines in 2008. These machines include two main types. The first is fluid cell, which uses only the downward action of the bladder to form sheet metal around or into one tool. The second type is deep draw, which uses the same principle at work in the fluid cell process, but it also features a hydraulic punch cylinder that raises the tool into the

“We employ a specific set of technologies aimed at increasing machine intelligence. This includes a pre-preventive maintenance system that monitors the health status of various press systems.”

bladder during the forming process.

The fluid cell presses range from the 16-5BD press with a 16-inch diameter forming area and 5,000 psi maximum chamber pressure up to its 2496-5BD press with a 24 x 96-inch forming area and 5,000 psi maximum chamber pressure. Its deep draw machines range from its 12-10-7BD press with 565 tons of force, 12-inch diameter forming area, 7-inch draw and 10,000 psi maximum chamber pressure up to its 32-10-12SC press with 4,020 tons of force, 32-inch forming area, 12-inch draw and 10,000 psi maximum chamber pressure.

For example Steelville Manufacturing (www.steelvillemfg.com) in Steelville, Missouri, uses a Triform 24-5BD and its 24-in. diameter forming area and 5,000 psi to save time on making parts for Boeing, Lockheed Martin and Sikorsky.

“Before the Triform, we were often forming flanges and other part geometries in a press brake,” says Joseph Dust, an engineer at Steelville, who managed Triform's integration. “We would also pre-form certain parts by forming them into stacked rubber against a male or female die before finishing them in a second operation that involved a traditional press with male/


female tooling. With Triform, we bypass those processes and form our parts more quickly and efficiently. The overall time required for the completion of our form tools has been cut in half.”

Beckwood reports its press systems use high-quality components from leaders in the industry. Hydraulic pumps are typically from Bosch Rexroth or Parker Hannifin, while Beckwood's go-to control platform is Allen Bradley from Rockwell Automation.

The deep draw presses typically achieve forming pressure control of $\pm 1\text{--}2\%$ of full scale and forming position control of ± 0.002 to ± 0.005 inches. In addition, the presses use proprietary Triform forming software and can make up to 30 pressure changes during the cycle for one part, which enables more accurate production of more sophisticated parts. Also, the presses have Ethernet-based, virtual private network (VPN) communications that enable Beckwood to perform remote monitoring and diagnostics of its customers' machine with their permission.

“Recently, Beckwood began employing technologies aimed at increasing machine intelligence,” adds Pendleton. “These include our Pre-Preventive Maintenance (PPM) system that monitors the health status of various press systems. PPM reports on its press' performance, faults, safety system status, etc. The reporting can be delivered in real time and sent direct from the press to key user personnel and to Beckwood's technical service team via email.”

In recent years, Triform customers have experimented with and successfully applied high-strength 3D-printed tooling, such as Stratasys' Ultem or polycarbonate thermoplastics, which are less costly and can be made much faster than traditional tools. It also uses ESI's Pam-Stamp 2G software to simulate the forming process and find the optimum form block and blank design. Likewise, Steelville is employing 3D-printed form blocks, which it can use on its Triform machine, and bypass its own machining centers to save even more time.

“These three technologies are revolutionizing forming operations,” says Jeffrey Debus, Beckwood's president. “Companies outfitted with these systems can go from a part drawing to a finished, net shape part in less than 24 hours at a fraction of the cost of traditional forming methods. This requires a fundamental shift in thinking, away from a bygone era that included complex tooling, days if not weeks of process development time and an overall part development cost that handicapped many projects. From an idea to a finished part in a matter of hours. That's the future.” 

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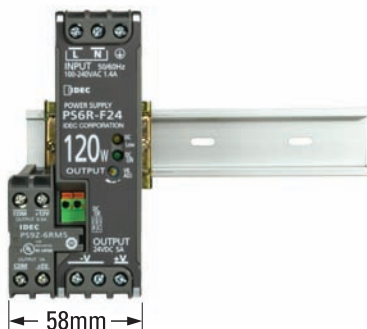


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Global Robotics Industry to Set New Record

"IN 2013, ABOUT 179,000 industrial robots were sold worldwide, again an all-time high and 12% more than in 2012," said Arturo Baroncelli, International Federation of Robotics (IFR, www.ifr.org), president at the Automatica show in Munich in June. "Incoming orders in the first four months of 2014 increased remarkably, and requests from all customer industries are on the rise. We expect that in 2014 growth of unit sales will continue with the same pace as in 2013."

Increases in All Regions

Robot sales reached record levels in Asia/Australia, the Americas and in Africa. Almost 100,000 new robots were installed in 2013 in Asia/Australia, 18% more than in 2012. The European market increased by 5% to more than 43,000 units, approaching the all-time-high of 2011. Robot supplies to the Americas continued to increase by 8% to

more than 30,000 units. More than 700 industrial robots were sold in Africa—87% more than in 2012.

China is by far the biggest robot market in the world in terms of annual sales and also the fastest growing market worldwide. Almost 37,000 industrial robots were sold in China in 2013. The sales volume was almost three times higher than in 2012. In 2013, every fifth robot sold in the world was installed in China.

Japan was the second largest market in annual sales, but it still has, by far, the highest number of industrial robots in operation with more than 300,000 units.

Robot installations in the U.S. continued to increase by 6% to the peak level of almost 24,000 units. Between 2008 and 2013, annual sales in the U.S. increased by 12% on average per year. The driver of this growth was the ongoing trend to automate production to

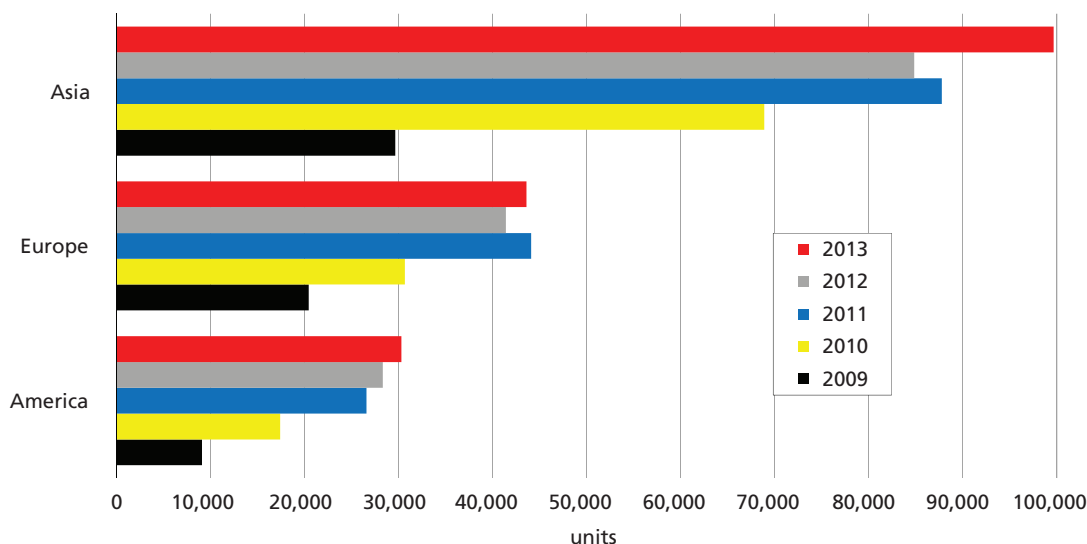
strengthen American industries in global markets, keep manufacturing at home, and in some cases, to bring back manufacturing that had previously been sent overseas.

In 2013, robot sales to South Korea increased by 10% to more than 21,000 units due to increased investments by the automotive industry. The electronics industry which is the main customer of industrial robots in Korea, reduced its robot orders.

Robot sales to the German market were 4% higher in 2013 compared to 2012, and reached more than 18,000 units, the second highest level ever recorded. The automotive industry was again the driver for the growth. Between 2008 and 2013, robot sales to Germany increased by 4% on average.

These four markets represent 50% of the sales volume in 2013.

Annual supply of industrial robots by regions 2009 - 2013



MORE ROBOTS EVERYWHERE

The global supply of industrial robots grew 12% overall between 2012 and 2013.

Cooling Water Control Boosts Production

PCT ENGINEERED SYSTEMS

(www.teampct.com) of Davenport, Iowa, builds the BroadBeam brand of electron beam machines that can be used for everything from cross-linking plastics to sterilizing surfaces. Because the machines produce up to 350,000 V, the company uses a cooling water system to test the units before they are sold. A booming business led the company to expand its facility in 2013.

PCT's presentation at this year's Siemens Industry Automation Summit held in Orlando, Florida, last month highlighted how the company used a new automation scheme to boost its production of electron beam machines.

With its expanding business, PCT

found that its existing water circulation system couldn't handle the higher production rates because the unit was outdated, undersized and had only one water circuit.

"We needed a reliable, automated system with a larger capacity that could supply enough water to let us test from one to 12 machines at a time," says Tim Riess, PCT electrical and controls engineer.

To address the problem, Riess said the company built a more advanced system that separates process water from cooling water, includes a water-to-water heat exchanger and features a sophisticated pump control system.

The process water circuit of the design consists of a 2,000-gallon tank, one low-volume pump, and



three variable-speed, high-volume pumps. The cooling water circuit has a 5,000-gallon tank, two circulation pumps and a 370-ton cooling tower. The two circuits meet in the middle at a large heat exchanger.

PCT's design uses a Siemens controller with digital, analog and thermocouple signal modules, a 22-inch touch-screen HMI, ac drives to control the pumps, and motor

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Through Siemens' TIA Portal, the company programmed the HMI via its Step 7 V12 and WinCC Advanced V12 software, and programmed the other components with Starter and Simocode ES software.

The control scheme has the individual water circuits controlled independently. PID loops control two of the process water circuit VFDs, ensuring that when the water demand from the manufacturing facility drops, the pumps provide more water, with the third pump acting as backup as necessary. Automatic control maintains process water at constant pressure.

For the cooling water circuit, automatic control maintains process water below set temperature. The operator interface for both main circuits allows changing of setpoints and other variables on the screen.

The benefits of the new water circulation system include easy diagnostics via the PLC display, remote access to the HMI and HMI-networked data logging. The automated system requires little supervision and works so well that, in addition to upping production, the company built an extra-large version of the machine.

No More Clumsy Robots

RESEARCHERS AT THE University of Birmingham (www.birmingham.ac.uk) in the U.K. have taught robots to pick up unfamiliar objects without dropping or breaking them. The research paves the way for robots to be used in more flexible ways and in more complex environments, especially where humans and robots need to work together.

In the university's School of Computer Science, researchers designed a way to program a robotic hand to pick up an object, and then use information learned in that first grip to grasp and move a whole range of similar objects. The robot was then able to generalize the grip and adapt it to other objects.

"The programming we developed allows the robot to assess the object and generate around 1,000 different grasp options in about five seconds," explains Jeremy Wyatt, professor of robotics and artificial intelligence at the University of Birmingham.

A video illustrating this technology can be seen at bit.ly/1lq90pu.

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MERGERS, ALLIANCES AND ACQUISITIONS

Ametek (www.ametek.com) completed its acquisition of optical equipment specialist **Zygo** (www.zygo.com) for approximately \$280 million net of cash acquired.

ISVI (www.isvi-corp.com) signed a distribution agreement with **Integrays Ltd.** (www.integrays.com) to address the Canadian machine vision market for high-speed, high-resolution cameras. It also signed a distribution agreement with **Virtech Labs Bt.** (www.gepilatas.hu) to promote and sell its high-speed, high-resolution cameras to the Hungarian machine vision market.

Metrix Setpoint (www.metrixsetpoint.com) entered into an OEM partnership agreement with **OSIsoft** (www.osisoft.com), producer of the PI System. Setpoint CMS software will use the PI System technology for its underlying, real-time data infrastructure.

Allied Machine & Engineering (www.alliedmachine.com) joined **Okuma America's** (www.okuma.com/americas) Partners in THINC, a network of companies developing applications using Okuma's THINC intelligent numerical control system, which combines OSPcontrol with an open-architecture, PC-based

platform. Allied provides advanced engineering and manufacturing capabilities to create value-added tooling available to metal-cutting industries.

Online Development (OLDI, www.oldi.com), an original design manufacturer of industrial products for factory automation companies, announced that **Softing** (www.softing.com/en) has acquired the company and will operate it as an entity under Softing North American Holding.

NEW & NOTEWORTHY

FreeWave Technologies (www.freewave.com) announced that its WavePoint platform was named a 2014 M2M Evolution Product of the Year Award winner from *M2M Evolution* magazine.

The **Association for Manufacturing Excellence** (AME, www.ame.org) opened the AME Manufacturing Job Board, a resource for job seekers and manufacturing companies nationwide.

Networking solutions provider **Moxa** (www.moxa.com) is one of 45 companies recognized by **Northrop Grumman** in the company's annual Supplier Recognition Program. [cd](#)

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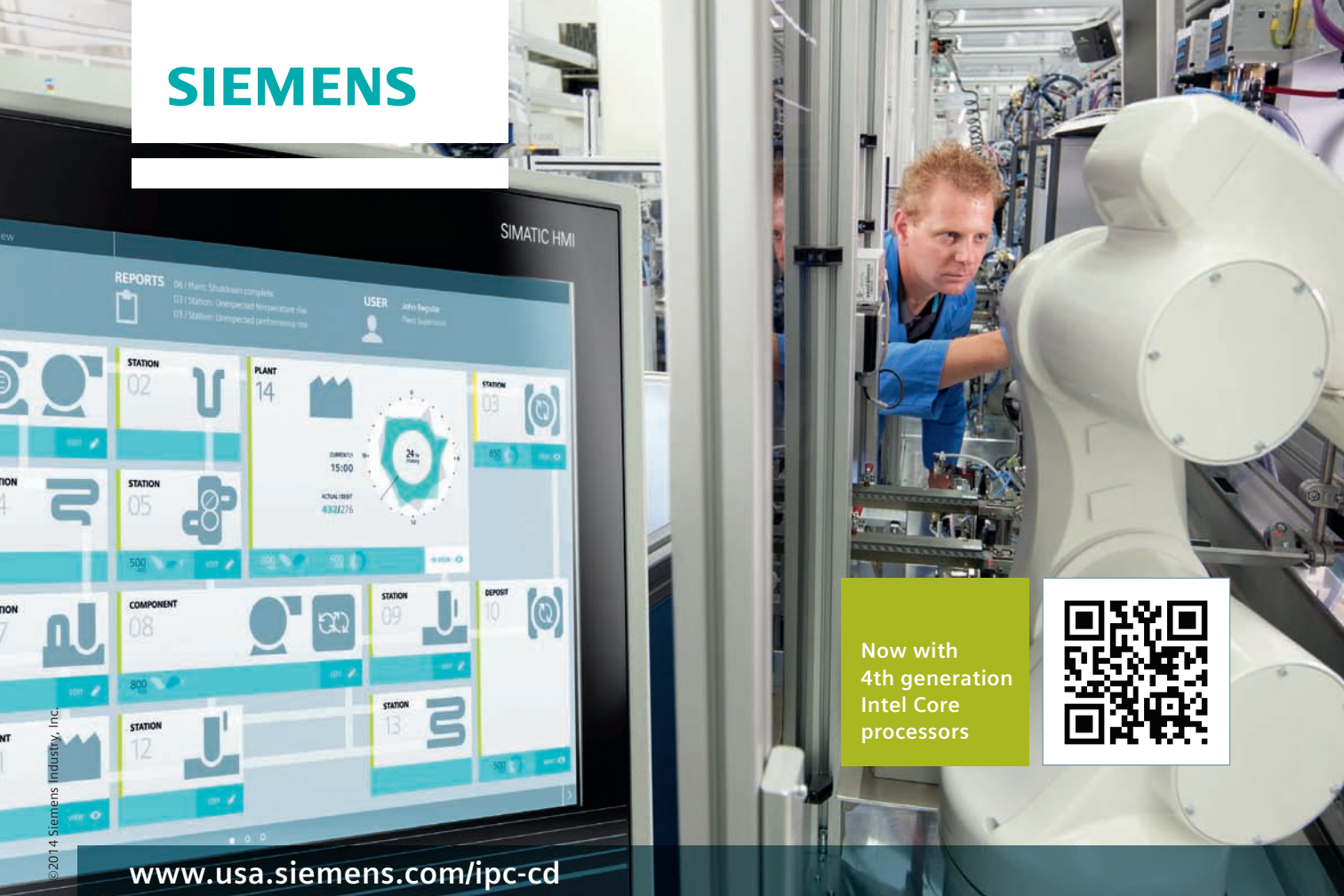


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Interface Interference

INTERFACE, INTERFACE, interface. Oh, what Windows and the mouse did for the interface. But now, gestures and multi-touch on small, portable, surface-based devices have changed the game. They will create, if they haven't already, a generation of non-verbal and frazzled participants.

So what happens when the lines of communications get broken or simply get hidden on the really big, three-inch screen of a smart phone?

Would a machine or process operator really use one? Do they stop trying? Or do they get weary or complacent and just forget to respond?

If you believe that this interface type is the real deal, why would any company put its future in the hands of a commercial third-party like Google (Android) to provide the window into "my" world, not knowing if the window is going to be shut at a moment's notice? We've done it, I know, but this time will be different.

Sounds drastic? Maybe, but I fear that not enough of us are at least thinking that their worldwide access platform might be a compromised arena.

I moved into the present day by grabbing a BlackBerry Q5 smart phone. It runs BB10 and has many really cool features and apps, so the conundrum of "free" lives on in such esoteric and non-pervasive apps as Flashlight. However, as I noted last month, it "needs" to know your location and personal information so it can turn on. Interface? No. Intrusion? Yes. But the flashlight did come in handy while I was on an emergency start-up, and had to peer into the dust-laden panel and pour over drawings.

So a Q5 phone employs multi-touch and scalability amid the illusion of modern. By that I mean that everyone knows that a multi-touch gesture of two fingers 'grows' the screen.

I write this thinking that our industrial operator stations are OK with these facts. "Oh, crap, is it a right finger or left finger hold or..?" This while Rome burns, and the system goes out of control.

The responsibility of control can be so easily given to those who have trouble remembering what they had for breakfast. So I guess it's clear that these new phones and tablets give us the interface we need for remote access and mobility with the interface of web-based commonality. Really?

Remember the F1 key? That was for help in any application. But in this new touch-based world, does F5 mean refresh in every web-based, remote, mobile

HMI app? I'm pretty sure the answer is no.

So where have we gone wrong?

When we got our new phones we were promised 10 hours a month of web-based real TV. The screen size is 3-in. diagonal, and I am well beyond 45. What were they thinking? Can't wait for Surround Sound from these bubbas.

One wonders how operators might respond to any alarm, issues, page, setpoint deviation alarm and setpoint change when they've used 24-in. screens for years, and I would suggest that they might not have dealt with or interfaced with them well.

Teamviewer is a common application for remote access internally, just as Remote Desktop Protocol (RDP) would be. This means that one would not have to have the SCADA client on the device. I installed it on the iPad to check the action out.

■ Remember the F1 key? That was for help in any application. Does F5 mean "refresh" in every web-based, remote, mobile HMI app? I'm pretty sure the answer is no. ■

The gestures are odd, since there is no keyboard/mouse as such. Tap is left-click (easy). Tap and Hold is right click, and there are four others. Once you get used to it, then all is good.

The Q5, however, is not the same. Tap is used often. Tap, hold and drag from various positions on the screen do different things, as well as introduce various components.

My biggest concern is visual availability. You can't see anything worthwhile because of the screen size. So an application such as Teamviewer accessing a normal PC with 100 tags on it would be silly.

You can wonder how that works. It's kind of like a mobile device vs. a fixed device accessing a normal website. You can get to the same data, but who knows where it is?

Make no mistake. It's not that we as a group can't learn, but just because we can, doesn't mean we should. As I said, the majority of us are not spring chickens.

Long live the 17-in. laptop with mouse! ☺

JEREMY POLLARD, CET, has been writing about technology and software issues for many years. Pollard has been involved in control system programming and training for more than 25 years.

Automat got Talk

STEM Programs Really Help Bring Rookie Engineers Into Machine Shops and Onto Factory Floors to Replace Retiring Veterans

by Jim Montague, executive editor

Just like everyone else, Arpac (www.arpak.com) couldn't find enough qualified engineers. Three years ago, the packaging machine builder and services firm in Schiller Park, Illinois, recruited, advertised, networked and posted available positions online, but all it got was a limited and inadequate response.

"We were doing all we could to recruit through the usual channels," says Howard Dittmer, vice president of engineering and technology at Arpac. "We even put a billboard up on the expressway, but that didn't work either. It could take a year for us to fill an engineering job. Finding engineers has become really difficult, so we decided to keep our traditional recruiting methods, but also develop some new ones."

This problem is common and widespread for machine builders, system integrators, control and automation suppliers, as well as their clients and end users in manufacturing companies almost everywhere.

Even though everyone talks about the need to replace

all the veteran engineers, technicians and operators retiring in the U.S., Europe and elsewhere, it can seem like no one's doing anything about developing the next generation of rookies needed to do it. The usual opinions are that young people only want to be sports and rock stars; they think factories are dirty; and they don't want to take all the math and science courses needed to become engineers.

"Mid-skilled engineering technicians are in shortest supply, but it's been hard to get kids interested in these professions," says Chris Paynter, dean of science, technology, engineering and math (STEM) at Central Piedmont Community College (www.cpcc.edu) in Charlotte, North Carolina. "Employers say this interest gap is real, production suffers, and it prevents their companies from growing." By combining many of its math, science, engineering and IT sections, the college established its innovative, multidisciplinary STEM operating unit in 2009.

solutions event

Plugging the Drain

While the Baby Boom brain drain is genuine, the perceived lack of solutions is fiction. There are plenty of high school and college students, recent graduates and mid-career workers looking to switch careers—and most are willing to learn and train. Many community college, university and high school programs teach automation and control skills, and many manufacturers conduct apprenticeship and training programs to develop the technical professionals they desperately need. Some colleges and companies are coordinating their efforts to refine curricula and focus more effectively on getting the best and most needed skills instilled in students quickly.

To give students technical instruction that has more of a point, STEM programs such as FIRST Robotics (www.usfirst.org) are multiplying nationwide. This is because STEM gives kids the same sense of purpose and accomplishment that veteran engineers have long reported valuing even more than good salaries.

“Robotics programs like FIRST are a lot more hands-on,” says Adrian Choi, associate field services engineer at Rockwell Automation (www.rockwellautomation.com), who works onsite with metalworking clients, most recently on controlling their chemical treating lines. “When you design, test and build a robot that has your name on it, you have more of a sense of pride. You want to do better, especially at an event where you’re competing in front of a cheering crowd. That’s encouragement above and beyond a regular class.”

Choi graduated from Chicago’s Whitney Young High School in 2007, where he participated in FIRST and its different robotic challenges. He earned a bachelor’s degree in mechanical engineering from the University of Michigan in 2012, where he participated in the Association for Unmanned Vehicle Systems Int’l’s (www.auvsi.org) RoboBoat navigation and other competitions for two years. “Solutions to classic mechanical problems might look good on paper in a class, but if you don’t take actual tolerances into account, then you’re going to have serious problems,” Choi says. “That’s what we learned in FIRST. I work on a lot of mechatronic systems now, and we often have to find out if we’re dealing with a programming error or a hardware error. Real-world forces usually require multidisciplinary skills, judgment and solutions, and FIRST teaches this as well.”

To bring STEM principles even closer to the controls field, Phoenix Contact (www.phoenixcontact.com) established its Nanoline Contest in 2008-09. Middle, high school and college students use its mini-PLC controllers and software to program robots and equipment to complete a variety of tasks. Thirty teams signed up for the 2014 competition, 17 teams competed in two regional contests, and a team from Walker Career Center (wcc.warren.k12.in.us) in Indianapolis won with its RoboDose automated, medical-pill-dispensing machine.

Unfortunately, these education, training and STEM programs just scratch the surface of what’s needed to break the intensifying drought of experienced engineers and technicians. Many more academic programs

are required, and they'll need to be much more closely integrated with manufacturers' factory-floor needs to be effective and successful.

Active Involvement = Successful Recruiting

To boost its own recruitment efforts, Dittmer says Arpac is at work on several additional fronts. "We started bringing in interns and sending our engineering managers, supervisors and HR staff to more job fairs at nearby colleges and universities, such as Purdue, Northwestern, Wisconsin and the Rose-Hulman Institute of Technology. "However, we've also learned that we have to be careful about what programs we recruit from because some are too theoretical, and we need people who've had more practical instruction and have a strong, hands-on work ethic."

Dittmer adds that Arpac has paid interns, with three or four more added in the summer—typically college sophomores who learn increasingly challenging tasks. "We give them as much responsibility as they can handle, and when they master one skill we give them another," Dittmer explains. "They do everything from drafting to changing gearboxes, which means they investigate required strengths, evaluate bolt patterns and then change out the hardware."

Back to School

Of course, the best way for machine builders and manufacturers to secure new engineers and technicians is to work with their local community colleges, universities and high schools. For example, some of Arpac's interns and recent hires came from Purdue University Calumet (www.purduecal.edu) in Hammond, Indiana,

which offers a Mechatronics for Packaging program.

The program is chaired by Nick Wilson, CEO of Morrison Container Handling Solutions (www.morrison-chs.com) in Glenwood, Illinois, and it uses federally recognized testing and certification input on PLC programming, electronic troubleshooting and other skills from PMMI, the Association for Packaging and Processing Technologies (www.pmmi.org).

"This is a four-year program that focuses on the needs of packagers and packaging machine builders, so it's more practical, job-oriented and modeled on the German principle of 'fachhochschule,' which translates as 'a university of applied sciences,'" says John Kowal, business development director at B&R Industrial Automation (www.br-automation.com), and member of the dean's executive council at Purdue Calumet. "These programs are especially useful because they give students a chance to learn about machine builders before working for them, and companies get to see the potential that the students possess. It's hard to let students know about careers, good salaries and growth potential in engineering and technical fields, but this is one of the best ways to do it."

Likewise, Chris Gioiosa just graduated from Purdue Calumet with a degree in electric engineering, but he's already been working for about seven months for Advanced Technology Services (ATS, www.advancedtech.com) in Schaumburg, Illinois, which provides automated factory maintenance. Before graduating in May, Gioiosa and fellow students presented senior projects at Purdue Calumet's Tech Day. Gioiosa designed and built a "Shot-O-Matic" automated liquid dispensing system that combines a programmable HMI using ladder logic, a 24-20 V power supply, 24-30 V stepper and a linear servo with 25 lbs thrust (Figure 1).

"I wanted to automate the process of bringing glasses to a beverage holder, so I took the turntable hardware out of a lazy Susan, added a base plate with the stepper motor, and then used the linear servo to push the table with the glasses into position," Gioiosa explains. "I also had to figure out that the stepper generated 30,000 pulses for one full revolution, so increments of 5,000 pulses would move it to each of six positions."

Arpac's ties to the university have grown strong enough that the machine builder is represented on Purdue Calumet's committees. "Relationships with community colleges and universities are very important, but you have work at it," Dittmer says. "So far, we've hired six fresh mechanical engineering grads in the past three years. We wanted the best graduates we could find, and we're very happy with the ones we got."



SERVO-DRIVEN SHOTS

Figure 1: Chris Gioiosa, who just graduated from Purdue University Calumet with a degree in electrical engineering, adjusts the controls on his Shot-O-Matic automated liquid dispensing system, which combines a programmable HMI, ladder logic, stepper motor and linear servomotor.

Continuing Education

The story doesn't end with successful hiring because training and education keep right on going. "We keep the challenges coming—along with more opportunities to grow and be recognized," Dittmer adds. "We have an awards dinner each year at the Museum of Science and Industry in Chicago because we know that celebrating our engineers and their significant others is very powerful too."

Paynter reports that CPCC's STEM department leverages expertise from multiple disciplines for more dynamic learning. Its students complete robotics projects, host FIRST Robotics teams and participate in human-powered vehicle contests. There's also more specialized instruction for students to learn automation from the IEEE Robotics and Automation Society (www.ieee-ras.org) or mechatronics from Skills USA (www.skillsusa.org).

"Other community colleges divide subjects such as math into college-level courses with students transferring credits to four-year colleges and applied courses with students learning skills to make

MAJOR STEM PROGRAMS

Local, regional and national science, technology, engineering and math (STEM) programs for young people of all ages (and their teachers) are multiplying in number and variety, but many more are needed. Here are some of the most significant U.S. programs:

- Association for Unmanned Vehicle Systems Int'l (www.auvsi.org) is a non-profit organization devoted to advancing the unmanned systems and robotics community.
- For Inspiration and Recognition of Science and Technology, (FIRST, www.usfirst.org) has four main components: FIRST Robotics Competition for grades 9-12, FIRST Tech Challenge for grades 7-12, FIRST Lego League for grades 4-8, and Junior FIRST Lego League for kindergarten to 3rd grade. It has 3,500 sponsors and 130,000 volunteers.
- IEEE Robotics and Automation Society (www.ieee-ras.org) strives to advance innovation, education, and fundamental and applied research in robotics and automation.
- Project Lead the Way (www.pltw.org) is a school-based, multi-disciplinary STEM program that stresses collaboration and problem solving in more than 5,000 U.S. schools.
- Skills USA (www.skillsusa.org) is a partnership of students, teachers and industry working to make sure the U.S. has a skilled workforce. It's also a member of WorldSkills Int'l.
- SmartAmerica Challenge (www.smartamerica.org) is a joint effort by industry, academia and government to show how cyber-physical systems can create jobs, new business opportunities and socio-economic benefits.
- UTeach Institute (uteach-institute.org) teaches K-12 teachers about STEM topics at 40 universities nationwide.
- Vex Robotics (www.vexrobotics.com) is a design system and robotic kit that introduces robotics to middle and high schools. Vex competitions include more than 4,800 teams from 20 countries in over 300 tournaments worldwide.



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them job-ready or prepare them for other courses like electrical engineering,” Paynter explains. “We put all our math into one department, which gives our curriculum more hands-on, real-world examples of how math is used in manufacturing, energy and engineering. Likewise, our STEM department lets us identify students’ interests and lay out broad disciplines, so

“We’ve also learned that we have to be careful about what programs we recruit from because some are too theoretical, and we need people who’ve had more practical instruction and have a strong, hands-on work ethic.”

they can follow their passions and find careers they want, or pivot to the right job. I see STEM as a brand that can strip away science and math’s old, stodgy environment, and make them fun, attractive and approachable. So if you’re good at science and math, STEM shows how they can be used in creative ways.”

Partnerships, Internships and Apprenticeships

Historically, students went to vocational and technical schools for a few years and then were hired and trained by companies for several more months or years. More recently, many STEM education programs and their industrial partners try to compress this process, so companies can get trained staff faster.

Paynter reports some of CPCC’s machinists recently were hired by Bosch Rexroth (www.boschrexroth.com) in Charlotte, North Carolina, which created its own apprenticeship program, but then arranged for the college to run it. Logically, more apprenticeship programs are being run in conjunction with—and even at the same time as—the STEM programs from which they’re hiring. This allows STEM students to get a technical education, get hired, paid and learn about the firms where they’ll work.

“We have a long history with apprenticeships, but it’s an idea that’s regaining traction now, especially among German firms in our area,” Paynter says. “The idea is that companies hire students and make long-term investments in them by paying tuition and a wage. In

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our program with Bosch Rexroth, they go to college one or two days a week, work at Bosch three or four days a week and complete their education in one to four years, depending on the skills they need.”

In fact, almost 20 years ago, two German companies with facilities in the Charlotte area, Blum (www.blum.com) and Daetwyler (www.daetwyler-usa.com), started their Apprenticeship 2000 (apprenticeship2000.com) program to train high school graduates as tool-and-die makers, CNC machinists, welding fabricators and electronics, machine and mold/plastics technicians. This four-year program pays salary and tuition, and teaches at CPCC and at firms where its participants are hired. Since its initial start-up, six more companies have joined Apprenticeship 2000 to teach future workers.

“Apprenticeship 2000 was a great opportunity for me to jump into the workforce and establish a career while earning a college degree,” says Trevor Seifts, electrical controls technician at Daetwyler. “Working with Daetwyler, I gained valuable experience, and I earned a college degree in electrical engineering (EE). Plus, I was paid for time at work and school, as well as having my



IN-CLASS MACHINING

Figure 2: Maximillian Hill, who just graduated from Niles North High School, programs a Haas TM1P CNC mill in the school's STEM Lab.

tuition and books taken care of by Daetwyler. I started out in the program with the mechanical pathway in mind, but after a year I found my drive was towards electronics. So I was able to study in the EE program at CPCC, join Daetwyler's engineering department and establish myself there as an electrical controls technician.

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“Developing relationships with community colleges and universities is very important, but you have work at it. So far, we’ve hired six fresh mechanical engineering grads in the past three years. We wanted the best graduates we could find, and we’re very happy with the ones we got.”

I’ve also had the chance to work on new and exciting projects, such as micro-waterjet technology. This included traveling to Switzerland for three-and-a-half months and learning everything from research and development to assembly, machine installation, and designing a process control system to interface with the machines. I’m also fortunate to be part of an experienced team that specializes in custom controls and machine design. Finally, I was welcomed as part of the Daetwyler safety team recently, and I look forward to integrating into that team and gaining more valuable experience.”

Sparking Minds

Beyond increasing their immediate hiring needs, more machine builders and other manufacturers are waking up to the need to develop and train potential talent for the longer term. For many, this means cooperating with local high, junior high and elementary schools to offer STEM enrichment programs and sponsoring and/or mentoring FIRST Robotics and other competitive teams. Also, many manufacturers conduct tours and open-house events for local kids and parents just to let their communities know what kind of work their technically specialized neighbors do—and maybe clue in a few youngsters that good-paying jobs are available.

“Guidance counselors tell kids who are good at math and science to go into engineering, but they

don’t give them a reason why or how to do it,” Dittmer adds. “So, much of STEM’s outreach is to educate students, teachers and parents about what engineering actually is.”

To increase that awareness, Niles North High School in Skokie, Illinois, offers seven Project Lead the Way courses in introductory engineering, computer integrated manufacturing and other types of engineering, which all culminate in AP exams with transferable college credits. It and sister school, Niles West, are reportedly two of only three high schools in the U.S. that offer a girls-only engineering class, which has been shown to draw girls into fuller participation in the curriculum compared to co-ed math and science classes. Niles North also offers a robotics course in summer, and its Engineering Club participates regularly in Vex Robotics (www.vexrobotics.com) competitions using Robot C and Easy C software.

Over the past few years, the teachers in Niles North’s STEM Lab have written state, federal and business grants, and gathered an impressive collection of machining centers, including three CNC horizontal lathes, two CNC mills, one CNC router and a 3D printer. The mills are from Haas Automation (www.haascnc.com) in Oxnard, California, which offers its machines at extremely low prices to schools and colleges to encourage their STEM programs (Figure 2). The students also are taught to use

Autodesk Inventor software to design projects and Mastercam software to model them for translation into the G and M code that will run the machines.

"When I was in college in 2000 at Purdue and Illinois State universities, we had one old Cincinnati mill and one CNC machine, and the rest of the equipment was manual," says Benjamin Brzezinski, engineering teacher at Niles North. "The machines we have here are much better because they give students real, hands-on experience and expose them to a whole different world. We get calls all the time from tool and die manufacturers, who want to hire our students as interns and for possible full-time employment later. Manufacturing makes up about 20% of our gross domestic product (GDP), but there are about 3 million jobs unfilled in the U.S. because people don't have the skills. Our task is to get students ready for those jobs."

Teaching Teachers, Mentoring Mentors

Ironically, an unexpected, but equally important, benefit of STEM education and training rookies is that they can bring fresh and valuable perspectives to their new organizations and veteran colleagues too. To maximize benefits in both directions, Bosch Rexroth recently set up a STEMersion program, a two-week summer camp for teachers in Raleigh, N.C. This year's camp has 50 teachers who make half-day visits to about 20 local manufacturers, which will help them tailor instruction to the skills that businesses seek. "The teachers can go back and tell their students that the Pythagorean Theorem is used on CNC machines every day," says Mark Rohlinger plant technical manager at Bosch Rexroth.

"Bringing in a student for a semester isn't expensive, and your company likely will get as much out of the experience as the student," Dittmer believes. "Our interns got small projects done that our regular staff didn't have time for. And any time you get a new person in, they're going to see problems that we've been looking at for a long time with new eyes and a new perspective. And they often can come up with very good solutions."

Though STEM is primarily for young people, its principles can be applied over entire lifetimes, according to Arnold Offner, industry standards manager at Phoenix Contact. "STEM shouldn't just end at high school and college," says Offner. "It should be ongoing and lifelong for everyone because we all encounter new technologies that we're going to have to learn and gain new skills to keep up with." **cd**

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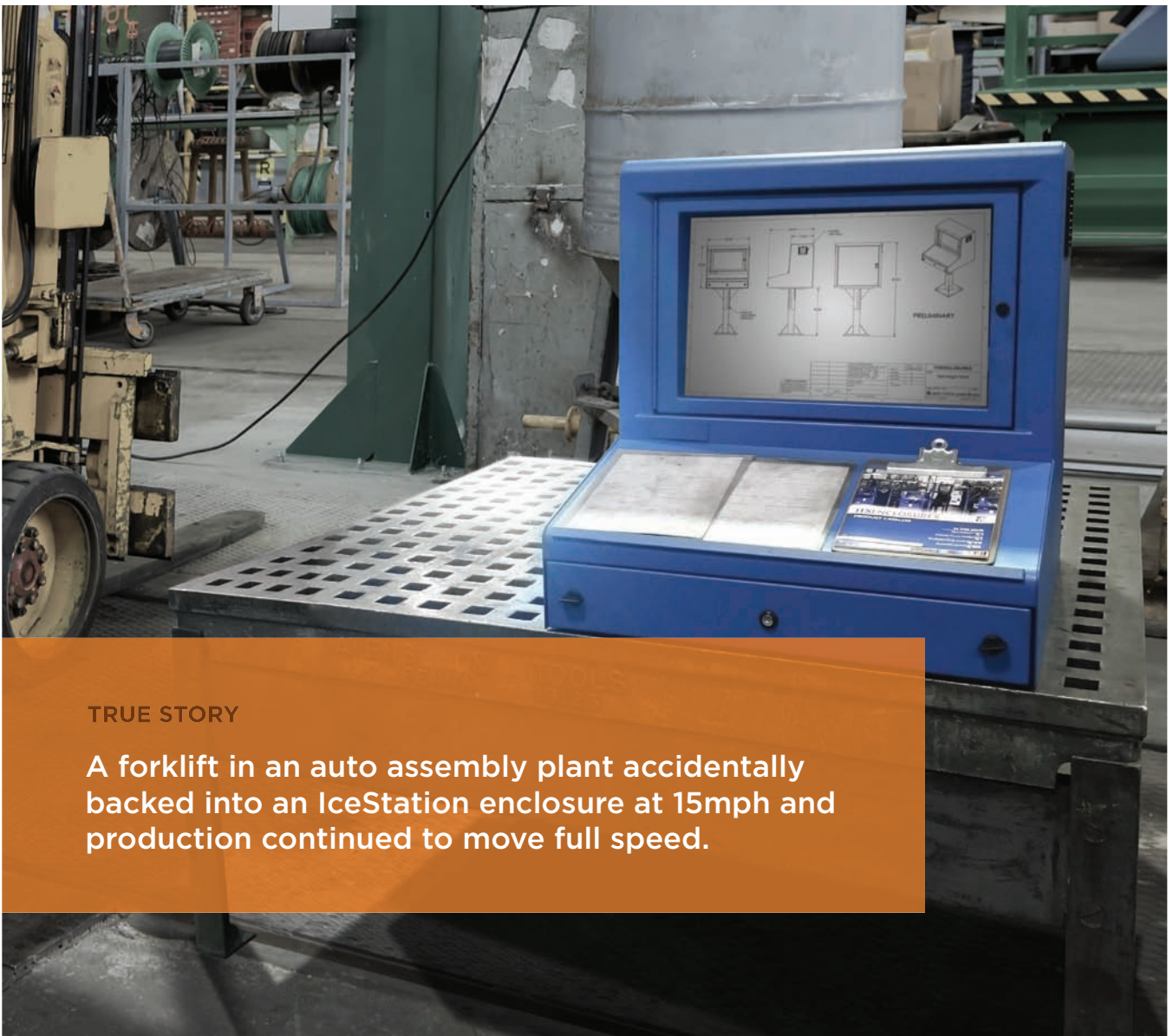
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Waterjet Cutting Systems for the Toughest Tasks

Ultra-High Pressure System with Five-Axis, PC-Based Motion Control System Reduces Operating Costs with Zero Controller Failures

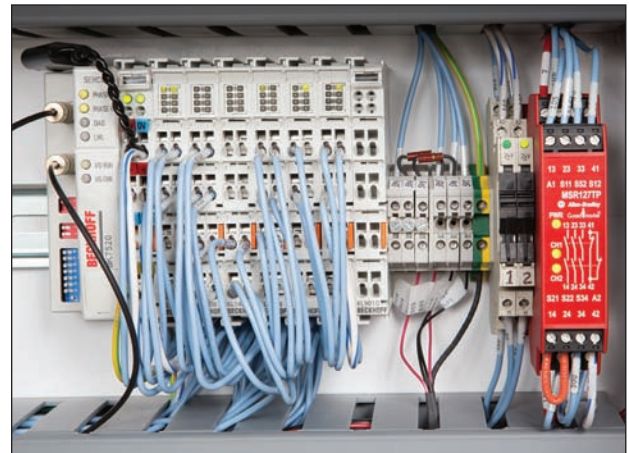
by Nancy Lauseng, Jet Edge

WATERJETTS ARE AMONG the most flexible cutting systems available. They can cut virtually any material and have become a principal method of fabrication and metalworking for a variety of compelling reasons.

Jet Edge (<http://jetedge.com>) in St. Michael, Minnesota, is a leading developer of this technology, designing and manufacturing ultra-high pressure waterjet systems for precision and mobile cutting, water blasting and surface preparation. Jet Edge offers an extensive range of systems that gives customers flexibility in choosing a solution that best meets their needs.

As a high-profile example, during the Gulf of Mexico oil spill in 2010, British Petroleum needed a waterjet system that was operable 5,000 feet under water. To deal with a major, time-critical problem that had never been solved before, Jet Edge created a system that blasted away hydrate ice crystals clogging a containment system and preventing BP from stopping the flow of crude oil into the Gulf.

Of course, most Jet Edge machines are on the shop floor, not the sea floor. Ultra-high pressure (UHP) pumps and waterjet cutting machines enable fabricators cut intricate parts in all types of materials ranging from soft foams and rubber gasket stock to thick tool steels and space-age composites. The cuts can be simple straight lines or can be extremely intricate, with large or small pierced holes. By using waterjet cutting systems (a cold-cutting process), fabricators avoid heat-affected zones (HAZ) and don't burn the material during cutting. They can enjoy reduced raw material waste and less damage from cutting that would otherwise require rework or secondary processing. Waterjet cutting systems also can be used in applications that process flammable materials. More traditional ways of cutting parts include stamping with metal dies, shearing and sawing (dies, knives and blades dull over time), laser cutters (limited to cutting



JET EDGE

TAKING THE BUS

Figure 1: Bus couplers connect the SERCOS bus system to the I/O terminals and provide the connection back to the central IPC.

thinner metals and can't be used to cut highly reflective materials) and plasma cutters (limited to cutting metals and can't cut materials as thick as a waterjet can cut).

Waterjet systems have a higher initial acquisition cost than saws, plasma cutters and flame/torch cutting systems, and they cut slower than saws, plasma, lasers or torch systems and stamping systems. Waterjets, however, are an excellent choice for shops that require the versatility to cut a wide range of materials, including thick materials and those that need to eliminate HAZ.

Complex Cutting With PC-Based Control

"To maintain extraordinary levels of precision, high-end motion control is critical, especially for maintaining cut edge quality and for meeting tight dimensional tolerances," says Jude Lague, Jet Edge's president. "Accuracies of cuts often must be within 0.005 inch

or less. Waterjet manufacturers such as Jet Edge meet these requirements by powering their equipment with fast, accurate, reliable and consistent motion control products and sophisticated software. Our gantries feature a closed-loop drive system on X and Y axes; ac digital brushless servomotors, absolute encoders and SERCOS communications. They include preloaded anti-backlash recirculating ball screws and linear bearings with hardened precision ground ways.”

The need for a flexible system is also important, Lague states. “We needed an open system that could easily integrate the full array of sensors that Jet Edge uses, while providing intricate motion control.”

Jet Edge motion controls started with traditional

The new control gives the operators an error code and tells them they should not do that because they are going to produce an inaccurate part.

industrial PC-based analog controls supplied by major vendors and more specialized custom manufacturers.

Ten years ago, Jet Edge decided to change to a digital motion control platform. “With the progression of our technology and our previous controls vendor not advancing its code, we needed a new platform that could help our technology grow,” Lague says. “After an extensive search, we chose to work with Beckhoff Automation (www.beckhoff.com) for a complete control solution. With Beckhoff industrial PCs (IPCs) and TwinCAT CNC software, Jet Edge was able to seamlessly and incrementally migrate to new technology. We chose Beckhoff for its flexibility and because the company is conveniently located here in Minnesota.”

The TwinCAT system has become an integral component in Jet Edge’s high-rail and mid-rail gantry machines. Jet Edge partnered with the Beckhoff to rewrite the Jet Edge HMI, and created an innovative CNC waterjet motion system by harnessing the power of the CNC capabilities in TwinCAT. The high-rail and mid-rail gantry systems are designed to be exceptionally stable with a rigid platform that minimizes machine vibration. The system is capable of advanced three-dimensional waterjet movement over the work area and ultra-high precision cutting.

Since making the shift to TwinCAT software, Jet Edge has seen an overall improvement in cutting tolerance and cut edge quality. “This is difficult to define as a

numeric value, but we can operate with higher machine resolution with the new control system,” says Jeff Schibley, Jet Edge regional manager. “This is partially associated with the speed and response time of the system in conjunction with SERCOS and a higher resolution motor and drive package. The cutting system now is less forgiving of programming errors. In the Aqua-vision 1, the operator could execute a program with sloppy geometry and overlapping kerfs in the cutting path. The new control gives the operators an error code and tells them they should not do that because they are going to produce an inaccurate part.”

Running TwinCAT CNC software on IPCs enables Jet Edge to implement complete machine control and HMI with tightly coupled PLC functionality and multi-axis motion control processes. “TwinCAT and the IPCs work together on positioning tolerance, speeds and positioning,” Schibley explains. “The IPC controls on/off functions of valves, block retrace, height sensors, laser mapping, servo communications and a portion of everything the cutting table does. The IPC can control the peripheral equipment without affecting the data execution of TwinCAT controlling the program path.”

For the machine display, Jet Edge uses “economy” control panels with DVI/USB extension technology, which permits installation up to 50 meters away from the IPC. The 15-in. display has an aluminum front with sheet-steel rear cover, front-side IP65-rated and rear side, IP20.

The system integrates with SERCOS II. The IPC-specified features include a SERCOS mini-PCI fieldbus card that connects via fiber-optic cables for the SERCOS networking used in the machine for I/O and drive networking. The compact IPC is designed for control cabinet installation and all connections, including fieldbus and standard PC interfaces, are conveniently located at the front of the IPC housing. Cooling is managed by internal cooling fins and an exchangeable fan cartridge at the bottom of the IPC housing.

“Bus terminal I/O is used to implement a variety of Jet Edge machine functions,” Lague adds. “Analog bus terminals assist with height sensors and plate mapping, while digital I/O terminals are leveraged for control relays and solenoid valves. Bus couplers (Figure 1) connect the SERCOS bus system to the I/O terminals and provide the connection back to the central IPC.”

With regard to integrated safety, Schibley says the light curtains, safety mats, shuttle tables, conveyors and peripheral equipment are controlled by the IPC,

which communicates the status of these to the Beckhoff system, adding that Jet Edge doesn't have to purchase a separate stand-alone PLC to control the peripherals.

Gives Us the Edge

The new technology resulted in the design and build of Edge X-5 (Figure 2), a five-axis waterjet system that cuts complex, taper-free and 3D parts from virtually any material (Figure 3, page 36). It features a Beckhoff IPC controller running CNC software programmed specifically for 5-axis waterjet cutting. The Jet Edge AquaVision Di controller offers an open architecture design that enables users to choose from many CAD/CAM/nesting software providers or to use standard G & M code.

The controller operates on Microsoft Windows 7, and it's customary for Jet Edge to supply nesting and cut optimization software by Swedish company IGEMS (www.igems.se). This software also produces the post processor file.

"While it's usually not the case, we don't always supply the operating software," Lague says. "However, it demonstrates the flexibility in the Jet Edge platform, so it does happen. Many or most of the large waterjet manufacturers will design and assemble their own proprietary hardware platforms and use their own CNC and cutting path trajectory software, as well as their own HMI software. This can limit the flexibility of their systems by restricting the customer's software selection. For example, if a Jet Edge customer wants to cut advanced aerospace components using proprietary software and cutting techniques, that customer often can integrate its software to the AquaVision Di control's operations without modifying the manufacturer's proprietary software. Our system's Intelligent Work Envelope automatically adjusts cutting processes depending on the angle of the cut to protect the operator, material and system components. Using this feature-rich solution, the machine operator can adjust the cutting parameters with ease. Even for the more technically advanced CNC users, engineers can still 'get into the software' and modify parameters to their specifications."

Michael Waltrip Racing Selects Jet Edge

To create high-performance mechanical parts, Michael Waltrip Racing (MWR) selected the Edge X-5 to complement an existing three-axis system from Jet Edge. MWR uses its waterjet machinery to cut more than 1,000 parts for each of its NASCAR Sprint Cup cars. The team



THE CUTTING EDGE

Figure 2: Jet Edge's Edge X-5 is a five-axis waterjet system that cuts complex, taper-free and 3D parts from virtually any material. It features an IPC controller running CNC software programmed specifically for five-axis waterjet cutting.

assembles about 56 cars per year, including the #55 Aaron's Dream Machine Toyota Camry and the #15 5-Hour Energy/Peak Toyota Camry driven by Clint Bowyer.

"To win high-profile business such as this, Jet Edge delivers high-pressure water solutions that operate at 36,000 psi to 90,000 psi with direct-drive electric or diesel-powered pumps ranging in size from 30 to 280 hp that can successfully run at 55,000 psi and produce UHP flow rates from 0.6 to 7.2 gpm to UHP cutting heads with advanced motion control systems," Lague

"If a Jet Edge customer wants to cut advanced aerospace components using proprietary software and cutting techniques, that customer can often integrate the software to the AquaVision Di control's operations without modifying the manufacturer's proprietary software."

explains. "These cutting heads can cut three-dimensional patterns in most materials when placed on a flat surface. The heads are connected to an overhead gantry system that moves over the cutting surface to make intricate and flawless parts." The powerful cutting force of the waterjet stream is kept under control using a 36-in. deep water tank that harmlessly dissipates the cutting stream and prevents it from cutting through the factory floor.

MACHINE CONTROL

Waterjet cut parts can range in size from that of a gear in a Swiss wristwatch to 100 feet long or more. However, parts are most often cut from plates or sheets that are 4 x 8, 6 x 10, or 6 x 12 ft in size. Waterjet cutting envelopes most often are designed to capitalize on these sheet sizes, although larger Jet Edge systems that accommodate 20 x 12-ft sheets are not uncommon.

Further pushing the limits of waterjet cutting, Jet Edge established its 90,000-psi X-Stream pressure pump technology, which enables customers to cut parts faster and reduce operating costs by using less abrasive material, water and electricity. "X-Stream pressure pump technology led to the development of a revolutionary metal-on-metal seal technology that eliminates 50% of the required seals on our pumps," Schibley says. "This is hugely important in terms of service and maintenance, considering that conventional seals eventually need to be replaced."

Bus Transfer

"The control system in our waterjet machines is no longer a limiting factor for volume, speed, accuracy or quality. Jet Edge is much farther down the road in reducing our production costs than we would have been with PLC controls," Schibley says.

In the initial selection of a new motion control platform 10 years ago, Jet Edge avoided any solution that didn't have an open architecture, Schibley notes.


"The control system in our waterjet machines is no longer a limiting factor for volume, speed, accuracy or quality. We're much farther down the road in reducing our production costs than we would have been with PLC controls."

"We would not accept buying an endless array of control-related equipment from the most expensive vendors out there," he adds. "This was another principal reason why Jet Edge chose Beckhoff Automation. Jet Edge replaced its controls and still retained the motor/drive components that formed a large part of its product platform. Some suppliers require that when you buy their control, you also must buy their motors and drives. Beckhoff didn't do that."

The analog controls previously used by Jet Edge in the 1990s generally had five-to-10 year operating lives, limited by computer component availability, operating software code changes and technical obsolescence. "The control products are extremely durable," Lague explains. "We have eliminated the warranty expenses and controller failures characterized by non-industrial PC platforms of the 1990s. In 10 years of operating Beckhoff controls in harsh waterjet cutting environments, Jet Edge never has had to replace a controller."

Next-Gen?

In continuing the company's evolution of automation and controls, Jet Edge is evaluating a change from SERCOS to EtherCAT industrial Ethernet for its motion and I/O bus. We think EtherCAT will help Jet Edge to extend its limits of machine performance into the foreseeable future.

What are the likely new short-term requirements our customers will ask for moving forward? How will the next-gen machine automation scheme be changing? "We know that customers need to cut volumetric shapes in 3D space," Lague notes. "When other waterjet manufacturers build that type of machine, I believe they switch to a higher-priced and higher-featured control rather than their proprietary control. Jet Edge will be able to simply integrate the 3D software into the existing AquaVision Di. We already use the higher-featured control system." 

Nancy Lauseng is the marketing manager at Jet Edge. Learn more about the company at www.jetedge.com.



JET EDGE

SUPER CUTS

Figure 3: The CNC waterjet motion system is capable of advanced three-dimensional waterjet movement over the work area and ultra-high precision cutting.



Have Presence Sensors, Will Travel

SOMETIMES WELL-KNOWN technologies like presence sensors don't change and gain new innovations as much as the world changes around them, wakes up to capabilities they already have and drags them into new applications.

"With so much economic globalization and new markets emerging, there's increasing demand for automation," says Kristen Chenowski, sensors and industrial products marketing manager at Omron Automation and Safety (www.omron247.com). "This means more need for worldwide safety standards and certifications, such as UL, CSA and CE, which means more presence sensors in mats, light curtains and other devices to protect people."

Just under a year ago, Chenowski adds, Omron released a series of fiber-optic presence sensors that have a maximum through-beam range of 6 meters, which is a big gain over the previous 4-meter maximum.

"An improved microprocessor, better fiber-optic connections to its amplifier and greater percentage of emitter light returned to the amplifier give it more stable internal detection, which allows it to help with more challenging targets," adds Chenowski. "Also, for food and beverage applications, we just released a photoelectric sensor family in June and our stainless-steel sensor, which is epoxy-sealed, washdown-rated and tested for EcoLab/Diversey chemicals and cleaning agents."

Tony Udelhoven, sensor division director at Turck Inc. (www.turck-usa.com), reports that the overall microprocessor revolution during the past 10 years is also enhancing many sensor designs and capabilities, such as Turck's Q-Track line, and giving users more control over their sensors' measurement spans and other parameters. Q-Track also added the IO-Link (www.io-link.com) protocol in 2011.

"Previously, a user might buy a sensor for an encoder with 1,024 pulses per revolution, but if they later needed 584 or 3,400 pulses, then they had to buy another encoder," Udelhoven explains. Now users can adjust pulse counts in the sensor. Linear distance transducers produce analog values over their sensing ranges, such as 0 to 10 V over 200 mm, but some users might want to adjust the span by starting at 110 mm and going to 190 mm, and now they can do it. They also can change outputs from 0 to 10 V to 4-20 mA, and even adjust the slope of their sensors. It's all done in the software."


Over the five years since they were introduced, Turck's inductive linear and rotary sensors have progressed from linear distance transducers to 12-bit rotary transducers to 16-bit, internal-resolution sensors with a wide variety output configurations, explains Udelhoven.

Even though new markets and applications are emerging, Will Healy, strategic marketing manager at Balluff (www.balluff.com), reports that new and existing users still share something in common—they all want lower-cost sensors with more features in smaller sizes. "Many machines worldwide are getting smaller, faster and using more robots, so users want more sensors onboard in less space," says Healy. "So in January, we launched a photoelectric sensor with a 2-mm lens and a family of miniature precision sensors. Smaller sensors are also light,

"Many machines worldwide are getting smaller, faster and using more robots, so users want more sensors onboard in less space."

and this lets robots move faster. IO-Link also gives us better diagnostics and answers more sophisticated questions, such as is a device there, is it powered, and is it running marginally? With inductive proximity sensors, IO-Link can help deliver data on assured and rated functions, including whether a target is at or beyond its assured range, or if it's sensing the right type of metal at the right distance and with the right shape."

To help presence sensors communicate with their new applications and users, Kevin Zomchek, presence sensing marketing manager at Rockwell Automation (www.rockwellautomation.com), agrees the biggest enabler is IO-Link, which is standardized, point-to-point and complies with the IEC 61131-9 standard.

"IO-Link eases commissioning, allows better troubleshooting and is more flexible," Zomchek says. "So instead of just getting simple, discrete on/off inputs from sensors, we can use IO-Link to communicate with sensors, see their operating margins and check more condition-based information, such as whether a lens might be dirty. We can even use IO-Link to change sensors' setups on the fly by accessing their profiles and parameters through the HMI, and use IO-Link's automatic device configuration (ADC) function to download new parameters." 

Making Sense of Safety

Some Safety Components Help Protect Workers; Others Ensure That Factory Data Remains Secure

IN INDUSTRIAL SETTINGS, safety obviously should remain paramount. We asked three industry experts to discuss the key trends that influence the latest advances in safety components.

An important trend has packaging, food and beverage, and automotive industries moving toward more integrated solutions that keep equipment safe, as well as highly productive and easy to maintain and troubleshoot, says Omron Automation and Safety product marketing manager Matt Dodds. "In the past, plants used safety monitoring relay units to monitor metal guards that surrounded equipment, and when the relays opened, it caused the entire process to stop," he says. "Currently, on smaller scales, facilities are replacing relays with standalone programmable safety controllers, which provide numerous capabilities including monitoring, diagnostics, flexibility in programming and zoning of outputs. The controllers typically can be monitored through a network connection to a PLC or HMI, making them easier to troubleshoot. Thus, to maintain integrity, the safety CPU is still a separate entity but is programmed using the same software, which makes system development simpler."

That said, relays still play an important role, says Rockwell Automation business director of safety components Brian Taylor, "A growing trend in safety is the proliferation of intelligent, cost-effective, network-enabled, safety components such as advanced relays," he says. "The devices feature integrated networking capabilities and advanced software that provides greater flexibility and access to more operating and diagnostic data. This lets plants meet safety compliance goals more efficiently while supporting their productivity goals. In addition, software advancements let users adjust safety settings without having to change their wiring. The advancements also provide improved visibility of potential issues for quick troubleshooting."

Because the Internet of Things continues to expand in the industrial automation arena, it's more important than ever for facilities to connect safety within their networks, adds Zachary Stank, product marketing specialist-safety at Phoenix Contact USA. "Previously, this was possible only through a fail-safe PLC," he says. "Currently though, safety technology is

growing to include networkable, stand-alone safety controllers and Ethernet-capable relays."

PROGRAMMABLE SAFETY CONTROLLER

SC26-2 programmable safety controller uses safety function blocks, Boolean logic functions and a user-friendly programming environment for creating safety control logic. The device has 26 input terminals and two redundant, solid-state, safety outputs. Free PC graphical user interface configuration software includes a ladder logic diagram and a text-based summary of all input device and controller output settings. Models are available with an embedded Ethernet node that provides up to 64 virtual status outputs.

Banner Engineering; 888/373-6767;

www.bannerengineering.com



SAFETY SENSOR SIGNALS

EP1908 EtherCAT I/O box has eight 24-Vdc safety inputs, which can be used to connect safety sensors via M12 connectors, allowing the acquisition of safety sensor signals directly on the machine instead of having to mount the safety I/O inside a control cabinet. The EP1908 conforms to IEC 61508 SIL 3 and DIN EN ISO 13849-1 PLe requirements.

Beckhoff Automation; 952/890-0000;

www.beckhoffautomation.com



E-STOP SWITCHES

XW emergency stop switches feature push-turn and push-pull action. Should the switches be damaged, NC contacts turn off. A bright-green mechanical indicator lets users check latched or normal status from a distance. The E-stops comply with international safety standards and are UL-, c-UL-listed, TUV-recognized, and EN- and CCC-compliant. Illuminated models are available.

IDEC; 800/262-4332; www.idec.com/usa



SAFETY LASER SCANNER

OS32C-4M safety laser scanner has a 4-m safety zone and a 15-m warning zone, and EtherNet/IP connectivity to support on-demand, real-time monitoring of operating status, including error diagnostics. Models with data collection functions can be used as an input to measurement or navigation algorithms, without disrupting the safety function. The I/O block can remain mounted when the sensor head is replaced, retaining the original wiring and mounting alignment with no need to reprogram after sensor replacement.

Omron Automation and Safety; 847/843-7900;
www.omron247.com



PROTECT YOUR WORKERS

RVS58S safety encoders and VBA-2E-KE4-ENC-S AS-Interface encoder input modules help ensure workers safe machine access during setup and maintenance. The encoders operate at 5 Vdc $\pm 5\%$ and deliver a maximum output frequency of 200 kHz in operating temperatures ranging from -20 to 80° C. The encoder modules have a compact 22.5-mm-wide housing and snap into place on a standard 35-mm mounting rail. Each module provides two safe inputs for the incremental encoders to monitor the standstill, rotational speed and direction of rotation on up to two axes of motion, and sends a safe signal via the AS-i network when a value falls below a set threshold. The system is suitable for applications that demand SIL3, PLe and Category 4 certification.

Pepperl+Fuchs; 330/486-0001; www.pepperl-fuchs.us



BRIDGE TO SAFETY

SafetyBridge Technology V3 includes an upgraded safety logic module and a high-density safety input module. The safety logic module connects with up to 16 satellite modules, and allows direct communication between logic modules. The safety input module lets users configure up to eight dual-channel or 16 single-channel safety inputs. V3 lets users visualize the safety program online to see the safe inputs and outputs, instead of mapping status bits in the PLC program. It is rated for SIL 3, Cat 4 and PLe safety levels.

Phoenix Contact; 800/322-3225; www.phoenixcontact.com



SAFETY RELAY

Guardmaster 440C-CR30 safety relay communicates diagnostic data via a built-in Modbus interface to Micro800 controllers, PanelView graphic terminals or CompactLogix controllers. Free software is available for selecting certified safety function blocks for the safety relay. The device meets PLe, SIL3 per EN ISO 13849-1 and IEC 62061 standards.

Rockwell Automation; 414/328-2000;
www.rockwellautomation.com



SAFETY LIGHT CURTAINS

C4000 Palletizer Advanced and M4000 Standard safety light curtains have IP69K housings, suitable for washdown applications, as well as corrosive and other moist environments. C4000 features a 30-mm resolution with a protective height of 1,050 mm. M4000 Standard has scanning ranges from 0.5 to 4 m.

Sick; 800/325-7425; www.sickusa.com



ONLY WAY TO FAIL

Simatic S7-1518F fail-safe controller has a Profinet interface with a two-port switch, two Profinet interfaces, and a Profibus interface. The controller accommodates up to 128 drive axes, operates isochronously in 250 μ s, has 10 MB of memory and is available with a bit performance of 1 ns.

Siemens Industry; 770/751-2000; www.usa.siemens.com/plc



FOUR-CHANNEL DIGITAL INPUT

750-633/000-003 4F-Ex i DI module is suitable for the connection of potential-free sensors with contacts for use in hazardous environments. The input data for the four-channel module is transferred securely using Profisafe protocols V1 and V2 on one fieldbus line. The 24 mm-wide module is approved for ignition protection class ia.

Wago; 800/346-7245, www.wago.us



TRAPPED

Dold trapped-key systems use a series of mechanical locks and keys to control access to gates or doors to running equipment or machines, ensuring safe access. They come in standard (SX) or solenoid-locking (ZRH) versions and one- to five-gate sets. Because operators must perform the locking and unlocking, the trapped-key systems provide first-hand, observable safety. Accessories include door actuators, captive safety key sets, key modules for key exchange box setup and tongue key actuators.

AutomationDirect; 800/633-0405;
www.automationdirect.com



SENSORLESS MONITORING

SVM4001 monitor provides sensorless, standstill monitoring for machine-guarding applications up to CAT4/PLe, including guard-locking applications to detect that a machine has come to a stop before letting an operator access the area. Monitoring is done by connecting the SVM4001 in parallel with the motor leads and measuring back EMF. It can monitor one- and three-phase ac induction motors, dc motors and variable-speed ac and servomotors. It's cULus-approved up to 690 Vac.

Wieland; 800/943-5263; www.wieland-electric.com



TRIP IF YOU MUST

STA safety trip alarm is certified by exida for safety instrumented systems (SIS) to IEC 61508:2010 for systematic integrity up to SIL 3 and for random integrity up to SIL 2. Engineers use reliability data from the certification to design and verify each safety instrumented function (SIF) in the system. The STA provides an alternative to backing up PLC or DCS soft alarms, serving as a single-use safety logic solver that acts on hazardous process conditions, and provides emergency shutdown and on/off control in SISs.

Moore Industries-International; 818/894-7111;
www.miinet.com/safetyseries



EMERGENCY STOPS

Platinum Series pushbuttons and switches withstand water jets, water immersion to 1 m, temperatures -20 to 70 °C and resist oils, solvents, and hydrocarbons to meet UL Type 4x, IP66, IP67 and 69K standards. Options include spring-return operator head actuators and pull-to-release, turn-to-release, and turnkey-to-release latch models.

Automation Systems Interconnect; 877/650-5160;
www.asi-ez.com



REDUNDANT CONTROLLER

TRC fully redundant controller has three independent, 100% isolated channels, and each monitors a single process via remote independent sensors, and compares the output results to each other and a user-programmable deviation. The meter has a 51-segment LED automatic tricolor bar graph and four-digit display. Each channel has its own A/D (14-bit), DAC (16-bit), relays, display, power supply (5-48 Vdc or 90-265 Vac) and serial I/O (RS232/485, USB, or Ethernet).

Otek; 520/748-7900; www.otekcorp.com



SOLENOID INTERLOCK AND MORE

AZM300 solenoid latching keyed interlocks have a built-in electronic safety sensor and individual coding options, as well as a built-in RFID sensor to detect the actuator and indicate a closed guard. A solenoid locking force of 1,000 N keeps the guard door securely locked until dangerous conditions, which can exist even after removal of power, have receded.

Schmersal; 914/347-4775; www.schmersalusa.com



SAFETY RELEASE

ESL safety escape release consists of a handle and an interlocking module that protects and monitors safety guards, such as doors and flaps on machines. It features transponder-coded safety technology CES, which ensures maximum safety according to EN ISO 13849-1 (Cat. 4/PL e).

Euchner; 866/547-7206, www.euchner.de



MONITOR YOUR SAFETY

DuelcoSC (DSC) modular programmable safety controller monitors several emergency stop buttons and sensors, such as light curtains, laser scanners, photo-optics, mechanical contacts, safety mats/edges and two-hand control buttons. It provides for reduced number of components, easy electrical installation, configuration with logical operations and drag-and-drop software. It's certified for SIL3, SILcl3, PL e, CAT4. **EMS Controls; 941/421-0238; www.emscontrols.com**



HAVE SOME INTEGRITY

PSSR-2 safety interface controller integrity monitors safety switch, mat, edge and bumper products with a 6.8 or 8.2 k Ω , end-of-the-line resistor at Category 3 SIL 2 PLd and EN 13849. It has a manual and auto reset, three output contacts, force guided relays, and two normally open and one normally closed contacts. **Tapeswitch; 800/234-8273; www.tapeswitch.com**



MULTI-BEAM MONITOR

Type 4 light curtains provide a multi-beam barrier of infrared light. If any of the beams are blocked by an object, such as a finger or a hand, the light curtain signals the machine to a safe state. The curtains come in protective heights 160–1,510 mm, and in 150 mm increments with optional muting and blanking. Installation doesn't require software or control boxes, and meets highest maximum achievable safety level requirements of SIL3, SILcl3 and PL e per IEC61496. **ifm efector; 800/441-8246; www.ifmefector.com/us**



RECEPTACLE EXTENSION

HL (hazardous location) receptacle extension threads into the conduit entry of a device in a CI D1 hazardous



location, and extends the connector into a Class I Div 2 (CI D2) area where it can be mated with the company's special connectors. The receptacle eliminates the need for intrinsic safety barriers by providing fully encapsulated housings joined by a welded aluminum armored cable available in lengths to 20 m. The housings resist pressure surges to 6,000 psi.

Turck; 800/544-7769; www.turck.us

ISOLATORS AND CONVERTERS

ACT20M signal isolators and converters are for thermocouple and RTD signal conversions where auxiliary or output-loop power is available and where range setting by DIP switch is required. Adjustable switch provides access to hundreds of temperature range combinations, selection of outputs, response time and wire-break failure mode. The devices come in both isolating and non-isolating converter versions, eliminating long thermocouple lead wires or RTD cables.

Weidmüller; 804/379-2593; www.weidmuller.com



TIME TO GO

TD-CSR time-delay control switch relay provides a means to mitigate arc flash danger in local circuit breaker operation by allowing a manually initiated, time-delayed trip or close. A flashing LED notifies the operator of pending trip or close operation and as a warning to evacuate the arc flash area. For safe operation, the control pushbuttons must be depressed for four continuous seconds to activate the 10-second delay.

Electroswitch; 781/335-5200; www.electroswitch.com



SWITCH ON, SWITCH OFF

Food-grade switches are manufactured using 316 stainless steel, and include mechanical keyed interlock switches, non-contact sensors, explosion-proof sensors and IP69K sensors. The line includes e-stop rope pull switches and enclosures.

ABB Jokab Safety; 888/282-2123; www.jokabsafetyna.com





When Steppers Measure Up

SELECTING THE right stepper motor—or any stepper motor at all—comes down to answering some questions about what's to be moved, how fast to move it and with what precision. After that, other factors such as cost and suitability to a given environment should be considered.

Before deciding to use a stepper or not, some basic motion requirements need to be established. Rick Halstead, president of specialty electrical motor and assemblies maker Empire Magnetics (www.empiremagnetics.com), spends a good deal of time with customers on this.

"They almost always say, 'I need a motor,'" Halstead explains. "Well, O.K., how big? How much torque do you need? How much speed do you need? What physical parameters do you need? The list of 'I don't know' answers gets long pretty fast. So my first step is to try to get them to better define what they're doing."

■ If what's needed is positional motion at relatively low speed and low power output, then a stepper motor could be appropriate. ■

If what's needed is positional motion at relatively low speed and low-power output, then a stepper motor could be appropriate, Halstead indicates. Stepper-suitable parameters are revolution rates of a few hundred rpm and fractional horsepower torque. On the other hand, for an application demanding 6,000 rpm or 50 hp a stepper motor would be the wrong choice.

Empire Magnetics provides solutions for some demanding environments, including space, underwater or in hazardous areas. Stepper motors can be the right answer for motion in such situations. A case in point is in a satellite, for which only a 24-V supply might be available. Any motor has to fit into a tiny space, and the time to complete a given motion may be unconstrained. In this setting, a small stepper motor may be the right answer.

Special circumstances also might dictate motor selection, according to Halstead. "In a nuclear reactor, for instance, the need is to have as few wires as possible penetrate the shielding," he says. "Then a stepper is preferable, as it requires far fewer connections than a closed-loop, servomotor system. Besides being sim-

pler in terms of wiring, a stepper also can be inherently safer, as it cannot go into a runaway situation due to feedback control failure."

If wiring is an important issue, then stepper motors could be the best choice. Steppers only require a handful of wires. "OEMs typically can expect to connect four wires and a ground," says Paul Coughlin, team lead technical support at motor maker Kollmorgen (www.kollmorgen.com).

A servomotor, in contrast, can have as many as six to 17 additional wires, with all of these due to the feedback mechanism. The relative simplicity in the wiring brings an added bonus. Incorrectly wired stepper motors could rotate in the opposite direction if the phase is reversed or simply not move, according to Coughlin. On the other hand, a servomotor wired in error could take off unexpectedly at high speed because the feedback control is missing or incorrect. Another aspect of ease-of-setup is that steppers require no tuning, something not true for the alternative.

Stepper motors also are simpler to deal with during the design phase of a project. Typically, they are sized for peak torque plus a safety factor of 50 to 100%, Coughlin indicates. Other motor technologies might involve more complicated calculations during design, with acceleration, deceleration, slew rate, RMS torque, dwell time and other factors that require consideration.

That simplicity translates into a lower initial cost as well. Stepper motors run about half the expense of a servomotor and its associated control mechanism. For an application appropriate for an open-loop system, such as bottles being directed one way or another by a lane diverter, a stepper motor can be the right choice.

Microstepping technology has made the decision to go with a stepper motor easier in circumstances where smooth motion is desired. The standard for steppers used to be movement of 1.8° or 200 steps per revolution. That approach resulted in a jerky start and stop because early steppers went from no movement to an immediate 60 rpm or vice versa.

With microstepping, the standard 1.8° is further subdivided by a factor of as much as 250. The result is smoother motion and better ability to move through and in the low-end-resonance speed region.

An application that could benefit from a stepper motor is a dosing machine, says Dave Beckstoffer, project manager at Portescap (www.portescap.com).

"If what's desired is the dispensing of, say, 5 ml, then a stepper motor could be a good fit," he says. "The speed is slow enough, and the torque is low enough for the technology to handle. The mechanical nature of the stepper motor ensures that the amount of liquid dispensed is precise."

That precision is achieved without the use of encoders and feedback mechanisms. Employing these devices and techniques can add to the burden of a CPU responsible for machine control, and could potentially require a more powerful processor.

When it comes to designing an application solution, vendors offer software that can make the job easier. Portescap, for instance, has MotionCompass, which guides users through motor selection in a three-step process. The final decision, though, should take into account the duty cycle of the application, Beckstoffer notes, as that can impact the size of the motor needed.

"It will potentially allow a smaller motor solution to be used. If you're turning on for a few seconds and then going to be off for a minute, you might want to overdrive the motor and let it cool down, and you'll have no adverse effects from that," he says.

So for torques in the fractional horsepower range and for speeds of a few hundred rpm, a stepper motor could be the best choice. Steppers cost less than the alternative, are less expensive to wire and place fewer demands on the rest of the system. Under the right circumstances, they also bring the benefit of precision, potentially leading to a

quick decision as to which motor technology to use.

As Beckstoffer says, "If I just need speed, I'm choosing dc or

brushless. But if I need precision, my first thought is that I want a stepper because that's what it is designed to do." *CD*



DESIGNED TO HANDLE THE EXTREME

The SEL-3355 Computer operates in harsh environments, allowing you to put industrial computing closer to the process being controlled—including exposure to extreme temperatures, vibration, or voltage transients. The SEL-3355 Computer's solid-state design with no moving parts comes standard with a ten-year warranty, and is designed, tested, and manufactured in the USA.

With an Intel® Core™ i7 multicore processor, redundant power supplies, and PCIe expansion slots, the SEL-3355 offers the performance and the flexibility needed for the most demanding rugged computing applications.

To learn more about the SEL-3355 Computer or to request a demonstration, go to www.selinc.com/7cd.



Any Termination Data?

WE HAVE CUSTOMERS with varying preferences for the method of terminating field connections outside the panel. We even have our own internal disagreements. We'd like to simplify, and we wonder if anybody, whether it's from vendors or independent test centers, etc., has compiled meaningful data, meaning some mean time between failure (MTBF) comparisons about termination failures, which include M8/M12 as well as screw, spring and IDC. It would be helpful to argue a preference based on data rather than mostly subjective or anecdotal viewpoints.

—from June'14 CONTROL DESIGN

ANSWERS

[The following are some of the responses we received when we posted the question on LinkedIn's Industrial Automation and Process Controls Network Group.]

Sooner or Later

I haven't compiled any meaningful data, but I would express reservations about the usefulness of MTBF calculations with connectors. I guess you meant mean time to failure (MTTF), as connectors are generally replaced rather than repaired. MTBF is more appropriate for electronic and electromechanical devices where there is some chemical or fatigue based wear-out phenomena. Connector life (or lack thereof) is generally determined by the initial installation, and after that by subsequent insults from mechanical or environmental conditions.

Wear-out phenomena reduce life deterministically according to the Arrhenius relation or similar. For example, insulation in most connectors contains antioxidants, with typically enough antioxidant to get to 20 to 30 years at maximum operating temperature (say 90 °C), then it goes chalky and brittle. The lifetime doubles for every 10 °C decrease in temperature. The temperature increases with (square of) current, and typically a pin-socket connector is matched fairly well to the wire gauge, so a 1.6-mm pin might be used on a 1.5-mm² (or 16 gauge) wire and be "rated" at 16 A. So if you run at 10 A, it should last four times longer (= 100 years), but overload to 20 A, and it will last only 4.5 months.

The point here is that most field wiring has a large safety margin, so it will fail because of something other than old age.

My experience is that non-overloaded connectors will last forever until they get wet or until bumped.

My personal experience with field connections is that the M12 connector, when fitted to the rear end of a proximity switch is incredibly unreliable (i.e., about six failures in 80 connectors in three years). The proximity switches are mounted in awkward places inside machinery and usually need to be adjusted by non-instrument-technician workers. The right-angle connector especially is used as a handle to stop the prox switch rotating when the stop nuts are tightened, and usually cracks internally or damages the prox, but it might take weeks before it starts failing intermittently.

The other big killer for connectors is lack of strain relief, and this can be made worse by poor choice of wire (e.g., 26-gauge wire with 600-V insulation is all sheath and no wire).

Finally, any pin-socket connectors that might get wet (i.e., not mounted in the computer room) should have silicone grease applied to the contacts.

Another problem connector is the rectangular one fitted to solenoid valves. Some of these fall apart in months (the ones with clear plastic, so the LED is visible, suffer environmental stress, cracking due to solvents in the oil/coolant/degreaser), and they're usually held on with a really flimsy screw.

BOB TURNER, director,

Salbay Engineering Pty, www.salbayeng.com

Dial M for Good Connections

I recommend fast connections such as plugs (M18/12/8, etc.) with molded ends. Our wiring problems are close to 0%. The additional material costs compared to the labor and troubleshooting is minimal. Most of the time the job has to be done during shutdowns or weekends. Time is money.

Spring connection (cage clamp) should be used because they never get loose, even from high vibrations. Stay away from putting wire furls on. It doesn't make the connection better and is unnecessary. We use, if the customer allows us, only cage clamp terminals, such as those from Wago, Harting Plugs, Phoenix Contact, even with relays, power contactors, motor controllers, power supplies, etc.

If the customer understands this, it's not necessary any more to tie up all connections. When someone doesn't understand the advantage of those connections, then troubleshooting must be fun for

him. I don't know one case in our company when we ever had a problem with the cage-clamp technique.

FRANZ STRANNINGER, CPO,
SAR Automation, www.sar.biz/AUT_e.asp

Same Here

We also go with over-molded connectors for connections outside the panel or for connecting multiple panels together. It simplifies wiring and, other than a rare bad cable, it's pretty much trouble-free.

MARK WILL, automated systems engineer,
Labeling Systems, www.labelingsystems.com

[We received these responses when we posted the question to LinkedIn's Automation Engineers Group.]

It's Technique, Not Type

I look forward to seeing empirical evidence. I have heard a lot of arguments from suppliers, consultants and end users. My experience is that the terminations that fail are the ones that are not correctly installed (i.e., screws not tightened, crimps not crimped properly, etc.).

MICHAEL MCKAY, principal engineer,
Pesce Pty, www.pesce.com.au

Cage Clamp for Me

I find cage-clamp style terminals to be the best. Much faster wiring and no loose screws. IDC is great too, but the big problem is the wiring needs to be within specification. Also the same wire can only be connected/disconnected a couple of times before the knife damages the core. Old fashion screw terminals: I see absolutely no reason at all to even consider using them. I think it will be hard to find some sort of statistics on this. If you look at the data sheets of the Phoenix Contact Cliqueline series, you will find test results of the various types of clamps.

PATRICK STAVE, automatiker,
Nordlaks Produkter, eng.nordlaks.no

Ask the Right Companies

The companies that could answer this are those that fabricate modules or equipment installed offshore, vibrate or move, and/or are in hazardous areas. The equipment failures due to improper terminations probably are some of their biggest issues.


ALEJANDRO VARGA MEDER, project management,
Devco USA, www.devco.com

[We received this response when we posted the question to LinkedIn's Automation.com Group:]

Spring for Me

I prefer spring terminal blocks over screw connections. Not only are connections faster, but you don't have to worry that the screws are tight. I don't use IDC terminals since wiring never seems to stay "carved in stone," and they aren't faster unless in high-volume assembly. I always use DIN crimp ferrules on the ends of stranded wire. Most automation wiring is with individual wires in terminal blocks. At www.plctalk.org there's a 12-page thread over 10 years with photos of member's automation cabinets.

A former co-worker worked at a local Siemens rail-car plant and related that he performed extensive testing to qualify terminations for that continuous vibration environment. I recall he said they hadn't accepted spring terminals when he left. The robotics industry similarly spends much time qualifying both connectors and flexible cables. In general automation, wiring is usually sessile, so attributes like corrosion resistance are of more concern. Aerospace is another high-vibration environment. Amphenol circular connectors have long been used there. I think multi-turn collars were first, then bayonet lock, and today a click-lock type seems most common. They can be very expensive.

WILLIAM GRISSOM, engineering specialist,
Aerojet, www.rocket.com 

SEPTEMBER'S PROBLEM

WE BUILD MOST of our custom, one-off control cabinets in-house. We've had success using vortex coolers to control the enclosure temperatures when we have heat issues. Now we're getting into markets that place our systems in hazardous environments. What's the experience with adding purging capabilities to vortex coolers? Are we better off with conventional gas purge systems or another approach? We need an effective, but still cost-responsible solution.

SEND US YOUR COMMENTS, SUGGESTIONS OR SOLUTIONS FOR THIS PROBLEM. We'll include it in the September '14 issue, and post it on ControlDesign.com. Send visuals if you'd like—a sketch is fine. Email us at ControlDesign@putman.net. Please include your company, location and title in the response.

HAVE A PROBLEM YOU'D LIKE TO POSE to the readers? Send it along, too.

Smart Ethernet in New LDT

A HOST OF AUTOMATION solutions require accurate feedback of continuous position to improve productivity and efficiency, regardless of the application environment. A traditional, preferred approach typically uses analog signal feedback. However, analog signals are limited by resolution, and the signals are prone to degradation over long cable runs. In addition, each axis needs its own dedicated cable.

Ametek Factory Automation offers a new alternative with its ReadyLink EtherNet/IP network linear displacement transducer (LDT), which uses field-proven, magnetostrictive technology to provide absolute non-contact feedback and resolution to one micron.

"There are times when the desired resolution isn't achievable using an analog device," says Blake Cawley, business development manager for Ametek Factory Automation. "There are many times when the customer is looking to update analog machinery, particularly when he has other EtherNet/IP devices on his machines, so continuous position, motion and velocity monitoring of equipment can be incorporated into the control system process via the network." Cawley adds that this also is a good solution when linear motion travel with multiple stops or position points is required.

"ReadyLink EtherNet/IP LDT is a smart device," Cawley says. "It has a RapidRecall network configuration module with a built-in web page to help aid in configuration of the LDT. A static IP address can be assigned via the web page, or by using three rotary DIP switches to set the last octet manually. The RapidRecall module also stores all user configurations. Once configured on the LDT, these settings can be uploaded and stored by the module. If the LDT ever needs replacement, the module can be removed and installed on the replacement unit, and all of the user configurations are restored without the need for a network technician to configure the sensor."

The intent of the web pages is to provide nearly the same functionality that exists through the network interface. The home web page is loaded when the module's IP address is specified by the user's web browser.

The network LDT is designed to operate anywhere between 7 to 30 Vdc at 2.3 W of power. "With this wide-ranging supply, the same unit can be used in 24-V industrial or 12-V mobile applications," Cawley says. "A key advantage with the wide-ranging supply is that on long cable runs, users typically need not worry about voltage drop to the incoming power, eliminating the need for a separate power supply to power the LDT."



FOR MORE INFORMATION

Call 800/635-0289; email blake.cawley@ametek.com or browse to www.ametekfactoryautomation.com.


Among the unique features built into the network LDT, Cawley says, are its position and velocity upper and lower limits. Users can program values into each of these limits. If the position or velocity of the LDT exceeds the limits, the device transmits a unique alarm bit for each alarm condition.

"The device provides alarm condition detection and annunciation based on position and velocity conditions, which improves response speed to defined fault conditions, and avoids having to write ladder logic and tying up process time to monitor the conditions," Cawley says.

Data is communicated over the Ethernet network using I/O messaging for time-critical data, such as position and velocity status, as well as explicit messages for configuration data, such as position scaling, resolution and count direction, among other parameters.

To aid in troubleshooting, the Network LDT is equipped with four network LEDs and a tri-color LDT status LED. The four top-row LEDs will display diagnostics and network status. The bottom-row LDT LED will display the status of the linear transducer.

"The network LDT has an auto-tuning capability and automatically compensates for non-standard magnet assemblies or adverse application conditions," Cawley states. "The automatic gain control feature automatically searches and finds the magnet on power up. If power is applied without a magnet on the LDT, the LED will turn red to indicate that no magnet signal is detected."

The new device is available in two package styles. The 953N is a rod-style package suitable for installation into hydraulic cylinders. The 957N Brik low-profile-style package incorporates the same electronics, but is housed in an aluminum-style extrusion. 

MULTI-AXIS DRIVES

UDMMC EtherCAT modules feature two- and four-axis universal drives with ratings 12 Vdc to 80 Vdc and 2.5 A (5 A peak) to 20 A (40 A peak) per drive. Each drive is programmable to control a two- or three-phase servomotor, dc brush motor, voice coil motor, and a two- or three-phase stepper motor. Safe torque off (STO) feature complies with SIL-3 and PLe safety levels.

ACS Motion Control; 800/545-2980;
www.acsmotioncontrol.com



6-, 8- and 12-mm lens versions with a built-in visible red or infrared ring light. It has an RS232 serial port and an Ethernet TCP/IP port.

Balluff; 800/543-8390; www.balluff.com

COOLS CABINETS

NEMA 12 cabinet coolers keep electrical enclosures cool with 20 °F air, while resisting heat and dirty environments. Optional thermostat control minimizes compressed air use, and keeps the enclosure at ± 2 °F of the setting. The coolers come in 275- and 550-Btu/hr versions, and are UL-listed and CE-compliant.

Exair; 800/903-9247; www.exair.com/nema12.htm



IT'S A STAGE

Precision ground, pre-loaded ball screw coupled with a low-thermal-expansion linear encoder gives MPS75SLE linear positioning stage 0.025- μ m resolution, repeatability of ± 0.1 μ m and accuracy of ± 0.75 μ m. The linear encoder comes with amplified sine (1 Vpp) or 50-nm TTL digital outputs. Motor options include a dc servomotor with a high-resolution rotary encoder or a stepper motor. Optional mounting plate provides direct mounting to English and metric optical breadboards.

Aerotech; 412/967-6854; www.aerotech.com



MOTOR CONTROLS

Brushless dc motor controls work with the company's line of BLDC motors and gearmotors. Designed to provide commutated power and variable-speed control, the closed-loop controls provide speed regulation over a wide range of loads. Features include chassis mount and NEMA 4 enclosures.

Groschopp; 712/722-4135; www.groschopp.com



SUPER MOTORS

Super-E motors have a carbon brush mounted internally to divert shaft currents away from motor bearings and prevent voltage spikes from damaging the bearings. These 1-50 hp motors come in totally enclosed, fan-cooled (TEFC) or open, drip-proof (ODP), foot-mounted designs, while ½-5 hp motors come in TEFC, C-face and foot-mounted designs.

Baldor Electric; 479/646-4711; www.baldor.com



MACHINE VISION CAMERAS

USB 3.0 uEye CP machine vision cameras come with e2v 1.3-MP, 2-MP and Aptina 5-MP CMOS sensors to deliver video capture in resolutions to 2560 x 1920 and a maximum, full-frame rate to 60 fps. The cameras with e2v sensors can switch between various shutter modes to capture sharp images of moving objects or low-noise, high-contrast images. USB 3.0 uEye cameras are available in housed and board-level versions.

IDS; 781/787-0048; www.ids-imaging.com



20/20 360

BVS Universal vision sensor performs 360° part-position detection, defect-finding, contour-based counting and matching, barcode reading (linear and 2D DM) and OCV. The device can read multiple codes at once, and locate, read and verify up to 40 codes per second in any orientation. It comes in



AUTOMATION HMIS

Kollmorgen Automation Suite HMI includes IP65-rated touchscreen HMI panels with a single-surface, wide-screen format, aluminum chassis housing, and configuration and screen-building software. All models have built-in Ethernet and data logging and trending software.

Kollmorgen; 540/633-3545; www.kollmorgen.com



TAKES THE CASE

Interscale M cases protect small electronics, including single-board computers (SBC), computer-on-module (COM), nanoETXexpress, Mini-ITX and Nano-ITX. Cases can be configured to range from 5.25-in. designs to standard 19-in. rack sizing, and they can be assembled or dismantled with just two screws. Interlocking case walls provide EMC protection higher than 20 dB in the range of 30 MHz to 2 GHz.

Pentair; 401/732-3770; www.schroff.biz/InterscaleM



HMIS TAKE THEM ALL

Graphite HMIs with built-in protocol converter let programmers select 13 or more simultaneous protocols from more than 250 to integrate disparate devices such as PLCs, drives, barcode readers and panel meters. The HMIs have a cast-aluminum construction in eight different models and in sizes ranging 7 to 15 inches. A built-in web server lets users monitor and



control applications via PCs, tablets or smartphones. SMS text-messaging and email alerts provide warning of process issues.

Red Lion Controls; 717/767-6511; www.redlion.net/graphite

VECTOR INVERTERS

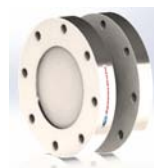
FID E2 Series vector inverters input voltage ranges from single/three phase 200-240 V, 50/60 Hz and three-phase 380-480 V, 50/60 Hz. The unit allows ac drives to communicate with standard Modbus protocols.

Rohtek Automation; 425/328-8445; www.rohtekautomation.com



WIRELESS TRANSDUCERS

Model BT4000 Series wireless, coupled-flange drive transducers feature encapsulated, on-board electronics that provide strain gauge bridge excitation, bridge output amplification and amplified signal conversion into a 16-bit digital word.



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SensorData Technologies; 586/739-4254; www.sensordata.com

FLOW AND MORE

Sitrans FC410 flowmeter features signal update of 10 ms, and provides flow rate data, mass, volume, density and temperature of the medium. The flowmeter works at pressure levels of up to 100 bar and temperatures -50 to 200 °C without loss of measuring accuracy. The unit has built-in transmitter capabilities, communicates with common process control systems via Modbus RTU485 and adheres to 3A, EHEDG and FDA standards.

Siemens Industry; 800/743-6367; www.siemens.com/fc410



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Motion Control Top Tips—Part II

LAST MONTH, I discussed what I consider to be 10 important considerations when starting to design a motion control system. I covered the first three of them:

1. Is the required motion linear or rotary?
2. Do you need a stepper, servo- or induction motor?
3. Do you need a dumb drive or a smart drive?

Let's continue with the remaining seven considerations on the list.

4. What kind of controller will you need? The answer to that depends on the kind of motion control you need, and if there already is some kind of overall machine controller (typically a PLC). For demanding motion control requirements, it's best to let a dedicated motion controller handle the motion control for the machine. Using various forms of communications, you can pass commands to the motion controller from your machine controller. If your machine's primary function is motion

■ If someone tells you that tuning parameters can be completely derived mathematically, don't believe it. If that were the case, auto-tuning would work perfectly. ■

control, you can let the motion controller become the machine controller. If your motion control requirements are not demanding, then it's possible to have the PLC handle these functions.

5. How will you interface to your motion controller? You somehow have to give commands to the motion controller. This can be something as simple as a push button or as complex as a machine network. If you need to change settings and monitor conditions, then perhaps a typical touchscreen HMI will suffice. If you need to log data and keep track of events, maybe you'll need a PC.

6. What electrical supply is available? If you only have 120 Vac, then you'll need to know that up-front. Your drive choices will be limited, and your motion system requirements could need more power. Higher power systems typically will need a three-phase power source. Sometimes, three-phase, 480-Vac power will be required.


7. Who will do the motion integration? If you're a seasoned controls engineer with motion control experience, you probably can handle this with little

outside help. If you have little motion control experience, you'll need quite a bit of help. Does your motion control distributor have a thorough understanding of motion control and the products it sells? If they have to refer you to the factory support team much of the time, they probably won't be much help.

8. Does your motor-sizing software know what it's doing? The short answer is "maybe." Motor sizing is very important. Even if torque requirements are met, the inertias could be mismatched. Even if your motion control system is properly modeled in the sizing software, it could select the wrong motor for you. Look at the motor requirements, then select the proper motor after looking at the speed and torque curves.

9. Does auto-tuning work? Sometimes. Most auto-tuning routines work very well for velocity control. Some work well for position control. There are none that work for very demanding positioning applications. Depending on your system dynamics, auto-tuning might result in acceptable performance. Auto-tuning will frequently get you close to where you need to be, but then you'll have to do some fine tuning. At this point, it's more of an art than a science. Even if the final positioning is accurate, how long did it take to settle at the final position? Long settling times kill productivity. If someone tells you that tuning parameters can be completely derived mathematically, don't believe it. If that were the case, auto-tuning would work perfectly.

10. Who will support the machine in the future? If the person who programmed the motion control won't be around for troubleshooting, then this task usually falls to maintenance personnel, who often have little or no motion control experience. An experienced motion control programmer will bring out any faults and alarm codes to the HMI to make troubleshooting easier.

The important theme to take from all this is that motion control system design is more involved than one might initially think. It's best to consult with an expert in the field to make sure your system will do what you need it to do. 

[Part I of Brian's discussion is at bit.ly/1jVHgZS and in the June 2014 issue of CONTROL DESIGN.]

BRIAN BEAL is president of Highland Controls, an integrator and distributor of industrial motion control systems and related products. Learn more at www.highlandcontrols.com.

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