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New Automation Technology BECKHOFF

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machine input

Women can find strength in numbers

Mentoring and societies help female engineers to avoid the feeling of isolation Mike Bacidore, editor in chief



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Alignment laser ups measurement efficiency

Hurco Manufacturing accelerates machine tool

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packaging

5 aspects of bottlecapping machinery

Trends to consider in equipment building, purchase and operation Alejandro Perez, Acasi Machinery



product roundup

Connections make the mark

Cables, connectors and cordsets for smarter manufacturing

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Other	2,857
TOTAL	40,020



Mike Bacidore

editor in chief mbacidore@endeavorb2b.com

Film puts the human in HMI

INTERFACES HAVE ADVANCED significantly. The very idea of a wireless personal mobile device being used as a human-machine interface (HMI) was pie in the sky 10 years ago. An operator would, at the very least, need a hardened, industrialized tablet to survive the harsh environments and the constant dropping of the device.

And yet, here we are, not only using phones on the plant floor, but taking the interface home and interfacing remotely.

Just when you thought it was safe to go back in the factory, UCLA researchers have designed ultrathin films suitable for applications on human body contours that could lead to on-skin sensors and can turn biomechanical activities, such as the pressure of a finger tap, into electrical signals.

Xiangfeng Duan, professor of chemistry and biochemistry, and Yu Huang, professor

and chair of the Materials Science and Engineering Department at the UCLA Samueli School of Engineering, co-leaders of the research team, compare the membrane's stretchability to that of kitchen cling wrap with semiconducting electronic functionality.

The layers are loosely connected by the nonbonding van der Waals forces.

The van der Waals thin film

(VDWTF) is held together by intermolecular interactions, known as van der Waals forces, that can only take place at extremely close distances between atoms or molecules. And it could open myriad applications, such as sensing and signaling. Plus, it can be powered by the wearer's movements, making it sustainable.

The 10-nanometer-thick membrane could connect with robotics and artificial-intelligence-enabled technologies.

The layered patchwork composition of the membrane comprises several even thinner layers, and, instead of being held in place by rigid covalent bonds, the layers are loosely connected by the nonbonding van der Waals forces. This allows the sheets to slide and rotate over one another.

Duan and Huang are both members of the California NanoSystems Institute (CNSI) at UCLA. The research was supported by the UCLA Physical Sciences Entrepreneurship and Innovation Fund, with additional support from the CNSI Noble Family Innovation Fund. The authors also acknowledge technical support from the Electron Imaging Center at UCLA and the Nanoelectronics Research Facility at UCLA.

The UCLA Technology Development Group has applied for a patent on the technology. And applications are already being tested.

M Bacidore





Jeremy Pollard jpollard@tsuonline.com

Less waste, more production with servo control

I WAS THE DRIVE specialist for my regional office at Allen-Bradley in early 1980s. Vector drives, variable-frequency drives, servos and big-horsepower drives were becoming commonplace. Then this thing called an ac servo came to be.

Wait. What? An ac servo? How could a servo motor driven by a 60-Hertz signal be used in such critical applications as motion control, slide control and robotics? That couldn't happen—dc all the way.

Well, here we are many moons later, and ac servos are the mainstay of motion at every level.

A servomechanism allows for the accurate positioning of a device slide, robot arm, insertion tools—using a feedback method to determine many components of the move set.

Consider a slide that needs to

move from Point A to Point B. Many

decisions need to be made to implement the movement profile—acceleration to a point, constant speed to another point, a deceleration curve to allow the inertia to dissipate in order to stop the device at the exact point that is needed.

We used to use profile-move-set configuration sheets, which created a starting point to the move. There wasn't a teaching moment available as such. Robot move sets were a bit trickier, due to the inertia of the arm and the bulky effectors in the early days.

Fanuc Robot controllers used the Karel language to program its moves. And, yes, there was a teaching pendant that allowed for that moment in time to create endpoint moves, which was very progressive.

There was no consistency in motion-control systems. It was typically proprietary and cumbersome. With the advent of IEC-61131 language standard, there was some hope of consistency. That was brought to the market by PLCopen, the global association that supports the standard.

PLCopen created a working group to investigate motion control through the use of common-language function blocks which could be used with any hardware interface.

PLCopen created a certification model that suppliers could embrace in order to show customers where the vendors' solutions fit into the specification. The certification has four sections: basics, coordinated motion, homing and fluid power.

There are 28 certified vendors for PLCopen Motion Control;

however, most are only certified for the Basics section (www. plcopen.org/certification-motion-control).

What this means for users of motion software is that, regardless of the servo hardware that is used, the motion profiling software would be similar if not the same.

The advent of the programmable automation controller (PAC) has brought integrated motion into the picture. The way the PAC motion-axis hardware can be implemented allows for an easy transition for any machine builder that may not be familiar with

providing this type of control.

Another advance in most control systems is communication strategy. A stand-alone motion controller can be placed on a network that communicates to the mother ship. Sercos (serial real-time communications system) was one of the first

interfaces used for motion in particular. I would suggest that Ethernet as a medium has taken motion to a new level. Fieldbus protocols over Ethernet have proliferated over the complete industrial spectrum. We have the choice of protocol, medium, speed, environmental requirements and the like for any motion application. Even stand-alone robot controllers can be an extension of any control system using a networking strategy.

With the ac servo motor, the user gets better life expectancy and higher efficiency. While the implementation of any servo system really doesn't differentiate between ac and dc, other factors come into play. In this time of supply chain issues, availability might just be the determining factor.

The change in the availability of motion for any control system really does allow for a truly integrated system where nothing in the system is an island.

There should be no hesitation in applying servo positioning control in any system. Something as simple as controlling the stroke of a screw cylinder to position a part under a drill bit can be utilized to maximize production and, with the feedback employed, reduce waste and the number of bad parts. The accuracy is just not attainable with proximity switches.

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.

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Rick Rice

contributing editor rcrice.us@gmail.com

What's a wireway?

MY LONG AND winding trip around the world of automation has given me a broad view on how controls can be applied to a variety of disciplines, but more importantly it helped me recognize the similarities that exist, no matter the end use of the control system.

By and large, packaging machinery design/build has been my bread and butter. I've always liked packaging-machinery design because of the relatively small control system and the centralized control point. Recently, however, I have rediscovered, as it

were, the advantage of using remotely located I/O stations and/or machinemounted I/O modules in even the smallest of machines.

Wiring times are dramatically cut down when all we have to do is bring power and Ethernet from the main control panel to the machine-mount-

ed point instead of landing a great number of individual wires. With on-machine I/O, everything is even plug-and-play using molded cables.

We look to keep power and control circuits completely separate from each other—ultimately in separate enclosures—to reduce or eliminate arc-flash considerations. While primarily to protect those who might be exposed to potential dangers, arc-flash separation/avoidance in design also serves to reduce the time to troubleshoot a problem when the person doing the troubleshooting doesn't have to suit up to enter a live control enclosure.

I recently encountered two different approaches to the same problem of routing wire around a control panel. Ostensibly to keep the power away from the control and network wires, these designs also wandered away from the traditional method of using wireway to bring wires around an enclosure.

The first design was very imaginative. The enclosure starts with the basic standoff backplane panel. However, where the high-voltage items were located—variable and servo drives primarily—the designer had a second panel mounted on top of the base panel. DIN rail ran across in rows—one for the motor circuit protection device and the row below to mount the drives—and the space between each row where one might normally have the wireway; this design has cut out the space instead. To wire everything up, the power wires would route down, or behind, the top-level panel and could then go in any direction, directly to the power bus or to the component on the row above or below. There's no need to follow wireways and use up a lot of wire when one can go in any direction, directly to the source or destination.

The control wires would stay on the upper layer and run horizontally only. These wires would be grouped with wire ties to keep them neat but, more important, keep them totally separate from

There's no need to follow wireways when one can go in any direction, directly to the source or destination. the power wires that run on the sub-layer only. The rows of the adder panel could be closer together because they didn't need to leave room to get wires in and out of wireways.

The second design I came across has some similarities with the first, but the main difference is this is

a complete panel building/wiring system that uses this same primary and sub-layer approach to wiring. In this approach, there is no sub-panel/backplane at all. Each row of DIN rail is mounted on standoffs to create the second layer. The whole enclosure is laid out on a grid of DIN rail on standoffs.

Like the first example, wires are brought from the component, through the "windows" to the sub-layer and wired directly to the next component in the path, without the need to do everything at right angles where great lengths of wire are needed to make the connections.

Also like the first example, the rows don't need the traditional spacing required when using wireway between the rows of components. Control wires, again, can be kept on the first layer, while the power wires drop back to the sub-layer, keeping power and control separate.

My rows in a conventional panel are usually 6 to 9 inches or more apart to allow room for the mounted component, the wireway and the space needed to get the wires from the component into the wireway. I didn't do an exact calculation, but, using this panel-building method, I would estimate that I can save at least one-third of the space in an enclosure and likely about as much or more on the amount of linear feet of wire required to navigate the traditional wireway path around the enclosure.

The first example came in the form of a palletizer we recently purchased, while the second example was presented



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technology trends

to me by a company out of Canada that has designed a whole system structure for executing this wiring technique and can either build complete panels for customers or can work with the customer to teach them how to implement the wiring system in their own designs.

As the cost of control components seems to be escalating at an alarming rate recently, these two vendors have come up with innovative ways to counter those rising costs.

In the case of the wiring-system vendor, they have come up with a way where an OEM or panel-building entity could just lay out some standard enclosure sizes and pre-assemble the backplane mounting structures, independent of the actual control design.

Incidentally, for a situation like mine, I can't see us using a

full wiring system. While we build a lot of panels here, we are producing replacement control systems for dissimilar products. Each one has enough subtleties that we really can't just pick an enclosure size or design and make them all the same. That particular product seems more appropriate for an OEM who would make the commitment to the new wiring system and then make everything using that technique.

The first technique, however, is something I might look into for future projects. Being able to cut down on the amount of wire that we use in a panel would definitely have a positive impact on our bottom line.

RICK RICE is a controls engineer at Crest Foods (www.crestfoods.com), a dry-foods manufacturing and packaging company in Ashton, Illinois.



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Shawn Cox

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OPC comes of age

OPEN-PLATFORM-COMMUNICATIONS (OPC) technology is client/ server-based. One program serves as a data server, while the other functions as a client, requesting data from the server.

A service is defined as data from the server that the client utilizes to carry out a task. Typically, remote procedure calls are used to implement service applications. Because multiple hardware and software implementations may be used without changing service behavior, this offers benefits. In contrast, polling-based systems demand standardized hardware across all devices.

A desktop PC application, a field remote terminal unit (RTU), a humanmachine interface (HMI) station and a shop-floor programmable logic controller (PLC) may all communicate data continuously thanks to an OPC server.

As a result of OPC, user and

technology-provider collaboration has

improved. OPC has enabled automation companies to create genuinely open solutions, giving users additional options in their automation applications. Accessibility is ensured by the development and maintenance of non-proprietary open standards specifications.

The original OPC standard definition was developed in partnership with Microsoft by a group of global automation providers. Originally based on Microsoft's component-object-model (COM) and distributed-component-object-model (DCOM) technologies, it specified a standard collection of objects, interfaces and methods for use in process-control and factory-automation systems to ease interoperability.

In 1994, a group of industrial suppliers spanning a range of disciplines founded what is now known as the OPC Foundation, which set out to provide a single client/server protocol that would enable any vendor to create software and applications that could transfer data in a quick and reliable manner and do it in a way that would eliminate the proprietary schemes that required these same businesses to duplicate development efforts.

The initial standard, known as OPC Data Access specification, was created by the OPC Foundation and issued at the start of 1996. Using this standard, vendors were able to construct client/server software. Eliminating the requirement for client application providers to create their own proprietary collection of communications drivers was a fundamental objective of the OPC Foundation and the Data Access standard, which specifies how to build both the client and server application interfaces.

A client vendor understands that any OPC server that is available for an industrial device can offer the connection required for data access if the standard is followed correctly. OPC applications are no longer constrained by issues like time-to-market or dependability.

OPC has added the advantage of allowing end users to pick bestof-breed software to solve application challenges. Historically,

An OPC server consists of three objects: the server, the group and the item. if the application software did not include the needed communication driver, or if the present driver did not function satisfactorily, the only option was to persuade the application vendor to either design the desired driver or repair an existing driver.

OPC servers are offered by several

manufacturers, and an OPC client can connect to one or more servers. Each server's access points, data names and specifics of how the server physically accesses the data are all determined by vendor-supplied code.

An OPC server consists of three objects: the server, the group and the item. The OPC server object stores information about the server and acts as a container for OPC group objects. The OPC group object contains and logically organizes OPC objects by storing information about itself. Clients can arrange data using OPC groups. For example, the group might represent things in a certain report or operator display. Data may be read, as well as written. Exception-based connections between the client and the objects in the group can also be formed and deactivated as needed.

An OPC client can specify the frequency with which an OPC server should provide data updates to the OPC client. When it comes to creating an OPC server, there are some special concerns. The fundamental issue is the frequency of data transfer to physical devices via non-shareable communications routes. As a result, we anticipate that the OPC server will be either a local or remote .exe that incorporates code responsible for efficient data-collecting from a physical device. Cl

Shawn Cox is a licensed master electrician/PLC programmer. He was co-owner/operator of Bobby Cox Electric for 15 years and is currently employed by BMW Manufacturing as an ESA.

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Women can find strength in numbers

Mentoring and societies help female engineers to avoid the feeling of isolation

by Mike Bacidore, editor in chief

EIGHT INDUSTRY EXPERTS provide advice for women in engineering and for the companies looking to hire them.

Kim Heinle Nelson is senior manager, research and development, at Digi-Key Electronics (www.digikey.com).

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According to U.S. census data, the percentage of women in engineering occupations has increased from a mere 3% to 15% over the past 50 years. While the needle is pointed in the right direction, there's still a lot of room to grow that number. What seem to be the biggest hurdles to women interested in engineering and automation fields? And what difficulties are employers encountering as they work to increase that number?

Pam Horbacovsky Klancewicz, marketing manager—traceability and vision, Omron Automation Americas (automation.omron.com): One of the biggest hurdles has been a lack of exposure to female

roles in an industry that is male-dominated. There is still a lot of work to be done, but, as women continue to grow their presence in different fields, exposure and recognition are crucial, so we can assure that girls and teenagers can see themselves working in automation fields in the future without feeling different, and young female professionals know there is a place for them, too. Schools and colleges, as well as employers, need to combine efforts to break the invisible obstacles all women face when they start studying or working in a technical field—gender bias and stereotypes. Raising awareness against bias and taking action toward diversity and equality should be the norm. Mentoring programs, diversity ambassadors, good maternity policies and development programs for women are steps in the right direction but need to be expanded and consistent over time. Inevitably, this will make automation and engineering fields more attractive to women, as they will see better chances to be successful and space to develop their experience, and they will try new things and follow their passions.

Amanda Beaton, U.S. program manager, Siemens Cooperates with Education, Siemens (www.siemens.com/usa): When I started in an engineering role nearly 20 years ago,

there were very few women in any room. Every meeting was all men. I had trouble finding role models in leadership and technical positions as there was such a lack of diversity then. We've improved over the years, but girls still struggle to see themselves in an engineering position because so many technical jobs are stereotypically held by men (Figure 1). At many companies, I've seen employee resource groups and efforts to connect and empower people from different backgrounds, ages and experience levels. This has been a

Seeing is believing Figure 1: Girls still struggle to see themselves in an engineering position because so many technical jobs are stereotypically held by men.

difference maker in networking and engagement, especially during the changes presented by the pandemic. I've also seen companies, colleges and volunteer organizations starting STEM-related camps and outreach activities earlier, as early as elementary schools, to win the interest of girls before they've made career decisions. In many cases, reaching the high-school- and college-aged audience is simply too late to ignite the spark in a technical career.

Kim Heinle Nelson, senior manager, research and development, Digi-Key (www.digikey.com): Growing up in a small rural town, I did not personally know any engineers or why engineering might be a good career fit for me. There is opportu-

nity for women to pursue roles in engineering and automation fields, but to grow the number of women interested in engineering takes better education for young people, so they can understand the day-to-day requirements of an engineering job and why an engineering career can be so rewarding.

It's so satisfying to use my engineering background to identify problems and then apply creative problem-solving to implement solutions, and I love to share that with women and anyone considering a career in engineering fields.

Nina Golder, vice president, global life sciences, process systems & solutions, Emerson (www.emerson.com): We have a long way to go to move the needle. The obstacles to achieving increased gender parity start before women even get into engineering roles. We need to continue to attract more females into engineering careers, starting with building and

sustaining interest at the elementary-school level. Once we have females in STEM roles, we must continue to work hard to retain them by fostering supportive environments and investing time and effort in ongoing development of their careers. At Emerson, we are fostering a safe environment to empower and support our female employees by elevating their visibility and inspiring achievement of their career goals through one of our employee resource groups called the Women's Impact Network.

Organizations must be intentional about the goal to achieve gender parity; Emerson recently released targets around doubling representation of women in leadership positions, with a goal of at least 40% global leadership by women by 2030. Although the concept of targets can create challenging discussions, we cannot close our gender gap without an intentional step change, as well as fostering and creating environmental conditions that will drive the change.

Nicole Otte, director of workforce development, Endress+Hauser USA (us.endress.com): There are smaller candidate pools of women in engineering-degree programs at colleges and universities across the country. These post-secondary institutions have indicated difficulty in attracting students to their programs. While there may be higher percentages in programs such as biomedical and environment engineering, that percentage drastically reduces for programs such as mechanical and electrical engineering.

Silvia Gonzalez, director of product management, software, Emerson (www.emerson.com): After the pandemic, one of the biggest hurdles for employees in general, not just women, is to have flexibility at work. It has become more relevant for companies to enable employees to have different work arrangements that promote better work-life balance, and I believe this improved flexibility could entice more women to join the workforce. Also, women and other diverse sectors are looking for organizations that attract talent based on merit and not diversity. Women want to be treated the same and want to be measured based on their results, the same as anyone else.

With the skilled labor shortage that began prepandemic and was heightened by the shutdown, how can organizations capitalize on the availability of women to fill these roles?

Amanda Beaton, U.S. program manager, Siemens Cooperates with Education, Siemens (www.siemens.com/usa): Many companies realized a full-time, in-person presence is not required to do a great job. The increased work-life balance offered by more flexible schedules and work-from-home opportunities are critical for many women to participate on an equal level as their colleagues. It took months of awkward zoom meetings, but I think Corporate America has finally figured out how to successfully work as a team from locations outside of one office. I think this increased flexibility is very helpful for women when considering these roles.

Nicole Otte, director of workforce development,

Endress+Hauser USA (us.endress.com): We have to start attracting females into STEM and engineering programs at younger ages, so that there are higher percentages of females in STEM-education pipelines.

Nina Golder, vice president, global life sciences, process systems & solutions, Emerson (www.emerson.com): The pandemic taught us to accelerate technology adoption and adapt to remote/hybrid/flexible environments. It also presents an opportunity to increase our ability to bring in females who desire or need more flexible work arrangements. The increased flexibility in work options may help to accelerate the increase

of females in industry and engineering roles. But, while a restructured work environment created new opportunities to bring more women into engineering roles,

we also need to reverse the current trend of women leaving fields, which was exacerbated by the pandemic. Traditional engineering roles are fairly tied to a physical location, which was particularly hard on female engineers who are parents and caregivers.

I am hopeful that acceptance of more flexible work arrangements can help retain female engineers who are caregivers or parents in the workforce. The operative word here is acceptance: flexible work situations can't be seen as career stallers or inequitable to fully in-person roles if we want to continue to win the talent war and drive to increase female representation. This again will only be one aspect of the complex challenges associated with driving more representation.

Kim Heinle Nelson, senior manager, research and development, Digi-Key (www.digikey.com): Employers can consider hybrid work models that may provide a better work/ life balance. Keeping an open mind for filling job positions is also helpful. For instance, could two part-time employees fulfill the job requirements of one full-time position?

Organizations can also increase interest by offering internships and scholarships to local high-school or college students. Providing mentors for local youth organizations like robotics teams, 4-H or Future Farmers of America (FFA) starts the business relationship early and can be a catalyst to grow long-term employee loyalty.

In her relatively famous study, published in the Harvard Business Review, MIT's Susan Silbey and her colleagues found that women in engineering experienced a significant amount of gender bias not only at the college level, but even more so in internships and co-ops and then when entering the workforce. She estimates

that 40% of women who earn an engineering degree either quit or never enter the profession. What can be done to nurture and develop these women, especially early in their careers?

Nina Bischoff, industrial sales engineer, Phoenix Contact USA (www.phoenixcontact.com): In my experience, gender bias was seen in all levels of my schooling and professional life. I have thought long and hard about what might make the fallout from this better, and the answer is clear-mentorship. I consider it my mission now to encourage young female engineers in their careers and to always leave my door open to them. Showing them an example of a woman who is on their side makes all of the difference.

Silvia Gonzalez, director of product management, software,

Emerson (www.emerson.com): I believe coaching and mentoring should be a big part of the effort for companies to support women in engineering. Communicating with new generations how relevant it is to continue learning and growing professionally, sharing experiences others had in the industry and supporting them to challenge companies where gender bias still exists. Some countries are better than others, but global companies can make a difference by training their employees and providing an inclusive environment where everyone is heard despite their gender, ethnicity or other differences.

Amanda Beaton, U.S. program manager, Siemens Cooperates with Education, Siemens (www.siemens.com/usa): I have an immediate response to this question: Mentors. I mention role models above, but I have been blessed with mentors throughout my career—both men and women—who offered unique strengths and helped to develop different parts of my career. They have been critical in offering perspective for networking, communicating and overcoming

challenges that would have been far more daunting without an experienced professional in my corner. And it can be a two-way transaction. Many mentors and mentees can learn from each other and fill in gaps to mutually benefit. Outside of formal mentors and one-on-one relationships, which may not work for everyone, networking and resource groups present a great opportunity to connect people and rise above common stereotypes and challenges faced by women early in their careers.

Pam Horbacovsky Klancewicz, marketing manager-traceability and vision, Omron Automation Americas (automation.omron. com): This can be done with exposure to the industry, through professional associations, access to mentoring programs and networking opportunities. As part of the educational offer, colleges should make available access to professional networks to women pursuing roles in technical fields. This will offer young women an opportunity to get a broader perspective of their future field and help them build confidence as they advance in their careers, understanding how their knowledge and new skills will suit them in the future.

Kim Heinle Nelson, senior manager, research and development, Digi-Key (www.digikey.com): Companies can provide a positive work environment in which new college graduates can succeed and even fail, because failure creates learning and growth opportunities. Recognize that every

employee, regardless of gender, brings a unique skillset to the position. Companies have to take the time to see what motivates a new employee and remember that treating employees fairly does not mean treating them the same.

Nicole Otte, director of workforce development, Endress+Hauser

USA (us.endress.com): Mentoring programs, such as Endress+Hauser's Women's Integrated Network (W.I.N.), initiate powerful ways to connect early-career women engineers to advocates and coaches in their organizations and industries.

Nina Golder, vice president, global life sciences, process systems & solutions, Emerson (www.emerson.com): There are many offramps where women are pressured to exit engineering careers, and to help women navigate around them we must be able to provide support at different critical junctures from the classroom all the way to the boardroom. The early career is one of the very critical phases where

mentoring is essential, and universities and organizations must be intentional about providing support.

I personally faced a moment where I was making a critical decision on whether to take a non-engineering/industry path, and, although I did not ultimately go an alternate route, I didn't know or have resources at the time to talk through the decision. We need strong mentors, advocates and role models to continue to inspire, coach and support our female employees in the early part of their careers. It is also important to have a personal network that can help women reaffirm their interest in getting into engineering careers, be a sounding board for the challenging times and share and celebrate their wins along the way.

One of the other findings in Silbey's report is that the women who participated were hoping to make a more socially conscious impact in their engineering pursuits than the males in the study. What, if anything, does this tell us about gender bias? And, if the report is indicative of a real female desire to make a difference, where might women find those types of jobs to have a positive impact on society and civilization with their engineering and automation expertise?

Nina Golder, vice president, global life sciences, process systems & solutions, Emerson (www.emerson.com): There is a new generation of talent emerging that sets a high priority

on social impact and purpose. Recognizing and valuing that purpose will be essential to attracting the best talent in the years to come.

Much like this new generation, the companies that will win the future recognize the need for innovation and disruption is greater than ever. At Emerson we have rallied around several causes. Our Roadmap to Industrial Sustainability is helping Emerson and our customers make the critical changes necessary to drive a more sustainable future. We are also focused on driving equity across our organization worldwide with goals of 40% global leadership by women and 30% leadership by minorities in the United States by 2030. We are focused on articulating the value that engineering and automation expertise is bringing to the world and society and know that we can best show that commitment through our own internal initiatives.

We must continue to showcase to women and future generations that engineering and automation expertise can bring

significant contribution to society. One great example of this at Emerson is how we were able to use our technology to help Moderna quickly and safely bring vaccines to market during the pandemic. Engineers have been our greatest problem solvers and world changers. Perhaps it is time to rebrand the word engineering-what about "innovationeering"?

Nina Bischoff, industrial sales engineer, Phoenix Contact USA (www.phoenixcontact.com): While female and male engineers may have been shown to have different motivating factors, this should not be looked at as ineptitude in either direction. Rather, it is an opportunity to succeed because having a diverse group of people involved in a project will bring about many different viewpoints and ideas. These different viewpoints, skills and motivating factors will encourage teams to tackle projects in ways a singular person may not have come up with on their own.

Kim Heinle Nelson, senior manager, research and development, Digi-Key (www.digikey.com): Studies show that women may be drawn more to the "people" aspects of a role, while men may be more interested in physical "things." Becoming an engineer doesn't prevent personal interactions, and, in fact, I find industrial engineering, the "people" side of engineering, to be a great fit to work with people on ergonomics, efficiency and other process improvements.

Amanda Beaton, U.S. program manager, Siemens Cooperates with Education, Siemens (www.siemens.com/usa): I can't

speak for all women, but I know my outlook changed once I became a mother. My concern for my children's future and the state of the world suddenly became a focus. Overall, I think we are generationally speaking up more about social and environmental issues. I also think we are more open in communicating these interests compared to 20 years ago. Particularly when you read about projects and the goals of companies like Siemens, there is an increased focus on the environment and our social impact. I'm not sure if it's specific to one gender any more, as more and more early career professionals prioritize social consciousness over other features of a job or a company. My advice would be to come work for Siemens. We are doing wonderful things in this area.

Nicole Otte, director of workforce development, Endress+Hauser USA (us.endress.com): I believe this is indicative based on female students choosing majors where they can

easily make a connection to making a difference-for instance, biomedical is about helping people, environmental and sustainability, helping our planet.

According to the latest research from the Society for Women Engineers, females earn 10% less than their male counterparts. How does this impact a woman's interest in entering an automation-related field, and what can be done to counteract this?

Nina Golder, vice president, global life sciences, process systems & solutions, Emerson (www.emerson.com): The battle for talent is challenging enough; therefore, we in the engineering and automation fields need to eliminate the gender-pay-gap challenge so that we can help ourselves build a larger talent pool-we can't be missing out on half of the population. Unlike many of the other challenges, which ultimately come down to more personal reasons for women choosing engineering careers or staying in them, the pay gap is a systemic issue that we can resolve if we are deliberate about it through process.

As hiring managers, let's set budgets based on role/skillset desired and constantly check our own biases throughout our hiring processes. We can also continually check ourselves by performing blind salary reviews and ensure we are removing any bias. In this data-rich world, I would also encourage women to know their worth and feel comfortable negotiating for what their value is.

Kim Heinle Nelson, senior manager, research and development, Digi-Key (www.digikey.com): Career training on how to research national salary statistics for engineering

positions and proven strategies for wage negotiations are needed. Networking with other engineers can provide realworld information, and college-placement offices are great resources that are not always used to the best advantage.

Nina Bischoff, industrial sales engineer, Phoenix Contact USA (www. phoenixcontact.com): Knowing that male counterparts could potentially earn more can be off-putting for future

female engineers. We, as a society, can combat this by encouraging salary transparency, encouraging women to negotiate their salaries and training hiring departments to compensate fairly.

Pam Horbacovsky Klancewicz, marketing manager-traceability and vision, Omron Automation Americas (automation.omron.com): Unfortunately, this is not unique to this field, and there is no doubt it will have a significant impact when a woman is considering professional opportunities in the automation field.

Organizations that are truly committed to breaking gender bias will need to address the gender wage gap at some point. Transparency over pay, skill-based assessments that don't ask for gender at the beginning and gender-equality promotion are just some of the different actions that can be taken to stabilize and make the field more attractive to women looking for an opportunity in this industry.

Amanda Beaton, U.S. program manager, Siemens Cooperates with Education, Siemens (www.siemens.com/usa): I think women are still challenged in some cases by speaking up and asking for what they want. Negotiating for higher pay and truly valuing experience and talents doesn't come naturally for some of us. Whether it's through mentoring, self-development or network-

ing to better understand pay, there are several opportunities to

grow and build skills in communicating value and worth.

Silvia Gonzalez, director of product management, software, Emerson (www.emerson.com): Part of the decision-making process to join a company or industry is the salary, but there are other factors that should be taken into consideration. For instance, is it the right role? Does the job represent a professional challenge? Will you learn something new? Will you gain exposure? Are there growth opportunities? Is the

company aligned with your values? Even though salary is very important, it shouldn't be the only factor considered or impacting the decision to enter the automation field. Even though the evaluation of a job opportunity includes many different factors, companies shouldn't make different offers based on gender or other diversity, but based on merit. Some even recommend doing non-bias interviews to accurately evaluate candidates.

How can mentoring programs help women to stay the course and feel fulfilled in their automation or engineering pursuits?

Megan Anders, technical support team manager, Endress+Hauser **USA** (us.endress.com): In industries in which women are the minority, it can seem isolating and intimidating

to determine the space that you hold. Mentoring programs give mentees the ability to develop, explore and be understood in an environment that facilitates growth and community. Being in a mentoring program myself, it has given me the opportunity to find my voice and have an ally who advocates for me, as well as continues to challenge me in the work I do.

Silvia Gonzalez, director of product management, software, Emerson (www.emerson.com): It is very important to provide formal and informal mentoring in a company to enable

communities to support each other. Being able to discuss your personal/professional situation with others helps everyone understand we all face similar challenges. Mentoring is a highly recommended practice, and it doesn't require formal processes to make it happen; you can have several mentors in different areas to help you where needed, on wide-ranging topics such as financial advice, coping with stress at work or help navigating a meeting. Acting as a mentor to some and being a mentee with others helps to ensure professional growth. Mentoring programs can help women get access to other women that can share experiences or guide them in decision making or role models. Men can also play an important mentorship role, and I had great mentors, both men and women, throughout my career, at different levels of the organization to help me navigate the industry.

Kim Heinle Nelson, senior manager, research and development, Digi-Key (www.digikey.com): Mentoring programs let women know they are not alone and offer ways to work past gender bias in the workplace. Mentoring offers ways to make a more socially conscious impact in their engineering pursuits.

Nina Bischoff, industrial sales engineer, Phoenix Contact USA (www.phoenixcontact.com): Mentorship programs are key to helping women feel fulfilled and welcome in their careers. Having another woman to show you the ropes of a new

company helps you to feel less alone. It also helps give the feeling of safety and security that is often lacking.

Nina Golder, vice president, global life sciences, process systems & solutions, **Emerson** (www.emerson.com): From the earliest stages, good mentoring is essential. The Women's Impact Network employee resource group—Emerson's

organizational structure to empower and support our female employees by elevating their visibility and inspiring achievement of their career goals—is a great step, but strong mentoring needs to start earlier than that. Ideally women in STEM

should have a strong support foundation from the earliest moments of elementary school all the way through college. This will require a systemic change both in applied resources and in the way we support and foster women who show an interest and aptitude in engineering.

Amanda Beaton, U.S. program manager, Siemens Cooperates with Education, Siemens (www.siemens.com/usa): I am not sure where I would be without the mentors over the years who played varying roles in my career development. Even the negative experiences with managers were great learning opportunities with the help of mentor guidance. I truly feel that diverse mentors matter, too. Internal and external mentors, women and men, with different functional areas and backgrounds, can be helpful; when the connection is valued, the results can be great.

What sorts of initiatives is your company involved with to encourage female participation in the automation field?

Nina Golder, vice president, global life sciences, process systems & solutions, Emerson (www.emerson.com): Emerson has several employee resource groups (ERGs), and one

that is encouraging and developing female participation in the automation field is our Women's Impact Network. The Women's Impact Network provides support, networking and careerdevelopment opportunities for women employees around the globe. In 2021, the 6,000-member group reached a milestone of 100 chapters across the organization.

In addition to the ERG's growth, the Women's Impact Network helped push Emerson forward as an organization, by helping to increase the number of women in leadership positions, hosting regular webinars and attracting a new generation of women in STEM to the company through partnerships with the Society of Women Engineers and several universities, as well as focusing on K-12 educational events. At Emerson, we make it a priority to promote STEM education and programs that prepare the next generation of critical thinkers and problem solvers; we must promote awareness at this level to move the needle far beyond where we are today.

Nicole Otte, director of workforce development, Endress+Hauser USA (us.endress.com): W.I.N. mentoring and Girls Inc. programming and partnering are examples. We are

hosting field trips for elementary and middle-school girls this summer to get them exposed to STEM and making a difference in their communities and world through our process-automation technologies. It will include hands-on and engaging activities to get girls excited about a career in our industry.

Amanda Beaton, U.S. program manager, Siemens Cooperates with Education, Siemens (www.siemens.com/usa): I

mention informal mentor programs, formal women's networks and other employee resource groups to connect and improve both the quality of work and experience within the company. I know firsthand over the past couple of years that seeing so many women in powerful leadership roles gives me more confidence in my work and advancement opportunities. Women aren't just leading HR or marketing any more; they are leading the whole company.

Megan Anders, technical support team manager, Endress+Hauser USA (us.

endress.com): Endress+Hauser has a global Women's' Integrated Network (W.I.N.) group to help facilitate opportunities for females in the automation field. Endress+Hauser provides opportunities to participate in national Society of Women Engineers (SWE) conferences, women in leadership trainings and the W.I.N. mentoring program. The company continues to work toward giving women a seat at the table and helping to create a support network within the company to develop a successful career in the automation field.

Kim Heinle Nelson, senior manager, research and development, Digi-Key (www.digikey.com): Digi-Key

Electronics mentors the local robotics

teams and sponsors "Girls Who Code" workshops for local youth (Figure 2). We also promote membership in Women in Electronics (WE).

Silvia Gonzalez, director of product management, software, Emerson (www.emerson.com): Emerson has

various programs to support inclusion and diversity, and one example is the Women in STEM, with a mission of fostering a diverse, equitable and inclusive environment. The heart of the work Women in STEM performs is around our chapters. Each chapter is where connections are made, professional development takes place, and we attract women to STEM careers through our community outreach including "We love STEM" events. These chapters have created a monumental impact to increase employee engagement reaching more than 5,000 Women in STEM members globally.

Pam Horbacovsky Klancewicz, marketing manager–traceability and vision, Omron Automation Americas (automation.omron.com): Mentoring pro-

grams are a powerful tool for both mentor and mentee. It helps you to adjust perceptions, better understand career ambitions, identify growth opportunities and gain confidence. For women, it is important to participate in programs where they have access to female mentors with experience in different industries. Learning from other experiences and stories offers a better picture of the challenges and opportunities other female colleagues faced in their professional lives and is an encouragement to think about what success could look like.

Mentoring programs should be promoted as the first step to developing a solid professional network that, among other advantages, can offer early access to new possibilities, including the right opportunity for the next step in your career path.

Nina Bischoff, industrial sales engineer, Phoenix Contact USA (www.

phoenixcontact.com): I am so lucky to work for a company that values its employees and future employees. Phoenix Contact USA is active in the community and hosts STEM-related events for the next generation. They also help with female engineer retention by having mentor and apprenticeship programs. C

Why buy capital equipment when you can pay for production with a subscriptionbased model?

at your service by Anna Townshend, managing editor

THE MANUFACTURERS AND suppliers that support industrial automation industries are loosening their grip on hardwaredominated portfolios and embracing software and service subscription-based models. Others outside of industrial automation are also recognizing the potential for sweeping innovation.

Software-based business models are both leading the digital transformation of industry and pushing traditional automation companies to both specialize and diversify. Individual products are becoming more customized for specific customers, and companies are also branching into new arenas, as the industry becomes less dependent on hardware overall.

Subscription-based business models are taking on many different forms. Machine builder Pearson Packaging Systems (www.pearsonpkg.com) is renting its machines for a per-case fee, with a nearly real-time payment system, but it has yet to move fully into predictive maintenance services.

Kaeser Compressors has offered compressed-air-as-a-service for more than a decade, for companies that want hands-off and guaranteed utilities. Many other companies are dabbling in equipment rental or production-as-a-service, and technology companies that specialize in data collection and analytics are doing the same.

As software becomes a larger part of every aspect of industrial automation, even replacing traditional hardware more often, it's probably not a surprise that software's subscription-based business model is also playing a larger role in industry. Many original equipment manufacturers (OEMs), machine builders or equipment suppliers and distributors can realize new profits. Industrial companies, particularly machinery and equipment manufacturers, are changing rapidly. And if traditional industrial automation companies aren't ready to fit the new mold, other third-party technology innovators are ready to take a leading place in industry.

Machines-as-a-service: standard equipment with innovative payment model

More than 20 years ago, Pearson Packaging, a machine builder for secondary packaging equipment, was one of the early adopters of Salesforce.com, a software subscription service for customer relationship management (CRM) technology. Early on, the company often asked Pearson Packaging to sit in on customer calls with Fortune 500 companies "to help sell them on the idea of software as a service," says Mike Senske, president of Pearson Packaging. "It took years and years to get that widespread adoption."

In 2019, Pearson Packaging launched its own machines-as-a-service business model. Armed with its experience with as-a-service models in its own business, Pearson Packaging saw potential for this business model in the packaging industry.

Senske first started thinking about the service model on a larger scale more than a decade ago. At the time, he had a few customers that didn't have money in their budgets to purchase new equipment. Instead, they asked to rent used equipment from Pearson Packaging. Even when the company's monthly rental fees had exceeded the cost of the equipment outright, they continued to rent the machines, rather than purchase them. They couldn't get the capital-expenditure budget approved, but the monthly fee was granted out of the operating budget. Senske says often companies can set a certain internal rate of return on automation projects, and, if projects don't meet that standard, no matter how close, they don't get funded.

"We were looking at that and saying there are a lot of customers who really have good business cases for automating certain processes in their end-of-line packaging, but, for whatever reason, they had finite access to capital," Senske says. "And yet many of those projects would have been accretive to their bottom lines and accretive to their shareholders, if they automated them." Enter the machines-as-a-service model. "There's an alternative approach," Senske says. "It allows them to pay for the automation with savings that they otherwise wouldn't have achieved in the absence of that automation, so it's kind of a self-funding mechanism (Figure 1)."

Pearson Packaging focuses on endof-line equipment in many industries, including food and beverage, personal care, chemical, online commerce and pharmaceutical industries. Food-andbeverage manufacturing make up about 50% of the business, Senske says. "Once the product is in its primary package, we're the last automation that helps get the product packaged safely into its final shipping container and then into the back of a truck," he adds.

While Pearson Packaging has never seen machines-as-a-service as a huge part of its business, it is committed to growing the as-a-service business incrementally. In its model, Pearson builds the piece of equipment and then delivers, installs and commissions the equipment, including training of any operations and maintenance personnel. Senske says most of its customers have expressed a strong preference for keeping maintenance activities inhouse. "They have entire crews that are dedicated to doing that now in the old model," Senske says.

Self-funding mechanism

Figure 1: The machines-as-a-service model allows users to pay for the automation with savings that they otherwise wouldn't have achieved in the absence of that automation.

Payment is not a monthly or flat fee system. Pearson Packaging uses blockchain technology, which Senske describes as "a distributed ledger system" that allows them to charge customers a per-case rate (Figure 2). The blockchain tech takes performance data from the equipment and puts it into a ledger, which cannot be manipulated by either Pearson Packaging or the customer.

The contract outlines what is paid per successful case, erected, packed and sealed or palletized, depending on the customer needs (Figure 3). "It's safe; it's secure; and it's based on the data that's coming directly from the machine," Senske says. On a weekly basis, the system automatically drafts the needed payment from the customer's bank account, based on the number of completed cases (Figure 4). It requires no invoicing from Pearson Packaging. The contract also includes spare parts, which are sent to customers based on performance and usage data without having to issue purchase orders.

This business model is not, however, for everyone, Senske says. The company does have pointed efforts to grow this part of the business and has developed a sales team that can educate customers about its benefits. Pearson Packaging does not offer its entire product line for machines-as-a-service, Senske says, and it's not a fit for every customer.

"What we're focusing on are the products that don't have a tremendous amount of customization in terms of their core functionality," Senske says, equipment like case erectors, case sealers or compact palletizers (Figure 5). "Even though each customer application is a little bit different, there's a lot of homogeneity in terms of the machinery itself." The ideal customer profiles for Pearson Packaging are higher volume manufacturers, running multiple shifts per day and running five or more days a week in a very demanding production environment. "It's not a methodology of getting people to automate that shouldn't be automating, or that should be automating with a different kind of technology," Senske says. "It's not making a really expensive piece of equipment affordable to somebody who doesn't need it."

A limitation of the service for now is that the available equipment is a subset of what Pearson Packaging offers. "We hope, as time goes on, to figure out how to make it work and how to build a business case to include the entire product line, but we're probably a couple of years from being at that point," Senske says.

The process will require a lot of education with customers. "You're overcoming the new approach, at least on the industrial-equipment side of things. But generally, there's a lot of interest, and I think we're trying to educate people about the technology, about how it works, about the model itself, and then also making some tweaks as we go to make it a little bit more palatable for customers, as well," Senske says.

Another area where Senske thinks the company can expand the business model is with predictive maintenance. Remote connectivity and data collection and analysis are intrinsic to how the service works, from sending spare parts to payment. Mostly, Pearson Packaging is using its data to monitor equipment usage and performance to ship spare parts, but it could expand its service doing more monitoring and predictive maintenance. In some cases, it does monitor data intermittently,

Case by case Figure 2: Pearson Packaging uses blockchain technology to create a distributed ledger system that allows the company to charge customers a per-case rate.

Seal the deal Figure 3: The contract outlines what is paid per successful case, erected, packed and sealed or palletized, depending on the customer needs.

Case completion

Figure 4: On a weekly basis, the system automatically drafts the needed payment from the customer's bank account, based on the number of completed cases.

and can alert customers to anomalies that might affect the efficiency rate of the machine, Senske says. The company knows its machines very well and knows optimal levels for their performance. While the company is not doing a lot of proactive maintenance engagement, Senske would like to build on that service. "Where I'd like us to be is where we can monitor mission-critical components on the machine," Senske says. They can detect vibrations or temperatures that are out of normal operating ranges, which could cause a component failure before it occurs. Pearson Packaging is dabbling in this area for now. "And I think that's only going to grow as time goes on and people continue to adopt that approach," Senske says.

Pearson Packaging is not expecting customers across the board to adopt this as-a-service model, even down the line. But Senske predicts that, in five years, machines-as-a-service will represent 20 to 25% of the business. "The adoption of this has been slow and steady," he adds.

Not only is the business model new to industry with its own learning curve, but the financial structure has also changed the sales process. When faced with approving an operating expense vs. capital expenditure, some customers don't even know where to go in their organization for permission. Pearson Packaging has had to engage with customer personnel that it hadn't traditionally in the sales process, and executive finance personnel need the same kind of education about how the model works.

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The machines-as-a-service program at Pearson Packaging started not that long before COVID, and the pandemic has had both negative and positive impacts on the business, Senske says. The whole education process and working with new people in the organizations was hindered by the inability to be face-toface in order to build trust and rapport. "That kind of slowed that process down," Senske says. But the company also did gain ground during COVID, as remote connectivity became more of a necessity and less of a luxury for customers. "That portion of the acceptance of the model has actually increased pretty dramatically," Senske says.

"What's really interesting is there are so many intrinsic benefits to having that kind of functionality and the ability to monitor a machine and in real time, that can dramatically lead to increased uptime and efficiency," Senske says. "I think a tremendous amount of savings can be generated by being able to predict failures before they happen."

CapEx vs. OpEx

There are advantages and disadvantages to buying machinery (capital expenditure) vs. leasing equipment or production (operating expense), says Bryan Powrozek, senior manager and industrial automation team lead at Clayton & McKervey (www.claytonmckervey.com), an international accounting firm.

The advantage of buying is that it's usually cheaper in the long run than renting. "If the equipment can hold its value over the long run, and I have the cash to pay for it, then I may want to buy it outright," Powrozek says. The obvious disadvantage of buying is that it eats up available cash.

"If cashflow is tight or there is a desire to preserve cash for working capital or

Homogeneous products

Figure 5: Although each customer application is a little bit different, there's a lot of homogeneity in terms of products without much customization, such as palletizers.

other matters, I'd want to lease, as it typically requires little to no upfront costs, and the payment is spread over time," Powrozek says. If the purchase includes technology that changes quickly or can become obsolete, leasing might also be a good idea.

"A business' financial statements and associated financial ratios will also be affected by this decision," Powrozek says. "Leasing is still a form of financing, so the business will want to determine if the rate being charged is less than the rate they could obtain if they financed the purchase through bank debt."

The equipment-as-a-service (EaaS) model may help automation companies and their customers that perform maintenance internally to work better together and keep machines running optimally. "Many automation companies are already engaged on some level of maintenance and services as part of their equipment contract, so this is a natural evolution, similar to many consumer products. The hardware is included in the monthly or annual subscription, rather than being sold separately," Powrozek says.

"Larger, more advanced consumers of equipment will tend to use an integrator to develop and implement systems but then handle the maintenance using internal resources. As the systems become more complex and new technologies are rolled out, it becomes harder for the internal resources to stay up to date with all the latest development. You end up with situations where customers try to manage the preventive maintenance and updates internally and resist calling the vendor in until the last minute. Having an EaaS relationship gets past some of this by having the vendors come in periodically as part of the agreement," Powrozek adds.

The complexity of advanced equipment might also be an obstacle for small to medium-sized companies that don't have the capacity for internal maintenance. "A properly structured EaaS agreement can cover the regular maintenance and upkeep the company may not be able to handle with their own resources," Powrozek says.

Utilities-as-a-service

End users can also use subscription services to operate parts of the factory process outside of the machines. About 15 years ago Kaeser Compressors (us. kaeser.com) started Sigma Air Utility, essentially compressed-air-as-a-service. For a monthly fee, Kaeser installs, monitors and maintains the compressor system. It remotely monitors equipment health to guarantee factory uptime. The uptime guarantee is possible because every system has backup equipment, should the original system go down, and the system is continuously monitored and serviced preemptively (Figure 6).

Customers no longer have to monitor their compressed air systems or call for service when needed, and most customers do not even see their systems, as they're housed in an engineered enclosure outside of the facility (Figure 7). "We can do our service without having to interfere with the production," says Werner Rauer, production manager, compressors and technical development, at Kaeser Compressors.

"While not all air utilities or air-as-aservice require that modular compressed air delivered enclosure, it is the most common thing these days," says Michael Camber, marketing services manager at Kaeser Compressors. "We can deliver it and commission it without them having to do any modifications (Figure 8)." The system also allows for great flexibility to

Consistent uptime

Figure 6: Kaeser can install, monitor and maintain the compressor system to guarantee factory uptime.

Out of sight

Figure 7: Customers no longer have to monitor their compressed air systems or call for service when needed, and most customers do not even see their systems, as they're housed in an engineered enclosure outside of the facility.

make it bigger or smaller if production requirements change.

"It's not very common, but it's becoming more so, I think, as more products become a service and so many things that used to be assets are now provided through some type of subscription," says Matt McCorkle, manager of branch operations at Kaeser Compressors. He also says some companies have plenty of experience with managing and operating compressed-air equipment, but they don't find it productive for them.

"When you're dealing with Sigma Air Utility, you're also dealing with finance contracts, so a broader range of people have to get involved, because the accounting does play a role in the decision to do this," McCorkle says (Figure 9). Depending on how the customer accounting department handles operating leases versus capital expenditures, that could impact their taxes or budget and, ultimately, their investment decisions.

As part of the process, Kaeser conducts an air-demand analysis of the facility. "We understand how much flow they're using, what kind of pressure, what air quality needs there are, what the environment is like," McCorkle says. "Then, we basically design a fully redundant system for their needs and certainly also consider their expansion requests." The contract will outline the monthly payment for a certain amount of air and penalties if the demand is not met.

Contracts typically run about 10 years. The model is much more accepted now, than it was 15 years ago, Werner says, and now Kaeser does offer contracts in smaller increments, down to five years. At the end of a contract, customers can renew or buy the equipment outright.

"It is a very predictable expense," Mc-Corkle says. Customers receive monthly reports, or more if they request, on equipment performance, and the service becomes an ongoing air study. Advanced controls on the individual compressors and dryers communicate energy usage, maintenance messages, temperatures and other parameters. With a large system, the Sigma Air Manager collects all the information from individual machines and monitors the entire system.

To properly size the system, the air-demand analysis also uses Kaeser's energy-saving system. This collects data over time to chart how much air is being used, which machines are running and the overall efficiency of the system and whether pressure stability is achieved. Kaeser then takes that data and runs software to simulate different machine mixes to determine the lowest cost and the most stable pressure. This is a highly in-depth simulation, which requires renting space in a supercomputer facility to do the calculations.

Kaeser also has a program called KAirFree, which is geared toward smaller systems less than 20 hp. Users choose from five different plan levels and pay a per-hour rate for a one-year contract, and it can all be ordered online for a small startup cost. The program began during COVID, but it has continued to grow, and 100% of the users have renewed contracts so far.

Signed, sealed, delivered

Figure 8: Modular compressed-air enclosures can be deliver and commissioned without any need for modifications.

Originally, Kaeser Compressors envisioned this program would be ideal for smaller businesses or contract manufacturers. "What we found is we even have some large manufacturing customers that might have a special need in one area of the plant for a smaller machine, and they'll go with this for that particular room where they just want dedicated compressed air for that particular space," Camber says.

"Our goal is that it's out of sight, out of mind," McCorkle says.

The program has also helped Kaeser from a research-and-development standpoint. All the real-world data it has collected over the years in the field is also analyzed and incorporated into the next designs.

The program is widespread across many industries, including automotiveparts manufacturing, cement plants, food distribution centers, food processing and binding and printing facilities.

Partnerships and technology adoption

Much like the different terms for equipment- or production- or machines-as-aservice, the business model is being envisioned by vendors and others in many different forms. Matt Ruberg, packaging industry manager for Beckhoff (www. beckhoff.com), says machines-as-aservice has the advantage of aligning industry interests. "The machine builder is only getting paid if product is leaving the door," Ruberg says. "That aligns the end users and the machine builders to a certain extent on uptime, quality and speed of production." This makes the machine builder more of a partner with end users, he says.

It could also encourage advanced technology adoption, if the return on investment increases production

More touches Figure 9: When dealing with finance contracts, a broader range of people have to get involved.

enough to cover the cost of new equipment. End users might also be more reticent to adopt new technologies without strong support from builders to train operators and keep up on maintenance, Ruberg says.

On the downside, it could expose the machine builder to additional liabilities, whether they're financial- and safetyrelated. "There's a financial liability shift to the machine builder," Ruberg says, and questions about safety can present liabilities, if they aren't addressed. "That is a topic that needs to be in the contract and discussed upfront," he adds.

Ruberg believes this model would work best with packaging equipment that is not highly customized and able to be easily redeployed elsewhere, like a stretch wrapper, for example. "It's something that many manufacturing facilities need, so I've got a pretty high chance of redeploying that," Ruberg says.

All the technology exists for machine controls and communication to collect the needed data and count product output. The more difficult part is in verification of those counts, Ruberg says. Third-party companies are doing this with blockchain and other technologies, and whatever process is used must be rigorous enough to survive the scrutiny of an audit.

Ruberg says there are also third-party companies springing up, which are investing in machines in order to offer them as a service to end users.

Rahul Garg, global vice president, industrial machinery business, at Siemens (new.siemens.com), echoes many of the same themes. Production-as-a-service provides more flexibility to users, which could be especially appealing to manufacturers that do small volume runs or want to serve regional markets where they don't currently have a presence. "Especially in today's world with all of the supply-chain issues, it becomes even more critical to have the flexibility and the availability of production in different parts of the world as needed, so this production-as-a-service provides a very good alternative where they can get something made without having to bear the startup cost or the infrastructure cost to get something going," Garg says. He also sees other third-party entities outside of traditional industrial automation that take this idea and build a business around it.

Siemens does provide some rented equipment for hardware services geared around digital-transformation technology. "We are also providing a lot of our automation equipment as rentable equipment, where they can subscribe to our hardware services," Garg says. One area where Siemens is driving the equipment-as-a-service model is with its edge suite of software and hardware, including renting the sensors and controllers needed to connect machines to the edge.

Garg doesn't see this as-a-service model being used for inexpensive equipment, but it needs to be standard enough that production setup times are low. This standard equipment may also be used across different manufacturers with proprietary processes, especially a third-party company that enters the market to provide equipment-as-aservice, Garg says. While flexibility is key in the model, intellectual-property risks needs to be addressed, and it may be that the model is not a good fit for end users that are innovating new processes and capabilities.

"The whole ability to monitor your production through the Internet of Things is certainly very important. That's what is driving a lot of the ability for machinery manufacturers to offer this," Garg says. That secure remote connection provides confidence that even off-site proactive and preventive maintenance can happen through data collection and analysis. 🕯

Alignment laser ups measurement efficiency

Hurco Manufacturing accelerates machine tool assembly checks

by Wang Shun-Chien, Hurco Manufacturing

THE ULTIMATE ACCURACY and reliability of a machine tool depends in no small degree on the alignment checking during its assembly. For machine tools produced in high volumes, the efficiency of the alignment-checking process is paramount.

Hurco Manufacturing is a provider of CNC machines, producing thousands of machine tools every year. We needed machine measurement and alignment to be highly accurate and faster. To increase both precision and throughput, Hurco (www.hurco.com) chose to adopt the XK10 alignment laser system from Renishaw (www.renishaw.com), which can be applied to linear rails to ensure they are straight, square, flat, parallel and level, as well as to spindles and chucks to assess direction and coaxiality of rotary machines (Figure 1).

The XK10 alignment laser system succeeded in significantly reducing the amount of time we needed to implement high-accuracy machine tool alignment. After testing the XK10 system repeatedly, we found that it provided a solution that is genuinely capable of replacing traditional methods.

Background

A true pioneer in the application of computer technologies in machine tool design, Hurco is a global provider of CNC machines. Founded in Indiana in 1968, the company manufactures a comprehensive range of products including five-axis CNC machines, multi-axis CNC lathes, vertical machining centers and turning centers.

Our worldwide customer base comprises precision tool, die and mold manufacturers, independent job shops, specialized short-run production manufacturing companies and OEMs of metal fabrication tools. Our product portfolio includes three well-known brands: Hurco, Milltronics and Takumi.

Hurco Manufacturing was established in Taiwan in 1999 and is today responsible for the manufacture and assembly of the complete range of Hurco machine tools (Figure 2). To ensure requirements for machine tool precision, safety and reliability are met, strict quality control is paramount for each step in the manufacturing process.

Challenges

With Hurco producing thousands of machine tools every year, increasing measurement efficiency was a vital driver for our inspection and verification processes. Not only did machine measurement and alignment need to be highly accurate, but it also needed to be faster.

Alignment inspections during the assembly process were carried out by using a blend of traditional measurement tools, coordinate-measuring machines (CMMs) and calibration equipment. We had long employed a range of Renishaw solutions, including the XL-80 laser interferometer, QC20-W ballbar system and XR20-W rotary axis calibrator.

The sheer size and scale of cast machine-tool components presented significant restrictions for CMM solutions, while the inherent weaknesses of traditional measurement techniques risked limiting operational performance. In the past, we have measured and aligned our cast products using coordinate-measuring machinery, but the larger dimensions of cast parts were always a limiting factor and made it rather labor-intensive.

We would also use traditional errorchecking tools such as granite squares, dial gauges and autocollimators during the assembly process, but these were never efficient enough, and the measurement results were too inconsistent.

When we needed to measure the parallelism of some large cast parts, if the granite square and guide rail are a distance away, then the dial gauge needed to be extended to reach the granite, which would then cause any deviation result to amplify.

We set the task of identifying a more accurate machine tool alignment solution—one that's less time- and labor-intensive to set up and use and that could replace the traditional measurement methods.

Solution

Following extensive research and testing, I was interested in the XK10 and asked for an on-site demo, which was satisfactory. We chose to adopt Renishaw's XK10 alignment laser system for its effectiveness in 2019.

An all-in-one digital measurement solution suitable for a range of different CNC machine tools, the XK10 comprises a launch unit for primary laser transmission; wireless transmitter and receiver units; a portable display unit and a fixturing kit. An additional XK parallelism kit carries out parallelism measurements.

The XK10 is used on straightness and parallelism for linear guideway assembly and quality control at the production site.

The XK10's compact size, wireless connectivity and versatile fixturing means that it can be used in many different configurations, enabling detection and measurement of both geometric and rotational errors across all types and sizes of machine tool.

The display unit enables the operator to collect, analyze and record measurement data (Figure 3). It provides step-by-step instructions for each type of measurement, with intuitive graphics and real-time readings guiding the operator through each stage of the measurement process.

Unlike an autocollimator, which depends on the principle of converting angular measurements into linear measurements, the XK10 alignment laser system takes linear measurements directly, thereby removing the inherent conversion error. Importantly, breaking the XK10's laser beam during data capture does not require a complete restart, unlike with a laser interferometer solution.

Linear alignment

Figure 1: The alignment system can be applied to linear rails to ensure they are straight, square, flat, parallel and level, as well as to spindles and chucks to assess direction and coaxiality of rotary machines.

Made in Taiwan Figure 2: Hurco Manufacturing was established in Taiwan in 1999 and is today responsible for the manufacture and assembly of the complete range of Hurco machine tools.

Results

The XK10 alignment laser system succeeded in significantly reducing the amount of time we needed to implement high-accuracy machine tool alignment. After testing the XK10 system repeatedly, we found that it provided a solution that is genuinely capable of replacing traditional methods.

As a conservative estimate, I'd say that Renishaw's XK10 alignment laser system has at least doubled our overall measurement efficiency, and our evaluation process has proven that the measurement results tally precisely with those from high-precision coordinate measuring machines. With a generous measurement range of 30 m, the XK10 handles the requirements of many large machine tools. Negotiating the span between guide rails for parallelism measurements has become easy, removing the need for large granite squares and avoiding the deviation risk of hyper-extended dial gauges.

The XK10 has particularly impressed us in terms of the parallelism measurement between two measurement rails. Compared to autocollimators, setting up the XK10 for multiple rail measurements is much simpler. We align the laser unit and turn the laser beams through 90° with the XK paral-

The sheer size and scale of cast machine-tool components presented significant restrictions.

lelism kit. The system then automatically analyzes the data collected and provides us with measurements of the parallelism between the two rails. It couldn't be easier.

By replacing various sizes of granite squares, the XK10 has also solved the problem of limited storage space and logistics. Thanks to its portability and flexibility, it is easy to take to site, performing precision measurements in real time. It is used for machine tool assembly, calibration and maintenance, and by enabling better understanding of the status of each CNC machine, resources can be allocated more effectively.

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5 aspects of bottle-capping machinery

Trends to consider in equipment building, purchase and operation

by Alejandro Perez, Acasi Machinery

A BOTTLE-CAPPING MACHINE is used in industrial production lines to securely apply caps, lids or plugs to bottles and other containers. The type and design of the cap-tightener machine depend on the caps or lid it handles. As machines used in the production lines continue to get smarter, five aspects have impacted their control systems and automation.

1 Smaller but smarter architectural footprints: Smaller and smarter bottle cappers come with advanced features that replace less-efficient manual and semi-automatic capping machines. The previous generation of automatic capping machines was also bulky and expensive.

Automatic capping machines are lighter, cost-effective and more versatile. They can be adjusted easily to suit various bottle types and to cap at faster or slower speeds. The smaller architectural footprints also mean lower energy consumption and smaller real-estate needs.

Additionally, the control architecture is slowly shifting from PLCs to PC-controlled systems. This shift allows for faster communication and controls, plus it supports more customization, thanks to the many programming languages the PC controller can support.

2 Distributed motion control: In every production line, motion control is necessary to manage how products move from one point to the other. For the Gen 3 capping machines and newer models, motion can easily be distributed to individual devices. This wasn't the case a decade ago, where motion control was linear.

Some capping systems allow for synchronization with other machines. They communicate with them and can work in unison at a predetermined speed. Coupled with the automation, distributed motion control has made capping and packaging a seamless process.

3 Variable-speed operation: Not so long ago, the speed of production in the industrial sector was limited to a few predetermined levels. This has changed. With a simple push of a button, it's possible to change the speed at which a cap-

ping machine tightens or secures a cap onto a container. This versatility and convenience have been made possible, thanks to variable-speed drives.

Speed drives are devices used to control the torque, or force, and speed of an ac motor. By adjusting the motor's voltage and input frequency, it's possible to change how fast the capping work is done. These speed drives can be used in mechanical, electric, electronic or even hydraulic applications. Advancements in technology have further made this technology more convenient—for instance, boosting power factor and improving energy efficiency.

4 Clean-in-place technology: Capping machines designed to handle different bottle sizes and types should come fitted with clean-in-place (CIP) technology, which helps to sanitize the capping machine and avoid contamination. It's common in the food-processing and pharmaceutical-manufacturing industries.

CIP technology is fully automated to minimize human contact, which is considered the primary source of contamination. A bottle capper fitted with this technology will have the filling pipes, vessels and filters cleaned without disassembly. Besides preserving the integrity of the packaged products, CIP technology also saves time and increases productivity. When choosing a capping machine, always select one with CIP technology, which makes it cost-effective in the long run.

5 Packaging line automation: An automatic bottle-capping machine is not really efficient unless it integrates with other packaging machines in the production line. A fully automated packaging line allows for maximum production efficiency. Automation and control systems have made this level of innovation possible. Companies invest in one machine that fills, caps, and labels the bottles ready for packaging.

Alejandro Perez is design engineer at Acasi Machinery in Miami. He holds a bachelor's degree in mechanical engineering from University of Camagüey. Contact him at ac@acasi.com.

Connections make the mark

Cables, connectors and cordsets for smarter manufacturing

Single-phase power supplies

Puls has 15 models of 24 Vdc field power supplies (FIEPOS) for decentralized power on machine mounting and IP65/67 applica-

tions. The six single-phase 100-240 Vac units are in addition to the nine three-phase 380-480 Vac models previously released. These power supplies include Puls' reliability and efficiency standards. Flexibility in mounting options (DIN-rail or surface mount), connector styles and power range make FIEPOS adaptable for almost any application.

Puls / www.pulspower.us

Connectivity for hazardous locations

Mencom Hazardous Location Connectors series is designed to meet stringent electrical requirements for protection under

Class I, Div. 2 environments and certified by Underwriters' Laboratories (UL). Class I is defined as a hazardous location in which flammable gas or vapor may be present in sufficient quantities to be considered ignitable or explosive. Division 2 is defined as

an area that is not likely to contain dangerous concentrations of flammable substances in closed containers. These connectors are available for most Mencom circular series, such as MIN & PMIN Series, MIL-SPEC series, M23, M12, M8 and Networks. They are rated IP65 (minimum) to IP67 (IP69).

Mencom / www.mencom.com

Compact design

The Amphenol LTW M Series is designed typically for industrial process measurement and control and is also a solution for a compact design where the environmental protection and stable connection are required. Amphenol LTW M12 connectors comply with protection class IPX7-IPX9K and offer three to

28 contacts with a rated current of 0.5 A to 4 A, depending on the number of contacts, with the following available mating style: screw thread / push-pull. Allied Electronics & Automation / www.alliedelec.com

Tool-free cable entry

The next generation of split cable entry frames for the KT grommet system has a tool-free assembly, high cable density and easy routing of pre-terminated cables. The

split KEL-FA cable entry system from icotek is a compact system for routing and sealing cables with and without connectors, as well as hydraulic and pneumatic hoses. After the frame has been assembled with KT type grommets and cables, the cover lid is put on and the two clamping levers are locked with the lower part by pressing them down. A two-stage clamping lever is used. In a first stage, the components are brought together and the grommets are positioned precisely. The second stage ensures the optimal pressure and a secure locking. This eliminates the need to screw the cover lid to the frame. The twist-proof construction of the KEL-FA enables an intuitive assembly. The mounting height of the cable entry frames is 22 mm.

icotek / www.icotek.com

No special tools

Altech's CP series of DIN-rail terminal blocks features pushin technology for tool-less wiring of solid wires and flexible wires with ferrules. The CP Series features a terminal block of 3.5 mm wide. By increasing wiring density over wider blocks,

applications that are space-constrained become more viable. Other key capabilities of the CP Series include stainless steel push-in springs, no special tool needed for pushbutton release of

wires. A wide range of blocks are available to accommodate many designs and applications. These include blocks that are single level, feed-through, double level and multiple level. Block uses include grounding, sensor and actuator as well as marshaling and potential distribution.

Altech / www.altechcorp.com

product roundup

Bimed cable entry systems

BPA series split-frame and BRM series solid-frame cable entry systems and cable glands from Bimed provide safe installation into enclosures or electrical equipment, securing cables and

providing strain relief while maintaining enclosure sealing requirements. The BPA series cable entry system allows cables to be installed through an enclosure or other bulkhead surface without requiring disassembly of connectors from pre-made

or terminated cables and without compromising environmental protections. The BRM series allows for a high density of nonterminated cables to be installed through a small area of an enclosure or other bulkhead surface while maintaining environmental ratings.

AutomationDirect / www.automationdirect.com

Industrial distribution frame

The pre-configured industrial distribution frame (IDF) is 12 RU and is made for two 19-inch rack mount switches. The IDF

is engineered to deploy and protect 19-inch rack mount switches on the factory floor. The IDF protects switches, both physically and thermally in harsh industrial environments. The IDF includes keys, cage nut rails, one fiber tray, two patch panels, cable man-

agement, ground whips/bar/cable, DIN rail mounting provision and cable/fiber/power penetration recommendation template.

Panduit / www.panduit.com

Sensor-actuator cables

Pepperl+Fuchs' sensor-actuator cables with optimized M8 and M12 connectors are designed to provide maximum service life, particularly rugged design and simplified installation and maintenance. In addition to M8 and M12, the range of sensoractuator cables contains numerous other common thread-

ing types such as ½-inch, 7/8-inch, M9 or M23. Gas-proof and gold-plated crimp connections increase vibration resistance and durability. Vibration-resistant knurled nuts are designed to enable reliable connection and fast and easy tool assembly.

Pepperl+Fuchs / www.pepperl-fuchs.us

High-flex Ethernet cordsets

High-flex Ethernet cordsets from Phoenix Contact have increased longevity for use in industrial and robotic applications. These 600-Voltrated cables and cordsets have Power over Ethernet (PoE) capability and can be run safely next to power circuits. The

al

cables have higher flex ratings for use beyond static applications. They are rated for up to 20 million bend cycles for lateral flex (drag-chain applications) and 4.8 million bend cycles for torsional flex (robotic motion).

Phoenix Contact / www.phoenixcontact.com

Plug-Socket Cordsets

Misumi's cordsets offer cabling and connectors. The M12PS-A4A4VFGY-5 plug-socket cordset comes with a cutto-length electrical cable. The cabling is then paired with a coded M12, 4 pin, male, round connector that is over molded onto the cable to provide an en-

vironmental protection standard up to IP69K designed for use in the harshest of production environments.

Misumi / 800-681-7475 / www.misumi.com

Wire-splicing connector

Wago's 221 series inline wire splicing connector comes with intuitive orange levers for a tool-free wiring experience for solid, stranded and fine-stranded conductors from 12-20 AWG. It also allows universal conductor connection and a visibly secure

conductor contact. Whether with or without strain relief, the freedom of a highly modular and flexible connection is possible with a snap-in mounting foot, screw, adhesive, tie-on or suspended mounting and can be placed on a 15 mm or 35 mm DIN rail. Wago / www.wago.com

product roundup

M12 L-code cable assemblies

M12 Power L-code connectors are an extension of the current M12 IEC standard and have been selected by Profibus and Profinet International as the standard for 24-Volt power supply systems used in Profinet devices. An extension of TE's M12 product portfolio, M12 L-code cable assemblies handle up to 16 A per pin, highest in TE's M12 family, delivering four times the power of standard M12 connectors while providing reliable and efficient power supply. TE's M12 Power L-code connectors are IP67-rated, protected from dust and resist temporary submersion in water at depths of up to 1 meter for 30 minutes. The Lcoding version is designed for dc power supplies with 63 Vdc/16 A, where a high current and low voltage is required making ideal for Fieldbus Ethernet I/O boxes, Ethernet systems, network devices, motors and drives and valve applications.

Newark / www.newark.com

Connect Power Feed-in and Distribution Terminal Blocks

Weidmüller's Klippon Connect power feed-in and distribution terminal blocks WPD series is designed to allow for an easy and safe installation of aluminum and copper conductors on a

> small footprint. A power supply or monitoring connection can also be used as an option, and customers can use the power feed-in terminal blocks WPD regardless of the conductor material. The terminal blocks can be mounted either directly or on DIN rail TS35.

> > Digi-Key Electronics / www.digikey.com

Connectors for inline splicing

These 0229 series connectors provide pluggable connectivity between wires for inline splicing and from wires to PCBs. They have a compact design for installation in constrained spaces and are available in mating plug designs with various pin counts of up

to 40 poles. They are suitable for making high-density connections and I/O wiring connections to controllers. The standard configuration is for inline splicing, while other configurations allow affixing the connector to a surface with screw flanges, self-locking tabs or lock-and-release levers. Flange latch designs ensure user-friendly and reliable connector mating. The connectors work with wire sizes from 28 to 14 AWG solid or stranded conductor.

Dinkle / www.dinkle.com

LinkIQ Industrial Ethernet tester

The LinkIQ-IE Cable+Network Industrial Ethernet tester is designed to troubleshoot network cabling. By combining

the company's cable measurement technology and basic tests for Industrial Ethernet switches, LinkIQ-IE speeds and simplifies the discovery of network failures in a touchscreen

interface, akin to a smartphone. The LinkIQ-IE is based on a single-test approach that provides the appropriate measurements automatically based on what's at the other end of the cable. It features an RJ45-type connector and includes cabling and adapters simplifying connection to M12-D, M12-X and M8-D connectors used commonly in industrial applications.

Fluke Networks / 800-283-5853 / www.flukenetworks.com

Field-wireable sensor plugs

Mencom's MIN series size I field-wireable plugs provide easy plug-and-play connectivity for a range of applications that

require three to six contacts. They support 5- to 17-mm cables and are rated for 600 V at 8, 12, 15 or 18 amps. Choices include nickel-plated brass and stainless steel coupling nut materials, with a polyam-

ide body in a robust, field-ready design. All of the sensor plugs are IP67-rated.

Galco / 888-984-2372 / www.galco.com

Overmolded X-code cordsets

M12 overmolded X-code cordsets from TE Connectivity contain male straight and right-angle versions that transmit data at

rates up to 10 Gb/s according to IEC 61076-2-109. The Cat. 6A cable jackets vary among PVC, PUR and TPE, offering solutions to meet the needs of motion systems supporting both flexing and stationary industrial high-speed Ethernet requirements. TE Connectivity also offers overmolded M12 X-code to RJ45 cable assemblies, key components to an overall industrial Ethernet application and suitable for indoor or outdoor use. Digi-Key Electronics / www.digikey.com

Gel technology for multicable entry systems

The round Skintop Multi-M multicable entry system with metric connection thread accom-

modates many cables. Depending on the size, as many as 30 nonassembled cables and media hoses can be inserted into a housing without taking up too much space. The innovation is based on gel technology. The cables are pushed through the elastic gel insert and are held securely in place by the static friction on the cable insulation. Foreign bodies such as water cannot get through. The graduated cone

geometry of the individual entry points also enables the maximum clamping ranges to be increased with up to 4 mm variance per cable diameter.

Lapp / www.lappkabel.com

RJ45 cables with multiple jacket types

RJ45/RJ45 double-ended cables are available in multiple jacket types and a variety of colors. Options include PVC for high moisture resistance; PUR for resistance against abrasion, oil and ozone; and TPE for flexibility and resistance to aging in sunlight, UV and ozone. These cable jacket materials are used to improve the robustness and survivability of the machine-to-machine or device-to-device connections in the plant. The portfolio offers Ethernet in five colors—red, orange, green, royal blue and teal-to help maintenance and IT teams troubleshoot and diagnose network issues. The colored cables allow companies to create a reference for quick recognition of the connection type. Balluff / www.balluff.com

Cat. 6A M12 X-code jack

This M12 X-code field-installable jack is suitable for 10 Gbit/s Ethernet and especially for industrial applications because of its mechanical and electrical stability and robust housing. No special tools are required. When plugged in, it is resistant to dirt and humidity up to the IP67 standard. It is vibration-proof (IEC 61076-2-109) and shock-proof (IEC 61076-2-109) with a 360° shielding concept. Metz Connect USA / 732-389-1300 / www.metz-connect.com

control desig

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How encoders handle harsh environments

A CONTROL DESIGN reader writes: The operating environment for our machinery is rough on encoders—contaminants, moisture, vibration and temperature. I'm not sure if it's just the conditions, but it seems our encoders are failing at an abnormally high rate. The majority of failures occur between three and four years of use, but a few have been less than two years old. We regularly check the output voltage with a digital multimeter to make sure it matches the input, but are there other ways to verify an encoder's functioning properly? It's easy enough to diagnose shaft runout when the encoder overheats from bearing failure. How do we diagnose other failures? I've heard about bearingless encoders. Is that a viable option for environments like ours?

Answers

Encoder vs. resolver

I would start by reviewing the operating environment and determine if the encoders are appropriate for the application. Does it have the correct IP rating? What is the temperature rating of the encoder? What level of vibration will it be exposed to? You state the encoder is exposed to contaminants and moisture. If that is the case, you want an encoder with a minimum of an IP64 rating.

Temperature can be a bit trickier. Some encoders are only rated up to 60 °C, but you shouldn't have trouble finding one rated for up to an 85 °C operating environment. If the operating environment is above 85 °C, you will need to do your research to find an encoder that can manage such temperatures. You also need to address the bearing failure. Do you have shaft misalignment that could be better managed with a proper coupler? Does the encoder manufacturer use inferior bearings to save money? Remember not all encoders are manufactured to the same standards, and this is definitely a product where the phrase "you get what you pay for" certainly applies.

Just to switch it up a bit, you may want to consider a different technology, such as a resolver. The resolver removes the electronics from the sensor and puts the resolver decoder in the panel with the rest of your control. This will eliminate failures to the electronics caused by temperature, moisture and vibration. Resolvers are often used in applications where high temperature and/or high shock and vibration are unavoidable. You can get a resolver with a mechanical package, similar to your encoder, or you can go with a frameless, or bearingless, resolver, if you decide that is a better path for your installation.

> MATTHEW TELLIER product manager / Advanced Micro Controls / www.amci.com

Identify wear: oscilloscope and grease condition

A multimeter is helpful to check voltages, but the best way to ensure an encoder is functioning properly is to use a portable handheld oscilloscope that gives you the full signal picture and detailed information.

You can use also a simple quadrature counter with an adapted cable assembly to connect the encoder. Use the power supply provided by the counter and check if it matches according to the native resolution. For flying leads, just add some clamps on the wires to make the test easy.

To diagnose failures in general, lost pulses, phase shift or deviations on the duty cycles are indications of bearing block wear or dust pollution on the encoder's optical disk or sensing chip. Detection is possible with the counter, but, to be more accurate, an oscilloscope will be helpful.

This wear can be easily detected by slightly moving the encoder housing in different directions to see mechanical clearance. Wear is mostly correlated to a leakage current, wearing the ball bearings and drying the bearing lubricant, or due to a dust pollution of the lubricant. In both cases, the best approach is to remove the seals—radial seal and/or bearing shields—and quickly analyze if the grease contains a lot of particles, such as dark and dry paste, or if the viscosity is higher than expected.

Bearingless encoders are ideal for mostly clean environments with very limited permissible mounting misalignment. If you can properly protect the device, it's an interesting solution. Be cautious though, on synchronous or asynchronous heavy motors, the mounting on the rear flange can be very difficult. If you are considering magnetic encoder solutions, you also need to take care with all the metallic particles that could be accumulated on the ring, as they will affect the signal.

JEAN-MARC HUBSCH engineering manager, encoders and position sensors /

Sensata Technologies / www.sensata.com

Bearingless encoders

When encoder signals appear incorrect, the most common response is to assume the fault lies with the encoder. However, many issues can be the result of mechanical or environmental factors such as loose couplings, shorted wires or other system-related issues. Many of these issues can be corrected with a bit of troubleshooting. Start by viewing the signals on an oscilloscope, if possible. This is the best diagnostic tool to use for this application. Leave the wiring to the encoder untouched and connect to the readout device end. Be sure to swap the trigger from one channel to another, as it can provide important insight.

Bearingless encoders are often used in applications such as outdoor applications where contaminants, extreme temperatures, shock and vibration are present. Without bearings included in the encoder design, this also means there is one fewer item that can fail over time as a result of wear. Magnetic sensing technology is far less susceptible to dirt, grease or water impacting the quality of feedback, especially compared to a shaft encoder using optical sensing technology where these contaminants can impair the optical encoder's code disc.

DANIEL WEISS senior product manager / Newark / www.newark.com

Waveform/pulse rate

There are myriad issues that come with using encoders in any environment. I am not sure that your issues are coming from the wear components on the encoder, but there are several options for non-contact encoders from several brands. These will work in the harshest of conditions and often work better than traditional options in abrasive-dust and high-vibration applications.

To look at troubleshooting an encoder there are several issues to consider, and output voltage is likely the least important. If you are sending a pulse input to a PLC or panel meter, then the turn-on voltage is likely well below the nominal voltage of the encoder. The more likely problem is the waveform/ pulse rate from the device. Depending on the type of encoder you are using, the way a pulse is generated varies. A good way to check is by using an oscilloscope to see the interval between the pulses. You know the specifications of your encoder, allowing you to calculate if everything is on track or where things are going wrong. If are able to see pulses but at an incorrect rate, then start looking for mechanical issue like bearing slip.

MARK RUSSELL tech application support manager / Allied Electronics & Automation / www.alliedelec.com

Automation / www.alliedelec.com

Physical test and interface diagnostics

When evaluating a rotary encoder, there are certain physical tests and interface diagnostics to determine whether the device is still functional. The condition of the bearings can be checked by looking at the shaft runout. Monitoring input voltage can be difficult, as voltage spikes can occur when the device is operating and not being monitored. Especially with mobile equipment applications, it is important to know the temperature and voltage limits of the rotary encoder, as exceeding them can cause damage.

The device's interface can provide diagnostic capabilities depending on the application. IO-Link devices can display both the temperature of the device and the hours of operation. The number of revolutions per single full turn of the device can also be checked by marking the shaft and performing one full rotation. Then compare the number displayed with the count specified for the rotary encoder. Failure diagnostics also rely on good training of equipment operators. They must be able to relay the failure condition to effectively troubleshoot the device.

Bearing-free rotary encoders eliminate many physical condition failures where rotary encoders are subjected to strong vibration and/or high shaft loads. These devices tend to be better sealed, as they limit the number of moving components. The result is a less expensive, more durable device that is suitable for some extreme applications.

RON SCHLEBUSCH

central technical sales support, factory automation / **Pepperl+Fuchs** /www.pepperl-fuchs.com

Smart encoders

As you may already know, selecting the proper encoder based on the proper IP rating for the environment and application is vital to the longevity and efficiency of the encoder, and there are models with rugged, enhanced construction for use in the more demanding industrial environments. However, smart Ether-Net/IP-enabled encoders can deliver diagnostics and send notifications, which allow for more predictive maintenance, alerting you to issues before the encoder fails. Bearingless encoders are also an option but not necessary for your operating environment.

AAMNA JANGDA product marketing specialist / **Rockwell Automation** / www.rockwellautomation.com **Cil**

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HMIs create a window of opportunity

The most basic HMI is

the light switch.

HUMAN-MACHINE INTERFACES (HMIs) play an integral role in the manufacturing world that allows us as humans to interact with machines for a number of specific purposes. Whether we are utilizing a handheld control unit on a small deburring robot or an onboard CNC control on a multi–axis, multitasking machine tool, our ability to engage with a machine to carry out tasks is all dependent upon an HMI. Each of these machines, from robots to machining centers, has been developed, programmed and tested through some sort of an HMI. They remain and will

continue to remain a crucial factor in the age of the machine that we are in now and on into the future.

A number of developments have been made in the field of HMIs over the years. Early HMIs were basic and carried out simple, direct functions of a machine and introduced the

ability for a machine to carry out the wishes of an operator or engineer. The most basic HMI is the light switch. You want the room to be lit up and no longer dark, but making a lightbulb glow on command is difficult without the ability of the light switch to allow the electricity to flow. So, you flip the switch from off to on, and, just like that, the light is on in the room. You, the human, have conveyed your wishes to the machine the lightbulb—and now you have light.

The leap from basic switches and pushbutton controls that we have seen over the past few years has been greatly influenced by the advent of the Internet and the ability to collaboratively develop the technologies and next levels of HMIs in our industrial world. We went from basic single-purpose controls to fully interactive graphical open-sourced controls that are utilized in the most sophisticated systems in the world in just a few short years.

Even the term HMI is evolving into a newer term called "visualization." Not only the actual control itself but also the way we understand and utilize and converse about HMIs is changing. We are able now to have whole systems under the control of an HMI and visualize how we are interacting with our machines and system while we collect and leverage the data to further enhance the productivity or reliability of a given system. Our HMIs today not only look down on their own machines to display specific information about it, but also across to other machines to collaborate with them and even up to networks and computers to utilize the data and increase efficiencies and learnings that are useful in the development of our systems.

If we take the time to consider literally everything around us right now, the computer I am typing on, the pages you are reading, the glasses you may be looking through or the lunch you are eating or the desk you are sitting at, everything was at one point a part of a dynamic world of manufacturing. Machines helped us humans to create and develop our world. We

> are able to enjoy the benefits of the manufactured world around us that in some way or the other we were a part of. The machines that make it all happen, from space flight to a phone call, from the roads we drive on to the beds we sleep on, are a part of our developed world, and

almost all of them have had an HMI involved in the process.

The pace of the development of HMIs has been a bewildering race of technological advancements and software enhancement that have truly changed how business is conducted. The one constant we can reliably predict is change. Our industries are changing and evolving at a rapid pace, and it behooves us to invest in ourselves by learning how to utilize, to the best of our capability, the best practices and advancements that are now available in our particular fields.

It would seem unimaginable to me in my industry of CNC machining to see a customer who was unwilling to take on the newest technologies in the machining world. The ability, for example, to do live machine simulation on the machine control as the program is being written, will win out over unproven code every time. The competitive edge that is lost by refusing to learn the newest machine controls is a terrible waste of precious resources. Many folks have experienced great difficulties in hiring top talent for a variety of reasons. However, if we can buy the technologies available to us today that enhance the skill sets that we do have available, it seems like a practical thing and perhaps the only thing we can do to keep us ahead of the crowd.

Andy Watkins is direct sales manager at Romi Machine Tools in Erlanger, Kentucky. Contact him at andy@andywatkins.com.

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