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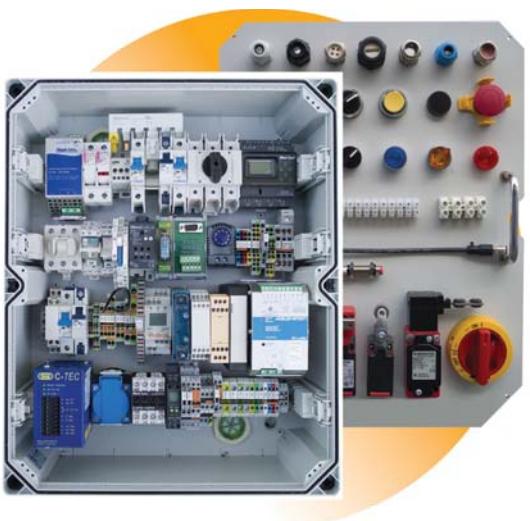
ABOUT ALTECH

Altech Corporation is an established United States supplier of components and devices used in industrial control, instrumentation, medical and automation applications. Altech provides a very broad line of products that meet UL and international standards and are RoHS and REACH compliant. Altech's commitment to continuous quality management has been recognized since 1999 when they were awarded ISO 9001 certification.

Altech provides a multitude of services for customers. This starts with its employees, where product managers provide technical support and partner with customers in design assistance, ensuring the best solution for the application. Next, an efficient customer service department ensures that customers are informed with complete order information. Depending on the product, the versatile assembly department provides manufacturing, value-added, or customization services to expedite delivery. Altech's marketing department has been highly recognized for its catalogs, advertising, and website designs, while the sales department motivates the sales organizations throughout North America, ensuring product information is current and complete.



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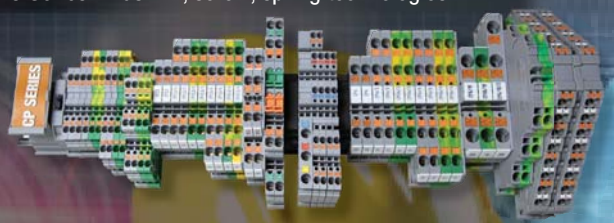

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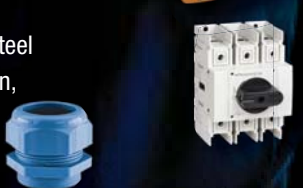

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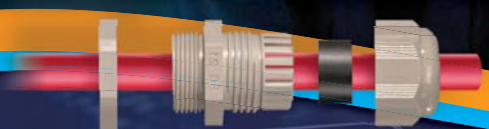

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FEATURES

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LOOK FOR ADS ON PAGES IFC, 1, 9-11

By Bob Vavra, Senior Content Director

Innovation is in the **Small Details**

THERE ARE A LOT of big ideas in manufacturing today. From artificial intelligence to robotic systems to new ways to collect, interpret and act on data, we are at the vanguard of seismic change in how we design, operate, maintain and optimize manufacturing plants.

As we stand on this precipice and gaze at the future, we see the vast possibilities. That's both necessary and appropriate. What gets missed as we look at the big future are the ways to apply all of these big ideas in smaller, measured ways. The barrier to implementation of big ideas is the notion that the execution has to be on a grand scale. As manufacturers around the world have shown, that's almost never the case.

This special Innovators issue certainly covers all the big ideas, but the real intersection of style and substance we want to discuss in these pages is the practical, nuanced ways those big ideas have been integrated by design and operation teams.

We have an article not just about connected workers, but how connecting workers improves training efforts. We see AI's influence on manufacturing as it relates to new ways to use data to create unseen insights—and improved operations. We look at the larger issue of how innovation itself can drive worker engagement—and create a longer-term impact of employee satisfaction and retention. And as we look to the future worker, we discuss new ways to interpret the STEM movement; in doing so, we increase the definition of STEM, and in the kind of workers we need to attract to manufacturing.

These all are macro-level ideas, but we look at them from an on-the-ground perspective. It is not, as we have discovered, how the big ideas drive manufacturing innovation. It is how those ideas are adapted, synthesized and reborn to meet the specific needs of individual manufacturers. Innovation is a beacon to the future, but the way that innovation ultimately has an impact is more like a flashlight that illuminates a specific area and brings that area into greater focus.

We don't innovate all at once. Innovation takes time. Above all, it takes attention to the small details. Get the small things right and the innovations will yield big benefits—particularly in this age of big ideas. ■

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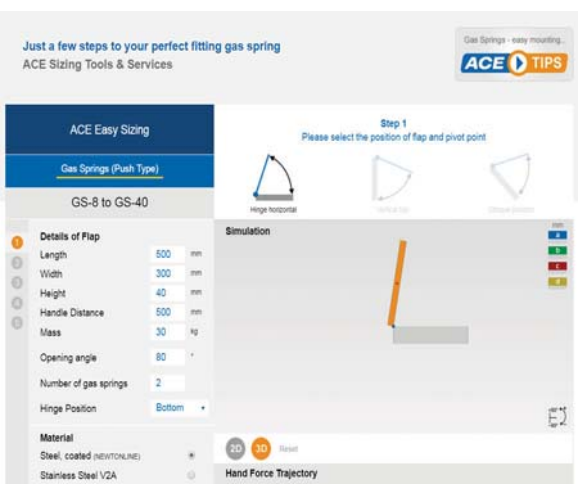

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Featured Video

Natural Language Conversation Assistants Cross Over from Vehicles to Industrial Machinery

iNAGO founder Ron Di Carlantonio is a Tokyo/Toronto-based computer scientist who is pitching intelligent assistant platforms for industrial environments.

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FAQ

Why Should You Incorporate Push-In Terminals in Your Next DIN Rail Application?

Interfacing different pieces of equipment in today's automation products means that design engineers must select terminal blocks that are more versatile and compact, and that offer higher densities.

DIN-Rail terminal blocks are used throughout multiple industries, integrating components within an individual machine to integrating multiple machines into a complete factory system. Both electrical and electronic devices are easily integrated using multi-use terminal blocks for a wide variety of industries, including aerospace, medical, oil & gas, automotive, semiconductor, packaging, transportation, power industry, and more.

What features should I consider when selecting a DIN-Rail terminal block?

Service life is the most important factor when selecting a DIN-Rail terminal block. Beyond that, engineers will want to consider ease and speed of installation, low maintenance capabilities, high efficiencies under multiple environmental conditions, and a high-density, compact design.

What are the basic types of DIN-Rail terminal blocks used today?

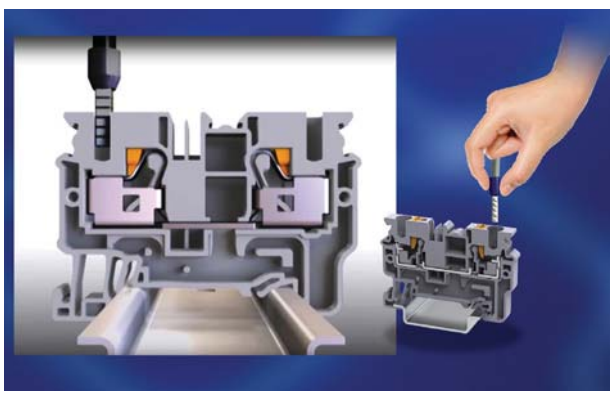
A variety of different DIN-Rail terminal blocks are available on the market. Some standard terminal blocks that have been available and incorporated for years include the screw type blocks. These devices have been used inside panels and junction boxes in factories and warehouses, and for distribution of electricity in homes and apartments.

These terminal blocks have been around for a long time and are highly dependent on human interaction due to the need for screw-tightening at various torque values. These terminal blocks also require the use of different handheld tools, and some provide a locking feature to guarantee connection and prevent screw loosening.

The spring clamp or cage clamp terminal block offers an interconnection that requires less human interaction. These devices need a standard tool, such as a screwdriver, to open the spring, but specific torques are not required. A preloaded spring is used to keep the wire safely in place. Solid or stranded wire can be used to create a secure connection in less time than using a screw type terminal. Since these terminals have a natural resistance to shock and vibration, they are often used in applications such as automotive, elevators, and machine tools.

How are push-in DIN-Rail terminal blocks different than other types on the market?

The most important aspect is that no tools are required to secure a wire into a push-in terminal block. This aspect alone saves time on installation and maintenance endeavors. Due to advancements in materials and the changes in users' needs, push-in terminals can offer additional benefits as well.



How do push-in DIN-Rail terminal blocks operate?

Users can simply push solid wires or stranded wires with ferrules directly into the terminal block for the fastest and most reliable connectivity on the market today (see Figure 1). With minimal human interaction, these terminal blocks are ideal for use with automated and robotic wiring operations. This benefit alone has OEMs switching from established technologies to push-in technology.

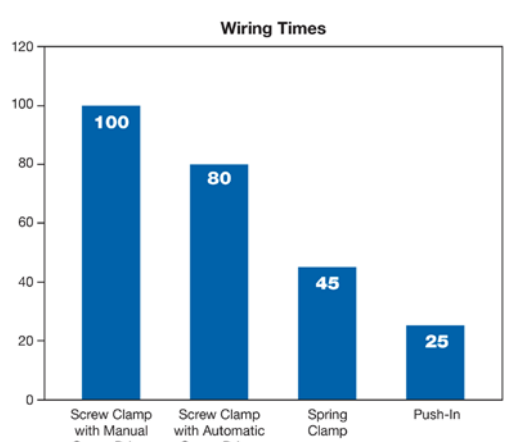


Figure 1: This chart illustrates the time savings gained from using push-in terminals compared with other types.

Do I have to worry about shock and vibration more if I incorporate push-in technology?

Not at all. In fact, switching to push-in technology also provides safety and reliability due to the terminal blocks' large pull-out force that is required to remove a wire once it's in place (see Figure 2).

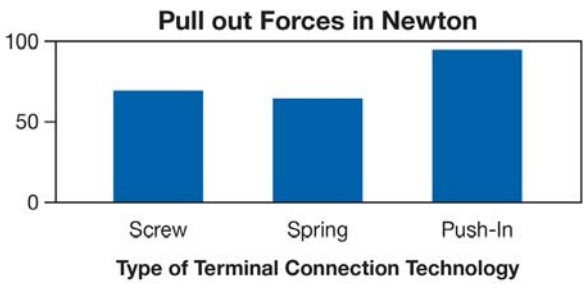


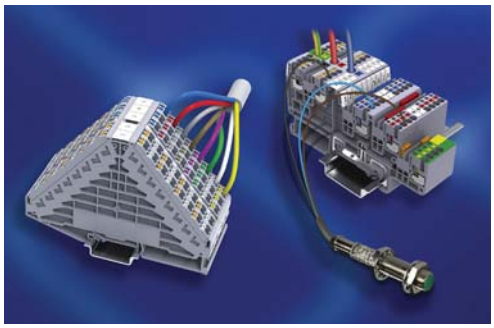
Figure 2: Pull-out forces for push-in terminal blocks are greater than that of screw or spring type terminal blocks, making them highly reliable for low maintenance and long-life applications.

How can end users benefit from push-in technology?

The key benefit gained while using push-in terminal block technology for end users is how well it streamlines the installation process for interconnecting all types of devices, including sensors, I/O, and DCS systems for process and automation control. Push-in terminals have minimum insertion force requirements — even to connect small wire sizes. The terminal blocks are designed to withstand harsh environmental conditions as those found in marine applications as well as chemical plants due to the use of non-ferrous metals in the connection components.

Are push-in DIN-Rail terminal blocks available for high-density designs?

The unique design of these terminal blocks allows them to be thinner than standard terminal blocks, even with a 600V capacity. Size reduction has allowed for 33% more wire density without compromising voltage stress, pollution degree, or surge voltage. For example, a compact 3.5mm wide terminal block thickness allows a 14AWG (1.5 sq mm) wire to be connected. In addition, specially designed terminal blocks are available for specific applications such as those on the following page.



This photo shows specially designed terminal blocks, such as the sensor and actuator terminal block and the marshalling terminal block.

What other benefits might I want to know about when considering push-in DIN-Rail terminal blocks?

Push-in terminal blocks offer independent rows for the insertion of jumpers for shorting different types of terminal blocks without using external jumper wires. Markers can also be attached easily for identification purposes. These markers are visible from any angle inside a panel or enclosure for quick recognition. Push-in DIN-Rail terminal blocks also come in seven different colors for global electrical system use.

Are push-in DIN-Rail terminal blocks available in a variety of versions?

Push-in terminal blocks purchased through Altech are available in single-level, double-level, and multi-level versions, all of which have grounding versions as well as fused terminal blocks for several fuse types and sizes. Also, special sensor and actuator, knife disconnect, and marshalling terminal blocks, plus a wide variety of accessories are available.

The Rise of the **Sustainability Engineer**

As a sustainability engineer, Iana Aranda is tasked with bolstering sustainability efforts by preparing the engineering workforce for social entrepreneurship and cross-sector partnerships.

by Rehana Begg, Editor-in-Chief

E4C Fellow Benson Maina leads user research with farmers in Kenya, 2019. *Images courtesy E4C*

WITH DEMAND FOR sustainability and engineering executives on the rise, Iana Aranda fits the profile of a woman forging change.

The senior director of Engineering for Sustainable Development at the American Society of Mechanical Engineers (ASME), Aranda harnesses her mechanical engineering background to support global sustainable development by leading a team that operates at the intersection of engineering and sustainable development. She leans in to ASME's climate strategy and what the association is doing to advance solutions to the climate crisis.

Iana Aranda, senior director, Engineering Global Development, ASME (The American Society of Mechanical Engineers) *ASME*

"I manage a portfolio of programs and platforms that advance the Sustainable Development Goals as envisaged by the United Nations," Aranda said. "In terms of practical application, we specifically [leverage] the engineering skill set and expertise to direct a diverse global workforce towards how they can participate, how they can contribute. We are really architecting new initiatives, new programs, developing the opportunities for these engineers to participate and get skilled in and how to contribute."

Sustainability Engineers are Up and Coming

The market pull for sustainable engineering roles is on the rise, confirmed Aranda. ASME hosted a stakeholder summit early in 2022 to probe this demand and to consider the intersections of sustainability in engineering.

"There are market forces that are already pushing this forward—namely environmental, social and governance, or ESG—factors that investors are considering," Aranda said. These factors are creating a shift in culture, as well as "a pull for reporting, for understanding activities, particularly of corporations related to sustainability, which ultimately trickles down to the entire workforce and engineers," she said.

The demand for sustainability in engineering solutions, Aranda pointed out, is further related to President Biden's Bipartisan Infrastructure Deal and the measure of investment being made in climate action and technology associated with advancing climate action. Given the engineers' critical role in developing solutions, products and services associated with technological advancement and the bottom line for many of these corporations, a move in this direction requires attention.

The shift has also been observed in academia, where students—the incoming engineering workforce—are interested in having meaningful and purpose-driven work. "They want to do this as their paid job, which is entirely sensible," Aranda

said. "They want to be rewarded for their time and talent and then, of course, we're also seeing this from the perspective of regulatory agencies."

The Design Engineer

Aranda has come a long way from her days as junior design engineer role in 2001, when she designed hardware and manufacturing specifications for electronic and optical systems using Solid Edge (Siemens) solid modeling software, or the time she was hands-on with SolidWorks (Dassault Systèmes) modeling software to provide engineering design and development of optomechanical, electromechanical and in-vivo imaging hardware for biomedical research facilities.

These days her daily routine is as likely to revolve around budgeting as it is to meeting with global collaborators to dissect the relevance of design for manufacturability methodologies in low-resource settings, such as sub-Saharan Africa, where taking work away from the economy will likely have negative implications.

For those who must know, her refined methodology when working with ventures in low-resource settings with limited access to advanced manufacturing and limited engineering resources includes location-specific questions, such as: How do you ensure that you design for manufacturability? How do you identify the right manufacturer in sub-Saharan Africa?

"To ensure that you are manufacturing products cost-effectively, you are likely going outside of the continent," Aranda said.

At stake are the short- and long-term implications for local communities. Aranda outlines the thought process: "Building out a [manufacturing] methodology that allows us to ask the right questions, to really pinpoint those issues, those hurdles, and then start to consider where might there be workarounds, or

Artisal gold mining in the Amazon.

processes, or ways for them to partner, or even approaches that may be transferred from elsewhere that they can leverage for the benefit of their venture."

Building on Success

The success Aranda brings to her current role is palpable, but represents a mere sliver of her career accomplishments and victories along the way. She led the development of Engineering for Change (E4C) on behalf of its co-founders ASME and other leading engineering societies. The digital platform educates and activates the international technical workforce by providing resources and access to expertise to accelerate the development of solutions and infuse engineering into sustainable development. E4C today services more than 1 million engineers, scientists and technologists around the globe.

Aranda is also the mastermind behind a highly competitive E4C fellowship of 200 fellows per year. The program enabled her to promote diversity and empower engineers early in their careers, as well as to establish an operational model and programs.

The E4C platform works by exposing engineers to critical issues across sectors (including water, sanitation, energy and health), offering training through online programs and by supporting organizations with their sustainability goals. "For instance, we augment their workforce with our subject matter experts, our fellows, staff and partners," Aranda explained.

In one impact services project, Conservation X Labs, the work focuses on preventing the sixth mass extinction. Working with USAID, the program aims to address negative social and environmental impacts in artisanal small-scale mining in the Amazon region.

"Artisanal miners are flying under the radar of regulatory agencies, often trying to extract gold throughout the Amazon region," Aranda said. "This requires using methods to extract gold that [are] incredibly detrimental to the environment, local and indigenous communities. And that includes using mercury to bind gold flecks, for example. This has demonstrated to be absolutely devastating to that region."

E4C Impact Project, Sanergy 2022.

CXL was tasked with sourcing technological innovators to deliver solutions that address the crisis. The team developed an accelerator, the Amazon CoLab, as part of their advancement model, which provides technical guidance and mentoring to business leaders, as well as guidance on how to scale innovations further and enter the market.

E4C's experience with social entrepreneurship and supporting innovators around the globe was instrumental in helping support Amazon CoLab by connecting their cohorts to "the right people, right networks," and by helping them think through their scaling strategies in order to get them on the track to succeed.

Grassroots to Greatness

Aranda credits her success only partly to being prepared to put out ideas and watch them grow. She said none of the milestones in her career could have been achieved without her mentors and the staff she worked with and who mirrored the desire she had to practice engineering differently. "It started with my first boss, who took a bet on me and allowed me a lot of responsibility; she allowed me to work with her and believed in me," she said.

Being at the grassroots level of an initiative that has grown to be massive and to rise to the forefront of the field has its rewards. "It's been truly incredible to see how E4C, for example, has grown from an idea in 2009 to a platform that encompasses more than a million people around the world," Aranda said. "I've had more than 200 fellows and worked with an incredible array of partners. We've had true opportunity to effect change."

Most recently, she helped to assemble a strategic advisory group, ASME's Committee on Sustainability, which she now facilitates. Aranda will also attend COP28 on behalf of ASME.

Still, the path to success is not always smooth. "When you are in uncharted territory, you have to make your own plan," said Aranda. "Some things work and some things don't. In the unknown, you have to be comfortable in discomfort." ■

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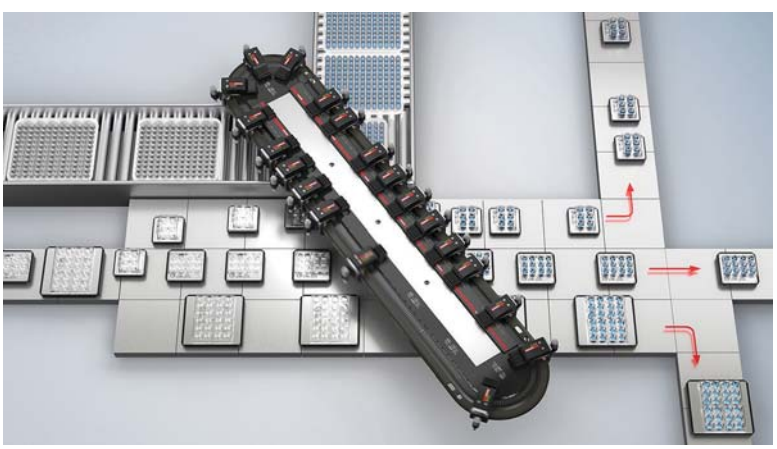

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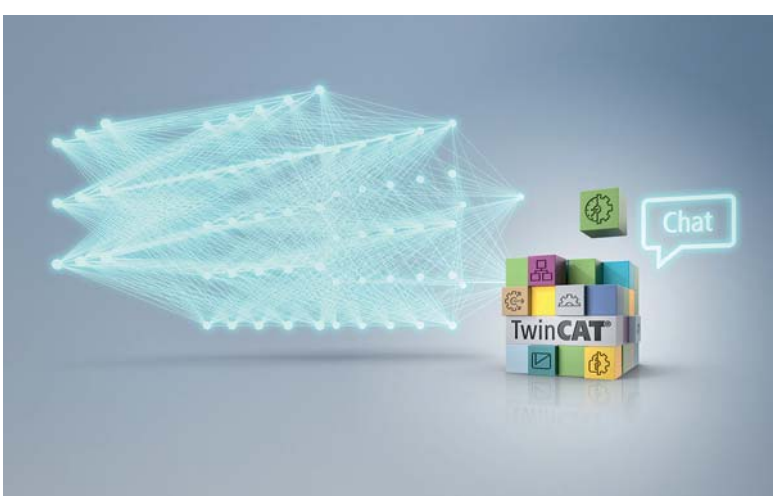

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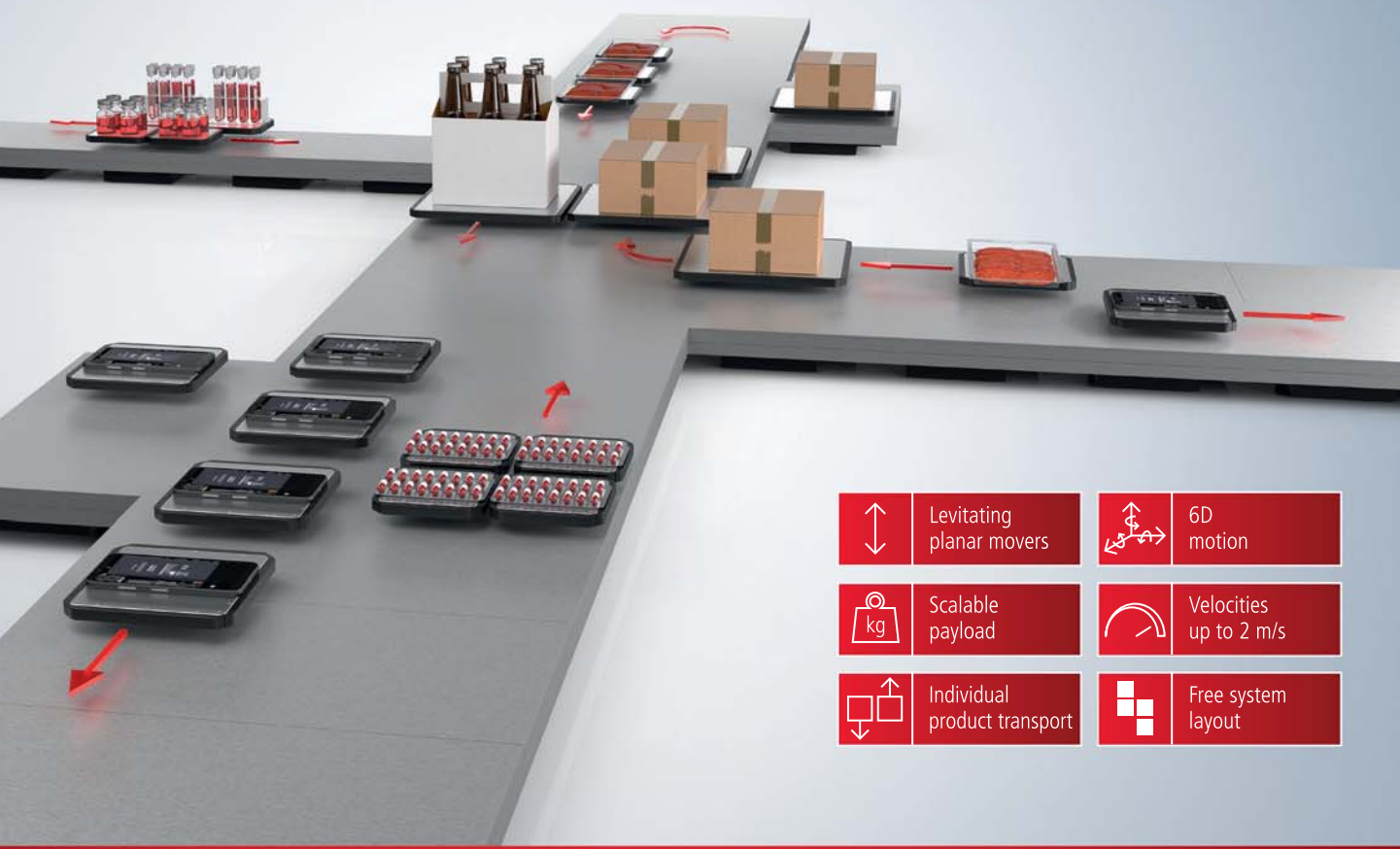

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Nurturing Innovation Can Lead to Employee Longevity

by **Sharon Spielman**, Technical Editor

According to *Machine Design's* 2023 Salary Survey, only 14% of companies have managed to retain their workforce for at least 25 years. Fabco-Air Inc., a member of Festo Group in Gainesville, Fla., is one of them. *Sharon Spielman*

In an ever-changing business landscape, where employee turnover rates are high, how can manufacturers retain their workforces and fuel innovation?

ACCORDING TO U.S. BUREAU OF Labor Statistics, more than 50 million people quit their jobs in 2022, and the turnover rate in the manufacturing sector is roughly 39%.

Machine Design's 2023 Salary Survey reveals that 41.7% of companies plan to increase the number of engineering jobs; 14% of respondents this year have worked at their company for at least 25 years, and 36% have worked at their current company for less than four years; but 46% of respondents have worked in engineering for at least 25 years, and 16% have worked in engineering for less than four years.

There are struggles to fill and retain manufacturing positions today, and the longevity of most people in engineering needs to improve. According to the Society for Human Resource Management, the cost to replace an employee can range from 50% to 400% of their annual salary, depending on the position. And because manufacturing facilities usually require specialized skills and knowledge, training costs can be significant.

Whatever the reason—from the skills gap to the changing perception of manufacturing to an aging workforce to global competition and outsourcing—the manufacturing sector will require effort from its stakeholders to address the challenges associated with employee longevity.

On the heels of a post-pandemic Great Resignation, however, certain companies have managed to cultivate a culture that not only retains their workforce but fuels continuous innovation. Among the 14% of companies that have managed to retain their workforce for at least 25 years is Fabco-Air Inc., a member of Festo Group based in Gainesville, Fla.

The pneumatic components maker has helped its customers build machines for more than 60 years thanks to its commitment to foster employee creativity, leverage new technologies and embrace calculated risks. The company was acquired by the German family-owned Festo in 2018 to supplement its metric product line with Imperial English inch products, according to Kevin Cradduck, director of operations at Fabco-Air.

A visit to the facility revealed that employee longevity can be found across all departments. Cradduck says the average tenure is 25 years and succession is balanced with experienced and entry-level employees. Manufacturing Technical Specialist Chris Kazimier is just one of the long-time employees (34 years), and he offered insight into the factors that contribute to at least one company's sustained success and employee longevity.

Culture of Innovation, Experimentation

According to Kazimier, at Fabco-Air, innovation is not confined to the boardroom but rather permeates every level of the organization. Employees are motivated and empowered to share their ideas for process improvement.

Chris Kazimier, a 34-year Fabco-Air employee, let *Machine Design* in on the factors that he said contribute to at least one company's sustained success and employee longevity. *Courtesy Fabco-Air Inc.*

How a Fabco-Air Technician Helped His Daughter Become a Doctor

MAHDI KARIM *(pictured below)* is a secondary operations technician at Fabco-Air. He has been working there for 38 years, and he used his income to support his daughter's education. "She wanted to be a registered nurse, and I never wanted to go to college," Karim told *Machine Design*. "I also didn't want her to have a mountain of debt when she finished school, so I was able to use the money [I earned at Fabco] to finance [my daughter] up through school," he said.

His daughter, Bridget, wanted to be a registered nurse (RN), and Karim paid for her nursing college. He also encouraged her to pursue higher degrees and become a nurse practitioner (NP) and then a medical doctor (MD). He shared a story of how a note from an NP inspired Bridget to continue her studies.

"I kept nudging at her to go higher…as dads do," Karim said. After a jaunt in the hospital led him to ask a nurse practitioner what it was like to be a nurse practitioner versus a registered nurse, Karim said, "She said, 'The view is so much better up at the top. You stay in the nice hotels in the big suites.'"

Karim wanted this for his daughter, so he asked that NP to help him plant a seed by writing a note to her. She obliged: "'Dear Bridget, the view is so much better from up here as a nurse practitioner. I look forward to having lunch with you one day,' she wrote. And that did it. The seed was planted," Karim said.

Bridget went on to become an NP, and Karim kept working at Fabco-Air to pay the tuition. He saw the potential in his daughter and encouraged her to keep going to become a doctor. He kept working and his daughter kept learning, and today she is an MD.

Karim is proud of his daughter's achievements and his role in helping her reach her goals.

"From the onset of my employment at Fabco-Air, everyone from the floor-level management to the president of the company has always encouraged the people operating the equipment to put forward new ideas to improve the way a job/task is processed," Kazimier said. There is encouragement for employees' perspectives, and this allows them to think outside the box.

"Upper management has always had an open door policy and pools the ideas of many employees before making critical decisions regarding new technology to the production schedules we keep," Kazimier added.

When asked for an example of how this company encourages employees to experiment with new ideas and take calculated risks to drive innovation, Kazimier talked about the purchase of its first multi-axis CNC machine in 2007.

"This machine took a process that required five steps and five different people down to two," he said. "It was through the collaboration of multiple shop floor employees to work together and develop the strategy for this machine's success—everything from the placement of the tools and why, to the types of tooling used, trials of many different vendors to find tooling that would last through an unattended shift of operations. This was all done with the teamwork from top management to shop floor foremen and machine operators."

Keys to Establishing Employee Longevity

Company longevity and employee longevity can be correlated. One factor that has contributed to this company's longevity, according to Kazimier, is the commitment to customer support. A company's approach to staying ahead in the market starts by listening to its

Russel Ramkumar has been a machinist for 29 years, nearly the last decade of which he has spent as a master CNC machinist at Fabco-Air. *Sharon Spielman*

Dan Peck joined Fabco-Air in 1993 as a tool and die maker. Today, he is one of the company's custom tool makers and trainers as well as a senior CNC setup/programmer/operator. *Sharon Spielman*

As a newer employee, Wendy Audas, senior CNC setup/programmer/operator, came on board in 2021 and is a beneficiary of long-term Fabco employees' experience. *Sharon Spielman*

customers, he said. "The Fabco sales team has always paid strict attention to the customer's needs and challenged our engineering team to make it happen."

He adds that "the support we provide our customers and always being willing to go above and beyond" has contributed to sustained success and reputation in the industry.

With 46% of respondents to *Machine Design*'s Salary Survey having worked in engineering for at least 25 years, there is much knowledge to be passed along. To drive innovation further and preserve institutional knowledge, Fabco-Air has found success with leveraging the expertise of its long-term employees. By developing standard operating procedures and digitalizing various processes, the company ensures that valuable knowledge is shared.

Seasoned employees, like Kazimier, play an instrumental role in mentoring new hires and transferring critical skills. "For the past five years, Fabco has been using the development of S.O.P. to digitalize specific processes and tasks," he said. "I have personally been working this past year with multiple new hires at the controls of the equipment, teaching the use of G-code and how to set up machines from beginning to final product."

During his tenure, Kazimier has seen a transition and transformation from manual machines to being able to run lights out. "When I started working at Fabco in 1990, the whole shop was filled with manual machinery that required a person or more to process any job. I've watched Fabco embrace the CNC technology and continually drive out waste from the company, making Fabco a world-class company," he said.

For more than three decades, Kazimier, along with dozens of his colleagues, have chosen to stay with Fabco-Air. This loyalty appears to stem from the company's people and culture. The stability and strong relationships formed at Fabco-Air have enriched Kazimier's personal and professional life.

"Fabco has been my workplace for all these years because of the great group of people and knowing the grass isn't always greener on the other side," he said. "I have been offered many opportunities during my tenure here, and I feel it's been a good decision. It has provided me with a stable home life and relationships that I hold dear."

For more than three decades, Kazimier, along with dozens of his colleagues, have chosen to stay with Fabco-Air. This loyalty appears to stem from the company's people and culture.

Motivated and empowered employees can lead to continuity and stability, reducing high turnover that disrupts workflow, increases training costs and creates an overall negative work environment. Long-term experienced employees, on the other hand, can provide mentorship and guidance, contributing to overall team cohesion, performance and higher retention stats. ■

Courtesy Stephanie Holko

Survey of Engineers: Pushing Roles to the Edge of Possibility

A thought leader on advanced manufacturing and professional engineers analyzes research on what drives attrition in engineering and answers the question of applicable skills.

by Rehana Begg, Editor-in-Chief

WHEN *MACHINE DESIGN* INVITED Stephanie Holko, director of project development at NGen Canada, a nonprofit innovation cluster focused on advanced manufacturing, to discuss a recent survey of engineers conducted by the Ontario Society of Professional Engineers (OSPE), we learned that the findings suggest a profession that is moving toward more equality and equal representation for women and men. However, an analysis further revealed that systemic barriers limit women's participation and slow the transition. In fact, some talented engineering professionals are driven away from the field to seek out adjacent lines of work.

Holko, a licensed professional engineer based in Ontario, is also the president and chair of the Board at OSPE. Holko brought 17 years of experience to these roles, having worked as a process engineer and engineering manager, leading teams and projects in the steel industry. She holds a Bachelor of Applied Science in chemical engineering from the University of Waterloo and an MBA specializing in the management of innovation and new technology from McMaster University.

Holko's twin roles—at OSPE and NGEN Canada—uniquely positions her to tackle an analysis of current trends in the engineering profession. "NGEN Canada, or next generation Canada, was founded on the principle that digital transformation and advanced manufacturing will enrich the lives of Canadians delivering better products and good jobs while generating economic growth, which is essential to our better future," Holko said. "It aligns very well with my own beliefs in my role as director of project development. We currently have an open call for projects in the zero-emission vehicle supply chain

Stephanie Holko on Protecting Psychological Safety in the Workplace

"I look at this from two lenses. If you're management or a senior leader, there are certain things that need to be in place. And then, as an individual, how do you protect yourself? One is for management and leadership to foster a culture of psychological safety; encourage collaboration and support, establish clear and realistic deadlines and workload expectations, and allow people to make mistakes…Psychological well-being is just a no-brainer, but very difficult to do by accident. Be intentional.

And for the individual, cut yourself some slack. If there's a day where you only have 60% to give, don't beat yourself up for giving that 60%. That's everything you had to give. And, you're not alone. So, find your people. If they're not at your work, then they're going to be elsewhere in your network. Find your mentor if you don't know how to approach a particular situation. I have used Google from time to time. See how to manage something or how to approach a tricky email or tricky conversation. You're not alone…reach out."

and upcoming funding in quantum technologies and industrial decarbonization. So very topical, very exciting work that I get to do at NGen."

In the abridged Q&A that follows below, Holko discusses how the benchmarking report, *Ontario's Engineering Community and Transition*, is used to define the shape and scale of change of the engineering pipeline.

Machine Design: **Can you give us a snapshot of human resources in the engineering landscape? Who is coming, who is leaving? What is happening around you?**

Stephanie Holko: With OSPE, one of their primary pillars of advocacy is equity, diversity, inclusion and accessibility (EDIA). OSPE believes—and I as well—that EDIA, and the lack of, is a major contributor to the success of individuals in STEM. So, I want to preface the comments about who is in the profession and what's happening there with that lens.

OSPE's report was published in late 2022. Of the 821 engineers and engineering graduates surveyed for the research, roughly half were over the age of 50 and only a quarter under the age of 35. You can see that there's a demographic shift in industry, and it's happening in the engineering community as well.

Of those respondents, 78% were men and they were mostly educated in Canada. The survey results indicated that 29% of employed engineers and engineering graduates were between 50 and 64. So not too far from retirement. Established engineers and engineering graduates, typically older and more often male, expressed greater positivity towards the profession.

The report also looked at the opinions and perspective of the different groups that were interviewed. Gender-diverse, younger and internationally trained engineering graduates were positive, but expressed noticeably more hesitation and uncertainty on key questions about engineering reputation in society and their own career opportunities.

One-third of all engineers and engineering graduates, predominantly from those latter groups, reported that the profession might be falling out of step with modern society. And certainly, that's a concern. And there was a reduced emphasis on core engineering disciplines, which makes sense because we've seen a lot of change in society over the last three years, but also over the last few decades. Certainly, since I graduated.

Fewer than half of engineers and engineering graduates believed that the schooling was affordable, that gender representation and other metrics of EDIA in the profession are sufficient and that wage standards are equitably applied. There's definitely some work to do there about how folks are seeing the profession showing up and OSPE is looking to address these gaps.

EDIA is one of OSPE's core pillars and advocacy is one way of interfacing with government bodies, regulators and other stakeholders to advocate for good practices and to promote EDIA in engineering. When OSPE conducts research, they're looking to conduct research with that lens so that they have more to offer.

"Fewer than half of engineers and engineering graduates believed that the schooling was affordable, that gender representation and other metrics of EDIA in the profession are sufficient and that wage standards are equitably applied.

MD: **You've alluded to the idea that core disciplines are shifting. These findings, with respect to an interdisciplinary shift, resonate across North America. We've seen it in other research as well, where there is greater demand for soft skills—for example, communication skills—certifications, use of emerging technology and emphasis on applied knowledge. Can you weigh in on what the in-demand skills are as you see it?**

What, in your estimation, does the industry get wrong?

SH: Classical engineering is always going to be required; it's always important to a functioning society. We always need bridges and roads and water treatment and buildings and those types of things. And from a technical perspective, those things don't shift. When you look at can we recycle, can we renew, are there heritage buildings that we can reuse...those types of trends shift the field of practice to align with societal trends. But the fundamental principles, I would say, don't particularly change. They may upgrade.

What's emerging as a cross-disciplinary focus that I see across the board, including skilled trades, and not just within technical disciplines, is being able to translate ideas into a business context, or even sales, when you're trying to express your ideas or move a project forward. By-and-large, the essential skills that are coming out are being able to find the right and correct information. It's no longer about going to an encyclopedia. There's so much information, and it is on the engineer to find the right information and then test it to make sure that it's correct. We need to understand new technologies and how those technologies impact society.

And then, regardless, essential leadership skills of empathy, collaboration, influence and communication will never go out of style and will become more and more important as we rely more on technology. It's an increasingly noisy and complex world, and someone who has a very strong technical background but can also communicate in a business context is going to do really well going forward.

MD: **Let's pick on women and underrepresented groups within the study. The research in that study shows that women feel less welcome in the profession. What did they cite as the barriers and what are the biggest challenges?**

SH: This is a tough question; it speaks to a leaky pipeline. And…was so frustrating to me, because these folks had self-selected into technical fields and then they leave due to a variety of factors—not because the work is difficult or they're not capable, but they could feel unwelcome. The attrition that we're looking at in STEM roles and engineering roles could occur due to job dissatisfaction, inadequate support or a lack of belonging.

> *"The top challenges survey respondents face as women engineers include fewer opportunities for field work than colleagues (23%). And then feeling disrespected and undervalued by managers or coworkers (>20%). That's definitely something to dig deep.*

There's a lot of implications that come from that. So now you're not only losing that talent and knowledge, but also a different perspective. A lot of the world is designed for a very typical male. Whether you look at car safety or truck settings or the way that building systems are created, they were created based on the 1950s model of a particular type of individual, and then everything else was deemed separate from that standard.

And that's not going to serve the people you need to serve if that continues to be your benchmark. So, understanding the causes of attrition means that you can get those diverse voices back at the table because you can launch those initiatives to address those issues. It benefits individuals, it benefits companies and it's going to benefit society as a whole.

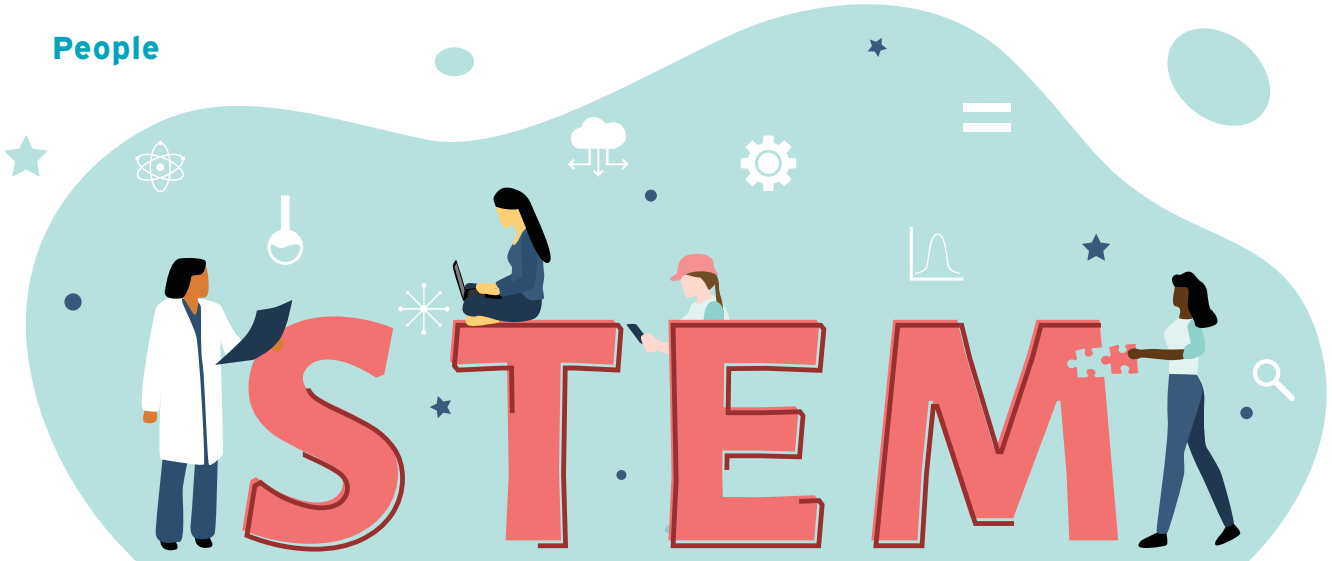
A little bit older research: In February 2015, OSPE conducted a needs assessment survey of over 1,500 respondents. In that study, 97% of female respondents thought mentorship was important when starting an engineering career after graduation. Mentorship programs are not new and, certainly, I don't think difficult to implement. You just have to do it with intention.

Two-thirds of the respondents agree that mentoring improves women's career prospects and retention in the engineering profession. So that's very important. Lack of confidence is common in the workplace—particularly among women—leading to dissatisfaction, often mental health issues due to work. So, OSPE found that women in engineering struggled to foster the credibility that is afforded to their male colleagues.

And, I will say that there have been times where I've maintained my professional licensure because it gives me that credibility when I walk into a room. That's a personal anecdote, but you can see that it translates in the research as well.

The top challenges survey respondents face as women engineers include fewer opportunities for field work than colleagues (23%). And then feeling disrespected and undervalued by managers or coworkers (>20%). That's definitely something to dig deep.

If you're leading a team or you're running a business, you need to dig deep and maybe consider some of the other factors that are affecting your workforce. And I want to say it's not just women. There are people of all genders that would feel those things as well. ■



Changemakers:

Expanding our Understanding of the STEM Field

Lifting up some of the amazing women who shared their expertise in *Machine Design's* WISE (Workers in Science & Engineering) series in 2023.

by Rehana Begg, Editor-in-Chief

NOTHING MAKES A GOAL seem more achievable than seeing others have done it—and that they want to help you to succeed as well. Yet, women continue to be underrepresented in science, technology, engineering and math (STEM).

Over time, the gender imbalance has been shown to be a reflection of underlying issues rooted in bias and discrimination that have resulted in far-reaching consequences on the personal, economic and future well-being of communities and the industries they serve.

Women remain underrepresented in engineering (15%), computer (25%) and physical science (40%) occupations, according to Pew Research Center. In cutting edge fields such as artificial intelligence, only one in five professionals (22%) is a woman.

Another study investigated the importance of exposure to innovation and estimated that if girls had the same number of women inventor role models as boys have of male inventors, the gender gap in innovation could be cut in half. Might that suggest that without intervention and active discussion, the industry will continue to perpetuate the same biases that reinforce stereotypes?

An important aspect of drawing more women to STEM roles is letting them know that they belong. *Machine Design*'s Workers in Science & Engineering (WISE) hub is grounded in covering workplace issues affecting equity-seeking groups. The coverage reinforces a commitment to help the industry create a more equitable landscape for current and future generations.

Greater scrutiny of the data will show why representation and intersectionality matters, pointed out the Society of Women Engineers' (SWE) associate director of research, Roberta Rincon. "We are a gender equity organization, but there are other identities that we want to acknowledge, and part of that acknowledgment is looking at the data," she said.

Rincon highlighted during a virtual roundtable that organizations that are serious about their DEI efforts and about diversifying engineering and technology would benefit from disaggregating data from their research and across the general population, as it exposes prevailing gaps in the education system and across the workforce.

"Black women are earning only about 1% of all engineering degrees right now,

"We are a gender equity organization, but there are other identities that we want to acknowledge, and part of that acknowledgment is looking at the data."

— Roberta Rincon, Society of Women Engineers

but they represent 6% or 7% of the U.S. population," she said. A cluster of data that shows only 14% of working engineers are women, or that 22% of bachelor's degrees earned in engineering are women, elicits a different understanding of where the needs lie than when the data is broken down, because the majority of those degrees are being earned by certain subpopulations.

"That prompts us to look at the educational pathways that we have been ignoring, whether that is the minority-serving institutions or the community colleges and the technical colleges looking at—not just bachelor's degrees in engineering and computer science—but also engineering technology," Rincon explained.

If we're going to make systemic change, she added, it is necessary to create inclusive cultures and environments that are welcoming to all in engineering, manufacturing and technology.

"Data is critical, I am convinced," reflected Jackie Mattox, founder, president and CEO, Women in Electronics. "But if the heart isn't in check, if there's not actual authentic intent, that means nothing. I believe that when we can educate on the heart of the matter, we will open up opportunities to collect all the data. So, educate as much as possible, and have patience and grace.

Many organizations *Machine Design* interviewed this year, including SWE, Women in Electronics and ASME (American Society of Mechanical Engineers), reported how DEI is showing up in their organization's strategic plans. "We are advancing DEI internally through volunteer engagement and by providing accommodations for people with disabilities, by fostering inclusivity in event participation, enhancing inclusivity for working parents and supporting women and career empowerment," said Monica Moman-Saunders, professional engineer and fellow at ASME. "We know that we must be diligent. This change is not going to happen overnight, so we must be…fast and consistent."

By way of thanks, *Machine Design* is showcasing a sampling of the 2023 WISE series virtual participants who volunteered their time and shared expertise on developing a robust channel of skills from all walks of life. Not only do the women featured below represent a diverse range of talent, creativity and possibility in STEM careers but, moreover, they are also committed to doing the work of building a sustainable future so no-one is left behind.

We are all better for their efforts.

1. Roberta Rincon, Associate Director of Research, Society of Women Engineers

Dr. Roberta Rincon is the associate director of research for SWE, where she oversees the organization's research activities on gender equity issues affecting girls and women in engineering, in education and career. She received her B.S. in civil engineering from The University of Texas at Austin, an MBA and an M.S. in information management from Arizona State University, and a Ph.D. in Educational Policy and Planning from UT Austin.

Machine Design: **What keeps you motivated to continue the work that you do?**

Roberta Rincon: I've been with SWE for seven years, and I've got to say that I just feel that this is this is such an important time. We have organizations at the national level—not just here in the United States, but in other parts of the world—that are paying attention to diversity, equity and inclusion. They are tying funding to some of this work and bringing greater recognition to the contributions of those who have been overlooked historically.

Roberta Rincon

We've got to take advantage of this time and push these initiatives that we believe are going to create the systemic change needed to create the inclusive climate and culture within these STEM spaces that are just missing, and causing a lot of individuals to choose either not to enter or to leave before they reach those executive levels, where they can really make the change that's needed.

2. Jackie Mattox, Founder, President and CEO, Women in Electronics

Jackie Mattox is the founder, president and chief executive officer of Women in Electronics, headquartered in Southern California. Mattox started her career in the electronics industry during college at a small rep firm in the area, where she worked her way into the roles of sales and distribution manager and took a passionate interest in strategic key account management. Mattox graduated from California State University, Northridge with a Bachelor of Arts degree in communication/journalism.

MD: **What keeps you motivated to continue the work that you do?**

Jackie Mattox

Monica Moman-Saunders

> *"We are advancing DEI internally through volunteer engagement and by providing accommodations for people with disabilities, by fostering inclusivity in event participation, enhancing inclusivity for working parents and supporting women and career empowerment."*
>
> *— Monica Moman-Saunders, Engineer & Fellow, ASME*

Jackie Mattox: I would just have to say, women like the ones on this panel, are so inspiring…and, being a part of the change. We're in a pivotal time. To have the opportunity to be a part of systemic change is really valuable to me. This is what I do with women in electronics. It is just who I am. It's a calling—you can't not do it. I'm so passionate about it…I don't want to just go around talking about things or making all kinds of money. I want to make an impact, and I want this world to be better than where I left it.

For my little part, it's really a calling. And I just love that there are other people doing the same thing, dedicated and focused. The importance of diversity in our world right now, and especially at that engineering table, with all the new innovations and technology. The more diversity we can bring to the table, the more equitable our world is. I wish more people would pay attention, but it's very encouraging that there are sponsor companies and all kinds of people investing in this. So that encourages me a lot.

3. Monica Moman-Saunders, Professional Engineer and Fellow, American Society of Mechanical Engineers

Monica Moman-Saunders, P.E., has more than 20 years of experience in engineering management and contract negotiations and management. Moman-Saunders joined ASME in 1985, where she is now a Fellow and Governor-Nominee. She earned a Bachelor of Science degree in mechanical engineering from University of Alabama, a Master of Science degree in business and management from Webster University of St. Louis, Miss. and completed the executive management program at IMD Business School in Lausanne, Switzerland.

> *"Data is critical, I am convinced. But if the heart isn't in check, if there's not actual authentic intent, that means nothing. I believe that when we can educate on the heart of the matter, we will open up opportunities to collect all the data. So, educate as much as possible, and have patience and grace."*
>
> *— Jackie Mattox, Women in Electronics*

MD: **What keeps you motivated to continue the work that you do?**

Monica Moman-Saunders: I'm a little engine that can. But as an African-American female mechanical engineer, I have spent my entire professional career working in a male-dominated field—I worked in the utility industry. I've always worked to improve diversity in this field, promoting STEM education. But progress is, and has been, slow. But now that the world has become more diverse, and it continues to change every day at a very fast pace, companies have come to realize that they will benefit from diversity and DEI initiatives.

They have also begun to change their culture. So, I am more energized than ever at the opportunity to help bring about this meaningful societal, cultural and systematic change. I'm actually very excited to work on this effort and do my part to foster change. That's one of the reasons I'm on the board of governors within ASME. My actions are intentional and my personal mission and goal in life is very clear at this point. I want to bring about the change that will make our world a better place for all. And so that's what keeps me excited about it for sure. ■

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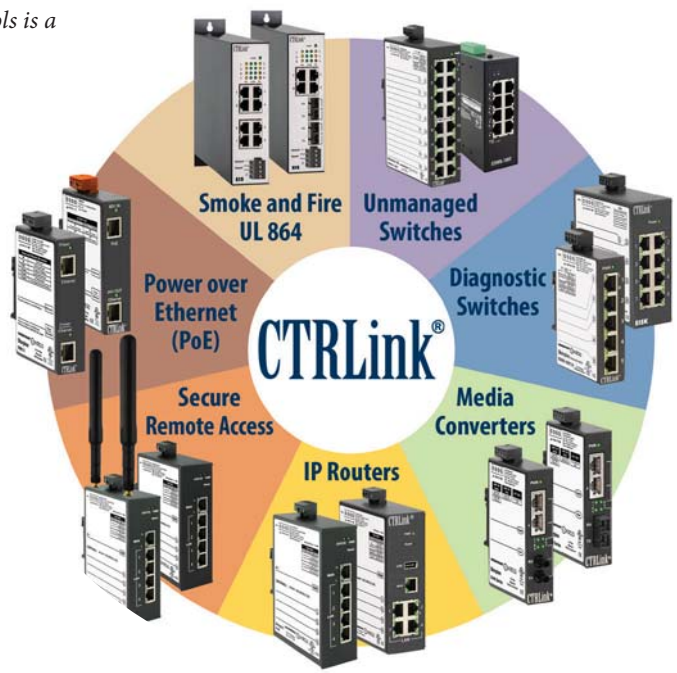

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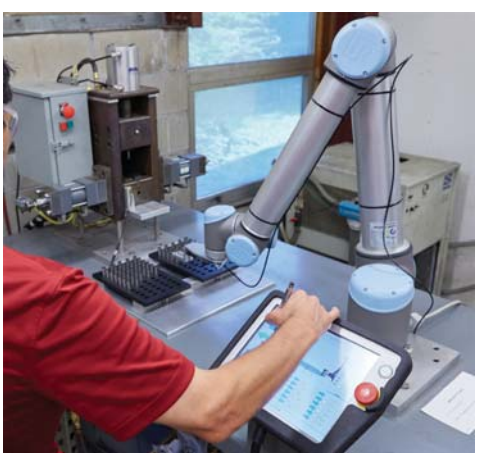

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4 STD	.236/.240	.020	.195/.201	13TW	.094/.096	.009	.075/.079	20V	.034/.0345	.004	.0255/.0275
5 STD	.218.220	.015	.187/.191	13 XTW	.094/.096	.005	.083/.087	20STD	.032/.0325	.006	.0195/.021
5 TW	.218/.220	.010	.196/.200	14 STD	.082/.084	.010	.061/.065	21 TW	.032/.0325	.005	.022/.024
6 STD	.202/.204	.015	.170/.1765	14 SP	.082/.084	.008	.065/.069	21XTW	.032/.0325	.002	.0280/.0295
6TW	.202/.204	.010	.180/.186	14 TW	.082/.084	.0055	.071/.073	21 V	.030/.0305	.0035	.023/.0245
6V	.187/.189	.010	.165/.171	14 XTW	.082/.084	.003	.075/.079	22 STD	.028/.0285	.006	.0155/.017
7 STD	.179/.181	.015	.147/.153	14 V	.077/.079	.007	.062/.066	22 TW	.028/.0285	.004	.019/.0205
7TW	.179/.181	.010	.158/.162	15 STD	.0715/.0725	.009	.0525/.0555	22 XTW	.028/.0285	.0025	.0225/.024
7V	.171/.173	.011	.147/.153	15 TW	.0715/.0725	.006	.0595/.0615	22 V	.026/.027	.003	.0195/.021
8 STD	.164/.166	.015	.132/.138	15 XTW	.0715/.0725	.004	.062/.066	23 STD	.025/.0255	.006	.0125/.014
8TW	.164/.166	.010	.143/.147	15 V	.0675/.0685	.007	.0525/.0555	23 TW	.025/.0255	.004	.0165/.018
8XTW	.164/.166	.009	.145/.149	16 STD	.0645/.0655	.009	.0455/.0485	23 XTW	.025/.0255	.002	.0185/.020
8V	.155/.157	.010	.133/.139	16 TW	.0645/.0655	.006	.0525/.0545	23V	.023/.0235	.003	.0165/.018
9 STD	.147/.149	.015	.115/.121	16XTW	.0645/.0655	.004	.055/.058	24 STD	.022/.0225	.005	.0115/.013
9TW	.147/.149	.010	.126/.130	16 V	.0615/.0625	.005	.0505/.0535	24XTW	.022/.0225	.003	.0155/.017
9XTW	.147/.149	.006	.134/.138	17 STD	.0575/.0585	.008	.0405/.0435	24V	.021/.0215	.002	.0155/.017
9V	.140/.142	.011	.117/.121	17 TW	.0575/.0585	.005	.0465/.0485	25 STD	.020/.0205	.005	.0095/.011
10 STD	.133/.135	.014	.104/.108	17 XTW	.0575/.0585	.003	.051/.053	25 TW	.020/.0205	.004	.0115/.013
10 TW	.133.135	.010	.112/.116	17 V	.0555/.0565	.005	.045/.047	25XTW	.020/.0205	.002	.0155/.017
10XTW	.133/.135	.008	.1165/.120	18 STD	.0495/.0505	.0085	.0315/.0345	25V	.019/.0195	.002	.0135/.015
10 V	.125/.127	.010	.104/.108	18 SP	.0495/.0505	.006	.0375/.0395	26 STD	.018/.0185	.004	.0095/.011
11 STD	.119/.121	.013	.092/.096	18 TW	.0495/.0505	.004	.041/.043	27 STD	.016/.0165	.004	.0075/.009
11 TW	.119/.121	.010	.098/.102	18 V	.0455/.0465	.0065	.0315/.0345	27 TW	.016/.0165	.003	.0095/.011
11XTW	.119/.121	.007	.104/.108	19 STD	.0415/.0425	.0075	.0255/.0285	27 SP	.016/.0165	.002	.0115/.0125
11 V	.114/.116	.010	.092/.096	19 TW	.0415/.0425	.005	.0315/.0335	28 STD	.014/.0145	.0035	.0065/.008
12 STD	.108/.110	.012	.083/.087	19 XTW	.0415/.0425	.0035	.034/.036	29 STD	.013/.0135	.003	.0065/.008
12 TW	.108/.110	.009	.089/.093	19 V	.0385/.0395	.006	.0255/.0285	30 STD	.012/.0125	.003	.0055/.007
12 XTW	.108/.110	.0045	.098/.102	20 STD	.0355/.036	.006	.023/.0245	30TW	.012/.0125	.002	.0065/.008
12 V	.099/.101	.008	.080/.083	20 TW	.0355/.036	.005	.025/.027	31 STD	.010/.0105	.0025	.0045/.006
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Big Tech & Big Ideas

Permeate Industrial Thinking in 2023

Behind industry buzzwords are some remarkable applications that are changing the way we manufacture and the way we foster the next workforce.

by Rehana Begg, Editor-in-Chief

AI-based solutions provide the agility to respond to changing conditions in real-time. *Images courtesy Machine Design*

THROUGHOUT THE YEAR, *Machine Design* invites subject matter experts to share insights about up-an-coming technologies and market trends. Headline topics this year included sustainable practices, energy efficiency, advances in industrial automation technology and design for high-tech manufacturing.

A philosophical thread tying these topics together has been the need to "optimize for change" through the introduction of technologies. This theme was specifically laid out by Barbara Humpton, president and CEO of Siemens Corporation.

"If you listen closely, what we're really talking about is who we are as people, and how we operate in this world of incredible opportunity," Humpton said during her keynote at Automate 2023. "And the question I've been asking myself, and I hope you'll join me in this quest, is to answer this question: Instead of trying to find an optimal state of being, what would it look like if we got our teams to focus on optimizing for being in a state of constant change?"

In one fell swoop Humpton's query would not only express a strategic purpose for her company, but also spotlight a trajectory overriding the industry.

It goes without saying that a range of global market forces underpin Siemens' vision for the future, but "glocalization" rises as a key imperative. "Think about what we've experienced in just the last few years," Humpton said during a press announcement on Nov. 3, 2023. "We've seen disruption and global supply chains reinforcing the need to not be overly reliant on one region for sourcing critical items. Supply chain challenges have been a major factor in evolving globalization into glocalization. It's a world that's bigger than ever. More global, evermore connected, but we're capable of manufacturing things closer to the point of demand."

Barbara Humpton, president and CEO, Siemens Corporation.

Building Local Infrastructure

Supply chain vulnerabilities, as laid out in a White House report, can be traced to insufficient U.S. manufacturing capacity; misalignment in incentives that fail to reward firms for investing in long-term, sustainable productivity; and industrial policies and partnerships that lure away trade.

The report, *Building Resilient Supply Chains, Revitalizing American Manufacturing, and Fostering Broad-Based Growth*, is replete with examples highlighting fragility and disruption. Consider, for example, how the semiconductor shortage

demonstrates the need to bring manufacturing back on course. A new car, stated the report, "may require more than 100 semiconductors for touch screens, engine controls, driver assistance cameras and other systems. The U.S. share of global semiconductor production has dropped from 37% in 1990 to 12% today, and is projected to decline further without a comprehensive U.S. strategy to support the industry."

For Humpton, this historical dependence on globalization for finding the next incremental savings such as labor and materials on the supply side should be a thing of the past. Global supply chains must be supported by strong local manufacturing networks that will help the industry prosper, she argued.

To this end, Siemens announced in November that the company would be investing $150 million into a new high-tech manufacturing plant in Dallas-Fort Worth. Included in these plans will be the use of Siemens advanced manufacturing tools, including digital twin technology and the Siemens Xcelerator portfolio for capturing and analyzing data in real time from the shopfloor on production and product performance.

"This is just the latest example of how Siemens is expanding our American manufacturing presence to meet demand," Humpton said. "In the past year, you've heard that we've already seen Siemens invest $220 million into a new rail manufacturing facility in Lexington, N.C. And construction there is already underway. It's in addition to some previously announced investments in two electrical products manufacturing plants, one in Grand Prairie and the other in Pomona, Calif."

Among this year's (October) rollouts, Microsoft and Siemens unveiled Siemens Industrial Copilot, an AI-powered jointly developed assistant aimed at improving human-machine collaboration in manufacturing. The tool allows users to rapidly generate, optimize and debug complex automation code, and shorten simulation times, noted a Siemens press release. The copilot extracts automation and process simulation information from Siemens' open digital business platform, Siemens Xcelerator, and enhances it with Microsoft's Azure OpenAI Service. Customers maintain full control over their data, and it is not used to train underlying AI models.

Ron Di Carlantonio, is founder of iNAGO, and an AI-driven advanced intuitive conversational assistant for automotive, consumer electronics and AI-driven manufacturing solutions.

Caspar Herzberg, CEO of AVEVA, said AVEVA Connect is a digital experience and provides the tools needed to design, build, operate and optimize better with industrial intelligence-as-a-service.

Generative AI is the Headline

No conversation this year has been complete without a reference to artificial intelligence tools such as OpenAI's ChatGPT, Google's Bard or Anthropic's Claude.

Mainstream curiosity with artificial intelligence and generative AI have been unyielding since the launch of ChatGPT on Nov. 30, 2022. ChatGPT has reportedly garnered more than 100 million weekly active users. More than 92% of Fortune 500 companies are using ChatGPT and more than 2 million developers use it.

Simply defined, generative AI refers to a broad field of AI that has to do with developing techniques and models that are capable of generating new content. ChatGPT is a generative AI implementation trained on large language models and is designed for conversational purposes.

The capabilities of these technologies hold significant potential for transforming industries. The general use of AI-based solutions in the automotive industry, for instance, stretches across the lifecycle of a vehicle, from design and manufacturing to sales and aftermarket care. AI-powered chatbots, in particular, can deliver instant, personalized virtual driver assistance, are on call 27/7 and can evolve with the preferences of tech-savvy drivers.

AI-driven intelligent assistant platforms are similarly working their way into the smart factory, said Ron Di Carlantonio, a Tokyo/Toronto-based computer scientist whose company, netpeople, developed a platform that allows companies to create intelligent, conversational assistants for their products.

Software-Defined Manufacturing Paradigm

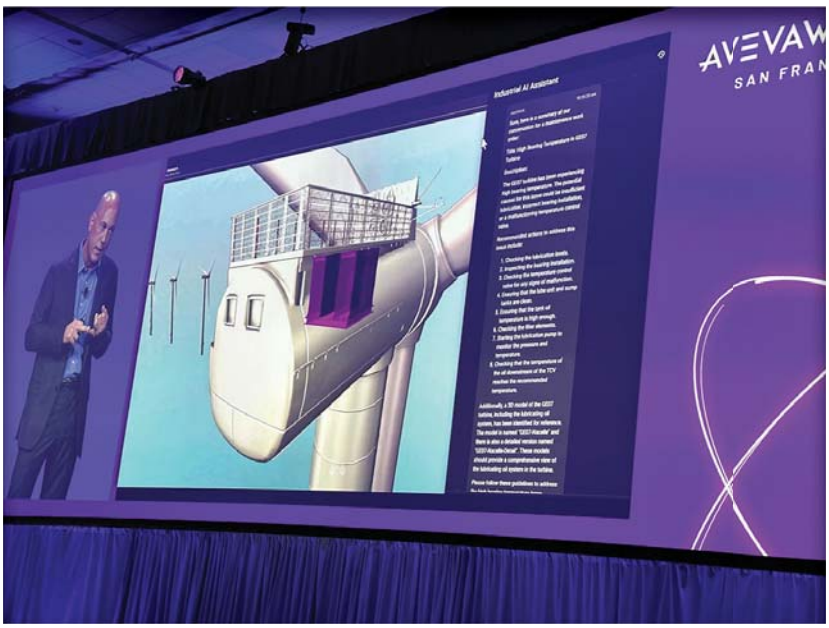
The case for AI in industrial AI-based solutions was made clear at AVEVA's flagship annual conference in San Francisco, where Caspar Herzberg, CEO of AVEVA, discussed how the company was building a new data infrastructure based on one industrial intelligence platform.

"This platform that we call Connect is designed to empower you at every step of the design, build, operate, optimize cycle, Herzberg said. "And what we are doing with our R&D is to bring disparate software together, so that users can easily exchange data, and so they operate seamlessly with each other."

Whether data is accessed via the cloud, on premises or is hybrid, the goal is to enable the easy flow of "trusted data" between AVEVA's solutions and its users, Herzberg said. "Trusted data in context is the foundation of the future; it is the foundation of industrial AI," he said.

Building on a long-standing strategic partnership, AVEVA and Microsoft announced their relationship will be further cemented, as Connect and the Microsoft Fabric data analytics solution will now be interoperable to streamline the process of collecting, transforming and organizing data from various sources. Their combined offerings will leverage AI and machine learning (ML) and allow users to make better, faster data-driven decisions.

"Our view of the world over the next five to 10 to 15 years is as follows: We believe that industrial manufacturing and critical infrastructure is going to continue to grow through fairly dramatic transformation, ushered in by huge market forces and market dynamics, geopolitical uncertainties, supply chains, energy transition, sustainability, as well as the vortex of interesting new technologies such as cloud computing, edge, AI (generative AI for example)," said Rob McGreevy, chief product officer, AVEVA.



Chief Product Officer Rob McGreevy discussed how AVEVA has by combined predictive and prescriptive analytics capabilities with large language models (LLMs) to develop industry specific use cases.

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AI Makes Machines Talk

During the keynote McGreevy demonstrated how AVEVA has created industry specific use cases by tying predictive and prescriptive analytics capabilities together with large language models (LLMs).

A chat-based UI (user interface) was set up in McGreevy's windfarm reference case. He prompted the program as follows: "The output we saw was lower than expected the last few hours. Are there any issues I should be aware of?"

The system was able to parse what the prompt meant and responded by indicating what the issues related to the turbine were and with a notification that it stopped functioning. An engineer or technician could then ask for a utilization dashboard, said McGreevy, and the system would produce data showing, for example, that the turbine was producing, but then flipped to a non-producing state because of high temperature problems.

Further interrogation allows the user to pinpoint all of the bearings and their temperature readings over the last 12 hours. The system lists all of the variables it is prompted for and infuses the response with real time min/max values.

"We've actually taken this and made it dynamic, whereas a lot of large language models are static," McGreevy pointed out.

In the context of industrial manufacturing critical infrastructure, he said, generative AI is a toolset and a means by which companies like AVEVA can change the way users and community interact with the systems they design and build.

"Together, these things command a new way of doing things that demand a hyper, interconnected digital backbone upon which we can erect the building blocks for the next generation of our solutions," said McGreevy. ■

Generative AI's Transformative Impact on Manufacturing:

Unleashing the Power of Industrial Data

An insider's view on why industrial generative AI capabilities hold promise for asset-heavy industries, this article highlights three common obstacles: hallucinations, data leakage, and access control to maintain privacy and security.

by Moe Tanabian, Chief Product Officer, Cognite

SOME WOULD SAY that ChatGPT unleashed the iPhone moment for digital transformation. Arguably, it is generative AI that will unleash the transformation of industry. But to harness it properly, it must be safe, secure and hallucination-free.

The business value of generative AI is only in its application to the real-world needs of field engineers and others operating in asset-heavy industries. When used correctly, generative AI can enable better collaboration, task automation, field productivity, maintenance planning and robotic automation, but the technology is only as strong as its data foundation.

Drowning in Data, Starving for Context

Generative AI can generate new data, content or solutions based on existing data patterns. Unlike traditional AI models, generative AI can learn from context-enriched data without explicit guidance, making it a powerful tool for industries where data is abundant but complex.

Generative AI can ingest diverse datasets, including historical maintenance records, sensor data, work orders and even unstructured data such as maintenance reports. However, for it to be effective, context is vital. Industrial facilities generate an overwhelming amount of data, and they are often siloed. Without context, it becomes an obstacle rather than an asset. To power generative AI, and empower subject matter experts and field engineers, data must be contextualized and easily accessible. This involves liberating data from siloed source systems and creating a strong contextualization engine.

The goal is to enable SMEs to extract the full value of industrial data. Operationalizing data and establishing a robust data foundation are key steps toward achieving this. It not only enhances work efficiency but also lays the groundwork for generative AI to accelerate various workflows.

LLMs + Knowledge Graph = Data You Can Trust

The key to making AI work for industry lies in the magic formula of Large Language Models (LLMs) + Knowledge Graph. An industrial knowledge graph provides an additional metadata layer to navigate relationships for both humans and generative AI to make sense of industrial data.

An industrial knowledge graph is the output of data contextualization and represents the connections between the many data types. This graph ensures that LLMs can understand and provide reliable and deterministic responses to even the most complex queries within your field. And, by applying this formula, you are able to have a complete and trustworthy digital representation of your industrial reality, free from AI hallucinations.

Industrial Canvas = Data You Can Use

Generative AI's transformative potential extends across all areas in asset-heavy industries. From field productivity to maintenance planning and robotic automation, generative AI can make a significant impact by making operations more productive, safe and sustainable. However, for it to thrive, a platform must provide essential AI features that grant easy access to complex industrial data for engineers, data scientists and subject matter experts.

A promising example of an interactive user experience is an Industrial Canvas. Delivering simple access to all industrial data in a single workspace requires a unique way to leverage contextualized data. Field workers deserve a way to work with live sensor data, interactive engineering diagrams, images, 3D models and more within a visual workspace where they can explore data in context, perform root cause analysis and collaborate by tagging other users in an open, free-form environment.

From Digital Maturity to Industrial Transformation

Digital transformation might be seen as a priority in the industry, but achieving real ROI still remains a challenge. Many organizations invest in cloud data warehouses and data lakes, but data often ends up unused. The true value of data lies in trust and usability.

To master the industrial data problem, we need a shift towards industrial AI at scale. This approach focuses on delivering business-ready, trusted, actionable data to all users. It promises to improve time to value, quality, predictability and scalability in data analytics. ■

Deliver Robust Automated Systems **Through Servo Maintenance**

Servo motors are critical to the function of many automated systems, so they require optimal maintenance. Discover how to refine servo motor maintenance strategies.

by Emily Newton, Technology and Industrial Journalist

MOST MANUFACTURERS TODAY understand the need to automate. Fewer realize that to make the most of their automated systems, they must keep their components in top condition. Servo motor maintenance, in particular, is an essential process to address.

Robotic systems vary widely between facilities and workflows, but many rely on servo motors. Despite that criticality, it's easy to overlook the importance of maintaining these small components. That presents an opportunity. Manufacturers that optimize their servo maintenance can achieve higher automation performance than their peers.

The Importance of Servo Motor Maintenance for Automation

Manufacturing uses automation more extensively than any other industry, and that adoption will only grow as robotics become more accessible. Given that reliance, keeping these systems working as efficiently as possible is crucial.

Unfortunately, many manufacturers overlook the importance of equipment maintenance. Factories suffer 20 downtime incidents a month on average, each lasting over an hour, according to a Siemens report. These disruptions—which better care could have prevented—cost millions of dollars in repair expenses and lost productivity.

Servo motor maintenance certainly isn't the only factor at play here, but it's an important one. Most industrial robots rely on servos to some extent, often to control their movement. As a result, issues with these components will likely impact the robot more heavily.

Servo motors are also more prone to failure than other components. As a critical moving part, these technologies encounter high movement speeds, heavy physical loads and long operation times, leading to more wear-and-tear.

Foundations of Servo Motor Maintenance

Servo motors' criticality and higher workloads make them ideal candidates for maintenance optimization. That begins with understanding which care practices are most crucial for keeping these components in top condition.

Temperature management is one of the most important considerations. Manufacturers must routinely clean servo motors and their cooling equipment and monitor temperatures to keep them cool. In addition to preventing performance issues, lower temperatures improve energy efficiency in electrical equipment, lowering servo operating costs.

As with other moving parts, lubrication is another leading maintenance concern for servo motors. Regularly lubricating bearings and other servo components will prevent excess temperatures and friction.

Electrical maintenance is another core concern. Technicians should inspect for frayed wires, loose connections and similar issues to ensure all the motor's electrical systems work well. Similarly, regular calibration is key to maintaining precision and repeatability.

Creating Optimal Maintenance Strategies

These foundational steps apply to all servos, but manufacturers must get more granular in their repair strategies. Optimal servo motor maintenance steps and timelines depend on the specific equipment in question.

Delayed maintenance results in higher repair costs and shortened equipment lifespans, but what defines "delayed" varies between motors. Manufacturers must refer to their OEM's guidelines to learn how frequently they should consider each maintenance step. Remember that these recommendations are typically general baselines, so take them as a foundation, not a strict timeline.

Similarly, manufacturers must deliver the right kind of repairs according to OEM recommendations. Some servo motors may require a specific lubricant. Some may have higher temperature tolerances than others. Understanding these unique factors is key to developing an optimal maintenance strategy.

Choosing the Right Maintenance Method

Once manufacturers understand their specific servo motors' needs, they can move on to selecting a maintenance method. While it's always best to use a preventive rather than reactive repair philosophy, the best non-reactive approach depends on the situation.

There are three main methods to choose from—schedule-based preventive care, condition-based and predictive maintenance. Predictive approaches offer the most uptime and long-term savings but are also the most difficult to implement. This method relies on Internet of Things (IoT) sensors and artificial intelligence (AI), raising upfront costs and requiring more IT experience.

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Facilities with less tech talent or smaller budgets may prefer condition-based repairs. The resulting savings may be less impressive, but it's easier to get right and costs less upfront. In some cases, it's best to apply predictive maintenance to some servo motors and condition-based approaches to others.

Minimizing Maintenance Errors

Optimizing servo motor maintenance is also a matter of error reduction. Automating condition monitoring through the IoT will prevent human inspection-related mistakes, but manufacturers can go further.

Manufacturers using IoT sensors to monitor servo conditions must carefully calibrate these tools. Use the servo's OEM's recommendations to establish a baseline for acceptable parameters. If these benchmarks aren't accurate, sensors may fail to determine the motor's condition accurately.

Employee training is another critical area to address. Switching to a new maintenance strategy will make errors more likely if manufacturers aren't careful. To prevent this, manufacturers must involve repair technicians throughout the transition, informing them of the change early and allowing plenty of time and resources to re-train and adjust to the new system.

Accounting for Unforeseen Failures

Even if manufacturers follow these other servo motor maintenance best practices, unplanned downtime is still possible. Predictive maintenance—the most effective method at decreasing downtime—improves uptime by up to 20%, but that's not a complete elimination of failure. Consequently, manufacturers must have a plan to respond to unplanned downtime.

Documentation is one of the most important steps. If a servo motor fails unexpectedly, be sure to record the incident. Keep track of what went wrong, how long the issue took to resolve and what damage it caused. These records will help address similar issues in the future.

Over time, data from these incidents can inform more effective strategy adjustments. If manufacturers analyze these trends with AI, they can discover their underlying causes. They can then adjust their maintenance approach to reduce servo motor failures further.

Optimize Servo Motor Maintenance to Improve Automation

Reaching industrial automation's full potential encompasses more than maintenance. Similarly, maintenance optimization should cover more than just servo motors. However, manufacturers must mind these smaller details to get all they can from their machines.

As automation becomes increasingly common, robots alone won't suffice to keep manufacturers ahead of the competition. They mustn't only automate, but automate better than other businesses. Optimized repair strategies are a crucial part of that endeavor, and servo motor maintenance is essential to those repairs. By following these guidelines and applying the same care to all factors, manufacturers can take their automation to the next level. ■

Pushing the Limits of **Drone Capabilities**

by Victorio Pellicano, Founder/CEO, Avianna

With the promise of operational efficiency and cost savings, the latest autonomous drone functionality and capabilities are prepping industries for greater integration.

Avianna has developed a suite of AI-driven software products—Fleet AI, Vision AI and Mission AI—for use in robotic vehicle applications. *Avianna*

THE COMMERCIAL DRONE market is experiencing rapid growth as new technologies and artificial intelligence break into the space.

In 2022, the commercial drone market size was estimated at $19.8 billion and is projected to grow at a compound annual growth rate of 13.9% between now and 2030. This growth creates space for innovation and integration like never before.

As the industry begins to scratch the surface for the integration of AI in autonomous drones, it is proving to bring forth numerous benefits, including increased operational efficiency and cost savings. By automating tasks that were previously performed manually, drones are able to perform them faster, more accurately and at a fraction of the cost.

Current State of Drone Technology

Drone technology is still in its infancy, which leaves room for rapid and needed innovation and improvement. Many early drones were developed for hobby and sport. Once the usefulness and potential of what drones can accomplish was understood, industries began to see the value they could bring and began to explore the capabilities of commercial drone usage.

Then AI entered the picture. The unique value that AI has offered to many everyday business practices makes its potential capabilities attractive to the drone industry. ChatGPT is a formidable example: ChatGPT has had over 10 million all-time page visits with an average of 1 billion page visits monthly. This curiosity has already inspired innovation within the industry.

The Monumental Impact of AI Integration

At its core, AI is machine learning with natural language processing capable of performing faster and oftentimes higher quality output than humans. It increases the speed and accuracy of code writing, productivity and accuracy beyond human capabilities.

Yet, many have hesitated to adopt such smart technology in fear that it will replace humans. In reality, it has the potential to become a worthy co-worker. A robot without smart AI integration capabilities is merely a hammer—a tool with limited capabilities. Once fused with the ability to think and react to situations, that tool becomes a partner or an assistant.

In the drone industry specifically, AI integration allows drones to become autonomous agents. One example of this is specifically with search and rescue. Consider the scenario where a person is reported missing and is lost in a forest. Typically, it takes cars, helicopters and oftentimes people by foot to search the area. They may utilize cameras with no automated technology and will need to take the time to analyze and process the footage.

Now consider an AI-empowered drone charged with the mission to find a missing person in the forest. With extended capabilities, this drone can hear things beyond human hearing and see beyond human capabilities. With real-time adaptability, a drone will be able to locate the missing person in a fraction of the time.

Also highlighting the impact of this integration is package delivery, which will become more prevalent as autonomous drone capabilities increase. Without AI integration, drones are programmed to deliver a package to a fixed pin location, and they are unable to differentiate the front door from the back door or adapt to any obstacles in their way.

The only way to know where the door is, what obstacles are in its way, and how to adapt and still complete the delivery is through AI. But if there is an obstacle to mission completion, the drone will return without delivering the package. Autonomous AI integration allows drones to adapt and adjust to dynamic environments to complete the mission.

Overcoming Industry Challenges

In the face of innovation, the drone industry is limited by regulatory control. Government agencies including the Federal Aviation Administration (FAA) play a major role in regulating the use of drone technology. While these regulations are a crucial part of public safety, they oftentimes can suppress innovation. Finding a middle ground is crucial to the drone industry's success.

Another hurdle to drone advancement is battery power. Current drone battery technology allows for a maximum flight time of 30-40 min. Once battery life is able to evolve and be utilized for longer periods of time, drones will be able to deliver a variety of products and fulfil services more effectively. Both the battery and navigation technology will need to become stronger in order to achieve efficient autonomy and serve a variety of purposes. ■

How to Build a Better Rat Trap—
with 70 Synchronized Servo Axes

A case study in using PC-based control and EtherCAT tech to deliver a sophisticated, highly efficient production line to enhance production for a major pest control brand.

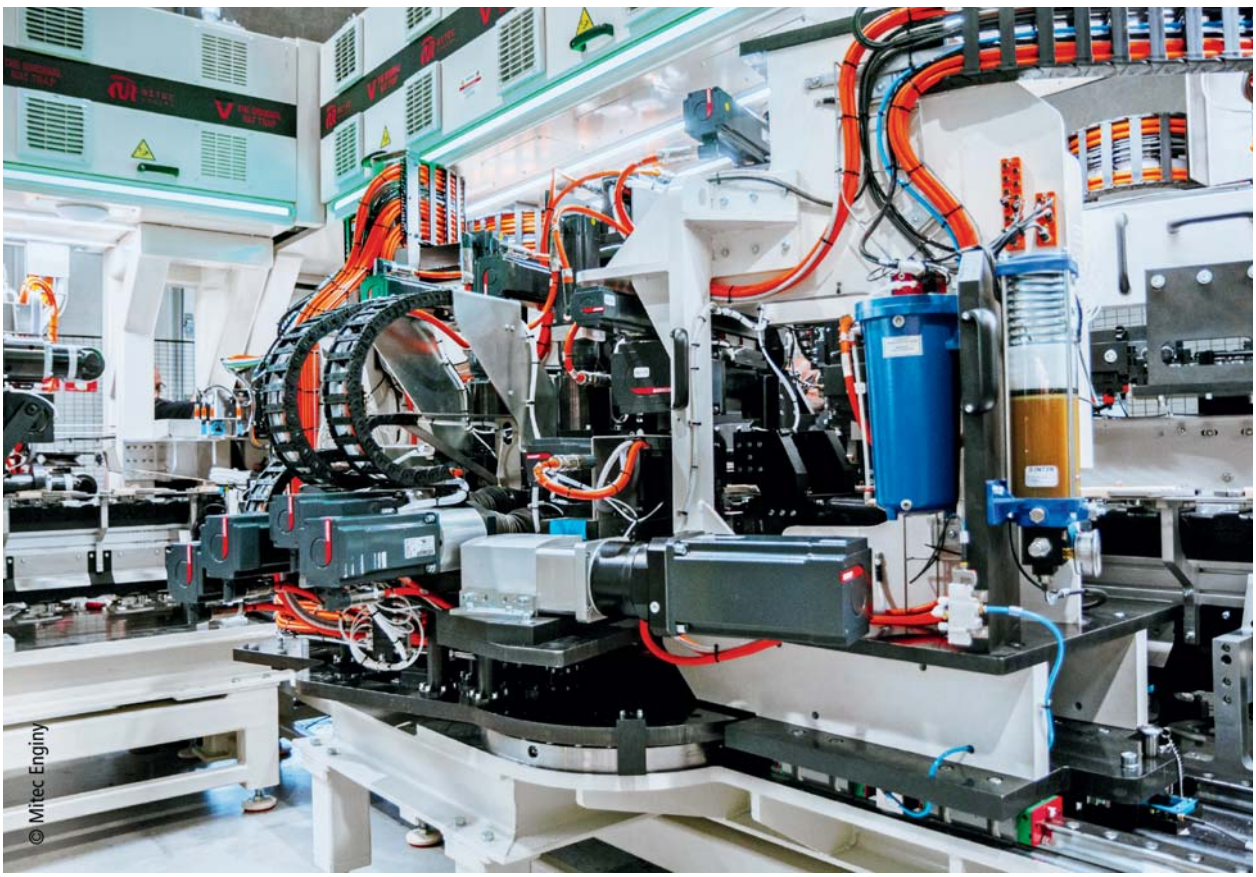
by Matt Prellwitz,
Drive Technology Product Manager,
Beckhoff Automation LLC

PEOPLE OFTEN FIXATE on how to build a better mousetrap. An equally important pursuit, according to systems integrator Mitec Enginy, is figuring out how to build a mousetrap better. And combining both goals, the northern Spain-based automation experts have developed a sophisticated manufacturing system to produce traps for household pests.

The machine's core element is a revolutionary motion control system with a total of 67 servo axes synchronized by camming function. The result is a production line that feeds, cuts and bends wire; produces springs; and mass-produces the final product—a rat trap—in just 1.5 sec. In addition to the servo drive technology, Beckhoff also supplies the required control performance with PC-based control, EtherCAT networking and TwinCAT automation software solutions.

Mitec Enginy has been developing and integrating application-specific automation systems for customers around the world since 2006. According to Managing Director Albert Gratacos, the engineering company focuses on innovation in the automation of industrial processes, the modernization of a variety of machines and the implementation of comprehensive solutions.

Despite the rather small end product, the rat trap production line is quite impressive in size. *Images courtesy Mitec Enginy*



The many dynamic motion sequences are provided by 67 AM8000 series servomotors from Beckhoff.

Servo Drive Technology Replaces Mechanics

"Looking back at the history of automation, it is essential to appreciate the foundations that are simply taken for granted today," Gratacos explained. "Eighty years ago, mechanically driven machines were quite common, often powered by a motor and connected by gears, crankshafts and cams. These inventions still drive our innovations today, yet these machines predate 3D CAD, CNC machining and software. With today's technology, mechanical machine components are replaced by multi-axis servo movements and controlled more reliably and flexibly by software."

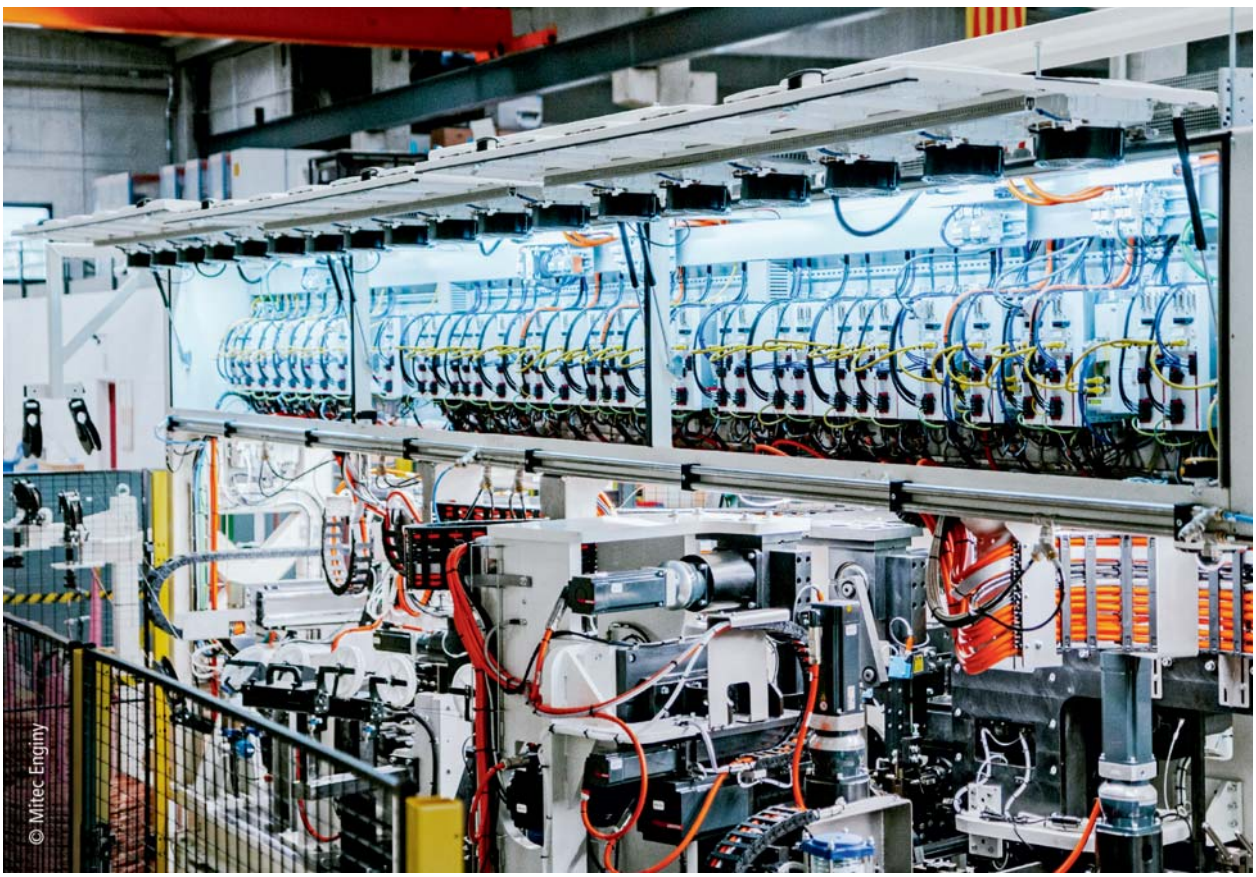
For a prime example, consider the latest application from Mitec Enginy—the rat trap machine. "The customer needed to modernize their product manufacturing to remain competitive, so we devised an appropriate way to do that," said Gratacos. "At first, the idea of precisely synchronizing around 70 servo axes sounded almost crazy, but it ultimately proved to be the right solution for the complex process sequences, and we were able to implement it using PC-based control from Beckhoff."

> *"At first, the idea of precisely synchronizing around 70 servo axes sounded almost crazy, but it ultimately proved to be the right solution for the complex process sequences, and we were able to implement it using PC-based control from Beckhoff."*

The system relies on 61 AX51xx and AX52xx servo drives paired with 67 AM80xx servomotors to power the various process steps. In terms of software, TwinCAT 3 with the camming function (TF5050 TwinCAT 3 NC Camming) ensures precisely synchronized motion sequences.

The EtherCAT industrial Ethernet system delivers optimal communication for motion control as a high-speed, high-bandwidth and extremely deterministic fieldbus. Ideal for all things motor- and drive-related, EtherCAT can handle the most basic PTP systems to advanced applications, such as the Mitec Enginy machine. In addition, EtherCAT supports safe motion functionality.

The rat-trap machine implements all necessary safety functions (STO, SOS, SS1 and SS2) directly in the automation system with TwinSAFE and Safety over EtherCAT communication. A Beckhoff



A total of 61 Beckhoff AX5000 series servo drives are housed in the control cabinets placed at the head of the production line.

CX2062 Embedded PC serves as the central controller, offering core processing power using advanced Intel Xeon processors.

These features delivered serious competitive advantages, according to Lluis Moreno, sales engineer at Beckhoff Spain. "[The solution] is fully equipped with powerful servo drive technology networked via EtherCAT and can be reliably coordinated with the CX2062 from just one computer," Moreno said.

Complex Solutions Require a Strong Team

Mitec Enginy's success can also be attributed to the team that has been created to develop complex automation solutions.

"We handle all of the mechanical and electrical design, programming and assembly of the automation in-house. At the same time, we recognize that no one person can be the expert for the entire automation system, which is why we have specialists in mechanics, electrics and programming working closely together to develop innovative automation solutions," said Gratacos, who also credited customers and suppliers as project partners.

Among the many projects Beckhoff has partnered on with Mitec Enginy, none have captured Morena's interest more than the rat trap machine: "I have to admit that the current production line is the most efficient and, dare I say, 'beautiful' machine in terms of design so far; each of the many movements is just so fast, precise and smooth that no unnecessary stresses are transferred to the mechanics of the machine." ■

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Mission Statement: Harmonic Drive's mission is to provide motion control solutions that give our customers a competitive advantage. To accomplish this, we continually invest in the growth of our employees and in our company's capabilities.

What we do: Harmonic Drive, LLC engineers and manufactures precision servo actuators, gearheads and gear component sets. We work closely with companies of all sizes to understand their application requirements and provide a standard or, in most cases, a custom-engineered solution to enable the success of their design project.

Our engineering department truly partners with our customers. We love challenges, and work to provide realistic, timely solutions. Experienced application engineers with expertise in motion control are available to assist you with your concept and detailed designs. Our design service is provided free of charge in most cases. We love what we do and are eager to share our knowledge and passion with our customers.

Harmonic Drive products are customizable. In fact, most of our customers use gears or actuators that are designed and manufactured specifically for them.

With over 60 years of experience, our expert engineering and production teams develop enabling technologies and products to meet the needs of an evolving motion-control market. Our high-precision, zero-backlash Harmonic Drive® actuators and gears have, and continue to, play critical roles in precision motion control.

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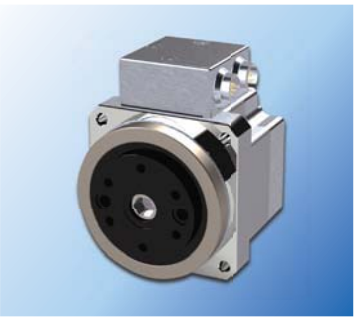

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ABOUT US

At igus®, we have been developing and manufacturing tribologically-engineered plastic components for six decades. We are a family-owned and operated company, and remain committed to using our innovative materials to develop creative solutions for customers while exceeding expectations through our quick and reliable service.

Our Mission: Improve all types of motion with motion plastics while maintaining a carbon-neutral footprint and being the easiest company to work with.

HIGH-PERFORMANCE MOTION PLASTICS

We center our business around four main product lines that are focused on the idea of "motion plastics":

- e-chain® cable carriers
- chainflex® continuous-flex cables
- iglide® dry-running bearings
- drylin® linear bearings and guides

We extensively test all of our products under real-world conditions in our 41,000-square-foot testing facility in Germany. The test data is compiled and then uploaded into our online tools and service life calculators to enable customers to find the best material and component for their specific application.

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At igus, nothing is more important to us than our customers. We often refer to the customer as our sun—the center of our universe; the light that guides us towards excellence. We organize our teams around the customer to quickly implement their ideas and meet their unique specifications, even when it requires innovation, since our success is dependent upon their success.

Our team of sales engineers is available from 8AM to 8PM ET, coast to coast, with a dedicated team of technical sales experts located across North America for quick on-site assistance or installation and engineering services.

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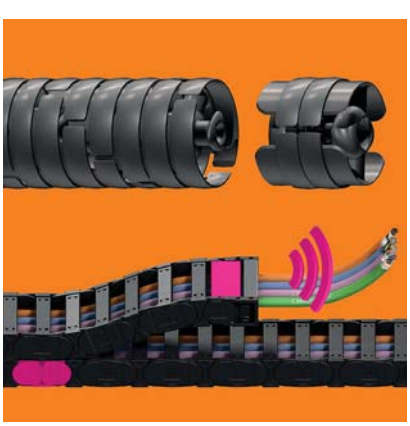
In addition to providing customers with reliable, high-performance products and superior customer service, we also believe in the importance of fostering the mechanical design ideas of students. Through our Y.E.S. (Young Engineers Support) Program, we donate free products to robotics competitions, schools, and hundreds of thousands of students worldwide.

OUR COMMITMENT TO SUSTAINABILITY

Being a producer of plastic components, reducing our environmental impact has become a primary focus for us. To that end, we recycle and reuse 99% of our plastic waste. We have also made the switch to exclusively green electricity and climate-neutral gas, and plan to reach CO2 neutrality by 2025. Finally, we've partnered with the National Forest Foundation to plant 10,000 trees in 2024, the same goal we also met for 2023.



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With igus, you can set the standards of tomorrow. Our innovative polymer components have long been used to solve difficult design challenges and redefine what's possible. Now, we're taking the next step into the future – **and we want to bring you along with us.**

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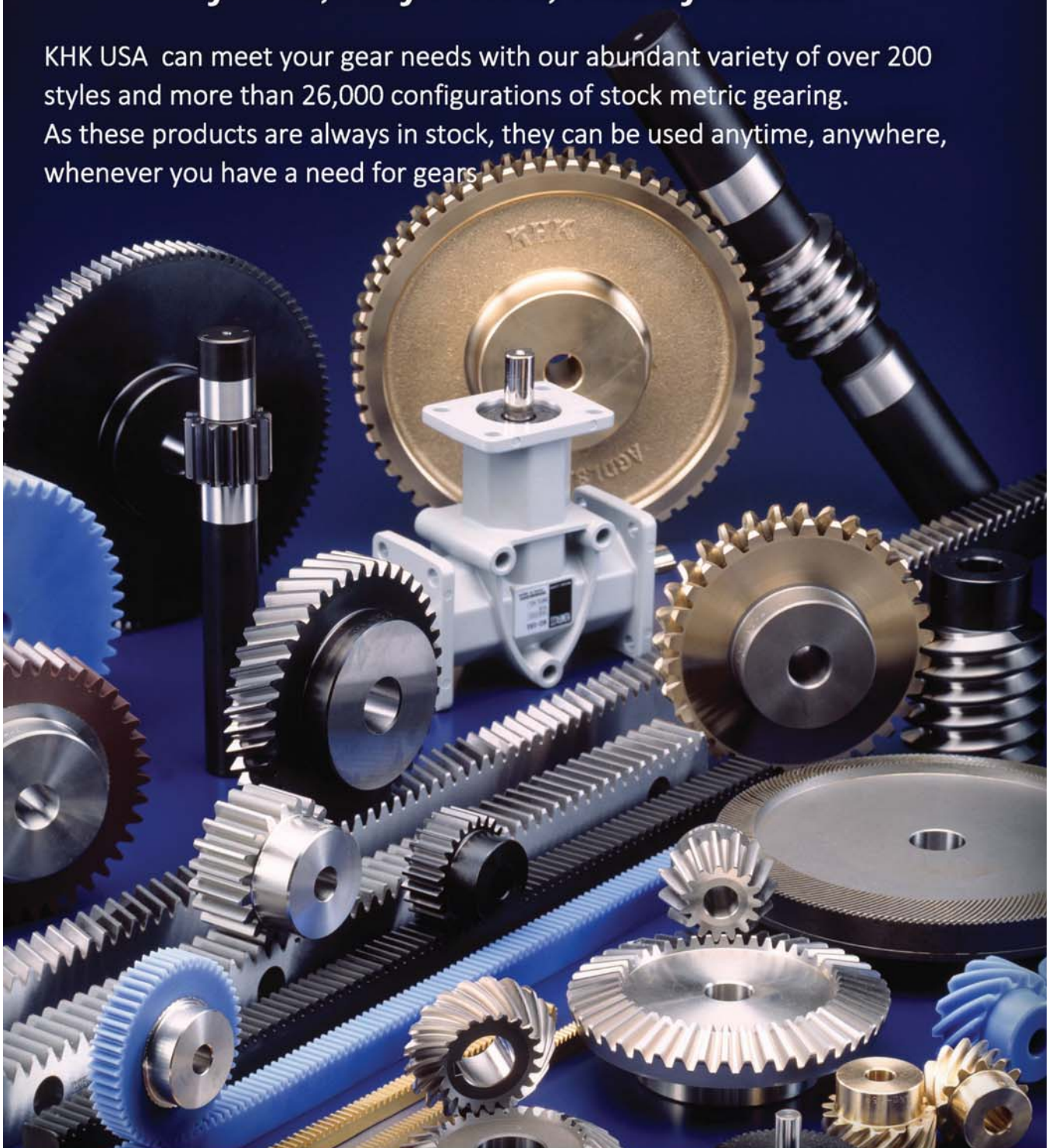

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Additive Manufacturing
Innovations Drive Industry Forward

Machine Design covered several additive manufacturing innovations during the past year—each with the potential to reshape the future of manufacturing.

by Sharon Spielman, Technical Editor

IN THE EVOLVING field of additive manufacturing, several innovations have emerged that have helped to drive the industry forward. From the development of advanced and multi-materials for 3D printing, to the advent of sophisticated software and engineering platforms for enhancing the 3D printing process, to the increasing investment in and use of 3D printing by universities, *Machine Design* keeps its finger on the pulse of the additive manufacturing industry.

Let's explore a few of these innovations and their capacity to transform the next phase of manufacturing.

Advanced Multi-materials for 3D Printing

A significant innovation in additive manufacturing lies in the expansion and diversification of the materials used in the 3D printing process. Beyond traditional plastics and metals, recent advancements have allowed manufacturers to create products with improved properties and functionalities.

Take multi-material 3D printing, for example. As nano3D-print CEO Ramsey Stephens noted in a Q&A, "No longer is multi-material 3D printing just about using different colored filaments; instead, it introduces material diversity by embedding into the design functional inks and pastes, which possess dynamic qualities, including conductivity, magnetism, sensing capabilities and responsiveness to external stimuli."

Manufacturers can incorporate functional materials into everyday devices, leading to the creation of custom devices like wearables, sensors, batteries and solar cells. "This customization can conform to space limitations and design constraints, accelerating innovation and research and development while reducing costs," Stephens said.

Another advancement in 3D printing materials can be found in dental prosthetics and other medical solutions where high-accuracy printer platforms and biocompatible materials are used. Desktop Health (a brand of Desktop Metal) and Carbon—both

leaders in the oral health additive manufacturing space—joined forces this past summer to bring the Flexcera family of resins to the Carbon Digital Manufacturing Platform.

The collaboration opened access to the nanoceramic resin for use in 3D printing permanent dental restorations, as well as advancements in digital dentistry, providing exceptional strength, life-like aesthetics and long-term performance.

Software, Engineering Platforms for 3D Printing

To complement the advancements in materials, software and engineering platforms streamline the 3D printing workflow and allow for design flexibility.

The integration of platforms dedicated to 3D printing has changed the way products are designed, tested and manufactured. Cutting-edge software solutions allow users to create complex designs, optimize support structure generation and simulate the printing process to identify potential issues before they arise.

These platforms facilitate communication between designers and machines and have resulted in customization, quicker prototyping and cost-effective manufacturing.

Dr. Elissa Ross, co-founder and CEO of Metafold—the developer of a Design for Additive Manufacturing (DfAM) cloud-based software—told *Machine Design* about the technology behind its computation engine. She said the company recognized the need for new digital tools to support 3D printing manufacturing technology and address the limitations of traditional CAD systems.

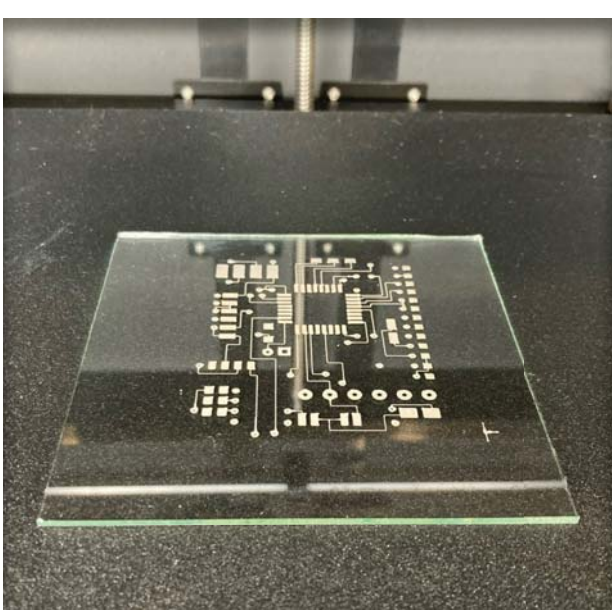
"[CAD systems] were developed for conventional manufacturing, and they are excellent in those capacities," she said. "But when it comes to supporting high complexity, geometry—that is…what 3D printing is really great at—those same digital tools are traditional CAD tools. They don't offer what we need." Metafold's technology addresses that, she said.

At the center of the platform is its geometry computation engine, which Ross said enables the design and optimization of complex geometries for 3D printing. The web application offers capabilities for creating lattice geometries, lightweight parts and high-surface area structures, which opens possibilities for a range of industries where optimized structures are highly valuable.

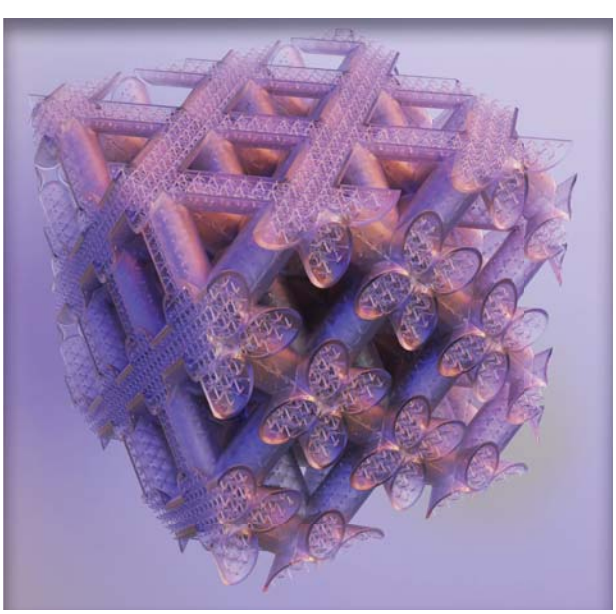
One of the key strengths, she noted, is the material and process agnosticism. Users can access the software via the cloud and API, regardless of the hardware used for 3D printing. This flexibility allows manufacturers to optimize their additive manufacturing processes, whether designing lightweight aerospace parts or creating efficient heat exchangers.

There are platforms to access and print parts as they are needed, too. Markforged, for example, offers Digital Source, an on-demand parts platform that allows for licensing and 3D printing of manufacturer-certified parts at the point of need. The platform enables vendors to upload digital part designs, which can then be licensed to customers, distributors and contract manufacturers. Once uploaded, end-users of the platform gain the flexibility to license the right to print parts either onsite or through a network of approved print service providers.

According to Jeremy Haight, principal engineer at Vestas Wind Systems A/S, Digital Source allows spare parts to be printed where needed, so the company got its machinery up and running faster. "Time equals a very high dollar value for us," he said. "A line down in one of our factories is a big deal but a turbine that has gone down can cost even more." He said if they can access and print the part needed, the turbine can be up and operational much quicker.



Multi-material 3D printing in practice. *Courtesy nano3Dprint*



Lattice geometries created by Metafold's web application. *Metafold*

Learning Institutions Invest in 3D Printing

In addition to materials and software advancements, investment in 3D printing by universities is driving growth in the additive manufacturing sector.

Universities and other higher-learning institutions have begun to recognize the potential of additive manufacturing and are investing in the technology. By establishing dedicated research centers, labs and courses in additive manufacturing, these institutions are fueling innovation and preparing a new generation of experts in this emerging field.

The collaboration between academia and industry has resulted in cutting-edge research, advancements in materials and the development of novel manufacturing techniques. Those that invest in 3D printing contribute to a knowledge-sharing ecosystem, helping to accelerate the adoption and development of additive manufacturing technologies and concepts. This progressive approach can foster the growth of 3D printing across a range of industries, stimulating innovation and economic development.

To support Missouri manufacturers and enhance their competitive edge, for example, the Kummer Institute Center for Advanced Manufacturing at Missouri University of Science and Technology (S&T) made a significant investment in technology. The purchase of a large-format metal 3D printer from SPEE3D is a crucial step toward incorporating additive manufacturing into the state's industrial sector.

Dr. Richard Billo, director of the Center for Advanced Manufacturing, emphasizes the importance of additive manufacturing becoming the new norm for Missouri manufacturers to thrive globally. "For Missouri manufacturers to succeed on the global stage, additive manufacturing must become the new normal," he says, noting that the upcoming Missouri Protoplex, an advanced manufacturing research and development facility set to open in fall 2025, is where the new printer and other equipment will be housed.

Apart from supporting manufacturers' projects, working with the WarpSPEE3D printer provides undergraduate and graduate students at S&T with valuable experience and understanding of challenges faced by manufacturers. Students can program the printer, document operating procedures, design CAD models, perform testing and develop maintenance plans. This holistic approach to workforce development aims to equip students with hands-on experience in product development and manufacturing methods.

As additive manufacturing continues to advance, the university's investment in equipment and research will play a pivotal role in supporting Missouri manufacturers, enabling them to embrace innovative technologies and maintain a competitive edge in the global marketplace.

Across the country at the University of California, Berkeley, students who are part of Space Enterprise Berkeley worked with Protolabs to manufacture 3D-printed components for the Eureka-1's (E-1) plenum and parachute system, achieving their goal of throttling and launching the first ever bi-propellant liquid-fueled rocket powered by a collegiate rocketry team.

The WarpSPEE3D printer. *Courtesy Bradley Deuser, Missouri S&T*

The E-1 was three years in the making for the SEB team as part of their goal to become the first collegiate rocketry team to pass the Karman line, which divides Earth's atmosphere and outer space. The December 2022 launch of the rocket put the team well on its way when it reached more than 11,000 feet in altitude.

The rocket's plenum and parachute system were printed via selective laser sintering (SLS) with PA12 40% glass-filled nylon. According to Asa Garner, structures lead, the team researched the options and ultimately chose this material due to its strength, temperature resistance, long-term wear resistance and cost-effectiveness.

Garner explained that without 3D printing the team couldn't iterate on the component designs as quickly as they did for this project. "Both of the critical main parachute bulkheads were entirely 3D-printed and we're using thermoplastic heat set inserts to fasten them to our primarily fiberglass airframe," he said.

Garner and his team plan to use 3D printing and machining for various components in their latest project, the Eureka-2 rocket, which they plan to reach an altitude of 20,000 feet. The key learnings from that launch will pave the way for what the team hopes is a Karman-line surpassing Eureka-3.

Driven by innovations such as advancements in materials and software, as well as universities investing in the technology, additive manufacturing continues to make progress as *Machine Design* continues to report on its potential. ■

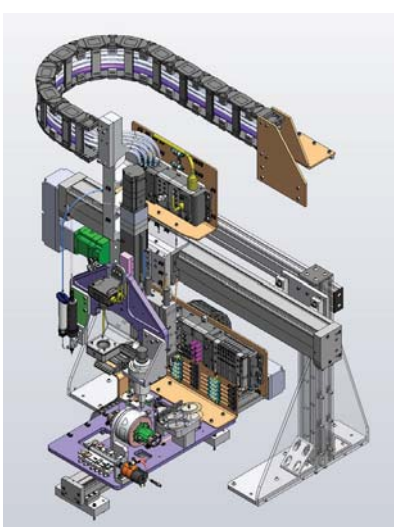
Custom Machine Builder

Develops Automation Solution That Increases Production Capacity Four-Fold

Kamp Automation developed a mechatronic solution to meet a customer's requirements. By automating a labor-intensive process, production capacity for an industrial electronic component was increased four-fold from a single machine.

AT A GLANCE:

- Custom machine builder KAMP Automation automated a labor-intensive process for a customer that increased production capacity for an industrial electronic component four-fold from a single machine.
- The authors maintain that the project stickhandled by KAMP Automation reveals the importance of custom solutions to the health of the U.S. manufacturing sector.



This CAD image shows the three axes. The X transverse axis is at the top with its energy chain. The Z axis, center, holds the various applicators and camera. The Y axis, at the bottom, is the platform for the housing fixtures on a rotary drive. *Images courtesy of Festo*

by Derek Limesand, Sales Engineer, Mechatronic Solutions
Ben Toskey, Vice President Sales, KAMP Automation

CUSTOM AUTOMATION suppliers fill the gaps between original equipment manufacturers that supply modifiable platform machines and end-use manufacturers, which may also require something special for their operation. Automation solutions of all types are especially important today as reshoring becomes a fact of life and the lack of public interest in 21st Century manufacturing jobs shrinks the talent pool.

At one time, most manufacturing operations had internal talent to design and build custom machines and provide for the organization's unique manufacturing requirements. As internal costs rose, these teams shrank and many were eliminated. Now custom machine builders fill those roles. They rely on close working relationships with suppliers and distributors to gain the latest technology. Custom machine builders employ talented mechanical and electrical engineers who creatively develop mechatronic solutions to meet customer requirements.

A Case in Point—The Adhesive Application Machine

A manufacturer came to KAMP Automation needing to expand the production of an industrial electronic component. The photoelectric sensor unit's small housing, made of die-cast aluminum, protects the electronics inside. LEDs and an LCD numerical display show the operating condition of the component. The LEDs and LCD display are protected by plastic covers adhered to the metal body.

While the metal housing and circuit boards were made efficiently and cost-effectively in high numbers, adhering three plastic covers to each housing with a quality seal was slow and labor-intensive. When this electronic component was first introduced, low output was not a problem. As demand for the component increased, however, the bottleneck of plastic cover application became a concern. The manufacturer asked KAMP Automation to design an automated machine that would significantly expand capacity and ensure quality seals for the adhered plastic covers.

The Manual Process

In the manual process, an employee placed two metal die-cast housings on a fixture and placed the fixture on a tabletop gantry system, with one cover opening facing up on each housing. On the fixture, the employee also placed plastic covers for that opening.

Entering a code into the HMI for that cover opening, the three-axis gantry used plasma gas to prepare the metal and plastic surfaces for a strong bond. Following the application of plasma gas (both the gas and adhesive dispensers were mounted on the Z-axis of the gantry), a Nordson dispenser placed a bead of adhesive around the perimeter of the

housing's opening. The operator then removed the fixture and, using a handheld light source, visually confirmed the adhesive bead was continuous around the mounting surface. The employee manually picked up the plastic covers and pressed them onto the metal housings.

The operator replaced the housings on the fixture, this time positioning the units so that the next openings faced up. The operator entered the recipe for that opening on the HMI and repeated the process. And lastly, the employee repeated the process one final time for the third cover. The covers had different shapes—round, oval and rectangular— that demanded a unique coordinated movement of the X-Y axis. The manual process required about 12 min. to apply plastic covers to the two units.

Creative Solution

KAMP Automation studied videos of the manual process. The design team identified three bottlenecks:

- Loading/unloading the die-cast housings onto the tabletop gantry for plasma and adhesive application.
- Manually picking and placing the plastic covers.
- Manually checking the quality of the bead.

Then, the team came up with a creative mechatronic solution that relied on three ball-screw linear actuators for X, Y and Z motion, a pneumatic rotary actuator and a reliable vision inspection system.

The engineers applied a Festo EGC ball-screw linear actuator for Y axis motion. The EGC and the other axes met the ± 0.1 mm required accuracy for this application. The team mounted a platform onto the Y-axis EGC to hold the housings, covers and required equipment. Housing fixtures like the ones used in the manual process were attached on both sides of a Festo DRVS semi-rotary pneumatic drive with a Festo SRBS position sensor.

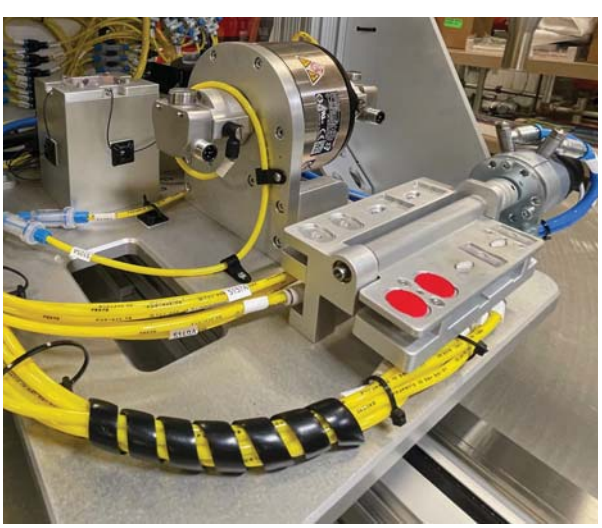
After covers were placed to the opening facing up, the DRVS rotated the fixtures to bring the next cover opening to the up position. Rotation eliminated the first bottleneck; there was no need to manually remove the housings and reposition them. The machine did the repositioning.

A Festo EGSC ball screw mini slide was used for Z axis motion. On the Z axis, the KAMP team mounted a plasma gas applicator, a Nordson adhesive applicator, a Banner iVu vision sensor and a Festo DFM pneumatic guided actuator with vacuum cup gripper. The DFM automated picking-and-placing covers, eliminating the second bottleneck. The vision system automated inspection and made it more accurate.

The X axis—also a Festo EGC ball-screw linear actuator—and the Y axis were programmed to work in harmony to trace the precise round, oval and rectangular contours of the openings and to position the applicators, vision system and pick-and-place unit precisely where they needed to be during the assembly process.

Putting it All Together

In the new automated process, the machine operator places two die-cast metal housings on fixtures and six plastic covers on a cover fixture (three covers for each housing). Vacuum holds the metal housings and plastic covers in place. Manually loading the machine made sense from a cost standpoint and only



The aluminum housing of the industrial electronic component is mounted on a machine prior to assembly. A round opening is pointing up ready for the insertion of a plastic cover.

Closeup of the die-cast housing mounted on the rotary drive. The circular cover opening is pointing up, ready to receive adhesive.

required seconds. Housings and covers in place, the operator starts the machine.

The X and Y axes position the vision sensor above the die-cast housings and the covers to verify all parts are present and correctly presented. The X and Y axes then trace the contours of the cover openings on the housings and over the plastic covers as plasma gas is applied to prepare the surface for a strong bond. The Z axis vertical motion ensures proper distance between the gas applicator and the part.

KAMP Automation's distributor, Mechatronic Solutions, Maple Grove, Minn., worked closely with KAMP on the project, identifying and supplying the key components. The distributor used the software productivity tool Festo Positioning Drives (recently revised and renamed Electric Motion Sizing) to properly size the EGC and EGSC ball screw actuators with Yaskawa motors and servo drives.

Following plasma application, the Nordson applicator applies adhesive to the perimeter of the housing's cover opening. The vision system confirms a continuous bead has been laid down, and the DFM picks and places the correct plastic cover. When both housings have covers, the DRVS rotates the housings to the next opening and the plasma, adhesive, vision inspection and placing of covers are repeated. In all, the two housings are rotated three times and six covers are applied in roughly three minutes, a 75% time reduction over the manual process.

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Mechatronic Solutions entered payload, loading, center of mass, acceleration/deceleration, cycle time and dwell data into the software, then Positioning Drives determined the right combination of actuator, motor, drive and accessories. KAMP has never had a Festo linear actuator fail in the field.

Mechatronic Solutions also identified a Festo CPX-MPA-L valve terminal as ideal for the customer's machine. The CPX-MPA-L offers one point of integration for both Festo pneumatics and remote I/O into the PLC. This single point of integration simplified commissioning.

As this adhesive dispensing machine example illustrates, custom automation solutions companies provide a vital service to the manufacturing community. ■

The operator's view of the adhesive machine showing the X, Y and Z axes.

A closeup view of the Y axis, center, and the Z and X axes, above. On the Z axis from left to right are the Nordson adhesive applicator, Banner vision system and plasma gas applicator. The pick-and-place guided actuator is mounted behind the plasma applicator and is not easily distinguished. A box of die-cast housings is visible on the lower left.

The Future of Connected Worker Technology

and Its Impact on Industrial Training

A new paradigm of work driven by technology is reshaping industrial skills and training efforts in profound ways.

by Eric Whitley, Director of Smart Manufacturing, L2L

THE INDUSTRIAL LANDSCAPE is undergoing a transformation. Gone are the days of static assembly lines and isolated tasks. Today's factories and facilities are dynamic environments where automation, data analysis and interconnected devices play crucial roles.

A connected worker uses technology to enhance their capabilities and seamlessly integrate their actions with digital industrial systems. Connected worker technology is reshaping industrial training in profound ways. This new paradigm is crucial in enabling workers to operate with increased efficiency and intelligence.

The Emergence of the Connected Worker

Industrial working environments of the past were marked by the manual execution of tasks and the segmented operation of machinery. The flow of information was linear and slow, with improvements and innovations being implemented at a glacial pace compared to today's standards. Such settings required the physical presence and undivided attention of workers, often at the expense of efficiency and safety.

The paradigm shift towards connected worker technology has brought a fusion of wearables, augmented reality (AR) and the Internet of Things (IoT) into the industrial workflow. This trio of technologies is reshaping the fabric of industrial environments, making them more responsive and interconnected.

Key Features of Connected Worker Technology

Wearables are now integral to the connected worker's gear, tracking health metrics and environmental conditions. They offer a dual benefit: safeguarding the worker while also collecting valuable data to inform safety practices and operational efficiency.

AR is a transformative force providing workers with real-time visualizations that offer guidance and clarity on complex tasks. This technology has turned complex schematics and manuals into interactive 3D models that can be superimposed onto the real work environment. As a result, workers can perform intricate procedures with greater precision and confidence.

IoT's prowess in data collection and real-time communication has turned each device into a beacon of insights, with sensors and actuators feeding a constant stream of information into the

industrial network. IoT has effectively created a digital nervous system that spans the entirety of industrial operations.

Impact on Industrial Training

The leap from traditional classroom training to digital methodologies is a seismic shift in industrial education. Traditional methods often relied on theoretical knowledge and simulated environments, whereas digital approaches provide interactive, hands-on experiences that mirror actual workplace scenarios—and a more effective transfer of knowledge.

The Role of Immersive Technologies in Training

Immersive technologies such as virtual reality (VR) and AR have taken center stage in training, propelling workers into environments that are both controllable and experientially rich. With VR, employees can navigate through life-like simulations that would be too dangerous or expensive to recreate in real life. AR overlays essential information onto the real work setting.

Interactive learning modules have revolutionized on-the-job training, facilitating an active learning process that is both personalized and engaging. These modules, often accessible via tablets or smart glasses, allow workers to learn by doing, which is instrumental in retaining complex procedures and protocols. The interactivity also ensures a more inclusive and effective learning environment.

Advantages of Digital Training Methods

Digital training methods have been proven to enhance engagement and significantly boost the retention of information among workers. Workers are transformed from passive recipients of information into active participants in their learning. Such engagement is crucial for translating training into practical, on-the-floor skills.

One of the most significant advantages of digital training is the ability to provide real-time feedback and adapt learning paths according to individual performance. Workers can immediately correct their actions based on the system's feedback, which accelerates the learning process and personalizes the experience to meet each worker's needs. This makes training tailored endeavor rather than a one-size-fits-all model.

Enhancing Safety and Efficiency

Connected worker technology has elevated safety protocols from being reactive to proactive, with predictive analytics anticipating potential hazards before they occur. Wearables alert workers to safety risks, and managers can monitor environmental conditions in real time, enabling immediate intervention when necessary.

Real-time data and collaboration have yielded impactful and measurable efficiency gains. For instance, connected devices enable the immediate adjustment of machine settings to optimize performance, while collaborative platforms allow teams to solve problems without the delays of traditional communication methods. These gains and advancements are not limited to speed; they enable workers to make smarter decisions that benefit the entire production line.

Real-Time Collaboration and Decision Making

The capabilities of IoT and AR are the foundation of a new era of teamwork. IoT allows team members to share operational data instantly, while AR can bring a remote expert's guidance directly into a worker's field of vision. Together, these technologies facilitate a collaborative environment where knowledge and expertise are shared regardless of physical location.

Data analytics is, to put it simply, turning vast amounts of data into actionable insights. Workers and managers alike rely on analytics to understand trends, forecast outcomes and make decisions that align with real-time operational intelligence. This data-driven approach has transformed decision-making from a gut-based to an evidence-based practice.

Adopting new technologies invariably introduces a learning curve. Training programs must be designed to bring workers up to speed without overwhelming them, and support systems should be in place to aid in the adoption process. Successfully managing this learning curve is crucial for harnessing the full potential of these innovations.

Future Trends and Predictions

The integration of artificial intelligence (AI) and machine learning with connected worker technologies heralds a future where industrial processes become even more intelligent and adaptive. These advanced algorithms can analyze complex data streams to enhance decision-making and efficiency. As AI continues to evolve, it will undoubtedly become a key feature in a connected worker platform.

The horizon for AR and VR in industrial training is one of boundless potential. As these technologies mature, we can anticipate even more refined simulations and augmented experiences that will further diminish the boundaries between digital and physical realities. The future points towards a seamless integration of our digital tools with the natural environment of the industrial workspace.

The role of humans within industrial settings is transitioning towards more cognitive and analytical functions. Workers are now the strategists and problem-solvers, with their irreplaceable human ingenuity complementing the precision of machines. It is an evolution that underscores the value of human insight, with technology amplifying human potential rather than replacing it.

Data analytics is, to put it simply, turning vast amounts of data into actionable insights. Workers and managers alike rely on analytics to understand trends, forecast outcomes and make decisions that align with real-time operational intelligence. This data-driven approach has transformed decision-making from a gut-based to an evidence-based practice.

Technology has been instrumental in bridging the gap between field workers and management, creating a unified vision of operational goals and challenges. With real-time data flow and communication platforms, the insights of those on the production floor can inform managerial decisions. This synergy ensures that decisions are not made in silos but are the result of shared knowledge between all organizational levels.

Challenges and Considerations

One important step towards robust and efficient infrastructure is striking a balance between data collection for operational efficiency and respecting the personal boundaries and data rights of employees. Robust cybersecurity measures and clear policies are non-negotiable to maintain trust and protect against potential breaches.

Retool for Growth

The transformative impact of connected worker technology on industrial training has been revolutionary, offering a new paradigm where efficiency, safety and knowledge-sharing are greatly enhanced.

The future of work suggests a landscape of continuous learning and adaptation, where digital tools become partners in progress and catalysts for an ever-evolving industrial workforce. ■

5 Common Machining Mistakes to Avoid

From adding thin walls to raised text to "non-threadable" holes, subtractive manufacturing such as CNC milling is not without its mishaps. Here are ways to avoid some of the most common DfM don'ts.

by Dan Snetselaar, CNC Product Leader, Protolabs

DESIGN BEST PRACTICES are highly technology dependent and CNC machining is no exception. As a subtractive manufacturing process, machining comes with a specific subset of design dos and don'ts. Here are five frequent design mishaps we often see at Protolabs as we work with customers to address design-for-manufacturing of machined parts.

1. Adding Tall, Thin Walls

Parts with walls—generally—don't tend to work well as they're prone to rippling, bending, chipping or breaking during the cutting process. Taller walls will likely require added thickness for support. Protolabs recommends walls with a width-to-height ratio of 3:1. Adding draft (a slight angled taper) to a wall is one way to sidestep potential issues.

2. Small, Intricate or Raised Text

It's common for parts to require a serial or identification number of some kind. Keep in mind that adding text to parts means added cost. While one might equate smaller to less expensive, it's the opposite in this case. Small endmills that cut the text run at a markedly slower speed and add more time on parts, meaning increased cost. Larger text is a faster process to achieve and recessed text, versus raised, is much more cost efficient.

3. Out-of-Pocket Features

Adding square corners or internal small corner pockets are common design tweaks attempting to cut down on part weight, but the small tools required to machine these features add substantial overall cost. Protolabs recommends thinking through how critical the pockets are to the part. If they're intended only to reduce weight, consider other ways to achieve that in the design.

4. Incorporating "Non-Threadable" Holes

Adding threaded holes to a part is easy if hole diameters are confirmed within the range for the static set of threads available. As a digital manufacturer, quoting software allows users to choose the thread and then automatically identifies holes that are in the specific diameter range for the selected thread.

5. Moving from Machining to Molding

Each manufacturing process has unique design requirements. Protolabs often sees molded parts uploaded to its machining services for prototyping prior to purchasing a mold. For example, a molded part may include ribs and pockets, which works well for molding; however, these features add significant run time for machining. All in all, ensure that part design is optimized for its intended manufacturing process.

Taking a bit of extra time in the design phase to ensure optimal machinability can save significant time and overall cost. After uploading a 3D CAD model, work with applications engineers to ensure that design is ready to run smoothly. ■

Protolabs works with customers to address design-for-manufacturing of machined parts. *Courtesy Protolabs*

Master Embedded Systems Security:

A Step-by-Step Guide to Protect Critical Components

How can you cover all the bases for embedded systems security? This step-by-step guide takes you through best practices.

by Emily Newton, Technology and Industrial Journalist

EMBEDDED SYSTEMS SECURITY is an essential concern in the modern landscape. Products ranging from aircraft control to washing machines contain and need them to run correctly. Many embedded systems work in real time, providing mission-critical information…which makes the consequences especially dire if they're targeted by cybercriminals.

An embedded system has the highest likelihood of being secure when everyone involved in designing it takes a methodical approach to reducing vulnerabilities. Here's how they can do just that.

Take a Security-First Approach

Unfortunately, too many people working to create embedded systems treat cybersecurity as an afterthought. They frequently find problems late in the design process and may struggle to adequately address them before products go on the market.

Shawn Prestridge is a U.S. field-applications engineer manager for IAR Systems, which makes security tools. He estimates only 20-30% of companies prioritize minimizing security vulnerabilities in embedded systems. Even worse, Prestridge said many people put little to no thought into cybersecurity for their embedded systems or are wholly unequipped to safeguard them against threats.

Securing a system begins with understanding how cybercriminals will likely target it and which approaches they'll take when trying to steal data. For example, an adversary that launches a software-based hack could infect the system with malware or perform a brute-force attack. Network-centered attacks, including distributed denial of service (DDoS) or man-in-the-middle attempts, are also possible.

Assess your client's cybersecurity practices and identify necessary improvements when building an embedded system. Designing a secure embedded system is essential, but preventing attacks also requires client preparedness and an attitude of continuously updating practices and procedures to reflect evolving attack methods.

Once development begins, people should strongly consider using tools that perform code audits on embedded systems. Although these checks can happen manually, they require time and skill to do well. One widely used approach is to let automated tools handle the initial review and then have a development professional see what may have been missed.

People may push back on efforts to emphasize security if it extends the development timeline. However, it's far better to take cybersecurity seriously from the start than to later discover severe vulnerabilities that could take longer than anticipated to fix.

Isolate Essential Parts of the System

One best practice for embedded systems security is to isolate the aspects a hacker might try to exploit. Successful infiltration of one component would not allow the cybercriminal to gain additional access elsewhere.

Relatedly, people should set dedicated access control measures for each part of an embedded system. Jean-Georges Valle, author of a book about the importance of penetration tests for hardware, clarified how embedded systems never exist in isolation, providing cybercriminals access to the rest of a company's IT infrastructure. Valle also noted how people often mistakenly think embedded systems are inherently secure, so they forget to follow established methods of keeping out hackers.

People might apply the principle of least privilege to the system as they explore the most effective ways to keep critical components safe. It means users only receive the minimum access privileges required for a desired action.

A secure boot feature is another widely utilized protection mechanism for the vital components hackers may target. The secure boot uses the root of trust (RoT) to verify all code loaded or executed. The RoT is a reliable source within the system and uses cryptographic principles to check the code. It also works in stages, where an embedded system's state can only progress after validation.

Create Logging and Monitoring Features

Cyberattacks are increasingly frequent and costly. Statistics from 2021 revealed a 17% uptick in the average cost of security breaches. However, improved visibility can help people detect intrusion attempts earlier, potentially reducing the damage and associated expenses.

Building logging and monitoring capabilities into the embedded system can tell users about any unusual characteristics of the critical components. Many designers prefer lightweight and fast loggers that let the system maintain expected performance. Some data loggers offer real-time collection, helping people know precisely when something's amiss.

However, just collecting the data is insufficient for embedded systems security. People must also develop a process for reviewing the information and investigating anomalies. Some companies have responsible parties receive notifications of anything unusual in the logs. Then, there's little to no delay in them checking it out and potentially preventing an attack in progress.

Designers and engineers must make clients aware that the embedded systems have integrated logging capabilities and emphasize the importance of analyzing them. Picking out unusual events takes time, but it's a practical way to increase awareness of cybercriminals and stop their attack attempts.

Use an IDPS

It's always wise to use an intrusion detection and prevention system (IDPS) in addition to any logging capabilities that strengthen embedded systems security. People can configure the IDPS to handle multiple tasks and alert the appropriate parties to suspected problems.

For example, an IDPS may monitor network traffic according to established parameters. Then, it could take either an active or a passive response. In the latter case, the IDPS would maintain activity logs but leave humans to investigate further. However, an active response might block network activity to thwart or slow cybercriminals' efforts.

People using an IDPS to safeguard embedded systems must regularly update it to recognize the latest threats. Otherwise, it'll be easier for attackers to break through the defenses.

Remain Aware of Industry Developments

Cyberattacks are occurring so frequently that even people outside tech development and related sectors know they must do what's necessary to protect against them. Many IoT products will soon feature specific labels that show they meet cybersecurity standards.

More products focused on embedded systems security are also arriving on the market as vendors see the customer demand for them. It's also becoming more convenient to update the software used for embedded systems. Many enable over-the-air updates so the products stay current with limited intervention from owners.

Consider how cybercrime advancements could make it easier for outsiders to compromise embedded systems security and proactively reduce that risk. Maintaining appropriate safeguards requires putting yourself in the position of a hacker and considering what they'll target, then creating preventive measures. Eliminating all threats is impossible, but you can certainly minimize them.

Embedded Systems Security Starts With You

Many of these tips are for people directly involved in building embedded systems. However, even if you only use them, you can do so more securely, maximizing the usage applications for your embedded systems so they support your business. ■

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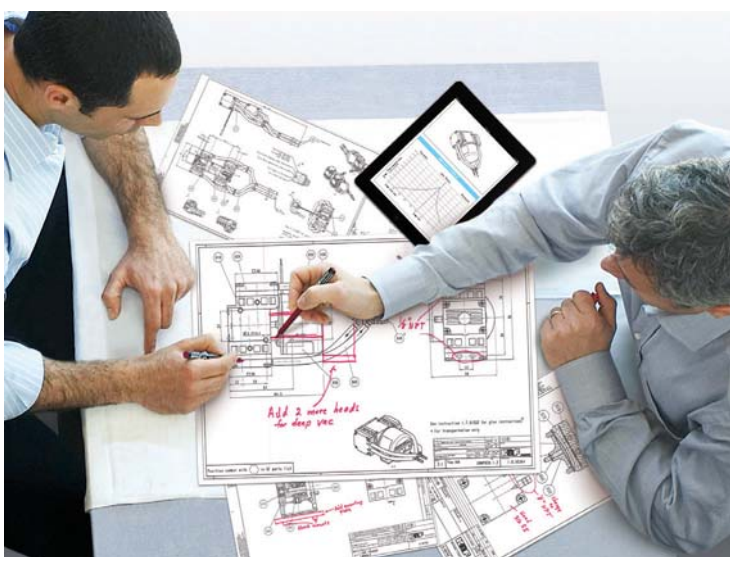

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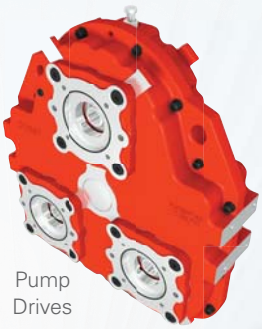

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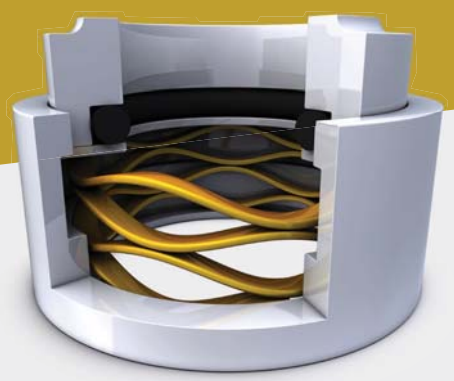

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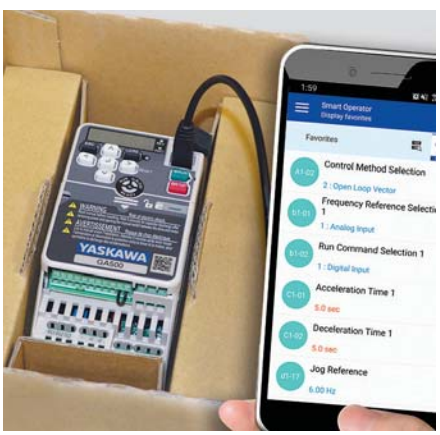

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