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A LITTLE ABOUT OUR PRICES

Our prices have been typically 50% less than traditional suppliers, and this is accomplished thru aggressive pricing from our suppliers because of our volume purchases. We can offer very attractive prices on everything from programmable controllers to terminal blocks. With our direct business model and focus on efficiency, we have the lowest overhead in the industry.

A LITTLE ABOUT OUR SHOPPING EXPERIENCE

Our product offering includes everything from cable ties, pushbuttons, sensors, wire, and tools, to pneumatics, HMIs, and PLCs, drives, motors and more. Our online store is available 24/7 for product research and ordering (no waiting for a distributor to contact you back) and our award-winning service is available if you need it during normal business hours.

Our store has many conveniences built in for customer satisfaction including easy online quotes, quick ordering by uploading CSV file, reusable BOM and favorite lists, secure checkout with convenient payment options including PayPal, upfront pricing (you get our low price no matter if you buy one item or one hundred), and real-time stock availability listed on each product page. We also have numerous helpful product selectors/configurator tools for PLC, servo system, motor, timing belt, and field I/O products. We have free documentation: manuals, comprehensive help files, price list, CAD files, free product tutorial videos, free (full package, no demo) software that you can take for a spin, and we list all customer reviews that we receive for our products, so customers know as much about the product as possible. Once the purchase is made our automated facility has an order accuracy of 99.98% but we do offer a 30-day money back guarantee on most products for any last-minute changes customers may need. Also, orders over \$49 ship free of charge.

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EXAIR Corporation manufactures Intelligent Compressed Air® products that improve manufacturing processes which involve blowoff, drying, cooling, vacuum, lifting and static elimination. Since 1983, EXAIR products have been engineered to reduce compressed air use, reduce compressed air noise exposure and increase safety for personnel. Their staff of industrial process experts are familiar with a wide variety of manufacturing segments and offer help to individuals trying to find the most efficient and effective solution to their problem.

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Most of EXAIR's cataloged products ship the same day when ordered by 2 pm EDT. EXAIR products are made in Cincinnati, OH and can be modified to suit a specific application. All of the cataloged products have a 30 Day Unconditional Guarantee, a 5 Year Built to Last Warranty, and ship factory direct from stock.

Tech support is available by e-mail: techelp@exair.com, Phone: 1-800-903-9247 or (513) 671-3322, and Live Chat from our website <https://www.exair.com>.



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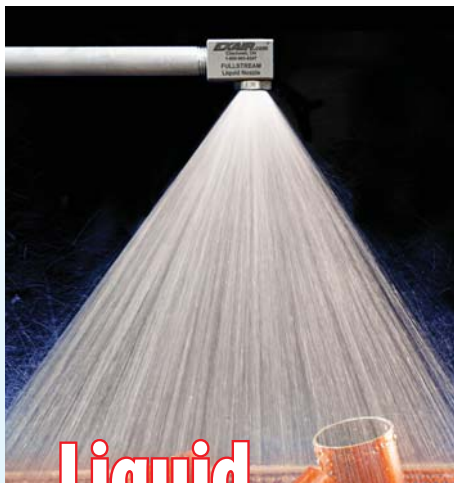


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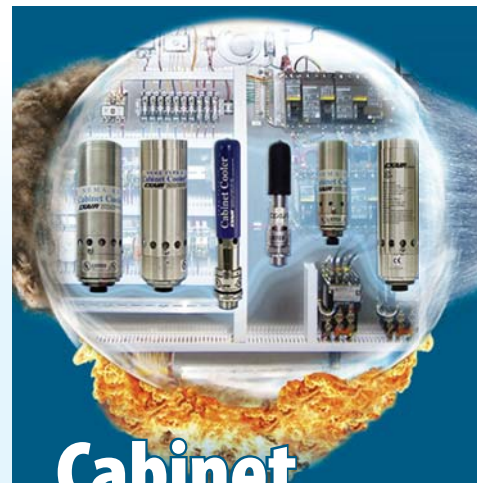


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Digi-Key Electronics, headquartered in Thief River Falls, Minnesota, USA, is recognized as both the leader and continuous innovator in the high service distribution of electronic components and automation products worldwide.

As the original pioneer in this space, **Digi-Key** provides more than 13.4 million components from over 2,300 quality name-brand manufacturers with an industry-leading breadth and depth of product in stock and available for immediate shipment.

Digi-Key is a \$5 billion company and employs more than 5,200 people in northwest Minnesota and beyond, delivering over 27,000 packages per day to customers in 180 countries around the world. **Digi-Key** is a leading global e-commerce company with a strong heritage of serving as a critical partner for companies around the world. This year, the company opened the doors to its new, 2.2 million square foot Product Distribution Center expansion, which will allow **Digi-Key** to meet and exceed customers' expectations more efficiently.



Digi-Key is the preferred supplier for Automation & Control and safety products, carrying a broad portfolio including advanced controls like PLCs, HMIs, motion, safety and robotics. **Digi-Key** provides customers with a frictionless digital interface, saving them time so they can focus on designing and building.

Beyond the products that drive technology innovation, **Digi-Key** also supports design engineers and procurement professionals with a wealth of digital solutions and tools to make their jobs more efficient. **Digi-Key** provides technical resources and robust search functionality to help you find the parts you need, including a range of EDA and design tools, reference design library and free online schematics tools, comprehensive article library and much more. By supplying customers with a frictionless digital interface, **Digi-Key** saves them time so they can focus on designing and building.

The **Digi-Key** Marketplace also gives customers access to an even broader variety of products and services in applications including bare PCB boards, industrial automation, test and measurement, IoT solutions and virtually everything related to technology innovation, all through a singular shopping experience.

The company also offers numerous supply chain solutions such as a complete set of APIs, bonded inventory and fast shipping, as well as a myLists tool for BOM management.

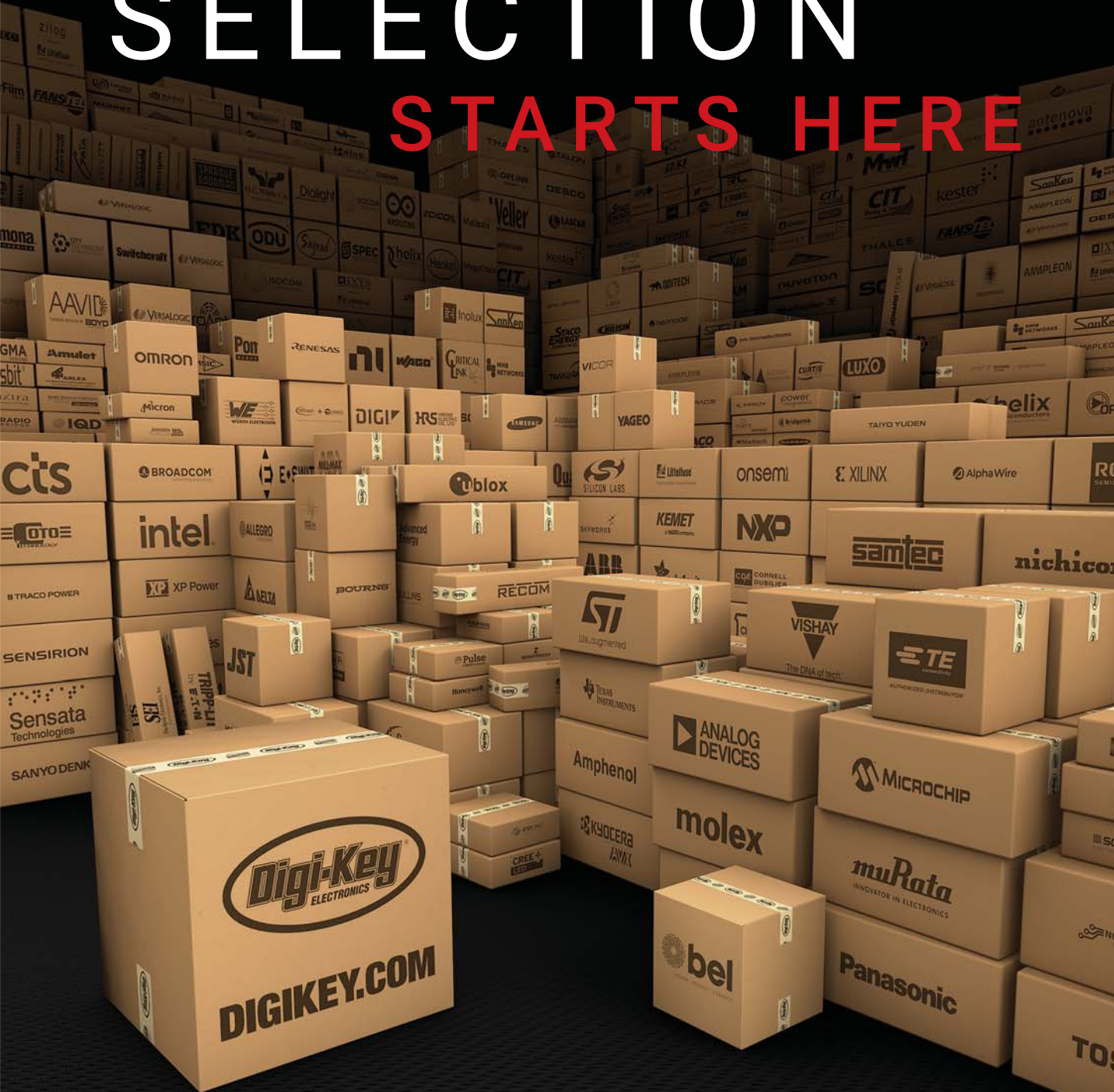


Digi-Key distributes the components and automation products used to build the machines and devices that propel industries like healthcare, automotive, energy, 5G and IoT into the future. From prototype to production, **Digi-Key** has the resources and products to take your design to the next level!

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ACE CONTROLS

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CONTROL MOTION AND VIBRATION WITH ACE

ACE Controls Inc., located in Farmington Hills, Michigan, is a leading innovator in deceleration, vibration and motion control technology. For over a half century, ACE has manufactured superior deceleration products, including industrial shock absorbers, gas springs and vibration controls to meet your most demanding application requirements. We are committed to delivering the highest quality and the latest technology to meet your challenges.

ACE components can be used in a variety of applications and industries such as aerospace, aviation, machine building, marine, medical, oil & gas, packaging and robotics. From up in the air to under the sea, ACE products:

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- Reduce vibration and noise
- Protect against wear and tear
- Reduce downtime
- Increase throughput
- Increase safety

With over 250 distributors across the globe, there's always an ACE expert nearby. Visit our website to find your nearest supplier, www.acecontrols.com.

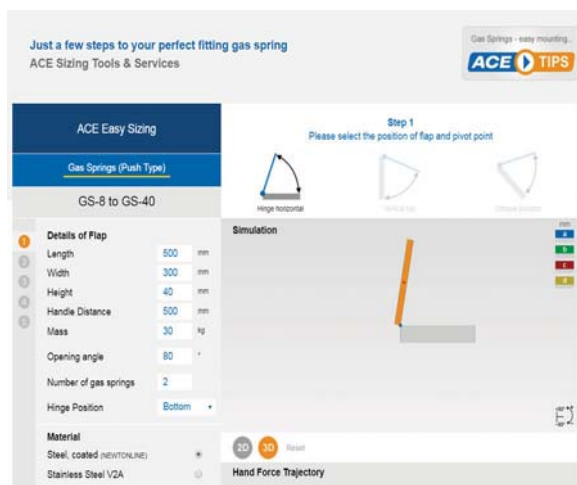
CUSTOM PRODUCT DESIGN & DEVELOPMENT

We offer a wide range of options to solve your motion and vibration challenges. Each product undergoes rigorous lab testing to ensure products are capable of meeting the most demanding conditions. Products are regularly evaluated for endurance, cycle life and material strength.

ACE specializes in custom engineering services, including working together with product engineers to prototype and develop patented components exclusive to your needs.



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- CAD library
- YouTube
- Blog featuring case studies
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trust ACE Controls with your motion
& vibration control challenges



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available to buy online

- Industrial shock absorbers
- Industrial gas springs
- Vibration isolation



Online Tools

- Calculations & product selection
- Chat function for application assistance



Resources

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- ACETips video tutorials
- Technical blog & case studies



ACE

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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.

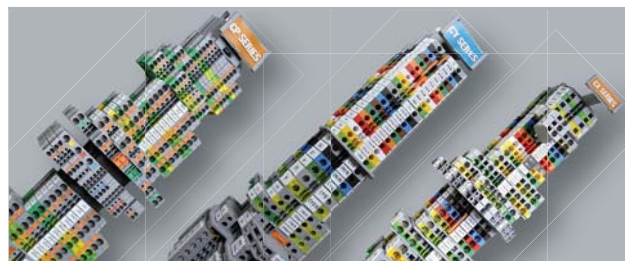
Altech provides a multitude of services for customers. This starts with its employees, where product managers provide technical support and partner with customers in design assistance, ensuring the best solution for the application. Next, an efficient customer service department ensures that customers 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.

SERVING AUTOMATION AND CONTROL INDUSTRIES SINCE 1984

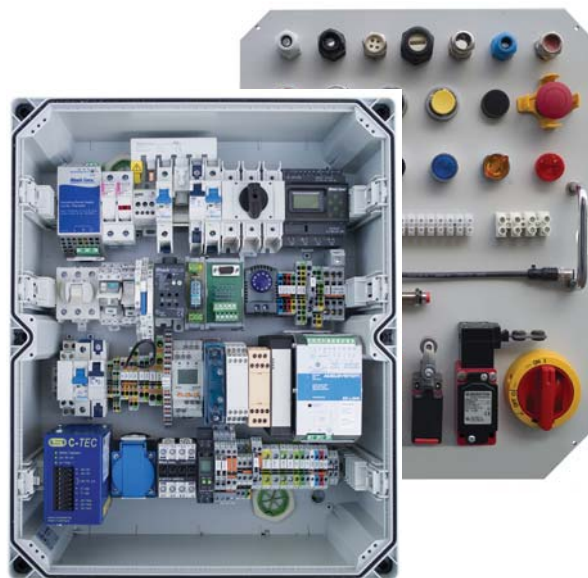
Altech's products meet UL and international standards, and all are RoHS- and REACH-compliant. Altech's commitment to quality and continuous quality management had been recognized since May 27, 1999 when it was awarded the prestigious honor of ISO 9001 certification. Since then, Altech has successfully gone through the recertification process and complies with ISO 9001:2015.

WIDE VARIETY OF AUTOMATION & CONTROL SOLUTIONS

The Altech product line includes miniature circuit breakers, busbars, DC-UPS devices, digital panel meters, DIN rail terminal blocks, printed circuit board terminal blocks, contactors, industrial relays, motor disconnect switches, pin and sleeve devices, receptacles, foot switches, relay modules, safety relays, slimline relays, solid state relays, push buttons, and pilot lights.



Broad Selection of Terminal Blocks
PUSH-IN • SPRING • SCREW

**Large Selection of Control Components**

Also available are metal detection systems, ferrules, marking and engraving systems, fuses, power distribution blocks, corrugated tubes, liquid tight strain reliefs, programmable relays, digital multi-timer, test and measurement devices, LED panel lights, mechanical thermostats, panel filters, tower lights, and wire ducts.

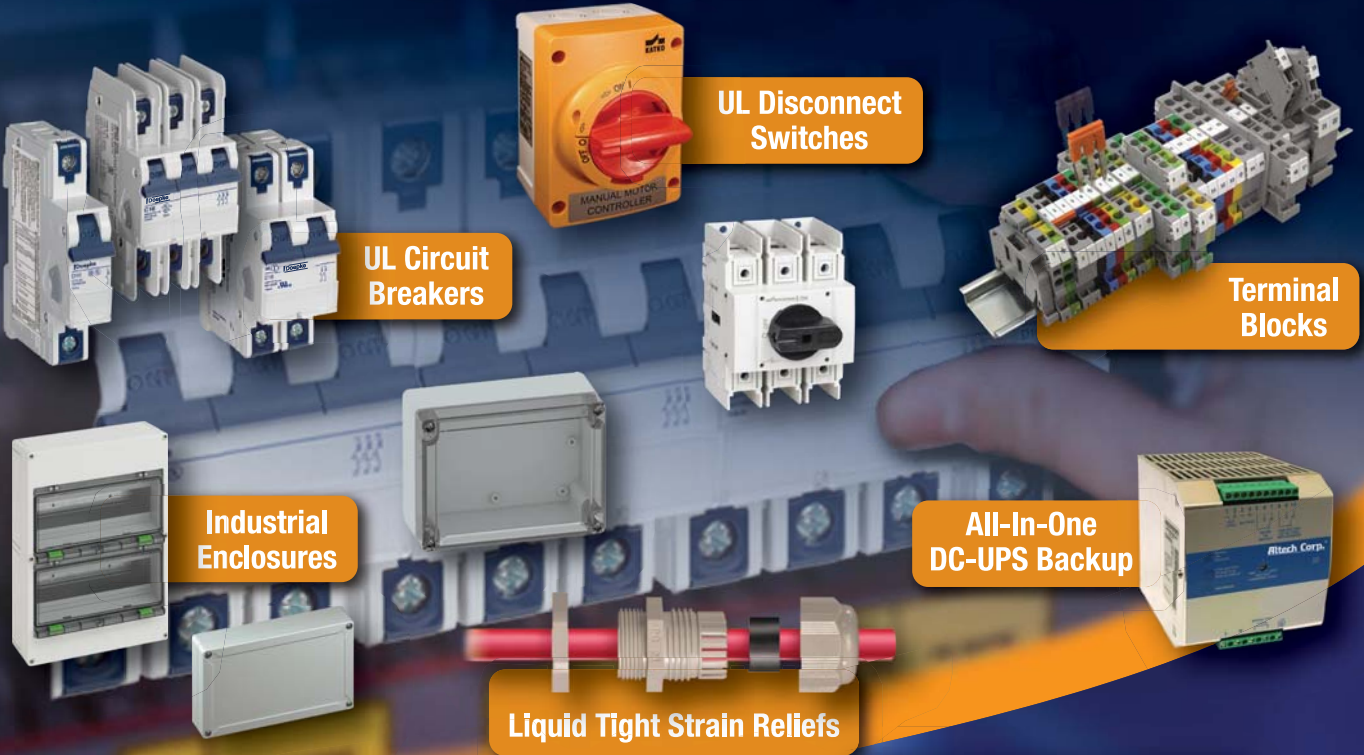
OUR POLICY

Altech Corp.'s Company Policy remains to provide adequately stocked quality products at competitive prices. Superior customer service and delivery are maintained through a quality management system and continuous process improvement and by performing these services with honesty and integrity. All Altech employees are regularly trained in quality management systems, and as a team are committed to achieving these goals.

Altech®

Your Source for Automation & Control Components

Altech® HI-QUALITY Control Components



We stock a Wide Selection of components!



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- Circuit Protection
- Contactors & Overload Relays
- DC-UPS • Digital Panel Meters
- Digital Timers • DIN Enclosures
- Eurostrips • European Fuses
- Ferrules
- Foot Switches
- Fuse Holders
- Industrial Enclosures
- Interface Modules
- Limit Switches
- Liquid Tight Strain Reliefs
- Marking & Engraving System
- Motor Disconnect Switches
- Pin & Sleeve Devices
- Power Supplies
- Push Buttons & Pilot Lights
- Rope Pull Switches
- Safety & Slimline Relays
- Safety Switches
- Solid State Relays
- Sensors
- Sensor & Actuator Cables and Connectors
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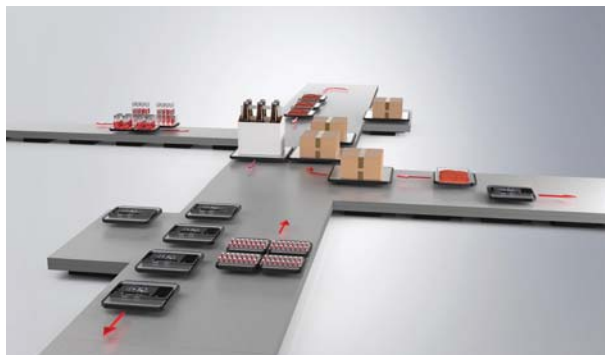
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Beckhoff Automation is a global provider of open automation systems based on advanced PC-based control technology. The “New Automation Technology” philosophy at Beckhoff represents universal and open automation solutions used in a wide spectrum of high-tech applications around the world. These applications range from control of machines and robots to Internet of Things (IoT) systems to category-defining mechatronics advancements and much more. The world headquarters of Beckhoff Automation is in Verl, Germany while the U.S. headquarters office is in Savage, Minn. (Minneapolis area).



A breakthrough in adaptive mechatronics technology, the XPlanar flying motion solution delivers unrivaled flexibility and throughput in part, product and package handling. The highly adaptive system uses planar motor tiles as a base to levitate passive movers that can fly at speeds of 2 m/s and up to 1 g acceleration. Path planning and collision avoidance software produce extremely efficient and maintenance-free motion control for complex assembly, packaging, inspection and material handling applications. Anti-sloshing functionality in TwinCAT 3 software optimizes XPlanar's transport capabilities in applications involving liquids, such as filling of beverages, cosmetics and other goods. XPlanar offers wear-free movement and the ability to cover planar motor tiles with stainless steel, glass or other hygienic surfaces.

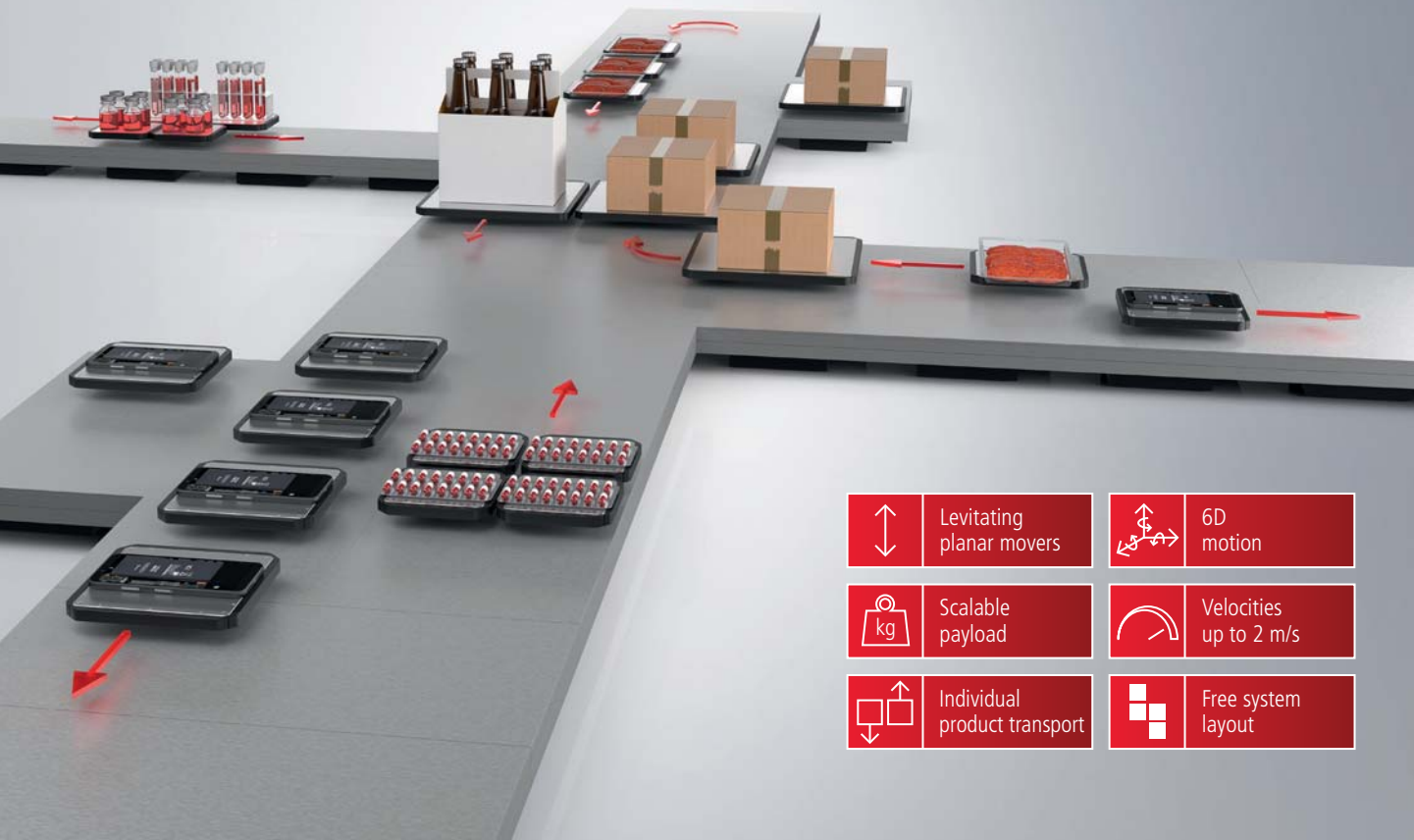
Beckhoff has also expanded the highly adaptive eXtended Transport System (XTS) portfolio recently with new hardware and software enhancements. With No Cable Technology (NCT), the XTS can provide contactless power supply and synchronous real-time data communication directly to its movers. This solution enables individual movers to serve as mobile handling and processing stations, essentially turning the intelligent transport system into a powerful, highly flexible multi-robot system.



BECKHOFF

XPlanar®: Agile machines with adaptive automation

Flying 2D product transport with up to 6 degrees of freedom



	Levitating planar movers		6D motion
	Scalable payload		Velocities up to 2 m/s
	Individual product transport		Free system layout

XPlanar enables new dimensions of freedom in product and material handling: Levitating planar movers fly over flexibly arranged planar tiles accommodating nearly any track layout and path planning.

- Individual 2D transport at up to 2 m/s
- Processing with up to 6 degrees of freedom
- Transport and processing in one system
- Wear-free, hygienic and easy to clean
- Free arrangement of planar tiles enabling totally customized machine and process layouts
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- Fully integrated into the powerful and standardized PC-based Beckhoff control system (TwinCAT, PLC IEC 61131, Motion, Measurement, Machine Learning, Vision, Communication, HMI)
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New Automation Technology

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FOUNDED IN 1931, CARLO GAVAZZI is a multi-national electronics group active in the design, manufacture, and marketing of electronic and electrical components for industrial automation and building automation.

With several ISO9001- and ISO14001-certified manufacturing and R&D facilities throughout Europe and Asia, and dozens of sales offices spanning the globe, you are assured that product support, service, and inventory are only a phone call, email or mouse click away. CARLO GAVAZZI products are developed and manufactured in full compliance with the most important standard regulations, such as UL and CSA.

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CONTROLS: Current/Voltage/3-Phase Monitoring Relays, Energy Meters/Software, Current Transformers, Switching Power Supplies, Timers, Digital Panel Meters, DuplineSafe Mining/Monitoring System, and Fieldbuses

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Putting the Digital Twin to Work

Bentley Systems sees wider application of technology beyond the design stage as it works with Siemens.

by Bob Vavra, Senior Content Editor

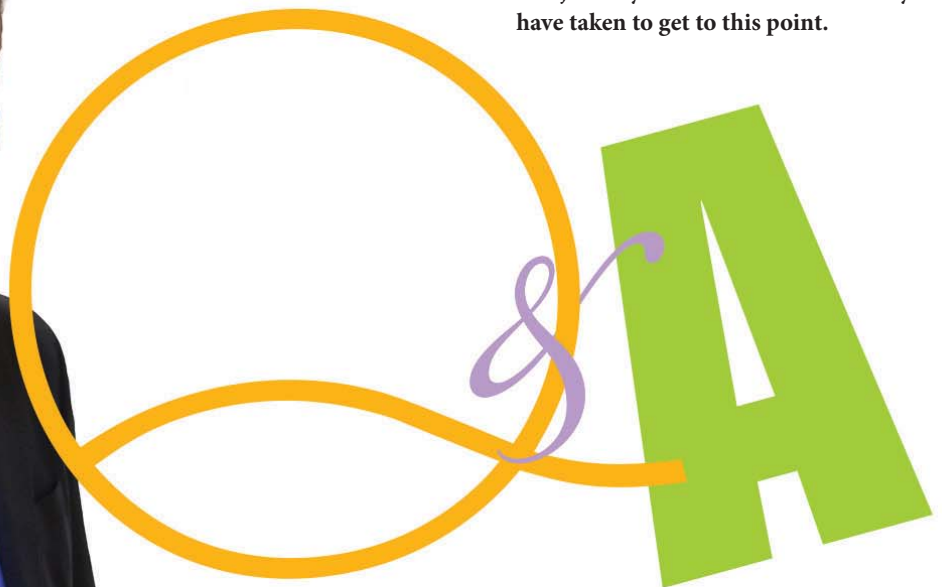
As Siemens rolls out its ambitious plans for Siemensstadt Square, a 180-acre mixed use development in Berlin, the company also is using the manufacturing, retail, residential and commercial site as a kind of test bed for the digital transformation technology the company has been espousing over the last several years. A critical component of that technology is the digital twin, which allows design teams to test and

commission operational parameters before construction begins. It also will allow for data management once the model is fully operational in 10 years, and to continue to test and add components without disrupting existing operations.

Bentley Systems long has been a Siemens partner on the use of the digital twin. When Siemensstadt Square was announced in October in Berlin, Bentley officials were on hand to present the capabilities and possibilities of the digital twin.

Bentley's use of the digital twin in the design phase of projects has been documented around the world with its annual Year In Infrastructure presentations and awards. *Machine Design* recently discussed the present capabilities and future plans for the digital twin with Nicholas Cumins, chief operating officer of Bentley Systems:

Machine Design: Bentley and Siemens long have collaborated around the concept of a digital twin. Siemensstadt looks to be a very visible way of demonstrating the design and operational potential of the digital twin. Talk a little bit about this journey that Siemens and Bentley have taken to get to this point.



Courtesy Nicholas Cumins



Nicholas Cumins: Bentley and Siemens announced their strategic partnership in 2016 to co-develop and co-sell digital twin solutions for infrastructure. Our joint focus is on process industries, rail and transit, and urban-built environments.

Bentley is strong in infrastructure engineering technology and Siemens is strong in operations technology. By putting our complementary strengths together to work across the lifecycle of the infrastructure, we are helping our users better design, build and operate better infrastructure.

The partnership is also about furthering our joint thought leadership in technology, as demonstrated at the recent Siemens Business Media Day in Berlin, where we presented the outlines of the emerging infrastructure metaverse.

In 2021 after a competitive bid, Bentley was awarded a contract by Siemens Real Estate to create a digital twin of the Siemensstadt district in Berlin. The project started the same year, and since then use cases and usage have scaled.

As the CEO of Siemens Digital Industries Cedrik Neike explained in May, together with the mayor of Berlin

Franziska Giffey, the objective is to use the digital twin of the district to simulate and test in the digital world first—to make Siemensstadt more sustainable, more inclusive and more livable in the real world.

MD: The Siemensstadt project now is in the design phase. What are some of the key considerations for designers as they look to bring all of these concepts together?

NC: Siemensstadt Square is a massive project. Around 1 million square meters of floor space will be built here by 2035 for industrial operations, commercial activities, research, education, residential units, temporary lodgings and social infrastructure.

As you can imagine, for a project of this scale and ambition, there is a wide variety of stakeholders to engage with, and the designers must take into consideration all the complex objectives of a hybrid city, bringing together space for living and working. This is why Siemens decided to create a holistic digital twin of the district, and then better build and operate it.

The digital twin includes not only the individual buildings, but also the infrastructure, including roads and open spaces as well as the supply of power and other utilities. The digital twin brings together a wide variety of data, all aligned with engineering precision to be leveraged in engineering workflows, all easily accessible to help the designers better coordinate with their stakeholders to make better design decisions.

The city planners have the ability to simulate and compare different scenarios to meet the objectives of the district—for example, carbon neutrality. They can integrate the designs from architectural competitions into the digital twin of Siemensstadt to better understand their impact.

The general public has also access to the digital twin, so an added benefit is to facilitate the engagement with the community, to share progress, and get feedback and acceptance.

The digital twin becomes the single source of truth for all involved in the project, whether designers, city planners, local government officials or citizens, and later on construction firms and maintenance crews, all equipped with the right data in

the right context, to make better informed decisions, leading to better outcomes.

MD: The finished project is many years off, but what are some of the things designers have already learned about a project of this size?

NC: The Siemensstadt Square project is fairly new, and as the project evolves it will surely drive changes in how the digital twin is used. Designers have learned to rely on the digital twin to access all the relevant information they need—for example, on a single module, building or lot.

Instead of looking for that information in various different files and systems, all the relevant data is now searchable or can be surfaced by a simple click on the related object in the 3D model of the district, making their workflows much more efficient.

The designers are also using the digital twin to do visual 3D volume studies of new proposed buildings while comparing them to the existing city structure and utilities. They can also do side-by-side comparison of proposed changes to a building with the existing conditions of that building, available in a high-resolution 3D model, derived from photographs or point clouds.

The designers use dashboards to do various KPI analyses while visualizing the results directly into the 3D model, making it easier for them to understand the impact of each decision.

The designers learned that having all that information in the same workspace not only makes their work easier, it empowers them to make better decisions.

MD: Bentley has presented its Year in Infrastructure and Going Digital Awards for many years. Are there lessons from your own users that have been beneficial as you've started to tackle this project?

NC: Absolutely. We launched our digital twin platform, iTwin, in 2018. More and more infrastructure projects presented for the Going Digital Awards are

“Digital twin technology provides tremendous value in all phases of the infrastructure lifecycle, not just planning and design. You can start using it during construction or directly during operations. The beauty of the technology is that it also allows you to mobilize data from one phase of the lifecycle to the next.”

making use of iTwin—more than 25% of the finalists in 2021—and we expect that number to be even higher this year. We have been in awe with the ingenuity and variety of use cases for which our users have leveraged the technology. They are, in turn, informing our product strategy.

The infrastructure sector is very file-centric. A file, after all, is the main deliverable of an architecture or engineering firm. The problem is that the data in that file is not easily accessible. It is siloed and in different file formats. It grows stale. It becomes dark. We estimate that 95% of the data in our sector is not accessible or is not used. Decision-makers are making under-informed choices about their infrastructure because they lack visibility and insight.

Our users are leveraging iTwin and the digital twin technology to light up dark data, crack open files, view data in context, align it with engineering precision, and get it to the right person at the right time to make better decisions, leading to better outcomes.

They are doing this during the planning and design phase of an infrastructure project, like Siemensstadt today—but also during construction and operations. They do it for all types of infrastructure, whether buildings, plants, roads and rail, bridges and tunnels, the electric grid or the water network.

MD: As presented, Siemensstadt is expected to migrate from design to operations to optimization, all on the same digital twin platform. Is this the ultimate use of digital twin? And can small to mid-sized manufacturers benefit from a digital twin in the same way as is envisioned for Siemensstadt?

NC: Yes, digital twin technology provides tremendous value in all phases of the infrastructure lifecycle, not just planning and design. You can start using it during construction or directly during operations. The beauty of the technology is that it also allows you to mobilize data from one phase of the lifecycle to the next.

Siemens clearly intends to leverage the digital twin of the district during operations. For example, the district will be monitored with Siemens sensors that measure everything from energy consumption, water and carbon footprint. The data collected will be surfaced in the digital twin and used in predictive analytics to suggest if and where maintenance work will need to take place. All the relevant data collected during the design, construction and operations will be readily available for the maintenance teams to prepare and execute the work, significantly reducing the time, effort and risk involved.

To answer your question about whether small to mid-sized organizations can benefit from a digital twin, the answer is a resounding yes. This is not just for mega-projects. Using digital twin technology is very easy to start with. You can start by simply taking pictures of an existing infrastructure asset and from there create a 3D model to create a digital twin.

You can also upload a simple design model into the Bentley iTwin platform to create a digital twin. From there you can overlay additional information from disparate sources, whether engineering, operations or enterprise systems, as needed for your specific use cases. The threshold to start a digital twin journey is low and can scale over time. ■

FAQ

The Key Elements to a High-End Safety Relay

Safety relays are used across a wide range of industries and in a broad array of equipment to protect machines and operators during a catastrophic fault to avoid costly maintenance or equipment replacement. Whether single function or multi-function, safety relays are a critical part of systems such as elevator controls, railway technology, robots, machine tools, packaging equipment, and more.

Q: What is the primary operation that safety relays provide to the user?

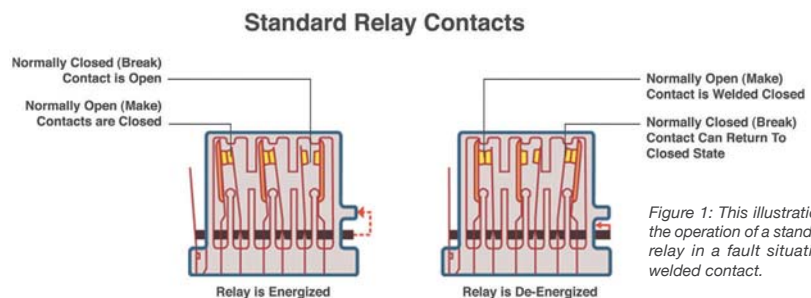


Figure 1: This illustration shows the operation of a standard safety relay in a fault situation like a welded contact.

A: Safety relays have forced-guided relay contacts (also known as positive-guided relay contacts, captive contacts, and locked contacts — see Figure 1). The contacts in a particular contact set are mechanically linked together so that no single contact in the relay can change state without changing the state of all other contacts. This makes it impossible for NO (normally open) and NC (normally closed) contacts to be closed at the same time. This forced guidance must be present even if a relay part fails to function correctly.

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Q: Why is having a forced-guided relay necessary?

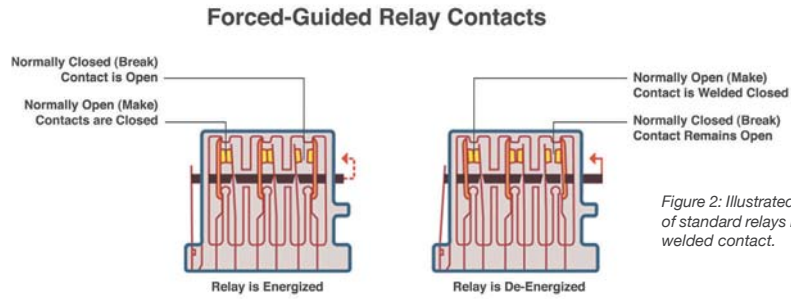


Figure 2: Illustrated above is the operation of standard relays in a fault situation like a welded contact.

A: It is important that your relay remain engaged when there is a machine failure. This not only keeps access to the area where the fault occurred restricted to protect the operator from being harmed, but it also stops the machine from causing further damage to itself. With standard relays, opposing contacts can end up in the same state causing a safety risk like providing entry to a dangerous location (see Figure 2).

Q: Are single-pole and multi-pole versions available?

A: A safety relay consists of at least one normally closed contact and one normally open contact. Depending on the company you choose to partner with, you'll find that there are a variety of safety relays available. Forced-guided relays can be found in 2-pole, 3-pole, 4-pole, 6-pole, and 8-pole versions for multiple applications where complex equipment and machines are installed. These various contact arrangements should come with international approvals so that machines can be sold around the world.

Q: Do contact materials make a difference when selecting a safety relay?

Safety Relay Selection Material Table

Material	Characteristics	Applications	Range
AgSnO ₂ + 0.2μmAu C	very low welding tendency highest burn-up resistivity very good arc suppression	special for switching, inductive loads	10mA - 10A
AgNi10 + 0.2μmAu N	low welding tendency high burn-up resistivity good arc suppression	circuits with medium to high switching current, DC current circuits	10mA - 10A
AgNi10 + 5μmAu S	higher welding tendency low burn-up resistivity low contact resistance	where very low to medium switching current and voltage is mandatory	2mA - 300mA

Figure 3: Different materials used in safety relays provide a variety of characteristics to the user.

A: Yes — material selection is important and varies based on the required switching current and the type of load. The chart above in Figure 3 indicates some of the materials used more often. Note that all contacts are typically gold flash plated for long shelf life and that mixed contact materials are available as options.

Q: Are safety relays available in a variety of formats for different types of equipment?

A: Both individual safety relays and modules are available for use, including those that fit DIN rail and PCB sockets. The relays are often available in standard vertical configurations as well as low profile flat pack designs. DIN rail mount modules are often available as well. These may include a choice of isolated or bussed channels, screw cage clamp connections, an LED coil voltage indicator, reverse polarity LED protection, and a broad enough number of channels to suit your application.

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The Key Elements to a High-End Safety Relay

Q: How can I be sure that the safety relay I purchase is fully operational?

A: Safety relays are required to have function testing performed on every relay produced rather than completing only batch testing. This ensures that the safety relay or module is 100% safe to use in your application. During relay use the force guidance of the relay ensures that opposing contacts are always in opposite states. This behavior enables simple diagnostics and fault detection when monitoring the forcibly guided feedback contacts.

Q: What if I don't see the exact combination of contacts or materials that I need?

A: Manufacturers of safety relays often run into applications that stretch the boundaries of the devices. In these cases, a company like Altech can offer technical assistance in determining a design for a custom system. Some common customizations include coil voltage and resistance, mixed contact materials, various contact pressures, contact arrangements, and operate/release times.

Q: What accessories should I make sure my supplier has on hand?

A: Accessories for safety relays are often specific to the relay's model number. Be sure that sockets are available for your DIN rail and printed circuit board projects. This is especially important in printed circuit board applications so relays can be removed without de-soldering them from the board.

Q: What are some standard applications where safety relays are necessary?

A: Safety relays can be used in any piece of machinery or equipment where the safety of the user and/or machine is paramount. Applications include safety door controls, two-hand operating devices, pressure mat controls, light curtains, speed controls, and a wide number of monitoring devices. Such equipment is found in rail transportation systems, elevator controls, cutting machines, medical equipment, stamping machines, robot and cobots, printing and textile machinery, cranes, and many other systems.

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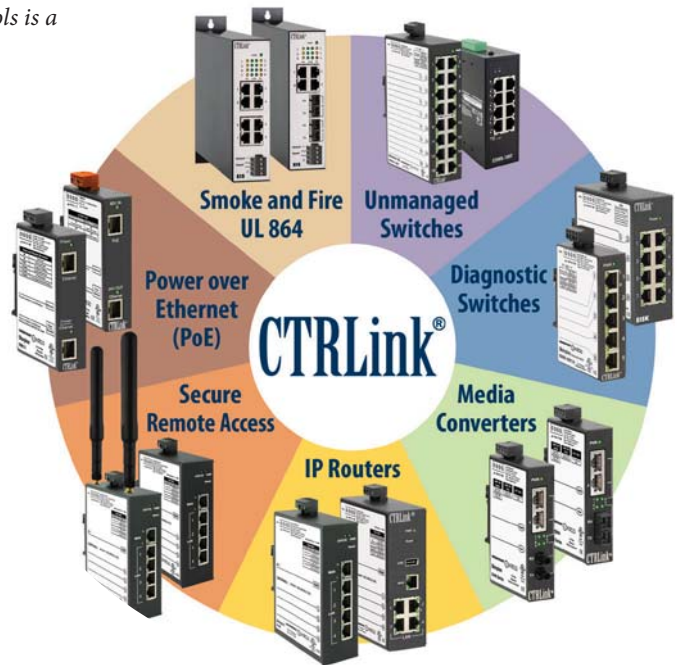
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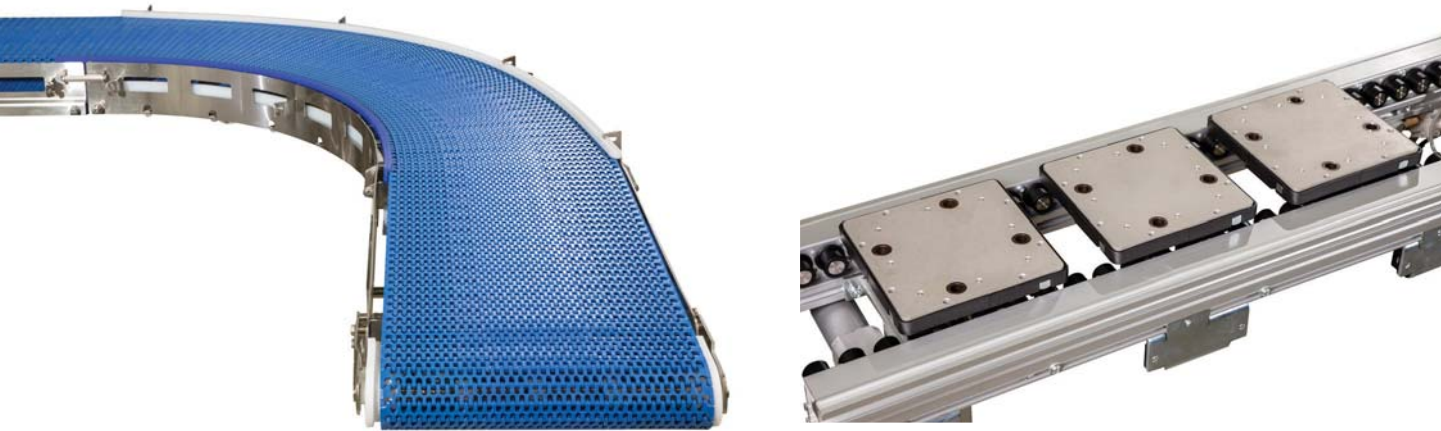
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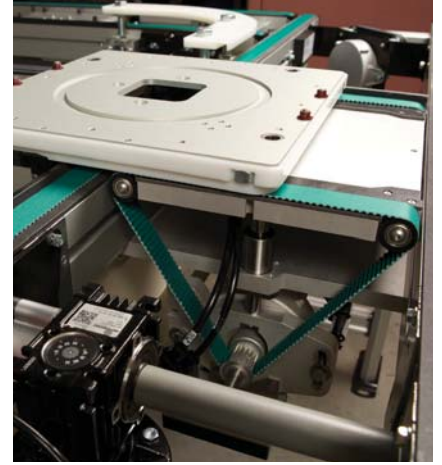
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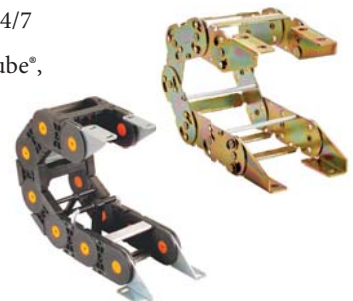
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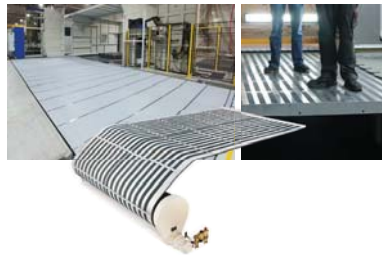
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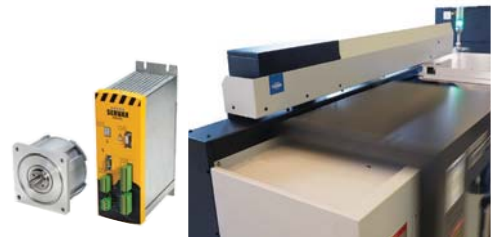
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Data Privacy: Why Automakers Should Be Proactive About Securing Their Chips

Hardware security must be ensured as stringent automotive cybersecurity standards loom.

by Mitchell Mlinar, Vice President, Engineering, Cycuity

The automotive industry must remain proactive and vigilant as the ongoing inclusion of connective technologies and the implementation of greater cybersecurity standards changes the way road vehicles evolve.

The auto industry is projected to lose \$505 billion by 2024 due to cyberattacks, according to Upstream's 2022 Global Automotive Cybersecurity Report. And as road vehicles continue to incorporate Bluetooth, Wi-Fi, cellular and USB interfaces as part of manufacturers' pivot toward connectivity, threats are evolving as rapidly as the vehicles.

Statista projects there will be 76.3 million connected cars by 2023, while Fortune Business Insights expects there will be a \$191.83 billion market by 2028. Road vehicles today contain as many as 150 electronic control units and about 100 million lines of software code, according to UNECE. Vehicles are expected to have

300 million lines of code by the start of the next decade.

That is a sprawling attack surface in which threat actors can jeopardize the safety and privacy of consumers. And while vulnerabilities in software can be patched, it is more difficult to address those in the hardware, especially on the semiconductor chips on which the software operates.

Given these developments, original equipment manufacturers (OEMs) will soon be required to improve cybersecurity from inception through delivery via new processes and standards. They will need to build upon ISO 26262, a specification that governs the functional safety of electrical and electronic systems, by adopting ISO 21434 (published July 2021) to account for emerging cybersecurity threats.

With the demand for connected cars growing and production returning to pre-pandemic levels, here are three reasons why the security of semiconductor chips

manufactured for the automotive industry is paramount.

1. There is No Easy Fix for Semiconductor Chips

Patches were issued and vehicles returned to the road when Mercedes-Benz USA recalled more than 40,000 SUVs in the North American market because a software error caused a front wheel to pull to one side during an automated braking maneuver. That would have been a far more challenging repair if a defect occurred in the vehicle's hardware.

Unlike mechanical failures, electrical failures require significantly more testing before deployment of any replacement hardware (and associated firmware), as well as confirmation checks after deployment. But similar to mechanical failures (and unlike software failures), the cost is much more significant as it does involve physically replacing one or more components in the automotive system.





Dreamstime

Secure software and firmware alone do not create tamper-proof road vehicles, nor do any necessary over-the-air updates. OEMs need to know what has been done to secure the chips that are being used and what potential weaknesses exist. Taking a post-deployment reactive approach to hardware security exposes them to significant risk.

A hardware bill of materials (HBOM) tracks and documents components' security vulnerabilities. It guides supply-chain security so defective or compromised chips are not used, and it creates transparency from development through circulation so manufacturers can make informed decisions before purchasing semiconductor chips.

Robust semiconductor chip security is more pertinent as more advanced electronics are being used in road vehicles. Integrated circuit breaches expose critical data and jeopardize safety, and businesses are impacted until the damage has been

assessed and the threat has been resolved. That can be costly for automotive manufacturers when liability and brand reputation are considered.

Chip security has not been seen as a significant concern because most cyberattacks target software. But software can be patched and rebooted once vulnerabilities are identified. As software becomes more secure, hardware is now getting more attention from attackers, especially as this additional hardware tends to have internet connectivity. Semiconductor chips are expected to last more than a decade, and that lifecycle comes with an increased cost given that security must be flexible yet well-built to protect against more sophisticated attacks expected during its lifecycle.

2. Higher, More Uniform Standards are Being Established

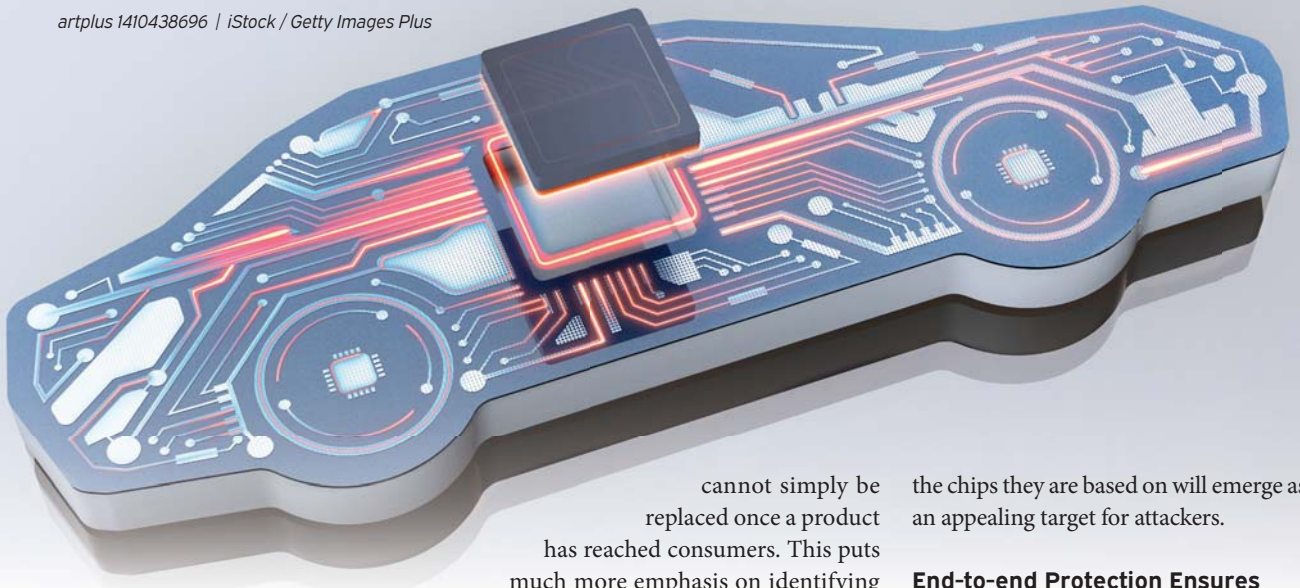
There are many benefits to driving a connected car, including navigation

systems, self-driving capabilities and features oriented toward comfort and luxury. Yet, as those technologies have been incorporated, vehicles' safety standards—especially regarding cybersecurity—have been inconsistent, incomplete and insufficient.

The publication of ISO 21434 and the near-simultaneous adoption of UNECE UN R155 will require road vehicles' cybersecurity to be standardized. It will not be long before OEMs and their supply chains must show their hardware and software development processes meet those standards that cover "concept, product development, production, operation, maintenance and decommissioning of electrical and electronic systems in road vehicles, including their components and interfaces."

Regulators are beginning to ensure OEMs have evaluated the cybersecurity features of new road vehicles and consider them throughout the manufactur-

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ing process. That's being done to prevent enterprises from introducing vehicles to market that affect consumers' privacy or safety, leading to significant consequences.

OEMs must begin assessing their existing cybersecurity processes and examining how adequately they align with the ISO and/or UNECE standards. They must also consider the incorporation of emerging technologies in connected cars and how each additional component dramatically increases the attack surface area. A gap analysis can determine their preparedness for these new requirements and the implementation of a CSMS should be underway as industry-wide standardization nears. Understanding the threats and attack surface is vital to ensuring potential weaknesses are addressed.

3. Threats to Hardware Continue to Emerge

Dramatic instances of semiconductor chip vulnerabilities have come to light in recent years, including things that seemed inconceivable just a short time ago.

The "Augury" flaw in Apple's M1 chips, introduced in 2020, and their unpatchable "Pacman" hardware vulnerability demonstrate how difficult it can be to secure modern chips. In the case of phones and tablets, the internal processor

cannot simply be replaced once a product has reached consumers. This puts much more emphasis on identifying and designing to mitigate any potential vulnerabilities.

The semiconductor chip threat landscape has rapidly changed since the Rowhammer attack in 2014 and the Meltdown and Spectre vulnerabilities identified in 2018. Semiconductor chip manufacturers must anticipate vulnerabilities by simulating scenarios in which chips can be compromised.

Any chip vulnerability detected by an OEM late in the design cycle will delay the introduction of the road vehicle to consumers. Although not every attack can be anticipated, transparency along the supply chain will offer assurance that weaknesses were probed and eliminated during the manufacturing process.

Remember, attacks on semiconductor chips do not always require physical access to be successful. One emerging security concern with electric vehicles (EVs) centers on connecting them to public charging stations. How do you know that physical link is secure and that vulnerabilities in the EVs are not being exploited while you are away from your vehicle? The evolving nature of hardware attacks will lead to privacy implications and security concerns that can result in physical injury and significant financial damages. As road vehicles continue to incorporate artificial intelligence (AI) and machine learning (ML) systems,

the chips they are based on will emerge as an appealing target for attackers.

End-to-end Protection Ensures Long-Term Viability

Vulnerabilities in semiconductor chips are creating a larger attack surface for cybercriminals, especially as road vehicles continue to incorporate increased means of connectivity throughout their development.

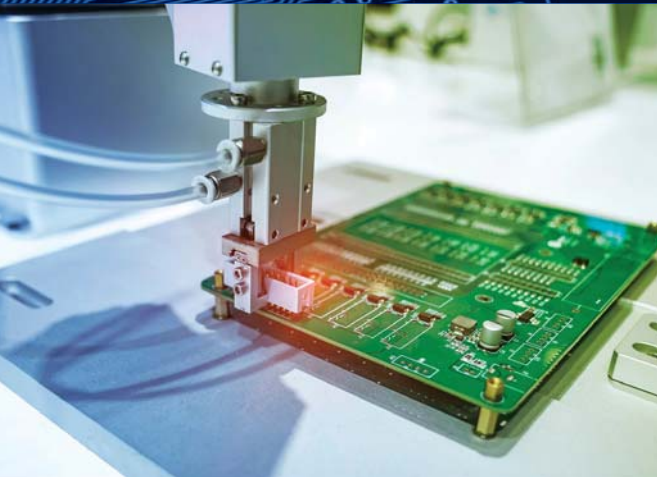
OEMs must ensure security from design through manufacturing, throughout the supply chain, and during the lifespan of a semiconductor chip or system. That can be difficult as components are assembled globally by a variety of companies and are expected to be viable for a decade or longer.

The increasing demand for connected cars and the return of their production to pre-pandemic levels underscores the importance of end-to-end cybersecurity throughout the automotive industry and supply chain. The semiconductor chips used in road vehicles must be rigorously tested to ensure they comply with industry standards. OEMs must also be proactive with flexible design and functionality as a reactive approach will expose them to significant risk. ■

MITCHELL MLINAR is vice president of Engineering, Cycuity, based in San Jose, Calif. The company focuses on security verification throughout the lifecycle of hardware product development.

Selecting PCB Connectors for Your Applications

Eliminating design challenges before they arise.



Printed circuit board (PCB) connectors are a critical component for a wide variety of applications from desktop electronics to industrial equipment and machines. Selecting the right connector for your application takes forethought and a deep understanding of needs.

Q1: Why is connector selection so important?

Like a swinging door that is broken, a connector that has exceeded its insertion or flex range can disrupt power and data from flowing into and out of the PCB properly. It also matters how your connector is attached to the board and the outside world—whether soldered directly to the board or a pluggable solution is preferred. The proper PCB connector can save time and costs for installation, maintenance, and replacement. In today's market, there are also concerns about purchasing knock-offs of popular connectors that provide substandard quality to the user. Paying attention to your connector choice early in your design can save time, money, and your reputation.

Q2: What is the most important point to consider when selecting a PCB connector?

One of the first things to take into consideration is the environment the connector will be used in when selecting the connection technology of the PCB Terminal Block—screw or spring connection. An automobile application would need to handle shock and vibration where spring type connections are preferred. Remote systems may have wider temperature concerns, while a factory floor application may need to be dust and moisture resistant. Although enclosures are often used to protect electronic components, PCB connectors can be in direct contact with the outside world, or the closest component to the outside world. Keeping the environment a priority early in your selection process will provide critical information when considering how long your connector will last in the field.

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Q3: What electrical specifications should we be most concerned with?

We'll start with current ratings. This can be tricky because you'll want to know the maximum current per pin as well as a maximum current for all pins. It helps to know how many pins in a connector will be carrying current (and how much current) at any one time. If the current carried over any single pin increases, then the number of pins carrying current must decrease, and vice versa.

Typically, a connector specification is provided for a defined ambient temperature, which can also affect the connector. Next, you'll want to think about the voltage rating of the connector, which depends on the spacing between contacts and insulating material used to secure the contacts in place. Balancing these two electrical specifications will help in connector selection.

Q4: Are there any other issues to consider when selecting a PCB Block?

Other valuable considerations include mechanical specifications such as the size and shape the connector needs to be. The required current and voltage ratings discussed above limit the size. Higher amperage ratings increase the size of the terminal block. Low current and voltage ratings allow for more compact board designs. Also what is the overall feel (pressure) when inserted or removed. You may have to get samples, which are often available through vendor demo kits, so you can try the connectors before purchasing hundreds of them for your application. Finally, check for existing standards that must be met. UL and IEC are the most common approvals. Knowing if your end system will be shipped out of the country may limit what connector types you can use and still be certified.

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The advertisement features a central image of a person's hands using a screwdriver to work on a green PCB terminal block. The block is labeled 'LEAD FREE/ROHS COMPLIANT' and '100%'. Below the main image, several different types of terminal blocks are shown, including a multi-colored strip, a grey multi-pin block, and a grey pin strip. The background is a dark blue gradient with an orange curved border at the top.

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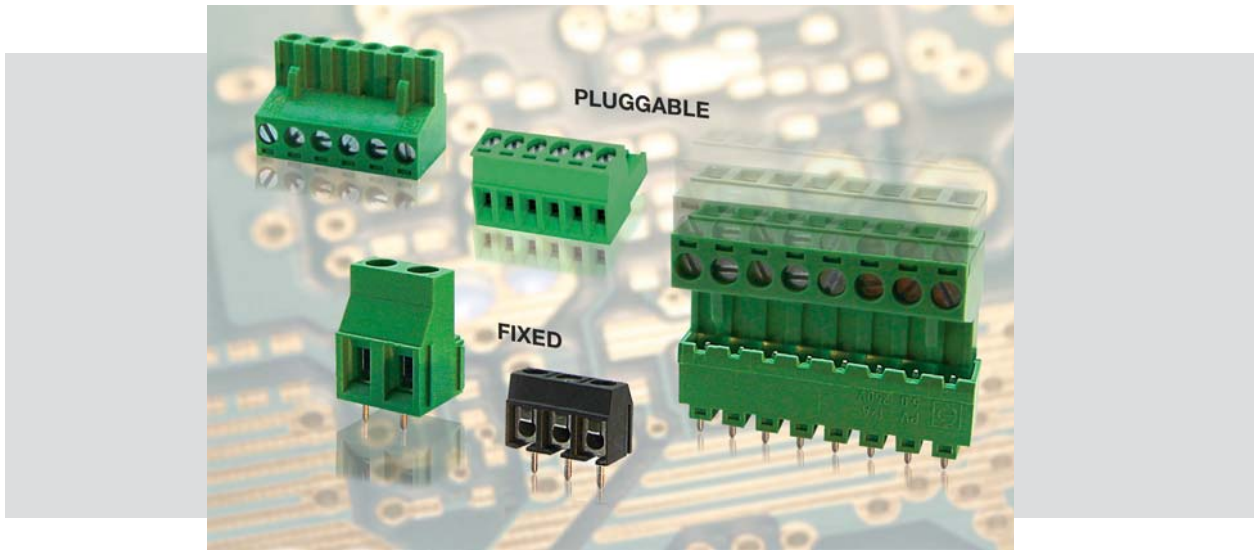
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Q5: How important are the materials used to manufacture the connectors?

Very important. You'll want to be sure that all machined metal parts are electrolytically plated to increase wear, abrasion, and provide corrosion resistance. Tin-plated solder pins can satisfy the most demanding current and voltage requirements. The connector housings should provide excellent strength and temperature resistance as well and be precision-molded from some form of self-extinguishing polyamide or glass-filled polyester for safety. V0 grade plastics are very common.

Q6: What should we look for as far as labeling?

Depending on the company you decide to work with, most manufacturers incorporate some method of marking connectors to identify them. For example, Altech provides their customers the ability to order hot stamp, inkjet, or laser imprinting for permanent marking of large quantities of connectors.

Q7: Once we've decided on a connector, will there be various ways to provide them for use?

Bulk packaging in different standard packs is how they are usually supplied. Special packaging is often available for connectors to fit specific production requirements. The three basic types include tube packaging, which is used for gravity feed systems making connectors easily available for automatic placement machines; tape and reel packaging, which helps to feed components into automation machinery and eliminates orientation errors from occurring; and tray packaging, which works well with pick-and-place machines.

Q8: What other information would be helpful when selecting PCB connectors?

Consider the company you partner with. Stock levels are key when selecting a supplier. Check their standard availabilities to be sure you can get the parts you need when you need them. Be aware of how accessible company services are and that you work well with their team so you get prompt answers when you have questions. Most importantly, partner companies need to have a complete line for you to choose from so you can decrease the need for multiple vendors as your products and applications evolve.

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Having ISO quality management certifications in place can also insure reliability to processes and overall value of the products. Quality management systems improve delivery times, reduce customer audit frequency and create an atmosphere of teamwork and customer service. Eagle has had ISO 9001 and ISO 13485 quality management certifications in place since 1998.

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- **Custom-fabricated components.** Working to customer specifications and specializing in Bending, CNC and EDM/ ECG machining and Laser machining. Eagle can produce close-tolerance parts for the medical industry as well as other industries.

Transforming a simple part into the part you need. Though thoughts of tubing may offer circular images, in fact, tubing comes in many shapes, sizes and thicknesses. Round, oval, rectangular or square, stainless steel tubing is versatile and popular. Secondary operations then tailor the tubing to the exact part needed. Formed components are ideal for uses in surgical devices, heat exchangers, instrumentation and handling equipment.

ORDERING TUBING

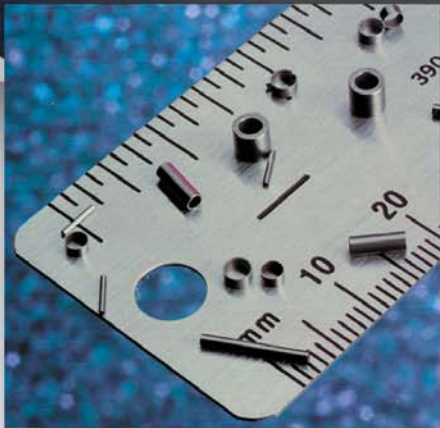
Stainless steel tubing is generally ordered to outside diameter (OD) and wall thickness. Tubing has 3 dimensions: OD, inside diameter (ID) and wall thickness. Only two can be specified with tolerances. The 3rd is theoretical. Other things to keep in mind are alloy, temper or hardness, welded or seamless tubing, how long, surface finish, straightness, and how clean does it need to be.



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The tubing below is available in 10 foot lengths. Eagle can cut your order to shorter lengths as required.

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Gauge Size	O.D. Range (Inches)	Nominal Wall (In.)	I.D. Range (Inches)	Gauge Size	O.D. Range (Inches)	Nominal Wall (In.)	I.D. Range (Inches)	Gauge Size	O.D. Range (Inches)	Nominal Wall (In.)	I.D. Range (Inches)
3 STD	.258/.260	.015	.226/.232	13 STD	.094/.096	.012	.069/.073	20XTW	.0355/.036	.004	.026/.0285
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	13XTW	.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	.0065/.008
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
								32 STD	.009/.0095	.0025	.0035/.005
								33 STD	.008/.0085	.002	.0035/.005

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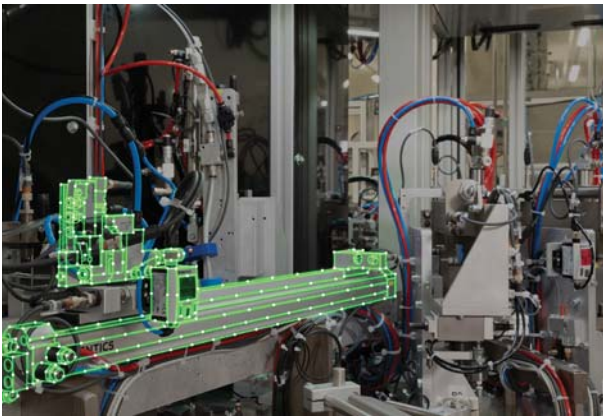
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- **Greening of** Emerson is how we improve environmental performance across our global business – including targets to reach net-zero operations by 2030 and net zero across our value chain by 2045.
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Going Mainstream: Additive Manufacturing Bolsters Production Methods

Additive manufacturing is making its way into the mainstream. Companies like igus are mastering new materials and integrating AM services to bolster value generation.

by **Rehana Begg**, Senior Editor

Additive manufacturing is blossoming as a serious contender in the mature industrial business environment.

This much was clear when an entire pavilion was dedicated to AM at the IMTS 2022 show in Chicago (Sept. 12-17). Add to that the fact that AM technologies were prevalent across pavilions, from metal working and metal removal to components for NASA's Artemis moon program and advances in hybrid technology (integrating additive and subtractive).

The global AM market is projected to grow from \$18.33 billion in 2022 to \$83.90 billion by 2029, according to Fortune Business Insights. The data correlate with how value chains are evolving with natural pressures brought on by advanced technologies, while reacting to a need to develop integrated manufacturing systems, say analysts.

That is not to say that there are no obstacles to overcome, noted Stephen LaMarca, a technology analyst with AMT (The Association for Manufacturing Technology) who participated in a virtual roundtable during National Manufacturing Week (Oct. 7-14). The economics for high volume AM products don't always add up.

Also co-host of the AMT Tech Trends podcast, LaMarca counted three enduring

AT A GLANCE:

- Thanks to fast production, low costs and high design flexibility, additive manufacturing (a.k.a. 3D printing) is no longer in its infancy.
- A leading manufacturer of high-performance motion plastics, igus, has for years been selling 3D-printed components into printers. The company is extending the line of business with enhanced AM services.
- Best known for accelerating prototyping, AM allows manufacturers to explore new design features and create custom products at no extra cost.

roadblocks for manufacturers: materials, standards and integration.

"Materials availability and supply was really bolstered by standards coming forward and being developed for AM," LaMarca said. "The biggest roadblock still is the integration—the acceptance of additive in the rest of the manufacturing industry."

These limitations are steadily being overcome through commercially viable innovation in technologies, raw materials and end uses, he said.

Show, Don't Tell

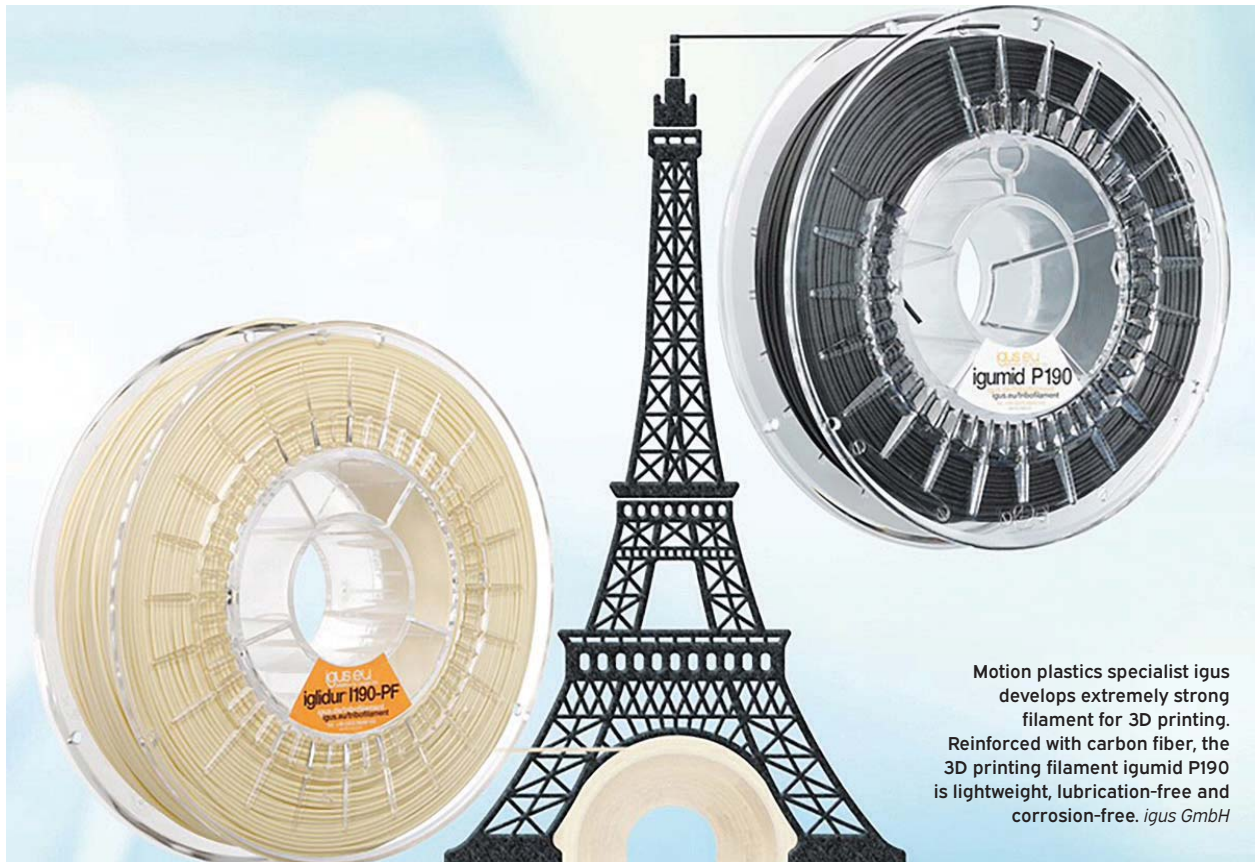
For a case in point, look no further than

igus, a manufacturer of high-performance motion plastics, that is demonstrating how an established, global operation with a tradition of injection molding is expanding opportunities harnessed from AM technologies.

According to Nicole Lang, iglide product manager at igus, the company's 3D printing business was initiated about six years ago, when colleagues at the igus factory and R&D facility in Cologne, Germany identified a need to help customers through their product development stages.

"Whether [a customer] only needed 500 pieces, or if they weren't really set on the design, igus wanted to develop a faster way to get the parts to test, but still offer the advantage of an iglide material," explained Lang. "We worked hard to develop 3D-printed materials, whether it be filament or SLS (selective laser sintering) powders for our laser sintering service, or now that we have a new DLP resin. It was important for us to develop materials that weren't on the market as a standard ABS filament or traditional 3D-printing materials."

To meet these goals, igus developed highly wear-resistant 3D-printed materials made of high-performance polymers that share the same corrosion-resistant, dry-running (no lubrication needed) properties as the company's signature iglide bearings, and were tested with the same rigor, said Lang.



Motion plastics specialist igus develops extremely strong filament for 3D printing. Reinforced with carbon fiber, the 3D printing filament igumid P190 is lightweight, lubrication-free and corrosion-free. *igus GmbH*

At first igus offered materials for 3D printing for those entities with desktop printers and who had the facility to process FDM printed parts, but soon recognized there was an opportunity for clients that produce larger quantities, recalled Lang. The 3D printing business unit grew from being a process and service provider to a fully operational business. The East Providence, R.I. facility where Lang works is replete with SLS printers and an FDM printer.

Plans to grow the business in the U.S. are in the offing; Lang pointed to an online service that allows a user to upload a CAD model and order parts that come directly off the SLS print service. In addition, CAD configuration tools provide the technical benefit of having a user design a custom gear, for example. The ability to customize is especially helpful for applications where wear-resistance is needed and where clients need advice, Lang said.

“The aerospace industry, in particular, has been a trailblazer in the use of 3D printing and benefits greatly from the versatility of 3D printing.”

Deposition Precision and Repeatability

AM can offer benefits where traditional manufacturing falls short. As a manufacturing method, AM has come a long way from being associated with prototyping and R&D modeling software and best-in-class characteristics; deposition precision and repeatability have altered the way companies design and select materials; and it informs the way products can be distributed, sold and serviced.

Lang said igus has no shortage of examples by industry—from aerospace

to automotive and the medical industry. The aerospace industry, in particular, has been a trailblazer in the use of 3D printing and benefits greatly from the versatility of 3D printing, she said. One of igus’ customers, who was accustomed to using an igus brand and materials for lightweighting, had been prototyping components for aircraft interior applications, but was not completely satisfied with their design.

“They had used igus iglide materials in the past, and are happy with them because of their lightweight characteristics,” said Lang. “We worked with them and went through many design changes. We 3D printed four different versions of a part for them throughout the product design stages, and we worked with them in the development of their product by printing the parts. We actually did some machining of parts as well. So, we have this full scope to help with all of these different changes that could potentially happen.”

“In my opinion, the most disruptive thing about additive manufacturing is that it took a huge chunk—the most difficult, painful part of the workflow, going from design to physical part—maybe not out of the equation, but it is certainly reduced.”

Another customer needed special geometries for gears. However, the product did not warrant the investment in an injection-molding tool, explained Lang, and igus could instead 3D print the gears with the required wear resistance every six to eight weeks as needed.

“They could order 55 gears with three different geometries, and it would be much more cost effective for them,” she said. “They didn’t want to invest in an injection mold and they needed the parts fairly quickly, because they don’t always know when they’re going to have demand or need for more. This was the perfect fit for them.”

Agile Production

If additive manufacturing is useful for designing the form, it has proven its place in testing functionality, too. An automotive customer needed a custom linkage but was unsure how long the linkage needed to be or where the wall studs needed to be positioned. “We were able to work with them through that process before we went to injection molding for much larger production quantities,” she said.

In Lang’s examples, the additional value generated through 3D printing methods outweigh concerns about higher production costs. Analysts like LaMarca

would add that in engineering-intensive businesses, where the need to accelerate prototyping and explore new design features at low cost or no extra cost is essential, AM is pulling its weight as a competitive advantage. The same holds true for the ability to compete in short-run production of new parts and spare parts for legacy systems.

“In my opinion, the most disruptive thing about additive manufacturing is that it took a huge chunk—the most difficult, painful part of the workflow, going from design to physical part—maybe not out of the equation, but it is certainly reduced,” LaMarca said. ■



Nicole Lang, iglide product manager, igus, relays the properties of bearings and associated plastic technologies at a press tour of the igus facility in East Providence, R.I. *igus GmbH*

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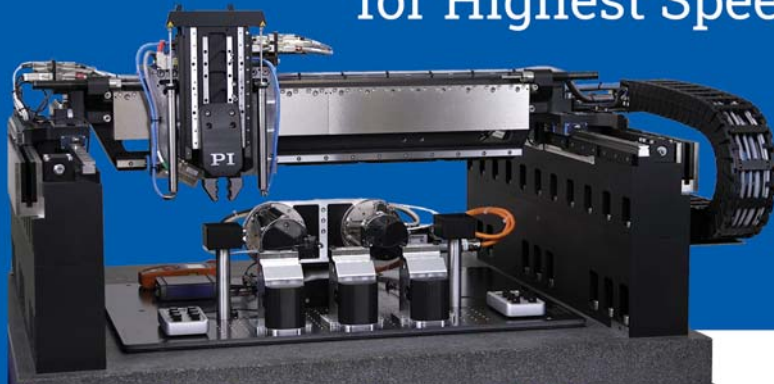
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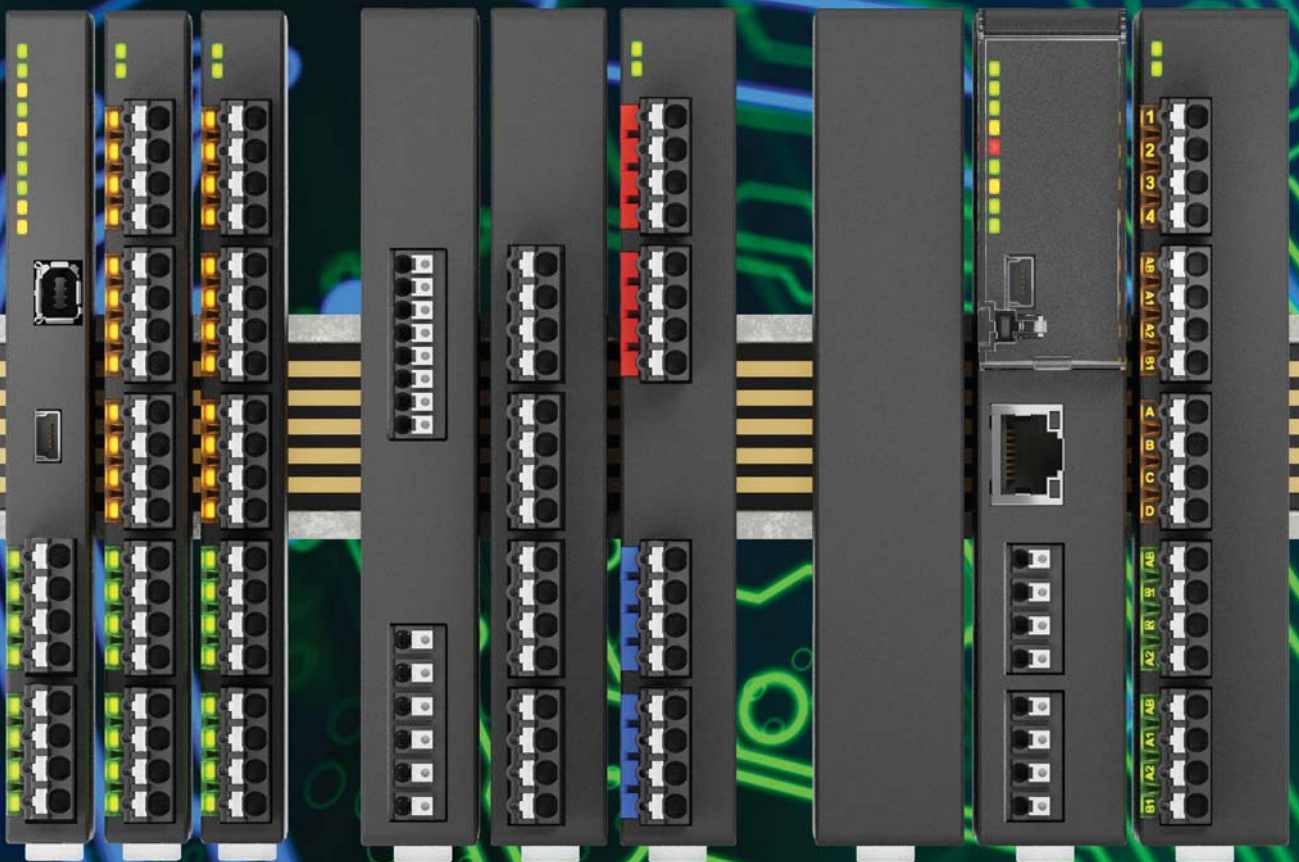
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MODULAR DIN ENCLOSURES PROVIDE FLEXIBLE DESIGN CAPABILITIES



Modular DIN Enclosures Provide Flexible Design Capabilities

Industrial control and operational electrical and electronics systems engineers must continually adapt their designs to the needs of a wide range of applications. Modular DIN enclosure systems have been developed to help make these designs adapt more easily.

Today's industrial designs are more varied and complex than ever before. Everything from industrial machines and equipment to electronic control system applications requires specific approaches that allow engineers to design more compact systems without sacrificing capabilities. When dealing with a variety of engineers in different industries, a modular approach to DIN enclosures can become a real benefit, allowing for the broadest amount of flexibility through the use of snap-together designs.

The flexibility of modular DIN enclosures, such as the KV 4600 from Altech, supports the extensive capabilities design engineers require in the market. DIN enclosure applications are limitless and are available to work with all electromechanical devices including relays, sensing and monitoring devices, transducers, and printed circuit boards. Once your design team decides the parameters needed for your application, enclosure configuration can match those requirements.

Enclosure Design

Altech's KV 4600 is available where the enclosure bottom is separated into two functional units (see **Figure 1**). This approach allows users to install an additional PCB within the bottom assembly. Manufacturers gain the ability to use this additional board to create independent interfaces or communications components for module networking.

Additional modifications can be incorporated through separate milling or molding-in of custom



Figure 1: Shown is the modular enclosure design approach used to provide flexibility to the design engineer.

openings for different types of connectors or ports that are needed for a range of standard or future communications interfaces. The overall aim in the design of these DIN enclosures is to provide simple integration into the front face or the side of the enclosure, depending on application requirements.

Light conductors, grounding springs, and tiltable front covers can also help manufacturers that need to provide status indication or manipulation protection to their systems. For example, when light conductors are incorporated with terminal connections, device faults can easily be located. Using flexibility as the focus, the KV 4600 modular DIN enclosures were designed with the broadest number of options and capabilities.

Connection Variations

DIN enclosures must be able to accommodate a wide range of functions and formats, including the handling of both fixed push-in terminals and pluggable push-in terminals (see **Figure 2**).



Figure 2: Capable of incorporating fixed push-in terminals and pluggable push-in terminals allows these enclosures to fit into multiple applications.

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Adapting to the needs of the latest applications often means that terminals must offer high signal densities to the user while taking up the least amount of real estate. Fixed push-in terminals, for example, provide more connection with minimal width—up to 40 pins per 22.5mm module. Available for use with reflow soldering processes, the terminals come in 4-, 6-, 8-, and 10-pin versions in 3.5mm or 5.08mm pin spacing.

Pluggable terminal connections can be arranged in a line to permit the user to incorporate prewired leads to be created. This approach saves installation time and improves connection handling during maintenance and repair operations. Optionally available coding of the individual terminal blocks further aids in avoiding wiring errors.

Tool-free conductor installation technology supports the modular terminal technology making wiring quicker, easier, and more reliable. The KV 4600 system of DIN enclosures also provide an optional integrated plug removal aid that allows for convenient unlocking of terminal blocks individually. Integrated terminal-to-connection wires from outside the enclosure to the PC boards inside the enclosure are also possible.

While most industrial DIN enclosures provide only side-facing terminal blocks that can be hard to reach during installation, maintenance, and analysis, the KV 4600 provides front accessibility of the terminal blocks instead. The large front area provides space for engineers to design-in easy access for more flexible arrangement of terminals including common communications interfaces such as RJ45, D-Sub, USB, light conductors, radio, and NFC. Quick and easy diagnosis is supported through the use of integrated test points for each terminal. Furthermore, the space-saving solution offers sufficient space for the individual labeling of the terminal points.



Figure 3: The open design allows for maximum PCB surface use.

PC Boards

Because the PC boards are mounted perpendicular to the DIN rail, design engineers are able to integrate up to two circuit boards inside a single enclosure. Also, the location of the PC boards permits the entire surface to be available for layout—they are not blocked by the terminals. Circuit boards offer a surface area of up to 9500 mm², which allows for multiple applications within a cost-effective design (**see Figure 3**). Engineers can easily design-in features not possible when using other enclosure systems. An optional rail bus that uses the company's In-Rail-Bus mounting design quickly snaps into place, providing power, signal, and data transfer capabilities.

Making common bus concepts available for incorporating into the assembly, the enclosures support integrated test points for on-site analysis access. A variant of the KV 4600 series, the I/O electronics enclosure, offers a compact module width of 12.5mm and a depth

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of 66mm. This is perfect for modern control systems as well as industrial IoT applications in process engineering, discrete manufacturing, or other situations where space is limited. The I/O electronic enclosure offers up to 20 I/O per module with five slots per board. The enclosure also allows for connecting elements that are separately available, making it possible to link the individual modules if device systems are managed in a decentralized manner.

When considering your application's environmental needs—including shock and vibration—be sure to focus on every component. For example, designs that tout vibration-resistant mounts for the PC board may not include that same protection in their fixed or pluggable interconnections. The KV 4600 includes vibration-resistant connection of the conductors as well as the PC boards.

Marking Capabilities

Marking capabilities for the modular DIN enclosure system are varied.



Figure 4: Printing can be added to the enclosure housing and cover to provide terminal marking, specifications or other information for application specific customization.

Since these enclosures offer a large surface area to work with, they provide an unusual amount of space for abrasion-resistant laser markings and pad or digital printing processes depending on user needs. Various methods can be used to code the individual terminal blocks incorporated into the system to eliminate wiring errors. In addition, Altech offers enclosures molded in custom colors when ordered in OEM quantities.

Conclusion

Working with the right supplier gives your engineers the greatest number of options, providing the design flexibility necessary in today's shifting markets. When it comes to adapting to a wide variety of customer requirements, having a single source will save time and money. The modular approach to enclosure design and development puts creativity back into the hands of the engineers rather than the supplier.

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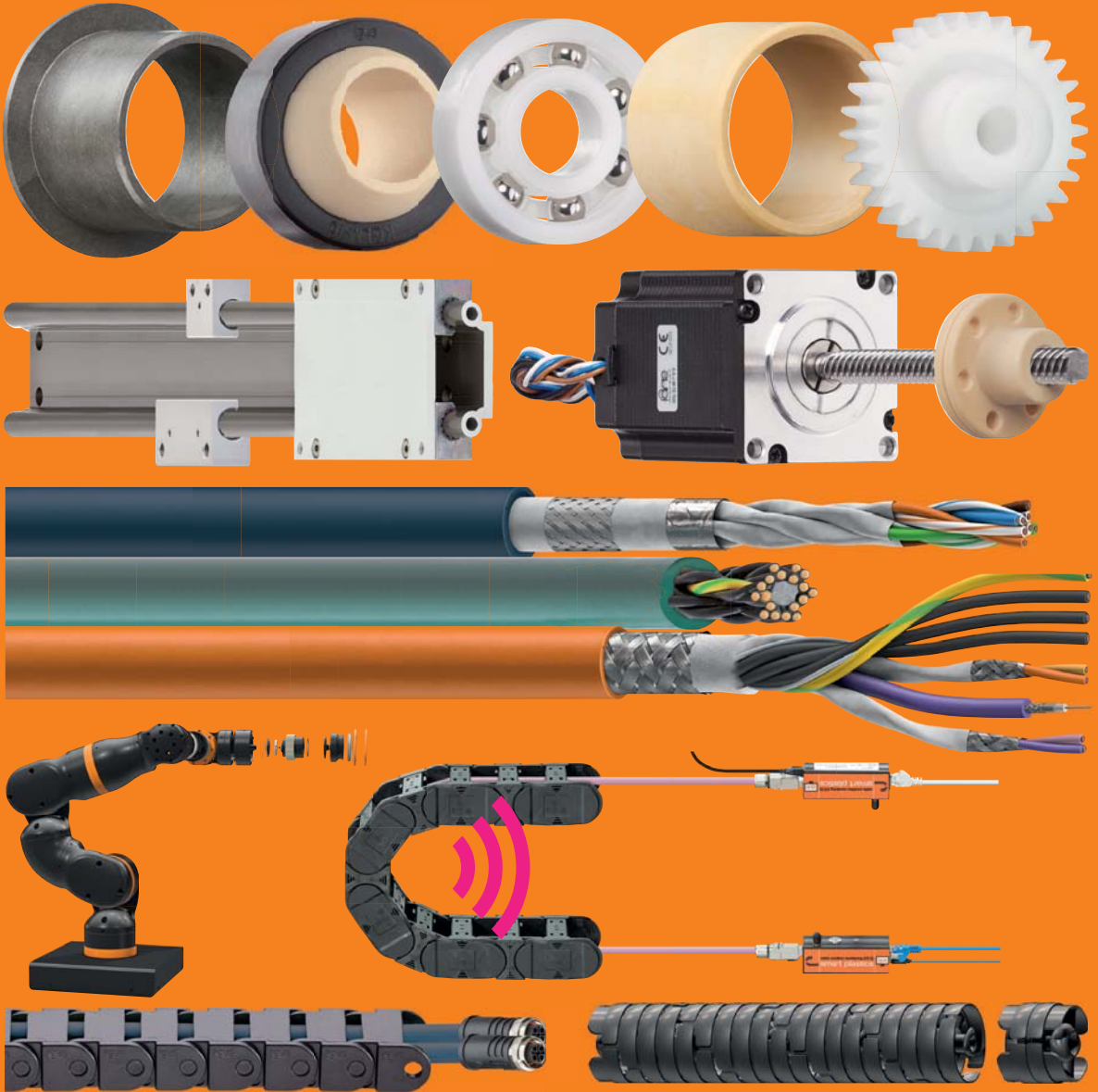
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Advanced Machine Engineering: Technology Changes are Driving Transformation

A digital thread approach to engineering encourages collaboration among engineering disciplines and leads to a simulation-driven digital twin.

by **Rahul Garg**, Vice President for Industrial Machinery and Heavy Equipment Industry

The industrial machinery landscape is rife with unprecedented challenges—supply chain shortages, labor scarcity and entrepreneurial market disruptions. At the same time, machine builders are tackling outdated legacy processes and technologies that threaten growth. These combined industry megatrends are pressing machine builders to rethink how they respond to fluctuating market demands while optimizing quality to remain competitive.

At the same time, changing consumer preferences are driving product manufacturers' need for highly agile, flexible machines capable of creating a wide range of products. Smarter machines are required that integrate hardware, software and services into one cohesive environment. Machine builders need greater automation to drive higher efficiencies into their processes while competitively differentiating themselves. Moreover, automation can increase sustainability within their operations while promoting the sustainability goals of their end customers.

All these trends are motivating machine builders to transform their day-to-day practices digitally. By implementing a digital thread approach to engineering,

machine builders can rapidly deliver tomorrow's highly complex machines, gaining a competitive advantage against those unencumbered by legacy processes. The digital thread approach takes the form of Advanced Machine Engineering to drive greater certainty in creating next-generation machines. It leverages a cloud-based methodology that encourages collaboration among the fundamental engineering disciplines leading to a simulation-driven digital twin. The result is greater flexibility while improving quality and time-to-market.

Cloud-based, Multi-discipline Collaboration

Advanced machine engineering leverages the easy accessibility of the cloud to create visibility across the many teams needed to develop today's smart machines. It encompasses all the engineering disciplines—mechanical, electrical, electronics and software engineering—and merges them into a single source of truth via the cloud. In addition, the approach maximizes data reuse and supports an integrated change process to ensure a standard delivery process.

Engineering teams can now store, access and utilize real-time dashboards, schedules and documents at any time,

AT A GLANCE:

- By adopting a digital thread approach to engineering, machine builders can speed up delivery of tomorrow's highly complex machines and gain a competitive advantage.
- Advanced machine engineering fosters visibility from the get-go; machine builders are able to capture and incorporate design feedback from numerous internal and external stakeholders.
- The author discusses how the virtual process, based on simulation and the digital twin, benefits the entire development and deployment of an advanced machine.

from anywhere. It drives efficiency into the machine development process, boosting overall productivity. In addition, machine builders can concurrently capture and incorporate design feedback from numerous internal and external stakeholders. This ensures the creation of the most effective machines possible while avoiding delays and managing product costs. By incorporating feedback earlier into the design process,

machine builders can also account for supply chain issues and source materials from outside vendors.

Simulation-driven Digital Twin & Virtual Commissioning

Cloud-based technology is a critical enabler for creating the digital twin in advanced machine engineering. By streamlining communication between disciplines, the cloud encourages the sharing of data vital to creating a comprehensive digital twin of the future machine. The multi-disciplinary model of the proposed machine connects mechanical, electrical and automation engineers to evaluate performance, energy use, output and other key indicators. Then a digital twin can simulate everything virtually, reducing the need for costly and time-consuming physical prototyping. The virtual process, based on simulation and the digital twin, offers benefits across the entire development and deployment of an advanced machine:

- **Design:** Machine builders can use the cloud-based digital twin to simulate models and test thousands of features against thousands of requirements. That leads to finding errors earlier in the design process while pushing the creative boundaries of manufacturing.
- **Testing:** The virtual analysis is enhanced through closed-loop test-

ing, where artificial intelligence and machine learning algorithms identify potential improvements—ensuring the production of the most flexible and optimized machines.

- **Manufacturing:** When it is time to commission the machine for the factory floor, advanced machine engineering supports testing the PLC code in a virtual world running on the digital twin. The result is streamlined, stress-free physical commissioning. Virtual commissioning can ensure your PLC code is tested and evaluated before getting it on a physical machine. A machine crash in the digital world costs nothing.
- **Lifecycle:** When customer requirements change, machine builders have an easily accessible process for updating machine programming logic or refreshing machine models using the digital twin and simulation.

Modular Design Leads to Mass Customization

Advanced machine engineering provides the foundation for true modular design with cloud collaboration and the digital twin. This setup is a highly desirable approach where machine information and specifications are contained within modular “blocks.” These blocks can be reused across projects and customized to fit customer expectations. For example,

engineers can open a block that contains a preexisting machine’s bill of material. They then can re-save the block as a new project and alter it to include updated parts or components that meet a customer’s specifications.

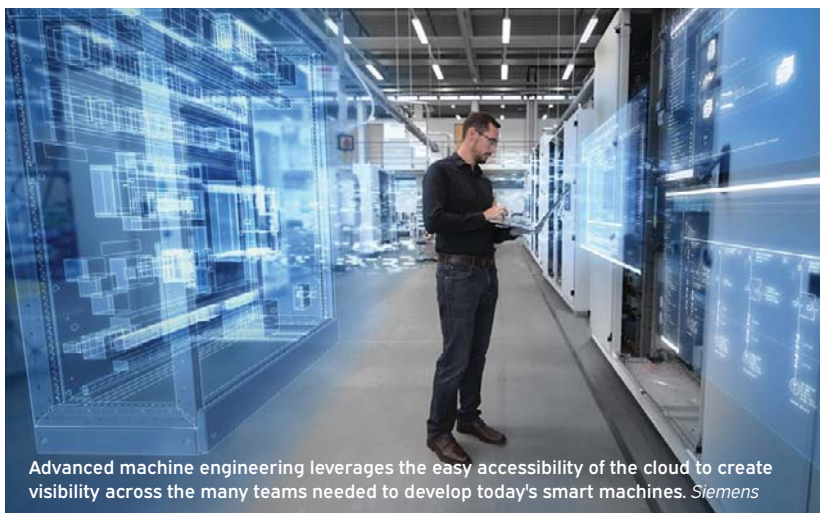
Using modular design, machine builders have a cost-effective path to scale for mass customization. It is now possible to produce highly differentiated machines quickly and cost-effectively from a shared set of modules.

As a result, machine builders can accelerate their bid times and respond to a larger number of inquiries and deliver a larger number of orders, expanding their business’s profitability. Modular design is also vital for rapid machine configuration. When customer requirements change, machine builders have an easily accessible process for updating machine programming logic or refreshing machine models. It is also possible to trace design iterations and understand why specific decisions must be made. The digital twin of machinery makes all this possible by offering a virtual mockup of a machine, where machine data can readily be referenced and updated.

Delivering Complex Machines Successfully

Advanced machine engineering gives machine builders the powerful capabilities needed to survive and thrive in today’s demanding industrial landscape. Integrating all the engineering disciplines empowers collaboration across the design teams through real-time cloud tools.

The result is the comprehensive digital twin of the machine that supports sophisticated simulation to create optimized machines without the need for physical prototyping. In addition, this method creates an environment for true modular design, where machine builders can quickly and cost-effectively adapt to shifting market requirements. Altogether, advanced machine engineering enhances machine builders’ productivity, speed-to-market and quality, helping them win big in the market every time. ■



Advanced machine engineering leverages the easy accessibility of the cloud to create visibility across the many teams needed to develop today’s smart machines. *Siemens*

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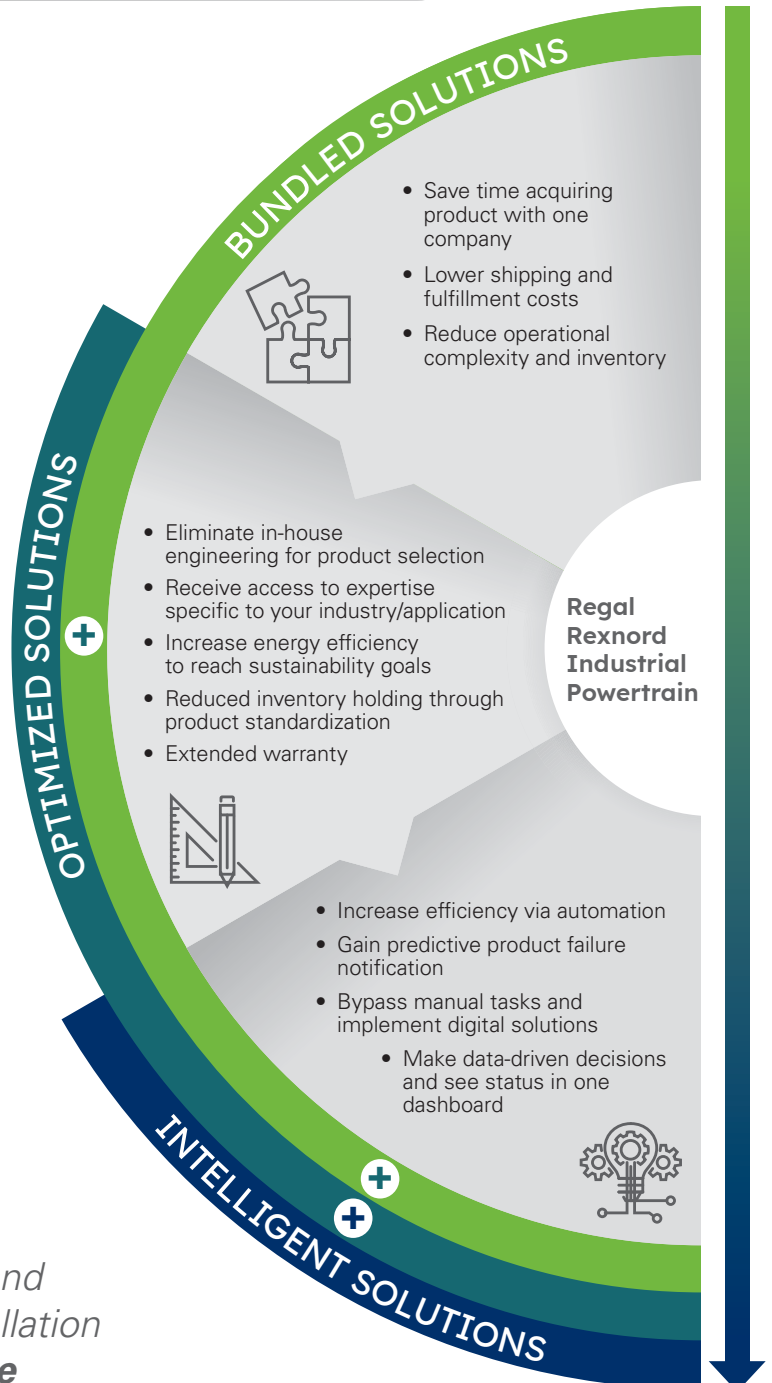
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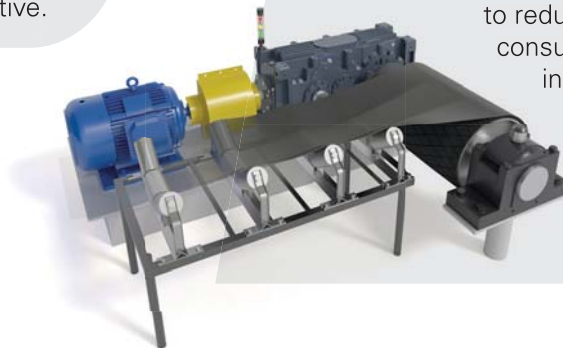
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Our **Product Design Guide M70** features products that are engineered specifically for use by OEM Designers and Engineers who create and develop state-of-the-art electronic products, instruments, and systems.



PRODUCT OVERVIEW

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- **Fuse Clips & Holders**
- **PCB Terminals and Test Points**
- **Spacers and Standoffs**
- **Panel & Computer Hardware**
- **Pins, Plugs Jacks and Sockets**
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While our catalog products meet most standard requirements, modifications as well as custom fabrications can be manufactured to meet customer-specific needs.



Keystone's design and engineering experts are fully integrated with our in-house precision tool and die shop. Utilizing the latest CAD/CAM and 3D modeling software, Keystone's Custom Manufacturing Division provides close tolerance Stamping, Machining, and Assembly services as part of their quality control and responsive customer service.

Keystone's Quality System is ISO 9001:2015 certified by DNV Certification, Inc. under the RAB and RvA accreditations. Our quality assurance program is in accordance with these requirements and applies to all standard and custom interconnect components and hardware. Keystone is also RoHS and REACH compliant. Keystone has USA headquarters with offices in Canada, Europe, Australia, and Asia.

For more details, contact Keystone Sales at 800-221-5510, Fax: 516-328-1080, Email: kec@keyelco.com. Visit www.keyelco.com for our Dynamic catalog of products or to request a copy of our **Product Design Guide M70**.

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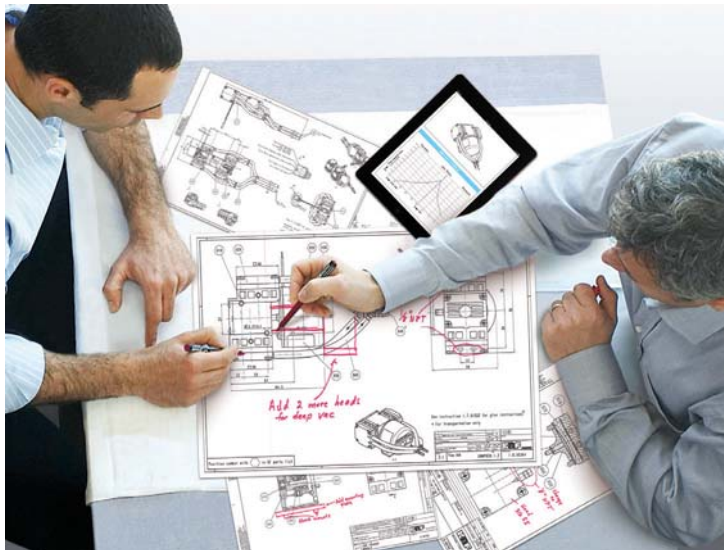
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Vacuum Filter Technology

Improves Uptime in Aluminum Die Casting Foundries

Dexwet Filters developed a patented aluminum particle filter technology that simplifies changeouts and reduces downtime.

by Clemens Sparowitz, President & COO, Dexwet Filters

In the production of modern and complex aluminum structural parts for the automotive industry, vacuum support systems for die casting units have come into common use over the past two decades. The larger, thinner-walled and more complicated the automotive parts—from powertrain to chassis parts or battery housings—the greater the need to clear the tool form, not only from air and gases but also from other substances applied to the tool throughout the process. In principle, what does not exist in the form before the injection of the liquid aluminum, cannot end up as a deficiency of the part.

Many parts today could not be produced without a deep vacuum down to 10-20 mBar to satisfy quality and acceptable scrap ratio. Dexwet Filters were contacted in 2017 by the first foundry in Germany to look at the identified filter problem caused by old-tech steel wool pad filters that are applied in the vacuum suction line to protect the vacuum valves and pump from the debris that is sucked off.

The Industry Blind Spot

As a common standard, these vacuum filters are exchanged preventively once

per shift, with an average machine downtime of 30 minutes. With 20 shifts per week, this task leads to the loss of up to 10 hours of production time per week. Three warming shots are commonly done when the machine is resuming operation, leading to 60 “warm-scrap” parts, which get melted in again, causing a loss of overall production time and a waste of energy.

A deeper analysis of the occurrence of parts with quality deficiencies showed that the ratio of quality deficient parts identified by final quality control departments with X-ray increased in the second half of the shift, indicating that vacuum filter malfunction may be the root cause.

Solving the Problem

Over three R&D stages, Dexwet Filters developed their aluminum particle filter technology from APF1 to APF2 and the final industry solution SUPER-APF, which has been awarded OEM (Original Equipment Manufacturer) Part status for the technology leading vacuum system supplier Pfeiffer Vacuum.

Dexwet SUPER-APF vacuum filters are permanent filters, with a stable filter inlet consisting of nine filter layers with a sophisticated and patented design. The

AT A GLANCE:

- The high-tech die casting industry relies on old-school steel-wool pad filters for vacuum systems that lead to unnecessary and long machine downtimes and high cold and warm scrap ratios.
- Dexwet Filters devised a unique method of filtration that protect vacuum valves and pumps from debris that is sucked off components in the die casting process.

first two APF versions allowed permanent operation of the die casting unit for 2-3 days without machine downtime, and the third and current version using Dexwet SUPER-APF filters nearly doubled its effectiveness.

Dexwet SUPER-APF normally gets exchanged once per week in the service shift and a maximum of one filter exchange during the week. Such preventive filter exchange is mandatorily dictated by the vacuum system itself and not by any general work direction, as standard nowadays, because such rules cannot take into account the specific conditions and emission behavior of each die casting unit.



Set box with filters. *Dexwet*

Why Old-Tech Filters Deteriorate Output Performance

The reason for fluctuations in output part quality caused by “old-tech” steel-wool pad filters lies in the extreme conditions within the vacuum suction line when the vacuum valve opens. On the bottleneck of the suction line, particle speed hits the sonar wall at 671 mph. Air and gases have to be let through, while any oily particles and hot liquid aluminum particles have to be captured to protect the vacuum valve, the most critical component of any vacuum system.

When a vacuum valve fails, the die casting units may fall out of operation for many days until replacement parts are supplied, which is a critical reason to have two filter housings and cartridges for each suction line.

When using steel pads as filters, and under extreme compression from under pressure, in combination with the maximum possible particle speed, the orientation of the steel fibers of the pads changes from each shot to the next, resulting in fluctuations in the throughput behavior of the filters. As more debris gets collected by the form-side filter over the shift, the effectiveness of the vacuum system to always form the very same under pressure conditions within the form is deteriorated, which causes quality fluctuations.

ROI Within One Year

Implementing Dexwet SUPER-APF is a one-time investment with guaranteed ROI in less than one year. When the filter cartridges need to be exchanged, users simply remove the dirty filter cartridge and clean them at a central cleaning station, rotating the cartridges in the foundry between their three locations (one in the machine, one at the machine, one clean in the central cleaning station). This reduces waste, but

much more importantly, allows users to gain valuable knowledge from the analysis of the filtered material or filter cake, which was not possible before.

Workflow Optimization

One set of replacement filters is always provided in a transport box directly at the die casting unit for easy and swift filter exchange. In case the vacuum system gives an alarm for preventive filter exchange, the machinist can easily replace all filter cartridges with machine downtime within 5-15 min. The clean filters are taken from the box and the dirty ones are put back into the box.



Filter inlet with filter cartridge. *Dexwet*

This short downtime of less than 15 minutes avoids warming shots. And the die casting unit can immediately resume production of good parts. This eliminates the necessity for warming shots and scraps due to vacuum filter exchanges during the whole shift week. At the end of the shift, in case there was a filter exchange alarm, the worker takes the transport box with the dirty filters back to the cleaning station, where a designated box with clean filters is always provided, and should be brought back to the mount at die casting unit for the next exchange.

Filter Cake Analysis and Process Gains

The workers designated to the filter

cleaning station play a very important role yielding the highest returns from using this technology. Since these filters are in operation for three days up to a whole shift week, the quantity and quality of the debris in the filter cake have to be looked at like a drilling core throughout its operation. This filter cake is a compound of aluminum particles with max. 0.5 mm particle size and various forms of oily or waxy particles coming from tool fats, separation liquids, silver fat, etc.

Within a few weeks of doing the filter cleaning, the worker designated for the job will learn how to differentiate normal filter cakes from abnormal or strange compositions. Such abnormalities must

then be reported to the machinist, which facilitates early flaw detection in the tool and other system parameter calibrations and dosing.

Dexwet SUPER-APF technology has been designed to give valuable feedback to the machinist to optimize the overall effectiveness of each die casting unit. With that, it helps to foster and improve process stability and security, and, by extension, helps to increase the overall weekly output of high-quality parts for each die casting unit while reducing energy and production time waste.

Real Costs of Low-Tech Steel-Wool Pad Technology is an Industry Blind Spot

The real costs of “old-tech” steel wool pad filters are the blind spot of the industry because the direct costs of these cheap filters were not recognized in the overall cost structure of a foundry. Technology leading companies are recognizing the benefits; Georg Fischer (GF+), for example, started using the technology early on in 2017 and has since implemented the filters in all of their foundries worldwide.

Offered as a Standard OEM Component

Dexwet Filters partners with Pfeiffer Vacuum, a global technology-leading vacuum system supplier and the only supplier to date to measure the advantages of the buildup of vacuum within the form using Dexwet SUPER-APF technology. Their patented two-tank vacuum system allows for exact and accurate pressure measurement within the form throughout the microsecond injection cycle.

While the first tank sucks from the side of the injection chamber, the second cycle sets in the very same moment as the first closes, providing the full vacuum capacity of the second tank during the shot curve. Due to positive results, Pfeiffer Vacuum has since 2018 offered Dexwet SUPER-APF technology along with their leading-edge systems. ■

SUPER-APF die casting unit set. *Dexwet*

SUPER - APF DIE CASTING UNIT SET
for 1-4 Suction Lines per Set

1	Form Side Super-APF Housing
2	Filter Cartridge Super-APF
3	Valve Side Super-APF
4	Circlip Plier
5	Transport Case

1	Form Side Super-APF Housing
2	Filter Cartridge Super-APF
1	Used Dexwet Filter Cartridge

ASK THE EXPERT

How Gearbox Selection Affects an Application's Performance



JOHN UZZOLINO

Business Development Mgr. — Parvalux
maxon precision motors, inc.

John Uzzolino heads up business development for the Parvalux product line at maxon, USA. As the Business Development Manager, John is responsible for managing and promoting the Parvalux products to the North American market. John joined maxon in 2019, bringing 20 years' experience in industrial motion control and mechatronics applications. John holds a BS in mechanical engineering from Rutgers University and started his career as a Sales Engineer working for a high-tech distribution company, focusing on solving motion control and mechatronic applications for machine builders in the North East U.S. John then continued his career, focusing on helping companies bring new mechatronic products to the US market.

Why do you use a gearbox with a motor?

A: A gearbox is a device that transfers mechanical power from a motor to another part of the machine. While a motor is designed to provide mechanical energy in the form of speed and torque, a gearbox is used in conjunction with a motor to reduce the output speed of the motor while increasing its output torque. Basically, when selecting a motor and gearbox combination, the speed and torque requirements are the first thing to consider. A gearbox helps to optimize these requirements by matching speed and torque requirements for a specific application. A gearbox also helps to match the load inertia to the motor inertia, which provides much better control and stability in the system.



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Are there different types of gearboxes used for different applications?

A: Yes, there are many types of gearboxes, but the most common ones designed for drive systems are spur, helical, planetary, and worm/wheel gearing.

- A spur gear is a gear wheel with teeth projecting parallel to the wheel's axis, which produces inline motion from the motor shaft. They can be mounted in series, called spur trains, to achieve high gear reductions. Spur gears are used in a wide range of applications, from slow to moderate speeds. You typically can back drive, or manually spin the gearbox in reverse, but this is highly dependent on ratio and materials of the gearing. Typically, they provide up to a 10:1 reduction per gear stage and can be combined with a worm/wheel to provide unique geometries.
- Helical gears provide similar characteristics to a spur gear, but the teeth have a helical cut, providing a more gradual and smooth gear interaction. This often results in a more efficient, higher torque and a quieter gearbox.
- Planetary gears consist of one or more outer gears (or planet gears) revolving around a center gear (called a sun gear) and an outer ring gear. The relative size of each gear determines the speed reduction between the motor and the output of the gearbox. Planetary gears provide inline, high-performance motor operation and exhibit a highly efficient and power dense transmission, often up to 97% or so per stage. Planetary gears are used in a wide range of applications from slow to high speed, are often back drivable, and can be constructed with multiple stages to provide very high reduction ratios. Planetary gearboxes are often the choice for high performance, high duty cycle applications.

- Worm/wheel gearing provides 90-degree motion from the motor shaft. These gears are typically used when high torque is required at low speeds. They provide very high gear reductions in a small space. For example, a 4:1 reduction is the same physical size as a 75:1—solely based on the pitch of the worm. Compare this to a bevel gear, which can only provide up to about a 10:1 reduction in the same package size. Typically, at or above 25:1, a worm gear is going to be self-locking, meaning it will be difficult or impossible to back drive. Although this isn't considered a safety feature, it could be very useful in certain applications. Worm/wheel gearing is often quieter than a spur or planetary gear, but there are exceptions.

What else do I need to think about when selecting a gearbox for my motor?

A: When selecting a gearbox, the primary goals are to select the correct speed and torque requirements while matching the motor to load inertias for optimal performance. Users should consider designing around the system dynamics, load types, duty cycle (run time versus non-run time), and other parameters, including physical size, ingress protection, external forces, backlash, and more. These requirements will determine the physical size of the gearbox, as well as the material selection, which dictates mechanical limitations, thermal limitations, audible noise level considerations and life expectancy of the gearbox.

Can you elaborate on importance of gear material selection?

A: Material selection of gearing determines sliding frictions between gears and impacts efficiencies and overall life expectancy of the gearing. For

example, the first helical gear in the gear train is often a reinforced thermoplastic with hardened steel spur gears on subsequent stages. This configuration helps to reduce the audible noise of the gearbox and supports a higher output torque and longer life. Another example would be to use a bronze gear over a composite gear to support higher continuous or impact loads. The downside is the bronze gearing will have higher frictional loads and run hotter over a composite gear, which can accelerate the wear of the bronze gear. Ultimately, you should select the gearing material that supports the most and least important parameters for the application.

How about noise levels?

A: The dB ratings are arguably similar between bronze and composite gearing at low to medium speeds and marginally higher for bronze at 100+ rpm. However, the composite material reduces the higher frequency and increases the very low frequency levels so the perceived audible level is often worse for a bronze worm wheel.

So, which is better—a composite gear or a bronze gear?

A: It depends. A bronze gear can be pushed harder, offers a better continuous/peak load ratio, and handles peak loads better than a composite gear in a similar package size. Yet, if your loads are within the specifications of the gear, then the composite gear is fine and provides additional benefits, such as higher efficiencies, lower noise levels, and longer life. A composite gear will have almost no wear if it is used within its design parameters, and you can often see them last in excess of 5,000+ hours. Compare that to a bronze gear, where you have metal on metal that will wear over time. In addition, the particles that shed

from the bronze gear can encroach on the lubricant and create a sandpaper-like effect, further reducing gear life.

What is your takeaway advice for someone selecting a gearbox?

A: When selecting a gearbox, there is a lot to consider. There is often more than one answer since different gearing types have different advantages and disadvantages. In addition to the performance of the gearbox, consider how the material selection of the gears can help achieve your application goals. Lastly, there are many parameters to consider, and calculations are critical to optimizing your application. That said, it is always good to test your solution to see how it reacts in the specific application.

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FAQs

Soft Magnetic Composites in Motor Applications

What are soft magnetic composites?

Soft magnetic composites (SMCs) are components made by applying powder metallurgy techniques to metal powders with magnetic properties. SMCs are generally made by compressing metal powder in a tool and following up with a heat treatment.

The metal powders that form the basis of SMCs consist of high-purity iron particles individually coated with an electrically insulating coating. The powder metallurgy process combines with the powder's specific properties to create parts with three-dimensional magnetic properties.

Where can they be used in motors?

SMCs have been used to improve the performance of claw pole motors that appear in applications like automobile alternators, consumer appliances and printers. In these motors, SMCs form precisely-shaped claws or inductors that fit these space-saving designs.

Linear tubular motors also use SMCs in their inner and outer stators in applications that call for precise and repeatable linear actuation. In these applications, they provide a broader spectrum of position control than pneumatic actuators.

In axial flux motors and yokeless axial motors, the magnetic flux paths are parallel to the motor axle as opposed to radial through the air gap between the rotor and the stator. These flat motors work well with the 3D flux paths made possible through SMCs. Designers are turning to these motors for their high power and torque densities and space-saving design that make them ideal for electric vehicles (EVs), pumps, fans, compressors, valve controls, hoists, and power and wind generators.

How do SMCs improve magnetic performance?

The materials that make up SMCs aren't hindered by the two-dimensional flux paths that form in stacked magnets or sheet metal laminations. A 3D flux path creates high flux density and high magnetic permeability, allowing for a more compact motor design and simplified assembly.

The individual particles that form SMCs are coated with an electrically insulating material, so parts made from the powder have high resistivity. This keeps the bulk eddy current in the material low, so less energy is lost to heat. This effect is compounded at high operating frequencies, making them an ideal choice to minimize losses.



For example, some SMC grades, compressed to 7.52 g/cm³ density, have a resistivity of 600 $\mu\Omega\cdot\text{m}$ and a permeability, μ_{max} , of 770. Its magnetic flux density, B , is 1.57 T at a field strength, H , of 10,000 A/m. Under those conditions, the power loss is approximately 9.5 W/kg at 50 Hz.

How do SMCs improve physical design?

With SMCs, two aspects of three-dimensional design open up design options for motor engineers. First, the material's 3D flux capability lets designers think outside the box when shaping their motors' magnetic components.

Secondly, powder metal processing techniques make it easier to manufacture complex 3D parts. Like polymer injection molding and metal casting, powder metallurgy enables part consolidation for parts that are ultimately lighter and take up less space.

The SMC material mentioned above has a transverse rupture strength (TRS) of 120 MPa. No change in strength is seen when testing the material at an elevated temperature of 150°C.

How do SMCs improve assembly?

In addition to giving designers more freedom to shape motor components to their specific applications, SMCs make motors easier to assemble. The laminated stacks of sheet metal stampings that are used in many motors are time-consuming to assemble. In addition, each assembly must be checked to ensure it has the right number of layers in each stack to maintain uniform motor performance.

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Components made from SMCs, on the other hand, permit error-proof assembly and optimize part geometry. SMCs let designers take advantage of the material's improved magnetic properties to save space. Some designers have used SMCs to take the winding step out of the assembly process by sliding pre-wound bobbins over the legs of the stator or other SMC object.

How are motor components created from SMCs?

The process of manufacturing motor components from SMCs is similar to other powder metallurgy processes. These processes always begin with precise blending of a variety of powders to achieve the desired properties. In the case of SMCs, the refined, coated-particle powder arrives pre-blended from the powder supplier.

The SMC powder is loaded into part-specific tools that ensure it is compacted to the desired shape. Compaction pressures and temperatures vary depending on the powders, geometries and end properties desired. For SMCs, compaction pressures and temperatures vary to achieve densities as high as 7.57 g/cm³.

After molding, the "green" part needs to be heat treated to bond the individual metal particles together. Heat treatment temperatures can range from 530°C to 650°C depending on the material system used. Different heat treatment atmospheres—including air, steam and nitrogen—can yield different results.

How can I learn more about SMCs?

More and more motor designers are considering the performance, form factor and cost benefits of SMCs for magnetic motor components. However, the range of available materials and design options may appear discouraging.

You can count on Symmco's experience in powder metal manufacturing in general and with SMCs for motor components in particular to help lead the way. They can discuss your manufacturing process, part options, material selections and other questions you may have about designing with SMCs.

SMCs May Be The Best Solution For Your Electric Motor Applications



Soft Magnetic Composite (SMC) material utilizes pressed and thermally-treated powder metal to produce components with 3D magnetic properties. These encapsulated iron powder particles are compacted to form uniform isotropic components with complex shapes in a single step. The use of these materials makes innovative electrical machine designs technologically viable.

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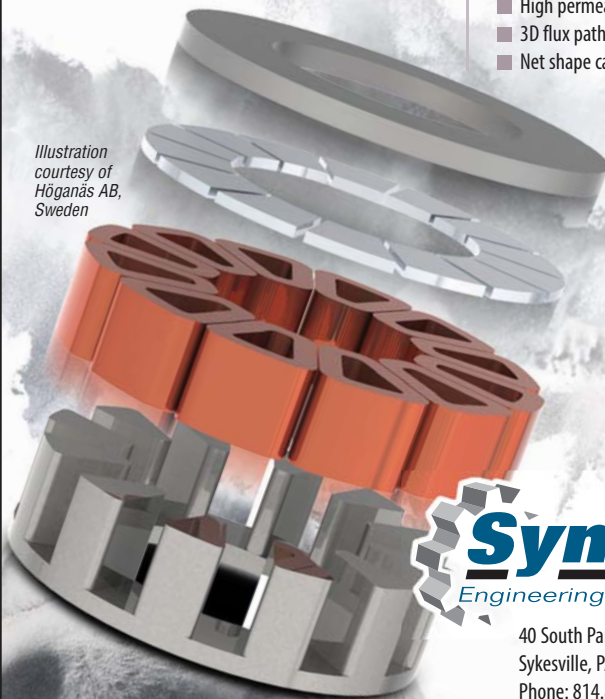
Benefits:

- Faster actuation (up to 50%)
- Cost-efficient production

Material Benefits:

- High resistivity
- High flux density
- Tight tolerances achievable
- Low core losses at high frequencies
- High permeability
- 3D flux paths
- Net shape capability

Illustration courtesy of Höganäs AB, Sweden



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While all of our manufacturing is produced in our U.S. based 300,000 ft² facility, our global network of offices, engineers, and distribution partners allows you to quickly receive parts and support from anywhere in the world. Smalley's dedication to quality and manufacturing excellence has earned us multiple service and quality awards as well as the trust of OEMs worldwide.



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From everyday consumer products such as the smartwatch on your wrist to life-saving medical devices such as robotic surgical instruments, Smalley has helped tens of thousands of engineers and professionals create application-specific solutions across every industry.

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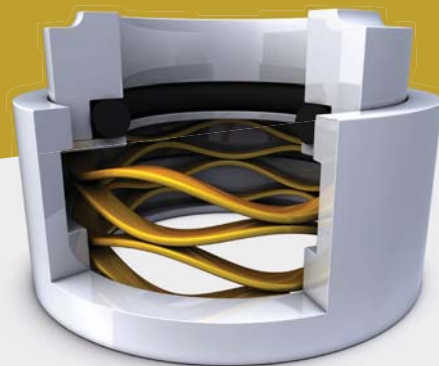
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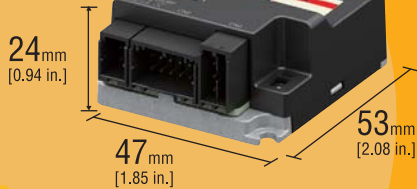
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Prevent Downtime: The Importance of Monitoring Water Supply and Flow During Welding

A turnkey, pre-engineered weld water control system has a few advantages over custom solutions.

by Kyle Hall, Tim Ritter, Turck

Weld monitoring can be a challenging and complex task. Good-quality repeatable welds are not only key for product durability but also the key to uptime in the weld cell. In resistance welding applications it is vital to monitor and control all welding parameters during production. One of the most critical functions to keep an eye on is the coolant supply lines. Routine equipment inspection may catch some of the supply line issues, but a turnkey, continuous monitoring system will ensure users are alerted when potential problems such as leaks occur—before it is too late.

Resistance welding has long been used in the metal forming and fabricating industry—automotive, white goods (appliances) and aerospace, just to name a few. With the ever-increasing demand to drive costs down, the pressure is on for manufacturers of these goods to streamline every step of the process. Although some stoppage to replace consumables is unavoidable in high-volume, low-cycle time resistance welding applications, stoppage for coolant system failure and the resulting repair, cleanup and cell reset can be one of the more costly events.

AT A GLANCE:

- One advantage to an off-the-shelf weld water control solution is that the assembly arrives ready to integrate with piping and fittings. There should be no need to thread or fabricate any piping solutions onsite, and the system designer would have specified sensors to tailor the control and data collection needs of the end-user.
- The authors discuss three noteworthy commissioning steps of a weld water control: the connection and leak testing of the assembly pipes and tubes, commissioning of the welding process and commissioning of the entire weld cell.
- Most plants have more than one welding robot, so the potential savings multiplies when waste is reduced.

Leaks, supply line failure, melted welding tips and a myriad of other things can go wrong in the coolant supply system within the weld cell and it is vital to have monitoring and feedback in place to act accordingly. Furthermore, the safety implications of spilled coolant in the work cell speaks for itself.

Custom Solution vs. Pre-engineered System

Current marketplace solutions are typically patched together by an integrator or the end-user and built on site. Often, custom solutions require a dedicated Ethernet connection or are a multi-component solution that needs a PLC or robot to function. Many Ethernet-dedicated solutions are not field serviceable; the entire solution must be replaced. A component solution is not designed to be a system, so the serviceability is a function of the designer, whose role invariably does not include maintaining the equipment.

The advantages to an off-the-shelf solution start the day the assembly is ordered—especially if the system incorporates IO-Link. The assembly shows up at the plant ready to integrate with piping and fittings—there should be no need to thread or fabricate any piping solutions onsite. Furthermore, the system designer can specify a myriad of sensors to tailor the control and data collection needs of the end-user.

There are three noteworthy commissioning steps of a weld water control system: connection and leak testing of the assembly pipes and tubes, commissioning of the welding process and commissioning of the entire weld cell. During the connection and leak testing of the assembly pipes

There are three noteworthy commissioning steps of a weld water control system: connection and leak testing of the assembly pipes and tubes, commissioning of the welding process and commissioning of the entire weld cell.

and tubes the system can be tested using the onboard pushbuttons and user interface to set flow and pressure parameters. There is no need for a PLC programmer to integrate the system, so the weld water monitoring system can be plumbed into the plant.

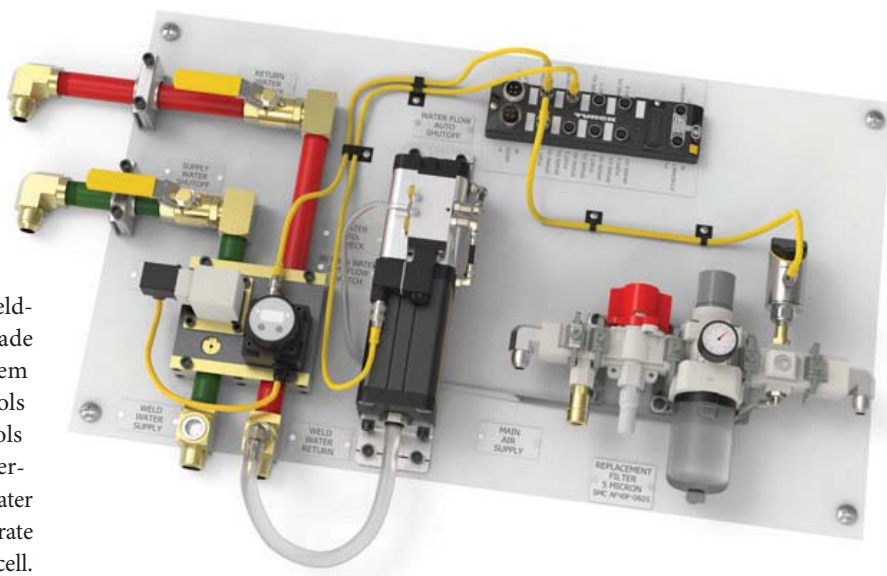
This advantage also holds true during the setup of the resistance welding process. Adjustments can be made to the pressure and flow of the system without the need to have the controls engineer present. Finally, the controls engineer can use the predefined interface to quickly commission the weld water control system into the PLC to orchestrate all the moving pieces within the work cell.

Monitor Critical Process Parameters Simultaneously

Once commissioned, the weld water control system offers several features including tip off (lost tip), insufficient flow and the capability to monitor all variables in the process. If any decrease in flow is sensed by the system, the weld water control system will stop the incoming flow from the pump or plant sourced coolant supply line and attempt to syphon the existing coolant out of the system return lines to minimize or eliminate any coolant that will spill onto the floor. Flow, pressure, temperature and several control variables are available over a single IO-Link connection that allows operations to collect and analyze detailed insights into process parameters. Gathering metrics from ancillary systems such as pneumatic pressure and weld current give the operators a full picture of the welding process and put them in control of the system.

Cost and Time Savings Add Up—Less Coolant Waste

While individual monitoring at the point of use certainly offers cost savings,



A weld water monitoring and control solution provides system protection during spot welding. Turck Inc. USA

the real money savings are realized when looking at the entire coolant system in a facility. Most plants have more than one welding robot, so the potential savings multiplies when waste is reduced. Water is a critical resource in many countries. If the user can now more closely track the amount needed in each cell, it will make welding operations more efficient and save water. Energy savings and energy efficiency are also potential advantages of a weld water monitoring system.

Safety Considerations

A weld water monitoring system also allows users to catch potential leaks sooner, preventing spills of chemicals and glycol solutions. Once a spill occurs, the cell must be disabled for maintenance workers to enter the cell and clean up the spill. Not only is downtime costly but the presence of liquids on the floor of the work cell presents a slip and fall hazard even to trained personnel. Another safety consideration is to monitor the system in case of a fault that would cause the

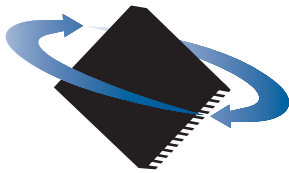
liquid coolant to fall below the designated threshold. Helping to protect expensive robotic welding systems from overheating reduces the likelihood of damage and other hazards.

Turnkey Advantage

The key factors to consider are water savings, improved process control, proactive alerts and better diagnostic tools. Using an off-the shelf systems solution to implement a weld water control system makes more sense from a financial and safety perspective. With a turnkey system the end-user can realize gains including decreased commissioning time and complexity as well as the ability to capture process variables from individual systems in one interface. ■

KYLE HALL is a senior product engineer and TIM RITTER a business development manager for Turck, a manufacturer of sensors, connectivity and fieldbus technology for factory, logistics and process automation.

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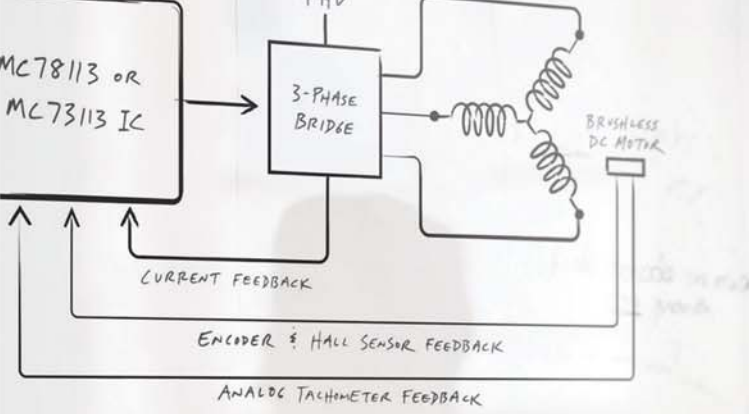
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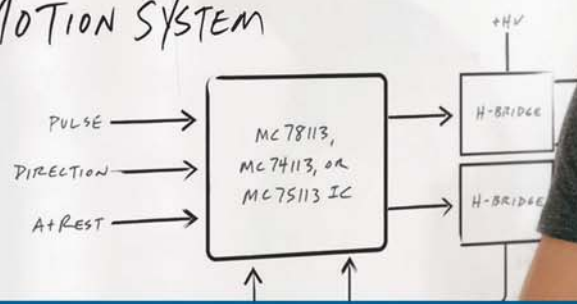
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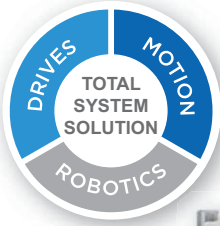
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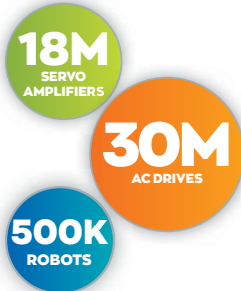
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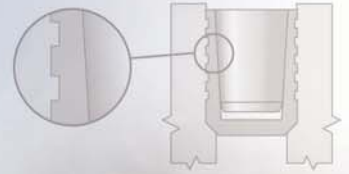
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How TIG Welding Cobots Support an Automation Enhanced Workforce



TIG welding system. Courtesy BOLD Laser Automation Inc.

Manufacturers can embrace an automation enhanced workforce when they include cobot-based welding and processing techniques.

by Todd Lizotte, Akshat Singh,
BOLD Laser Automation Inc.

We've been aware of the shortage of skilled welders due to retirements for some time. In recent years the shortage has been exacerbated by furloughing or the early retirement of workers during the COVID shutdown.

By one estimate, the U.S. will need more than 375,000 welders to satisfy the demands of several industries by 2023, according to the Welding Society.

Even with new welders entering manufacturing, most do not see themselves working on a manual assembly line where repetitively welding products is the daily grind.

The past 10 years has seen a continuation of middle-to-low-skill jobs being replaced, creating an opportunity for the welding industry to implement automation to develop new high-value-added

projects that can attract and retain new employees.

An automation enhanced workforce (AEW) would allow high-value employees to focus on supporting sales and new product development, while simultaneously expediting prototyping or high-volume work facilitated by the use of cobots or robot-based welding.

The AEW approach is skills-centric; it meets employee skill development needs while keeping pace with manufacturing goals. Millennials and Gen Z are highly skilled in digital technologies. Within high school, tech school and colleges, these generations have been exposed to technologies such as CAD, programming/coding and 3D printing. But the complexity keeps evolving and leads to increased intellectual demand. Failure to keep abreast of advances raises the real fear of being superseded both in the marketplace and with the workforce.

For these reasons, accelerating new employee training while retaining good employees are emerging as priorities for manufacturers. These conditions make it essential to offer employees opportunities to enhance their skills to expert level.

What follows below is a rundown of welding process techniques that support upskilling the workforce:

The Tungsten Inert Gas (TIG) Process

As a joining technique in metal and alloy manufacturing, the Tungsten Inert Gas (TIG) process offers a number of advantages over other methodologies, not least in producing superior, high-quality welds that also have appealing cosmetic finishes. The term “stack of dimes” derives from the favorable appearance typically observed post-TIG welding. It isn’t just aesthetics, though: In addition to the possibilities in joining aluminum and stainless steel, TIG can accommodate more exotic material combinations including titanium, tantalum and nickel-based superalloys.

Another hallmark of TIG is the ability to produce a narrow heat-affected zone

(HAZ), reducing solidification stress, cracking and distortion in the finished weld. This is highly desirable, as is the possibility of automated operational control parameters such as travel speeds, weld path programming, precision penetration, gas coverage and temperature control. Heat control, for example, can minimize shrinkage and distortion augmenting quality control in the process.

Cobot-Based TIG

In terms of welding techniques, the gas tungsten arc welding/tungsten inert gas (GTAW/TIG) process epitomizes a skill set driven by a need for practitioners to constantly develop their skills in precision. This fact is reflected in industry wage reports that indicate TIG welders and their particular expertise command amongst the highest wages earned within the sector.

The AEW strategy offers a step-change within the industry, whereby automated TIG welding platforms implementing robotic hybrids can handle large volumes of throughput without compromising quality or obviating labor shortages.

Transitioning Manual to Automated (Certifications)

As with any welding process, the equipment and personnel must conform to standards and pass certifications. Industry standards such as the American Welding Society (AWS D17.1) and the American Society of Mechanical Engineers (ASME) provide widely accepted standards for TIG procedure qualification. TIG welding to a specific code requires a welding procedure specification.

WPS is a formal document describing welding procedures to guarantee repeatability by trained welders. This procedure is described in the American Welding Society standards. A procedure qualification record, or PQR, records welding variables used to produce an acceptable test weldment. The results of tests conducted on the weldment to qualify a welding procedure specification must be strictly followed in subsequent welding.

The advantage of automated, repeatable, uniform, consistent welds that robotic TIG can provide is handing small manufacturers increased productivity and several quality control advantages while upskilling their welding workforce.

TIG & AEW

Robotic TIG is currently being used extensively. Within the manufacturing sector, heavy equipment, food & pharmaceutical equipment, aerospace repair & overhaul and automotive are all segments benefiting from its implementation. The advantage of automated, repeatable, uniform, consistent welds that robotic TIG can provide is handing small manufacturers increased productivity and several quality control advantages while upskilling their welding workforce. Skilled welders can focus their work on critical lower-volume/high-value applications or support sales and product development if, for example, the dead time associated with torch repositioning between welds and fixturing can be minimized.

In fact, the variety of capabilities—when a company is ramping up to pilot or production levels—brought by automated TIG doesn’t stop there. From repeatable, precise heat control and exact penetration to on-the-fly parameter adjustment from between thick and thin materials, the list goes on. Torch motion trajectory and automated control of pre-flow, starting amperage, upslope time, welding amperage, pulse frequency, downslope, crater-fill and post-flow are among the mix of capabilities.

Automated TIG not only positively impacts the bottom line by reducing operator training time and inspection costs (doubling welding productivity when compared to the manual counterpart) but high-quality aesthetics are achievable

when automatic voltage control dictates arc length, bead width and penetration and lead to pleasing surface appearances.

Automated TIG Cobot Systems

Critical to maximizing the return on capital is a platform's flexibility relative to the manufacturing environment, along with an ever-expanding marketplace for different automated cobot and robotic TIG welding systems. An operation with this level of automation is conducive to Millennial and Gen Z employees who are comfortable with coding technology. Further ease of use is exemplified by robotic welding hybrids that incorporate remote desktop 3D CAD-based tool path generators that underpin vision system-based tool path verification and tracking.

Once a system has been taught a weld path (using an onboard camera and vision system), highly complex or expensive parts are reinforced by the TIG torch maintaining that path on the seam with minor adjustments throughout

the process. Some top camera platforms, such as Keyence and Zebra, are tooled to undertake precision performance. 3D laser scanners generate tool paths with tens of micron tolerances, often key in the manufacture of aerospace components.

The Future with AEW and TIG

Manufacturers are mindful that turnover within the marketplace is accelerating. On the one hand, the older generations, with their highly focused skill sets, have been bearing most of the responsibility to keep production running. But their involvement is rapidly coming to an end. On the other hand, manufacturers are cognizant of a limited candidate pool with any real welding experience amongst new graduates.

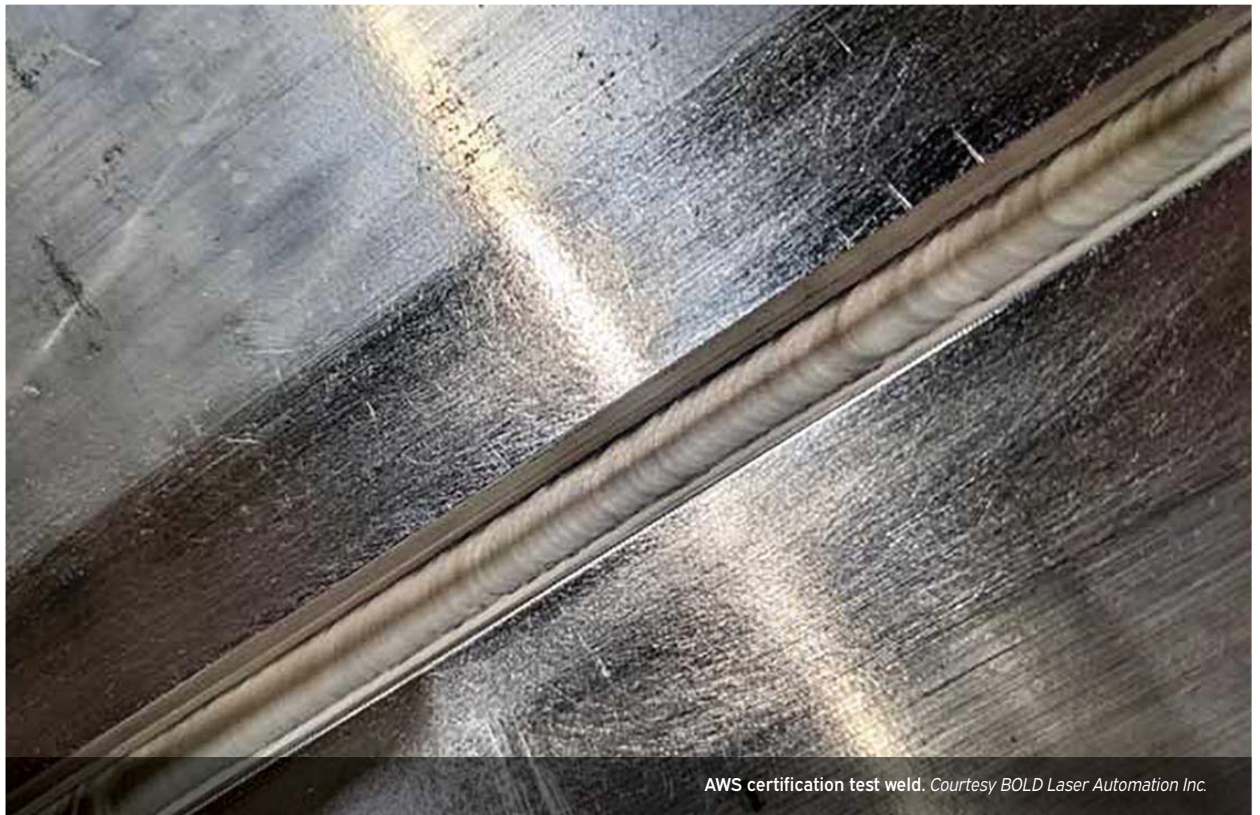
High-volume applications are part and parcel of many industry sectors, but none more so than within the aerospace and aviation repair industry where TIG is a critical mainstay. Investing in robotic/cobot tools to augment capabilities is part

of the solution. One benefit of augmenting welding capacity is the prospect of freeing up some experienced operator time. If this time is dedicated to educating the less-experienced talent pool, this one measure can help ensure business continuity.

As the next wave of automation disrupts production functions, an automation-enhanced workforce is inevitable. Manufacturers will need to adapt to survive. It starts with investing in that first tool.

Moreover, how adaptable a manufacturer will prove to be depends on how well the workforce is trained in the face of new automation challenges. Embracing hybrid welding automation can help shift tasks to raise overall efficiency. ■

THIS ARTICLE was submitted by BOLD Laser Automation Inc., a laser process development and systems integration group located in New Hampshire. Todd Lizotte is the firm's president and CEO, and Akshat Singh is a system integration engineer.



AWS certification test weld. Courtesy BOLD Laser Automation Inc.

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- The app serves as an installation alignment aid as it displays the signal strength of each beam.
- Real time monitoring of the active operation mode, the status of the OSSD outputs and the status of the protective field provides the information necessary to quickly resolve faults.
- The app can provide documentation on the light curtain, either emailed or saved to the smartphone or tablet.
- Additionally, you can see which functions have been enabled and their parameterized settings.

Contact us to learn more about this innovation in safety light curtains
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