Design World

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July 2023

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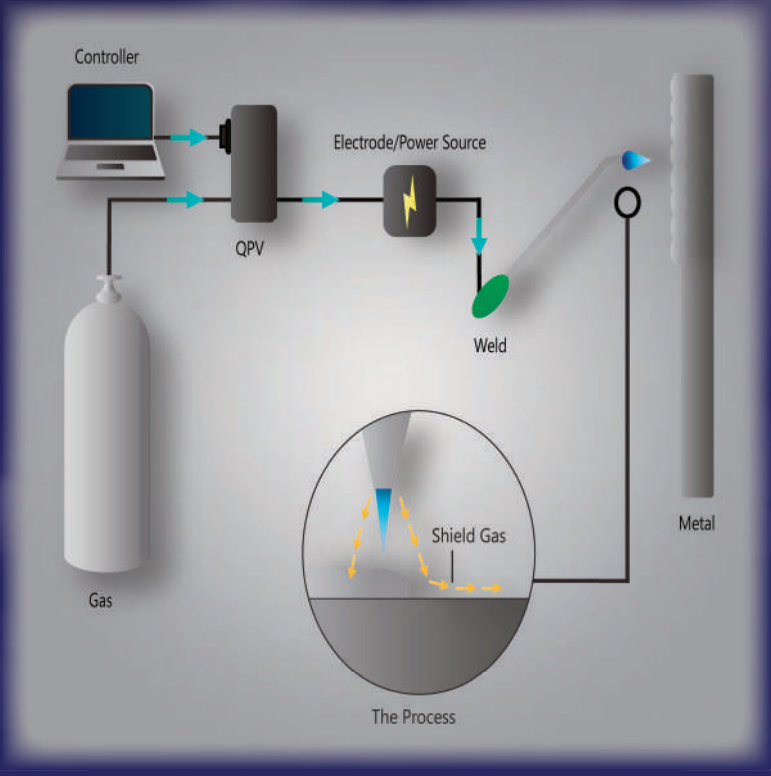
RETOOLING AMERICA



Welding Shield Gas Control

The COVID crisis and resulting supply chain issues opened our eyes to the fact that the US has become overly dependent on overseas manufacturers. Caught off-guard with a need for critical equipment and supplies, we struggled to keep our citizens safe.

These challenges are not limited to the production of finished goods. Many intermediate products are required before an item lands on a shelf or a showroom floor. The semiconductor shortage is one example of how important it is to manufacture locally.

How can we bring back production, and ensure that we don't risk falling into this situation again? A commitment to what we're calling "retooling": bringing back manufacturing at the local level.

We're approaching retooling several ways:

Keeping manufacturing here: Indiana has been our home for manufacturing since 1985. We also have an office in Texas, and a new building is being erected for our existing Florida location. Our manufacturing base will always be in the US.

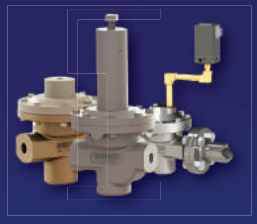
Sourcing domestically: We prioritize other domestic manufacturers and suppliers when sourcing components for our products.

Educating students: It's not just producing tools in the here and now. Today's students should be exposed to all elements of the manufacturing process and how to apply them, not just the last few steps of assembly. We've started by sponsoring capstone projects at Purdue University and will be offering demonstration kits to schools interested in teaching students about electro-pneumatic control.

The US has a long history of manufacturing products from start to finish. From early immigrants setting up textile factories, sawmills and glassworks to the automotive boom of the 20th century, there is no question of our capabilities. It's in our hands to support domestic products.

Join us in Retooling America.

BV BURLING VALVE



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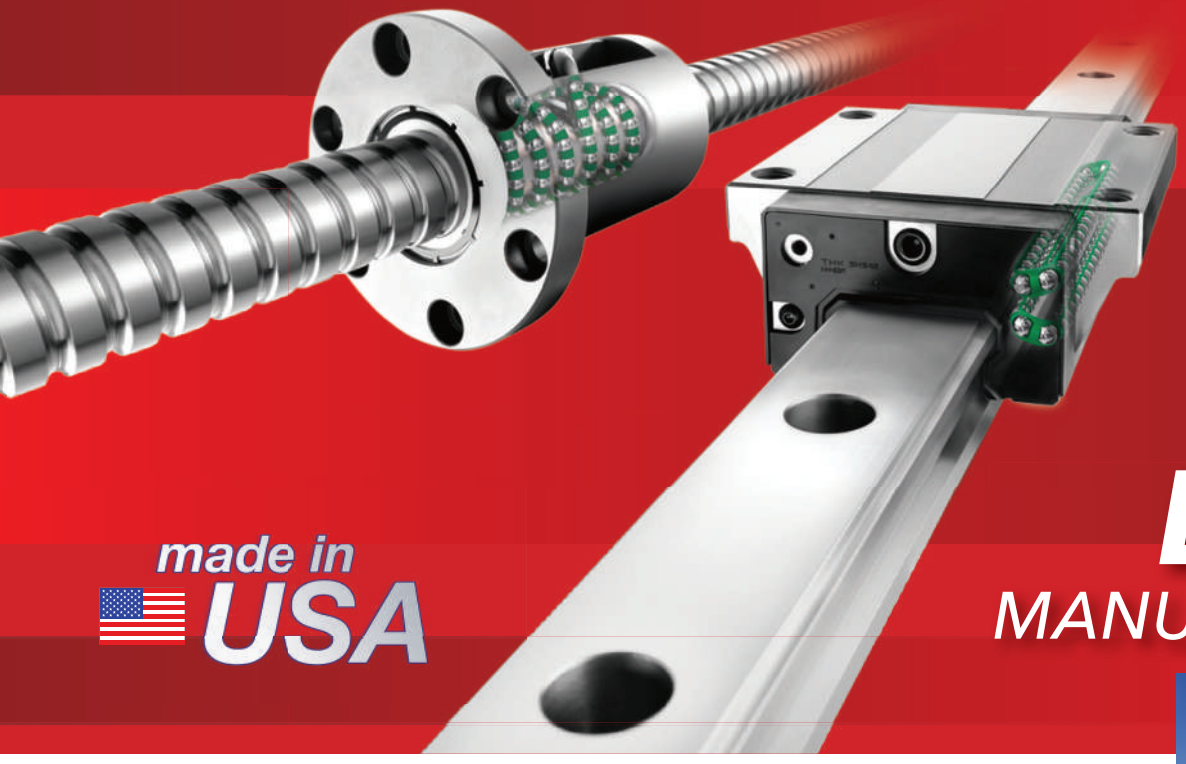

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Insights

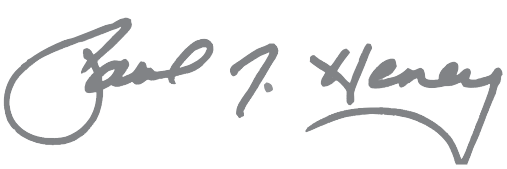
Working toward more inclusive engineering

Over the past five years, our editorial staff has produced an extra issue each Fall to examine the challenges facing women in the engineering space, as well as celebrating the achievements being made by female engineers in the industry. We're proud of the light we've shown on these readers, including how passionate so many of them are about mentoring young girls interested in STEM/STEAM careers. And we've received such positive feedback from the community over the years, so it's been a very gratifying project for our team.

So, I'm excited to unveil the evolution of this special issue where we will be expanding the scope in 2023 — and also adding in more researched feature stories on big-picture trends. This October, we will celebrate communities underrepresented in the engineering space with this special standalone issue, which we are calling "Engineering Diversity and Inclusion."

Our team feels passionately about promoting industrial automation and engineering to people of all races, abilities, ages, orientations, and ethnic backgrounds. We are also committed to strengthening our industry by boosting the diversity within it so all the markets we serve can better leverage heterogeneous talents to maximize innovation and productivity. In the Engineering Diversity and Inclusion issue, our editorial team will present an updated salary survey for 2023; discuss the intersection of industry ethics and diversity initiatives; summarize the recent NFPA Diversity, Equity, and Inclusion Group (DEI) panel discussion; report on a reader survey covering corporate diversity topics; and comment on neurodiversity and what it means specifically for engineering teams, where numbers and trends are critical.

In addition, our editorial team will highlight engineering readers who are positively influencing design technology or general engineering practices. And that's where I'm hoping you will come in and assist us. While we've already started this process, we're still looking for readers — perhaps one of your colleagues comes to mind — who would be interesting to profile for this issue. If you'd like to suggest a colleague (or even yourself), please drop me an email at the address below and explain what interesting perspectives they bring to the engineering world and how they're succeeding at making their design teams better representative of the beautiful, diverse world we live in. DW

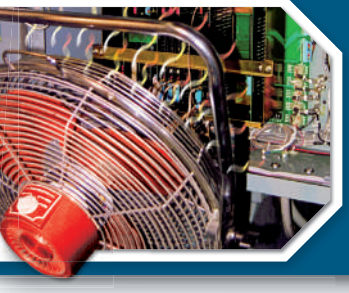


Paul J. Heney - VP, Editorial Director
pheney@wtwhmedia.com
On Twitter @wtwh_paulheney

The Secret to Keeping Electronics Cool!

Benefits of EXAIR® Cabinet Cooler® Systems

- Less expensive to purchase than refrigerant A/C units
- Less expensive to operate than refrigerant A/C units
- Quicker to install than heat exchangers and refrigerant A/C units
- Little to no maintenance
- More reliable in dirty, hot, or remote environments than alternative cooling products
- Not affected by machine vibration which can cause refrigerant leaks
- Ambient temperature does not affect performance like it will with alternative cooling products



Don't Blow A Fan on an Open Cabinet!

It is an OSHA violation that presents a shock hazard to personnel.

The fan blows hot, humid, dirty air at the electronics.

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For large heat loads up to 5,600 Btu/hr.

- **Enclosure remains dust-tight and oil-tight**
- **Measures 8" (203mm) high**
- **Mounts top, side or bottom**

NEMA 4 and 4X

For heat loads up to 5,600 Btu/hr.

- **Enclosure remains dust-tight, oil-tight and splash resistant**
- **Suitable for wet locations where coolant spray or washdown can occur**

Type 316 Stainless Steel

For NEMA 4X applications available for heat loads up to 5,600 Btu/hr.

- **Resists harsh environments not suitable for Type 303/304SS**
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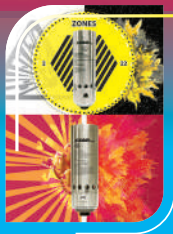

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- **For heat loads up to 5,600 Btu/hr.**
- **NEMA 12, 4 and 4X**

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An ounce of prevention... hot bearings in the hot seat

When a bearing system is neglected, or a problem goes unnoticed, we have a specific phrase for the subsequent event — catastrophic bearing failure. It's hard to think of a recent incident that encapsulates the expression quite like last winter's devasting Norfolk Southern trainwreck in East Palestine, OH.

The National Transportation Safety Board suspects hot wheel bearings could have been at least partially responsible. The crash derailed 38 of 149 railcars, the lives of residents all throughout the small Ohio town, and the full scope of the larger environmental impact is still being calculated five months later. A trainwreck indeed. And that's to say nothing of peace of mind for folks that live near tracks — a reality that hits particularly close to home for me.

I also live in Ohio, near tracks, and write about bearings for a living. A little extra railway anxiety feels unavoidable. Each morning, as my car crosses the "T" of those tracks, I can't help but think, what if...? Here's a railway safety Rorschach test: According to data from the Federal Railroad Administration, there were over 1,100 derailments in 2022 alone. But of those 1,100+, there was only one fatality and 16 injuries... I have trouble deciding if those numbers make me feel better, or worse.

Recently, I reached out to Jeremy Luchies, who specializes in lubrication solutions for the Semiconductor, Aerospace, and Bearing segments for FUCHS Lubricants Co. I asked him about some of the ways bearing failure can be prevented. He said,

"Catastrophes can take many forms, from economic crises to fatal disasters. When these catastrophic events hit the news, the first questions usually asked are how

did this happen, and how can we prevent this from happening again? Often, these catastrophes, caused by mechanical or human error, could have been prevented with the proper precautions. Insufficient maintenance, faulty components, and a lack of, or malfunctioning diagnostic technology, are a few of the preventable causes of mechanical failures."

To be fair, both the NTSB and a late-March DOJ lawsuit stop short of accusing NS of negligence. Trackside "hot-box detectors" did recognize a temperature spike in a wheel bearing, and the engineer did begin to stop the train after the alarm sounded. But it was too late. The railroad industry has long been criticized for insufficient regulatory measures. So, if things were, in fact, handled by the book, and a catastrophic derailment was the result regardless, perhaps the book needs a rewrite.

In the near decade that I have spent covering the bearing industry for Design World, making bearings safer has always seemed paramount to the companies I interact with. Reliability is the lifeblood of their products. Either through better predictive maintenance, tribological properties, anti-counterfeiting practices, or other advances, bearing companies appear to hold safety as a top priority. Bearings are critical components for countless applications — especially trains. I hope NS, and other railroad companies like it, begin to treat these components with the care and attention that the original bearing manufacturers already do. DW

Mike Santora
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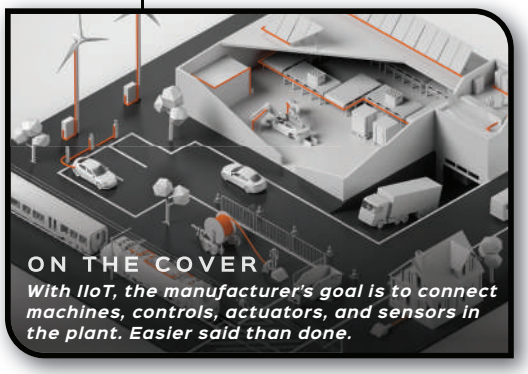

ON THE COVER

With IIoT, the manufacturer's goal is to connect machines, controls, actuators, and sensors in the plant. Easier said than done.

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This fully integrated wafer lift assembly from Bosch Rexroth exceeded the target of five million cycles and provided a 30% cost reduction.

| courtesy of Bosch Rexroth

Advanced wafer transport automation improves precision and processing time

Danielle Collins • Business Development Manager — Semiconductor • Bosch Rexroth

With computer chip shortages affecting virtually every industry, semiconductor manufacturers are working rapidly to build new fabs and expand existing production lines. This increase in manufacturing capacity creates major opportunities — and challenges — for automation technology suppliers.

Consider that the typical chip production cycle takes six to eight weeks for completion. Some chips can take longer, involving 1,500 to 2,000 steps and six months to process. By some estimates, only a quarter of the processing time for a semiconductor wafer is spent in chambers — the rest is spent transporting wafers in and out of chambers and between tools or waiting for tool time.

Wafer transport requires precise, vibration-free motion to avoid damage or costly scrap. Endpoint accuracy is equally critical. Before processing can begin, the wafer must be perfectly stable and properly aligned. Any additional time required for vibration to dissipate or for the system to reach its precise position significantly impacts throughput and cost.

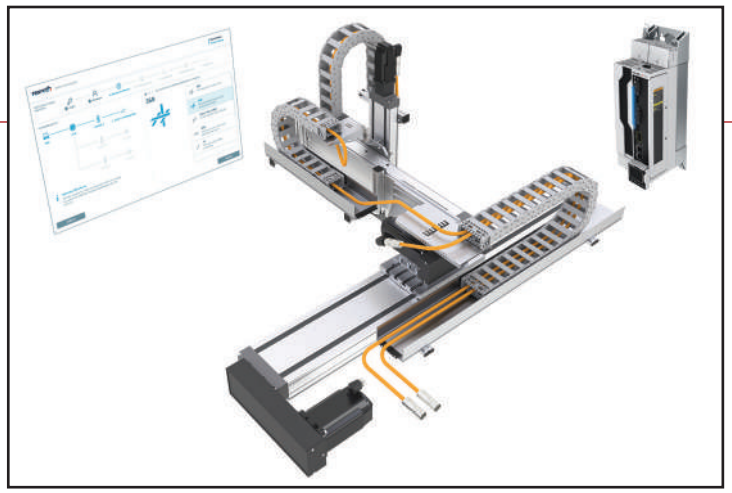
Tool builders can address these challenges with new controller and servo drive platforms that offer more flexibility and precision in motion control. Refined motion control techniques, such as feed-forward algorithms, predict and compensate for position and velocity conditions at the end of a motion sequence to ensure precise positioning and minimal vibration and settling time.

With an open, app-based approach, a new generation of automation controls offers greater scalability and engineering freedom. For example, engineers who need a specific drive or controller capability can add the functionality as an app — just like adding an app on a tablet or smartphone — rather than reworking the entire automation program.

Plus, to minimize footprint and maximize performance, servo drives that combine compact, space-saving designs with performance characteristics and that minimize vibration and settling time equip tool builders with control and size capabilities to address their most critical requirements.

But high-performance wafer handling systems require more than powerful controllers and drives. The linear systems that physically move the wafer stages need equivalent precision, rigidity, and positioning accuracy. Linear motion systems used in wafer transport assemblies must have high levels of mechanical stiffness to minimize deflection and ensure high accuracy in both travel and positioning.

Ball screw drives provide superior stability and control for semiconductor tool applications. They are ultra-efficient at converting rotary motion to linear motion, offering a unique combination of high rigidity, high precision, and fast travel speed while maintaining the necessary cleanliness.



Bosch Rexroth's Smart MechatroniX handling system uses a "plug-and-produce" concept to simplify mechatronics development. | *courtesy of Bosch Rexroth*

Regarding linear guide systems, it's essential to assess the smoothness of ball recirculation inside the bearing block as it moves along the linear guide. As the balls travel through the bearing block, even minute pulsations can adversely affect applications requiring high accuracy. Technologies that optimize recirculation at key transition points provide extremely smooth and consistent motion as the balls circulate.

With the pressure to rapidly engineer and deliver wafer transport solutions, tool designers and builders are more frequently turning to experts in mechatronics and automation for complete, ready-to-install subassemblies. Effective subassembly development should utilize a holistic view of design rather than a serial design. Best practice is to begin by assessing the mechanics before forging ahead with the electrical and control design. Understanding how mechanical elements affect motors and controls will help avoid problems later.

Some semiconductor fabs can improve throughput and efficiency by using new multi-axis handling and linear motor conveyance systems.

Smart mechatronic handling systems now offer a "plug-and-produce" concept to simplify mechatronics development. Online selection tools let machine builders and system integrators quickly size and select key components — linear systems, drives, motors, cabling, and more — to create a complete handling solution delivered as a single product.

These systems also come with commissioning software for automated drive recognition and utilize drag-and-drop motion sequences pre-configured for various functions, along with digital twin capabilities for programming efficiency.

For fab operations with multiple vacuum chambers, linear motor transport tools with an external noncontact motion system provide a new solution for wafer handling. Coils mounted outside the chamber provide drive power for magnetic carriers inside the chamber, offering the precision, feedback, and control of linear motors without having cables pulled into the vacuum chamber. They also allow individual carriers to move independently for specialized processing needs. DW

Bosch Rexroth
www.boschrexroth-us.com/semiconductor-info

A new "Twiist" on position transducer design measures multiple data points

After 10 years of research, Gefran, an Italian sensor and control company, has launched its Twiist contactless linear position transducer to the North American market. The transducer not only measures position but can also measure temperature, velocity, acceleration, and tilt angle.

"There are several products on the market that measure position, and Gefran has them as well, but only Twiist can measure position, acceleration, speed, vibration, and three spatial angles (x, y, and z axes) all at the same time," said Edoardo Zilioli, marketing manager, Sensors Division, at Gefran. "And if desired, Twiist can also monitor the ambient temperature inside the transducer. Readings and data processing happen simultaneously."

This multi-variable position transducer is in the Hall effect category, but what truly sets it apart is its unique helical magnetoelectronic design, its ability to take multiple measurements simultaneously, and its focus on improving operator safety. This patented technology results from a decade-long partnership between Gefran's internal R&D department and the University of Brescia's engineering department in Brescia, Italy.

"The Twiist is perfect for mobile and industrial hydraulic applications," said Ron Akers, business development manager for fluid power at Gefran. "It allows for multiple types of measurement in one component. Signals for linear and angular positioning and temperature readings are all communicated at the same time. Furthermore, with the onboard electronics, Twiist provides real-time velocity, acceleration, and tilt angle measurements to keep operators safer."

The compact design is not limited to 250 mm stroke ranges like traditional Hall effect sensors.

"Measuring linear displacement with a Hall effect chip encapsulated by a magnetic helix is an innovative and ingenious idea. It revolutionizes the classic Hall effect sensor in the range of 5 mm, which among other things, is limited to strokes of up to 250 mm," said Zilioli. "Not only does Twiist reduce the number of expensive components needed for a project, but it is a redundant position transducer with a more useful electrical stroke of 50 to 900 mm."

Twiist's compact, air-tight design has a steel barrel with a diameter of 5/8-in. (16 mm), and it comes with a choice of two types of connection points, ball joints for swivel connections and rod ends with eyes for pivot connections. Available in full-scale (FS) strokes from

50 to 900 mm, it has typical linearity of 0.15% FS and typical repeatability of 0.05% FS. It can operate in a temperature range from -40° to 185° F (-40° to 85° C).

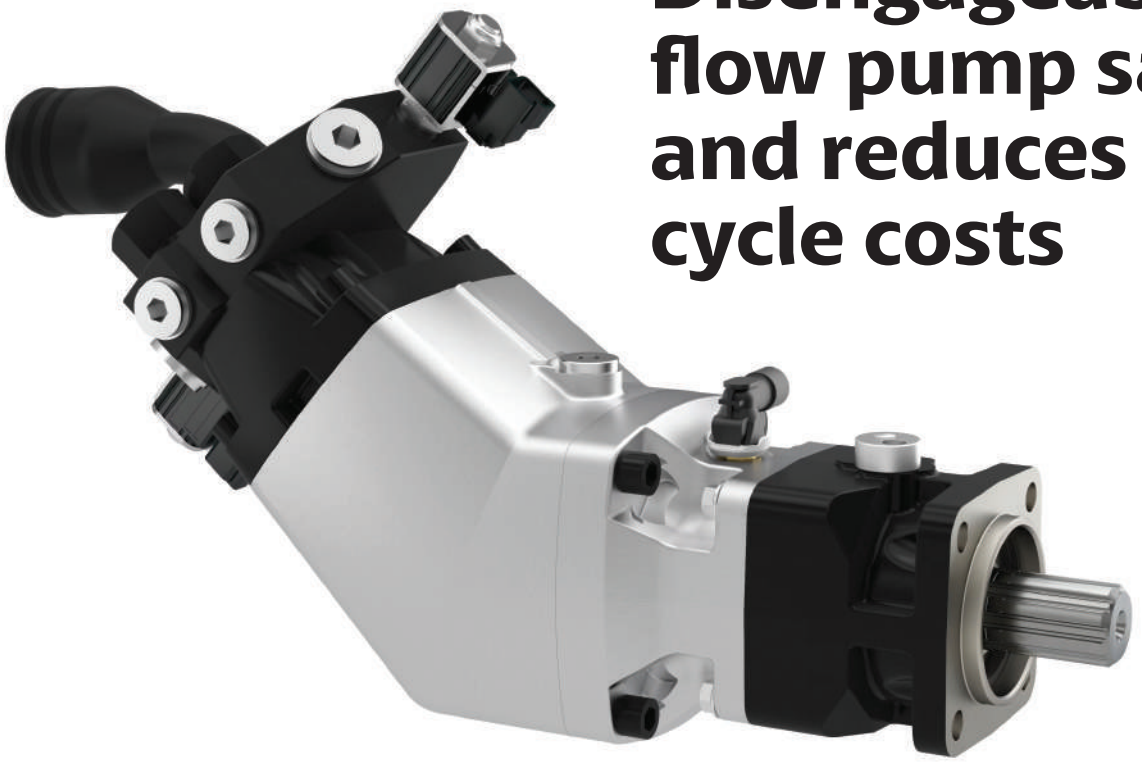
The Twiist has an IP67 environmental protection rating, offering complete protection against dust, airborne particles, water, and other liquids when submerged up to 39 in. (1 m) deep. This resistance to contamination makes it ideal for fluid power applications and extends the life of the part and equipment.

In mobile hydraulics, applications abound. For example, when steering a vehicle and using spatial inclination and acceleration, the Twiist verifies, at each millisecond, if the ground is stable underneath the construction equipment and can alert the operator if there is a danger of unstable ground. All of this is directly on the steering axis, without any mechanical interference — or worse, mechanical play.

Other applications include control of stabilization footings in area platforms (extension and subsidence), monitoring position and vibration for mining, fracking, and drilling, and measuring position and inclination for phytochemical sprayer arms on agricultural sprayers. Practically all medium-complex vehicles could use a Twiist multi-variable transducer. DW

Gefran | www.gefran.com

Disengageable twin-flow pump saves fuel and reduces life cycle costs



The ability to disengage a twin-flow pump is a huge money saver in terms of fuel savings and less wear on the pump.

Parker Hannifin's new F4 disengageable twin-flow hydraulic truck pump merges technology from the successful F2 twin-flow pump and F3 axial piston fixed pump series, resulting in a simple and flexible solution for any vehicle requiring separate flows of differing capacities. This will have multiple applications in vehicles such as salt spreaders, hook loaders, forestry cranes, sewage trucks, snowplows, and many others.

The patented clutch function lets the user engage and disengage the pump from the diesel engine on the move, without turning the engine off, by pressing a switch on the dashboard. This enables substantial fuel savings and a significant reduction in CO2 emissions.

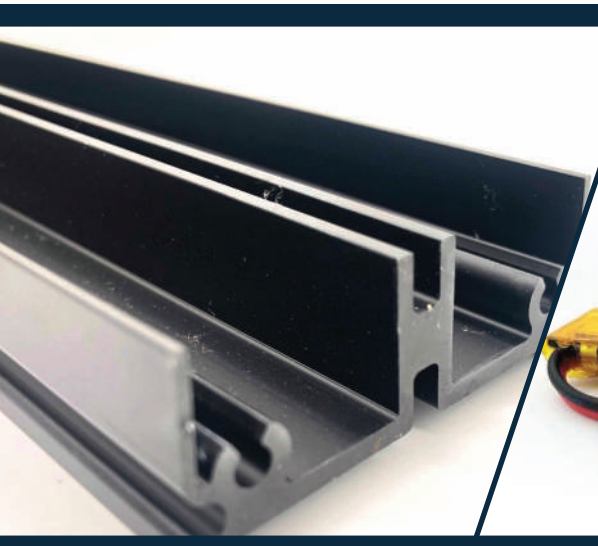
If, for example, a truck (with a hook loader and a detachable snowplow) that utilizes the new F4 series pump runs for 260 hours in its first month using power take-off (PTO) for just 56 of those hours, around 1.2 kW per hour less power is required when the pump is disconnected. This equates to about 50 liters less fuel needed in that month alone, and in a year, the possible savings could exceed 600 liters (especially where the snowplow is in use only for a few of those months). The CO2 emissions are therefore also reduced by around 1.8 tons.

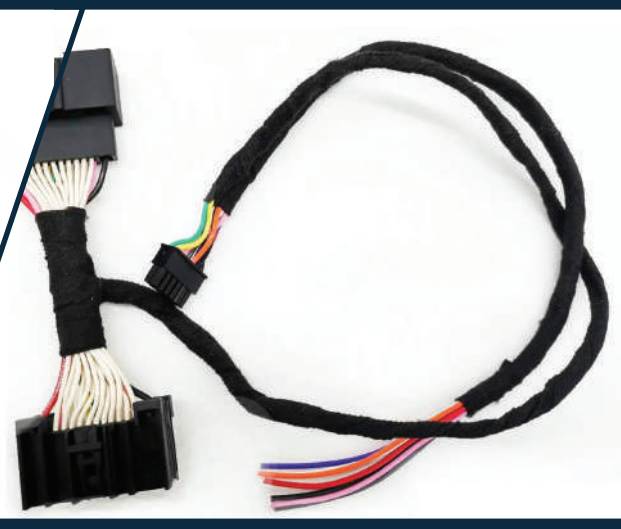
In addition, the clutch feature reduces wear and tear on the pump and minimizes the risk of costly downtime and standstills while reducing noise emission levels.

"In the situation of a hydraulic hose failure, users also would be able to drive to the workshop instead of the truck being towed, resulting in less downtime," said Anders Larsson, product leader at Pump & Motor Division Europe. DW

Parker Hannifin
www.parker.com

Kingway





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Hygienic vacuum pumps ready for daily cleaning

Vacuum systems used in food and packaging processes must contribute to a safe and efficient food supply. With the new wash-down vacuum pumps DV 650 and DV 800 FP-r of the established, dry-running DRYVAC series, Leybold has developed two models for these industrial processes. Their use facilitates production, increases food safety, and extends the shelf life of foodstuffs.

The new DRYVAC DV 650 and DV 800 FP-r screw vacuum pumps are characterized by their proven functional principle and compact design. In demanding, harsh food applications, they require only a small footprint and little installation space. In addition, they can be washed down inside and outside in any installation position.

In addition, their compact size and low noise level enable uncomplicated, near-machine installation in the immediate vicinity of the production line. The advantage for users: during daily system cleaning, the DV 650/800

FP-r pumps can be washed down with the production equipment in one process. This results in fewer system downtimes, better cycle times, less maintenance, a higher standard of hygiene, and higher filling and packaging outputs. This is a real advantage in packaging applications requiring good vacuum levels (low pressure), such as skin packaging.

Due to their rotor design, the robust DRYVAC models operate energy-efficiently and at low lifetime costs. In line with the requirement profile in most applications, their use also guarantees a high pumping speed from atmospheric pressure to low-pressure ranges. With modern, oil-free pump technology, the risk of contamination of pumped media with lubricants is minimal.

The DV 650 and DV 800 FP-r models have a frequency converter for easy monitoring and control, enabling a variety of functionalities. For example, it provides only the energy required at a time, which leads to lower energy consumption overall. Furthermore, it offers the possibility of a definable ramp-up of the rotation frequency with which a vacuum chamber can be gently evacuated. This is particularly advantageous when processing foodstuffs, such as bakery products, that would change their shape if the pressure in the chamber lowered too quickly.

Advantages at a glance:

- Water cooling enables installation directly in the air-conditioned process area
- Suitable for daily wash down and flushable with liquids inside
- High tolerance to vapor, liquid slugs, and soft particles due to the dry screw principle
- Easy maintenance, longer maintenance intervals
- Optional integrated, easy-to-clean stainless-steel silencer

DW

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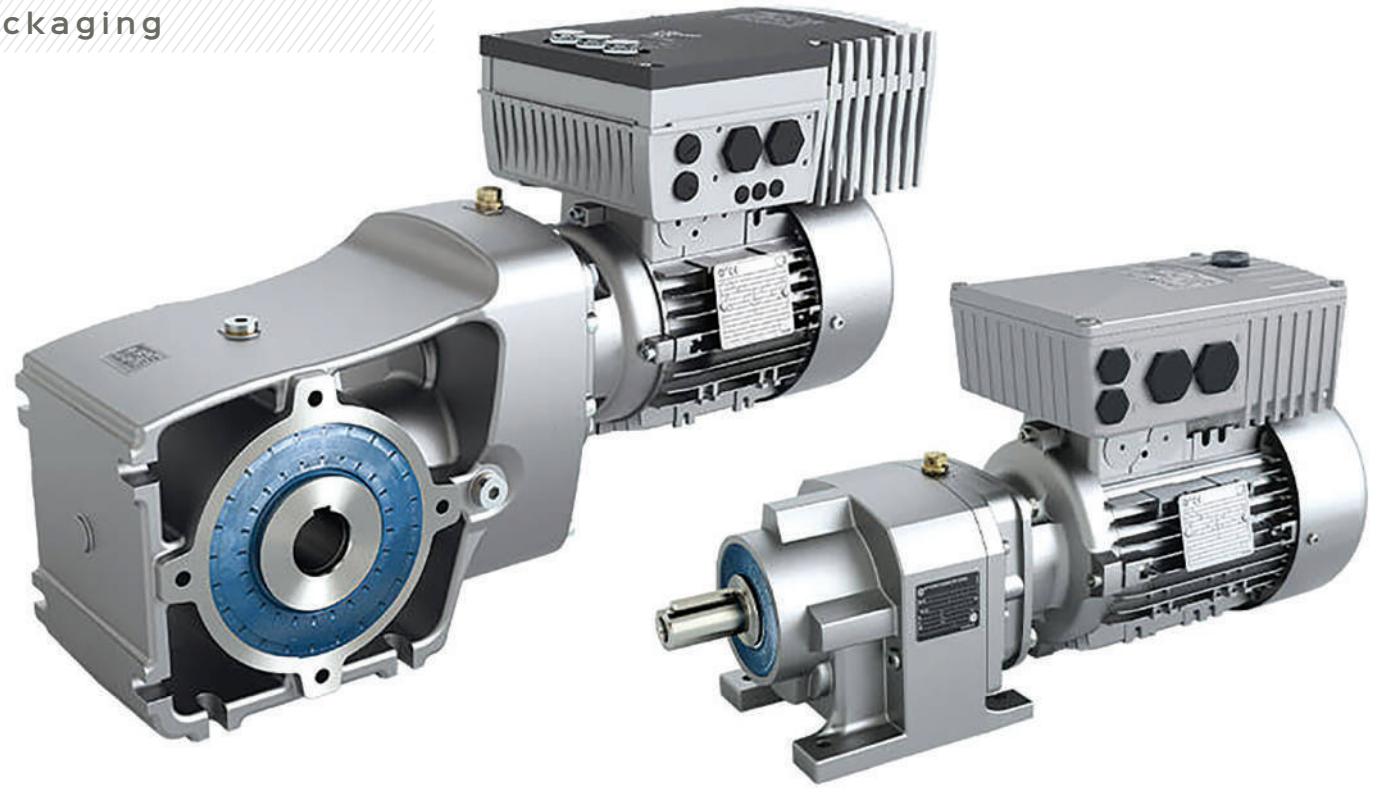
Packaging



Efficient, economical solutions for end-of-line packaging

Decentralized drive solutions with asynchronous motors can achieve cost benefits of up to 50% while providing a more compact footprint and high-efficiency operation.

NORD's decentralized drive technology enables end-of-line packaging systems such as palletizers to operate smoothly and precisely while delivering lower operating costs, reduced maintenance work, and a more compact design.

End-of-line packaging processes can include heavy loads, high forces, and long travel distances. While drives with centrally controlled servo motors are commonly used in these applications, they are not always required for palletizing, stabilizing, and handling applications. For these systems, decentralized drive solutions with asynchronous motors are more efficient and cost-effective.

The NORD asynchronous motors are widely available in power ranges from 0.16 to 75 hp and are made for use with NORD's full line of gear units and variable frequency drives. When moving heavy loads, asynchronous motors deliver a higher level of control and movement than conventional servo solutions that require adjustment to the application via large gear ratios. They also provide higher process stability and quiet operation while reducing vibrations and the risk of damaging loads or packaging machines.

NORD's decentralized variable frequency drive options include the NORDAC BASE, NORDAC FLEX, NORDAC LINK, and NORDAC ON/ON+. These electronic control products can efficiently control conveyor speeds, manage individual product placement and pickup, and smoothly operate palletizing machines without slowing product flow. NORD VFDs offer flexibility as the modular design concept allows changes and maintenance to occur anytime without significant structural modifications, extensive downtimes, or changes within a control cabinet. The decentralized solution also saves space, as the VFDs can be directly mounted to the motor without needing a full control cabinet setup or extensive wiring system.

Depending on the system type and application, these decentralized variable frequency drives paired with asynchronous motors can amount to up to 50% savings compared to the legacy design. The high efficiency of asynchronous motors works to lower operating costs and reduce the number of system variants, saving money and storage space. The motors decrease procurement costs and include more options, wider availability, and simplified maintenance. DW

NORD
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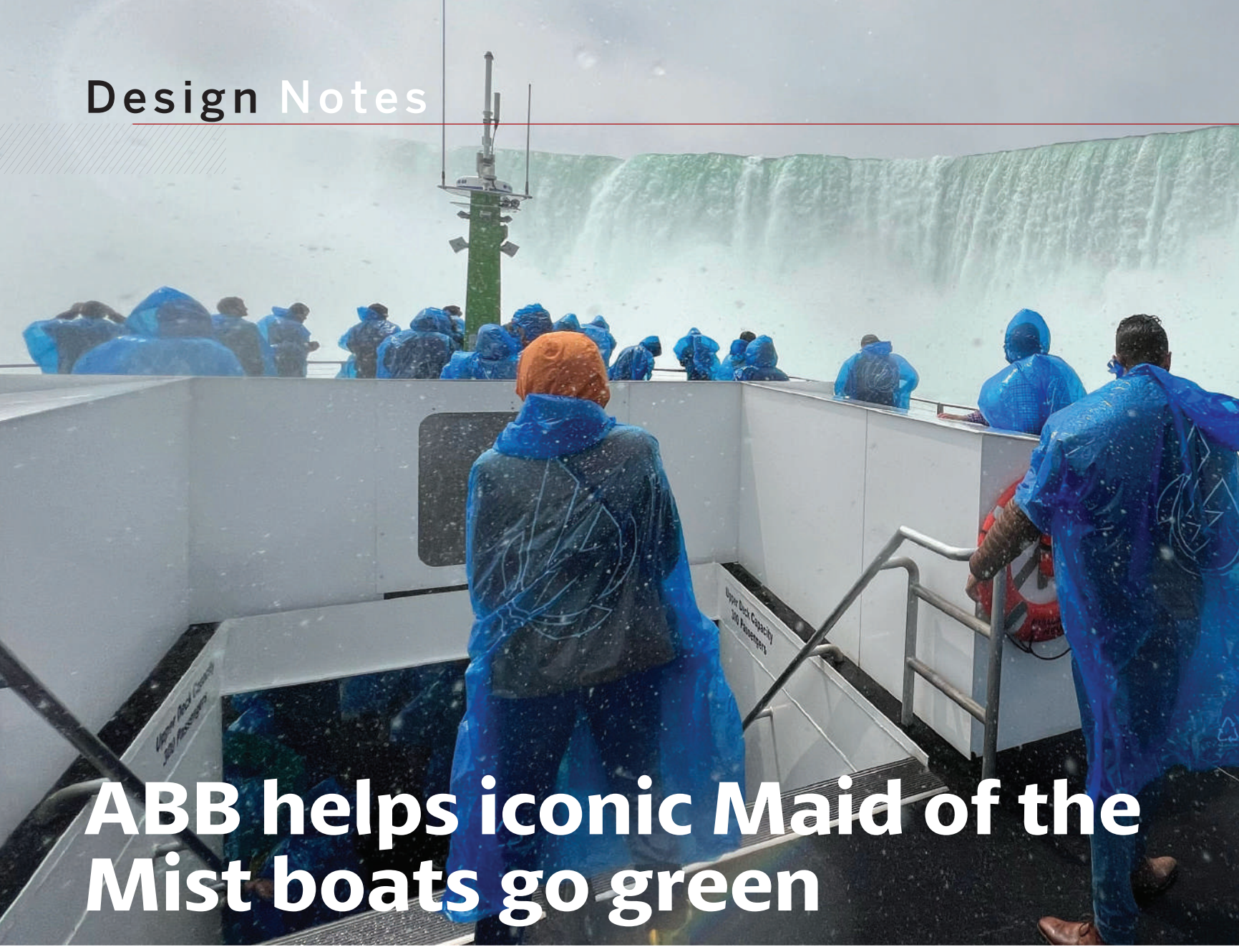


ABB helps iconic Maid of the Mist boats go green

Paul J.Heney • VP, Editorial Director

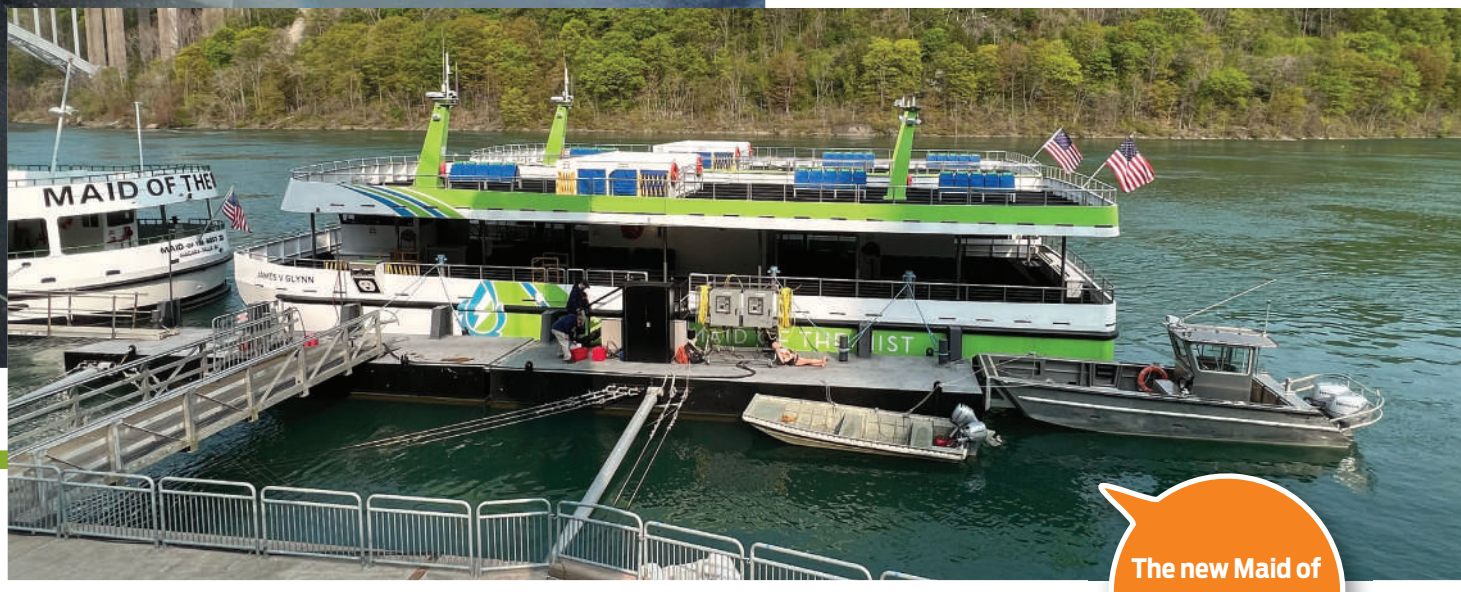
Anyone who's visited Niagara Falls in the summer has surely watched the famed Maid of the Mist boats ply the waters of the Niagara Gorge. These sightseeing tour vessels, which appear tiny from above, seem to get perilously close to the thundering water from both the American and Canadian falls, crashing down roughly 180 feet. Now, the American operator of the two ships has decided to move into 21st Century technology with all-new craft that use ABB zero-emission technology to power the fully electric ferries. These new ferries can hold 600 passengers each and replace the former diesel vessels.

Design World recently received an exclusive invite to tour the new boats, including getting down below the hatches and taking a ride into the mist.

The Maid of the Mist Corp., founded in 1846, is family owned and operated. This step forward to demonstrate the commercial viability of all-electric boat technology has attracted global attention to the company. The Niagara boats are believed to be among the first all-electric vessels — but won't be the last. Industry experts say that passenger ferries, river barges, harbor tugs, and dredgers are well-suited to all-electric operation.

Passengers experience the thrill of an up-close ride to Niagara Falls on the new vessel

The new electric Maid of the Mist heads toward the falls



The new Maid of the Mist sits at the dock

ABB noted that marine vessels are one of the largest contributors to transportation emissions (3-5% of global CO_2 and more than 5% of global SOx), so electrification of shipping cannot come soon enough. Today, it would be difficult to build 100% electric ocean-going vessels. However, as equipment becomes smaller and more cost-effective, new opportunities keep opening. Autonomous, all-electric seagoing vessels may be possible and practical in years to come.

New horizons in marine battery technology

Global interest in marine electrification is being spurred on by, for instance, new International Maritime Organization rules, such as the 2020 IMO fuel sulfur regulation, which will reduce the limit on the sulfur content of bunker fuel. Maritime operators are, therefore, keen to explore fuel cell technology.

Jon Diller, the commercial director for Kansas City-based Spear Power Systems, explained that the batteries used on the ferries are split between left and right sides; each side has 168 kWh of embedded energy, so it is a 316- kWh vessel. The batteries are

One of the ship's rear thruster L drives

The Maid of the Mist hooked up at the daytime charging station

The Niagara boats are believed to be among the first all-electric vessels — but won't be the last. Industry experts say that passenger ferries, river barges, harbor tugs, and dredgers are well-suited to all-electric operation.

arranged based on the Spear energy module, which uses a rectangular pouch cell from LG Chem.

"Each module has 64-amp hours, which makes it roughly 21 times the size of the cell that's in a cell phone. We take two of those and put them in parallel, and then take 24 and put them in series. That produces a module that has 11.3 kWh of embedded energy. That's an 11-kWh unit, and it has a 100-volt maximum voltage," Diller said. "We then take that module and put it in series with other modules to get to the system voltage that's desired to work with the propulsion system. In this case, the drives want their voltage range to operate somewhere between 640 volts and 420 volts. So, I go with seven modules in series to get to a maximum voltage of 100 volts."

From a safety standpoint, Diller said that there's a battery management system to stop the electrical abuse of the battery. It prevents operators from doing the things that will cause a

The ship's power distribution station, located below the main deck

battery to catch on fire: overcharging it, charging it too fast, charging it when it's frozen, or charging it after it's been depleted to a 0% state of charge.

Charging and propulsion

The Maid of the Mist boats set off from a downstream landing to head toward the base of Niagara Falls daily, serving more than 1 million guests each year. While the ferry is docked and passengers are embarking and disembarking, the new boats' lithium-ion batteries are partially recharged. The seven-minute charge provides a battery boost enabling the vessel's dual electric propulsion motors to maintain their total output of 400 kW (563 hp). Each trip consumes about 38 kWh. The batteries still have 80% power at the end of the working day.

According to Esteban Guerrero, master electrician for Maid of the Mist Corp., they have two charging stations.

The company uses a daytime charging station, and a nighttime charging station. The nighttime charging station is a trickle charge, with about 30-40 volts. The one the company uses during the day has a high output of 600 amps that charges the unit within seven minutes.

There are two motors operating L drive 360° directional thrusters in the stern (rear) of the boat (for propulsion), and there are two bow thrusters in the front that help with directional control. The result is a very maneuverable craft.

The old boats used a common straight shaft diesel design for the rear propeller. Kyle Taylor, one of the Maid of the Mist captains, explained that if you were to simply convert that setup to electric, but using the same basic transmission and components, the result would be much less efficient. So instead, the team decided to go with azimuth drives operating a propeller underneath the water. "It just made total sense for what we were doing here," said Taylor.

Taylor said that the rear thrusters use L drives manufactured by Veth Propulsion (a division of Twin Disc, Inc.) and that maximizing lifespan and minimizing downtime are key concerns of Maid of the Mist Corp.

"These L drives have a super-low profile and are easy to maintain," Taylor said. "We're spoiled for space here, so we can crawl all around them. The goal is to have a warehouse full of spare motor drives and all the other components to minimize downtime. Our Veth drives are about 250-hp equivalents; there's one per side, a 200-kW electric motor that we run at a maximum 80% output. So, it's the same as the batteries — we don't really charge above that or use components above that. We just try to get a long lifespan out of things."

Even more green

ABB is supporting e-mobility for applications outside the maritime world as well — for example, with public and private EV charging solutions. By early 2019, more than 10,000 ABB DC fast chargers had been sold in 73 countries. Looking ahead, products such as the company's Terra HP high-power charger are designed to accommodate the higher-capacity batteries of tomorrow.

Additionally, ABB is helping stakeholders across the globe establish electric bus services that reduce human impact on the environment. The company launched its first DC fast charger in 2010, the first nationwide DC charging networks in 2012, and the first eBus charging networks in Europe in 2016. DW

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Figure 1: Pacific Cheese operates various automated equipment to convert and package cheese in many different sizes and styles for major retailers and foodservice customers. Maximum uptime and flexibility are a key to success.

Automation upgrades keep cheese manufacturer sharp

Edited by **Mike Santora** • Managing Editor

When Pacific Cheese Company realized its highly manual legacy systems were constraining throughput and making product changeovers more time-consuming, they knew it was time for upgrades. In other cases, installing new and improved equipment on the production line — or adding additional production lines — meant that upstream and downstream systems needed upgrades to fully take advantage of potential production gains.

By standardizing on a proven and easy-to-use automation vendor, their team was able to perform all of these upgrades smoothly and cost-effectively. Furthermore, improved technology has enabled them to deliver a superior operator experience and to add better sanitation and automatic operation capabilities, along with diagnostics to help keep production running at capacity.

Big cheese, small controls

Pacific Cheese converts and packages cheese for major retailers and foodservice customers. Most of the products are blocks and pouches of various sizes, each with specific demands for processing and labeling. Retail products might range in size from eight ounces to two pounds, while food service options could be five or even ten pounds. Various equipment is necessary to perform this work (Figure 1).

Although the original production lines did use a programmable logic controller (PLC) associated with a motor control center (MCC), there was also some hardwired relay logic, and the company didn't have the software or capability to access the legacy PLC. There was no HMI to provide status and control options, and operators needed to perform many tasks manually.

The existing system frequently stopped running unexpectedly and without any alarm function, required maintenance personnel to delve into potential causes. Belt speed changes

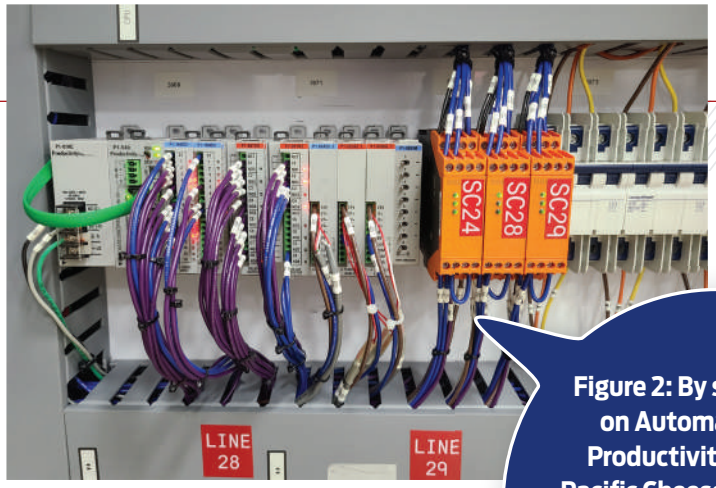

Figure 2: By standardizing on AutomationDirect Productivity1000 PLCs, Pacific Cheese Company has performed many automation retrofits and upgrades while minimizing the number of parts they need to specify and stock.

and timing adjustments, necessary for changing product sizes, also needed to be performed by maintenance personnel, often using a variable frequency drive (VFD) potentiometer. In any case, because cutting functions were mostly manual, the packaging equipment could only run as fast as these operations could proceed.

For better flexibility and performance, some changes were needed. A new high-speed cutter and flow-wrapper were part of the solution. Also, a third production line for handling larger pouches was added, which was associated conveyor belts, mixing drums, a shredder, and other equipment to be synchronized. It was clear that the new throughput and production capabilities simply could not be well served by the old controls.

Serving up new automation

Sanitation is an important aspect because Pacific Cheese typically runs two consecutive production shifts and then a third sanitation shift. The new design would need to minimize downtime because production capacity was already fully sold out.

Their team initially gained experience with AutomationDirect products at one site for a single project, with excellent results.

Pacific Cheese has generally standardized on the Productivity1000 stackable micro PLC, which provides all of the control, data storage, I/O, and communications capabilities they need in a compact form factor, which retrofitted easily into available cabinets (Figure 2).

Combined with a C-more HMI, it can now provide a new level of functionality in its plant. Many times, the company was able to repurpose the existing MCC and integrate it with the new controls, resulting in significant savings during installation and commissioning.

Automation upgrade yields many benefits

The baseline for the new automation upgrade was to supersede existing functionality, but the team went far beyond this initial goal. For the production lines mentioned earlier, one PLC was used to control and orchestrate all three production lines.

Normally, the lines run completely in automatic. However, if a line is stopped, operators can now manually command equipment using the HMI to stage a line for operation (Figure 3). There are clear HMI messages such as “Waiting for Scale” and “Scale Override.”The amps consumed by the shredder are displayed so operators can monitor and fine-tune operation, and some equipment uses the amp readings so the PLC can feed the proper amount of ingredients in a controlled manner.

A new sanitation mode runs the line slowly for 90 minutes with an extendable countdown timer, giving the crew good access to the equipment

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With the ACOPOS P3, B&R is setting new standards for motion control. This 3-axis servo drive offers a power density of 4 amps per liter, making it one of the most efficient servo drives with integrated safety functions on the market. It also offers unrivaled dynamics and precision, with a sampling time of just 50 µs for the entire controller cascade.

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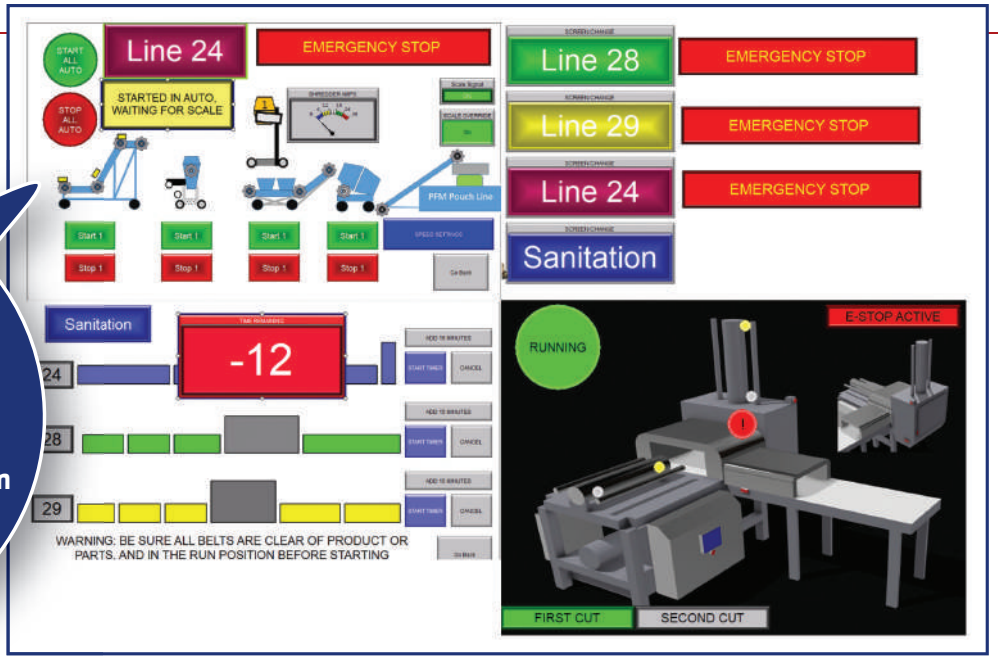

Figure 3: The new automation system makes extensive use of an AutomationDirect C-more HMI so operators can visualize the equipment status, receive warning indications, and perform necessary automatic, manual, and sanitation functions.

for proper cleaning and keeping them on schedule. Also, they don't need to remember to stop the equipment, saving energy.

The Pacific Cheese team had to tackle the learning curve of designing and programming their own systems. However, the accessible and easy-to-use PLC and HMI products and associated support resources have made this possible. Now they control their own destiny regarding legacy automation upgrades, and their in-house programming capability lets them improve operations in dozens of ways based on what their team and operators know, learn, and need. DW

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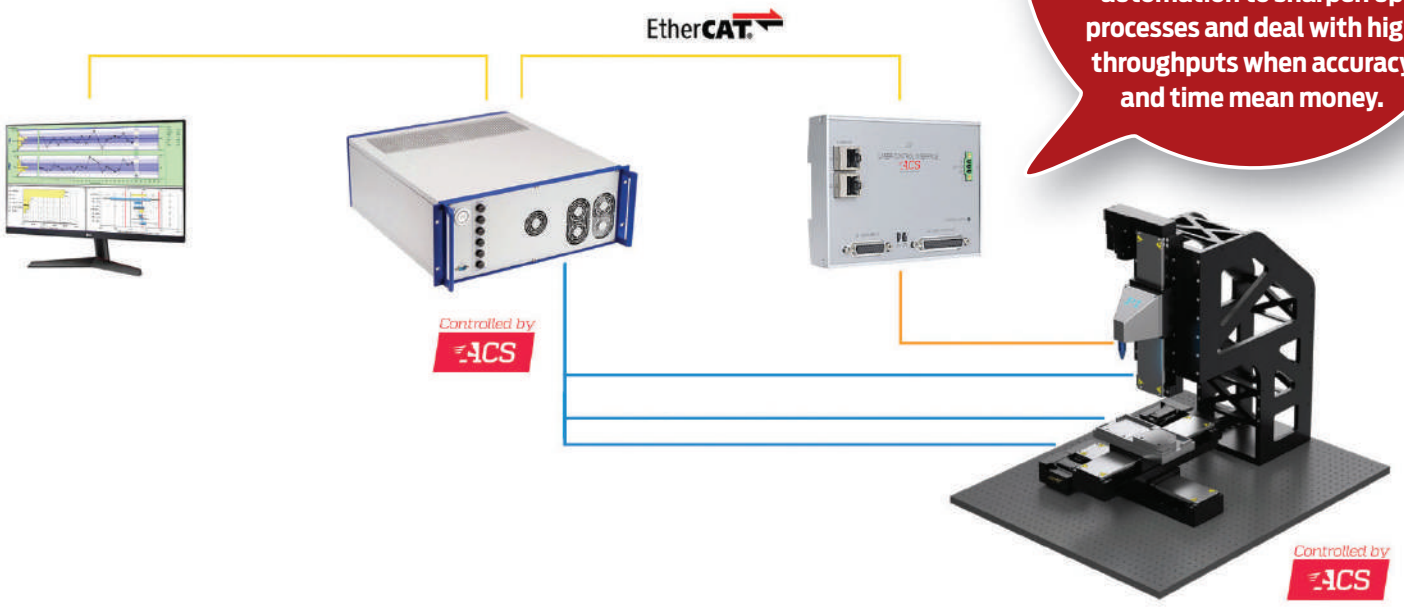
Pyramid Engineering specializes in the final sealing of electronics packages. It offers its client expertise in combining the best hardware components with control and automation to sharpen up processes and deal with high throughputs when accuracy and time mean money.



Accurate, cost-effective solutions for the welding market

Edited by **Mike Santora** • Managing Editor

High-precision welding is important in many industries — especially sectors like semiconductors, electronics, and telecommunications — that rely on the ability to process precise features and paths on delicate devices. The techniques up to this challenge are resistance welding and laser welding, the more traditional choice, followed by the newcomer gradually taking over the scene. Laser technology has gained in popularity in recent years because of its ability to accurately deliver heat to a very small area without damaging the material around it and avoiding tool wear and tear. On the other hand, resistance welding is still widely used because it is perceived as better suited for fabricating larger volumes.

The importance of control

One thing that is crucial to both welding techniques is control. A uniform weld relies on the same energy being consistently applied to the whole path, and, if this fails, it can create heat-affected zones that break easily or gaps in the weld. This means that laser power, firing time, and position all need to be carefully controlled and monitored.

Creating a uniform weld when the path is straight is relatively simple, but when it is curved or has corners, it can be tricky. When moving in a straight line with the same speed, the two velocity components x and y remain constant, but they will change when turning, even if the total velocity is still constant. This effect must considered by the laser, adjusting either the frequency or the power to deliver the same result to the whole path. This increases demand either on the welding instrument itself or on the positioning tool since both need to work together to achieve excellent results. For example, YAG lasers can be held at a fixed spot, with the motion stages responsible for moving the product along the desired path. There is also an option to use a continuous wave (CW) laser with a galvanometer head that works in unison with the motion stages to correctly position the product.

Purpose-designed control systems, such as those developed by ACS (a PI motion control company), can give users far more flexibility in how they build and then repurpose set-ups. Even tiny changes to a fixed configuration can be complex and time-consuming if each of the different parts needs to be programmed separately and, until recently, it has been common for companies to have one set-up made for

each specific task. However, newer controllers that connect the motion stages and the laser pulsing hardware through EtherCAT make it far more straightforward to change an existing build. This flexibility also reduces the complexity of drives that are needed and so cuts costs.

Reducing costs

Anything that can reduce costs this way is quite welcome in the highly competitive laser welding market. Making a high throughput process automatic can also help; Industry 4.0. is all about using machine-machine communication — either directly or wirelessly — to automate the manufacturing procedure, and several companies have already started to adopt this approach for quality control purposes.

For the same reason, less expensive components are now available and can make a significant difference to overall costs. Not every application needs every component to be at the highest possible specification; for example, for some tasks, lower specification stages — such as the new L-812 range from Physik Instrumente (PI) — are significantly cheaper than high end stages but still provide accurate motion control. Similarly, finding a supplier with the expertise to build a system around your application can be a very cost-effective approach. For example, the UK company Pyramid Engineering specializes in the final sealing of electronics packages. It offers its clients expertise in combining the very best hardware components with control and automation to sharpen up processes and deal with high throughputs.

High-precision laser welding has carved a niche into many industries where processing precise and complex features is a routine and sometimes high throughput requirement. Control is key for quality, and the choice of systems and hardware components for system builds can have a significant effect on overall manufacturing and running costs. New developments continue to bring cheaper — but still high quality — options into this competitive marketplace, giving users more flexibility and carving out even more potential applications for laser welding. DW

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Virtual twin technology helps manufacturers make the shift to eco-friendly packaging.

| courtesy of Dassault Systèmes.

Design sustainable packaging with the virtual twin

Raymond Wodar • Global Business Consultant — CPG-Retail Industry • Dassault Systèmes

Most manufacturers know (or want to know) about the digital twin, which the Digital Twin Consortium defines as "a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity." The digital twin and its more comprehensive successor, the virtual twin, promise to make manufacturing more productive and less wasteful.

However, a virtual twin goes beyond digital continuity by representing a product or system as it exists in the present and the past. The past includes the traceability and history of the product or system's design, testing, and manufacturing. The virtual twin also helps manufacturers simulate how a product will operate and must be maintained in the future.

Virtual twins help companies develop complex systems and products with hundreds or even thousands of parts. By applying virtual twin technology to the design process in the transportation and mobility industry, for example, planes, trains, and electric cars not only have more advanced features but are safer and more fuel-efficient. Similarly, healthcare companies can ensure better patient outcomes, and city planners can improve infrastructure and the quality of life for citizens.

Consumer packaged goods companies increasingly leverage virtual twin technology to design and manufacture more sustainable food and beverage packaging. This technology helps packaging manufacturers fully assess tradeoffs between cost and eco-friendly designs, and it simulates decisions from materials to future recycling options before producing physical packaging.

CAE Solutions

Decisions made during initial design phases determine up to 80% of a product's environmental impact, including a product's packaging. According to estimates, only 9% of all plastics are recycled, and American consumers throw out nearly five pounds of trash each day — the majority of which is food and packaging. Thus, it's easy to see the massive opportunity to improve sustainability. Manufacturers will play a significant role in the circular economy by creating durable products that are more easily repaired and recycled.

Consider Biopak of Australia and New Zealand. The company began producing compostable packaging from renewable plant-based materials to reduce the number of single-use takeout food plastic containers going to landfills each year. Similarly, New York-based Evocative Design harnesses the power of hemp hurds and mycelium (the root structure of mushrooms) to develop insulating, water-resistant packaging. Contrast the 500 years it takes Styrofoam to decompose with the "mushroom packaging" that composts in 45 days.

Leading manufacturers employ the virtual twin from the molecular level to the system level to achieve sustainable packaging. Plastic container giant Amcor began using advanced software simulation through virtual twins to lightweight their products, reducing the weight of its hot-fill beverage bottles by up to 50% and cutting consumption of thermoplastic polyethylene terephthalate (PET) by more than 100 million pounds annually.

Like engineers developing an electric vehicle, Amcor's packaging engineers applied these technologies to optimize the material placement and increase strength without adding weight. Running hundreds of simulations on a virtual 3D representation of a product reduced time and increased fidelity compared to testing physical prototypes, resulting in reduced development costs, project lead times, and waste.

The virtual twin goes much further than optimized box and bottle designs. A thorough and collaborative lifecycle assessment of a product in the early concept and design phase allows manufacturers to plan and validate its circular journey virtually before die-cutting or plastic injection molding begins.

Packaging designers can analyze which raw materials best suit the application. For example, by simulating the virtual twin of packaging for

mushrooms, the designer or simulation analyst evaluates the optimal balance of cost, quality, performance, and recyclability to select the most sustainable option.

With validated packaging models in place, manufacturing virtual twins follow, which help packaging designers determine tooling investments, the optimal production floor layout, and workforce headcount well in advance. Using a virtual twin to simulate all processes and factory floor decisions not only saves significant financial costs but allows manufacturers to account for mistakes in the virtual world, which eliminate physical world mistakes and rework.

In addition, the virtual twin provides post-manufacturing visibility into last-mile delivery puzzles and solutions. Manufacturers can collaborate with logistics providers to optimize truckloads better and reduce instances of empty miles. Powerful algorithms applied to virtual twins help fine-tune shipping routes, adjust for traffic and workforce disruptions, and more. By optimizing logistics, companies can lower CO2 emissions while minimizing shipping and warehousing costs.

The competitive pressure to make products, services, and operations more sustainable aligns with providing the best possible customer experience. Approximately 88% of consumers in the U.S. and U.K. combined want manufacturers to invest in methods, processes, and technologies that improve their environmental and social footprint. Some estimates expect the value of the global sustainable packaging market to hit $255 billion by 2026. With the right tools in place, such as the virtual twin and a platform for future-ready operations, consumer packaged goods companies can enable sustainable operations and support the circular economy. DW

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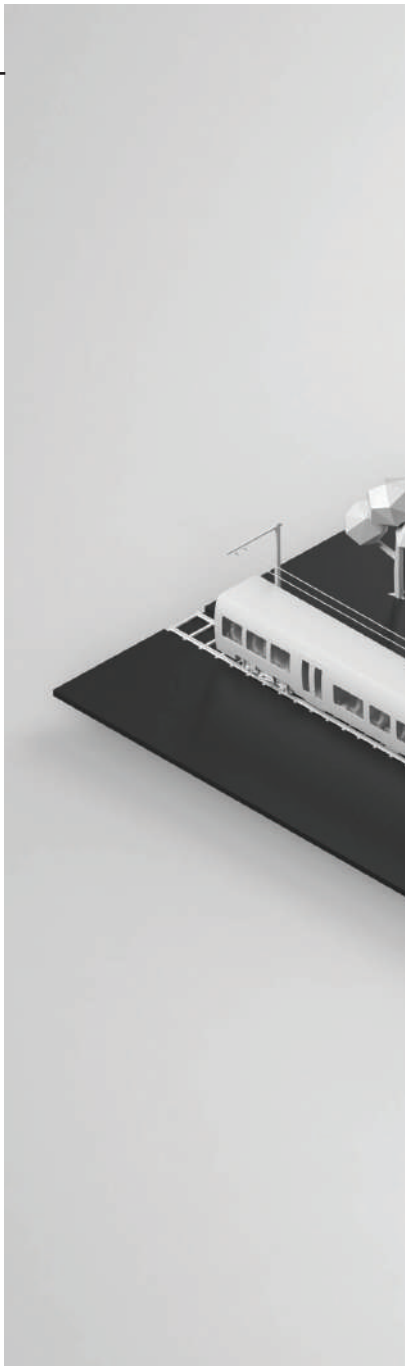


Single-pair Ethernet:

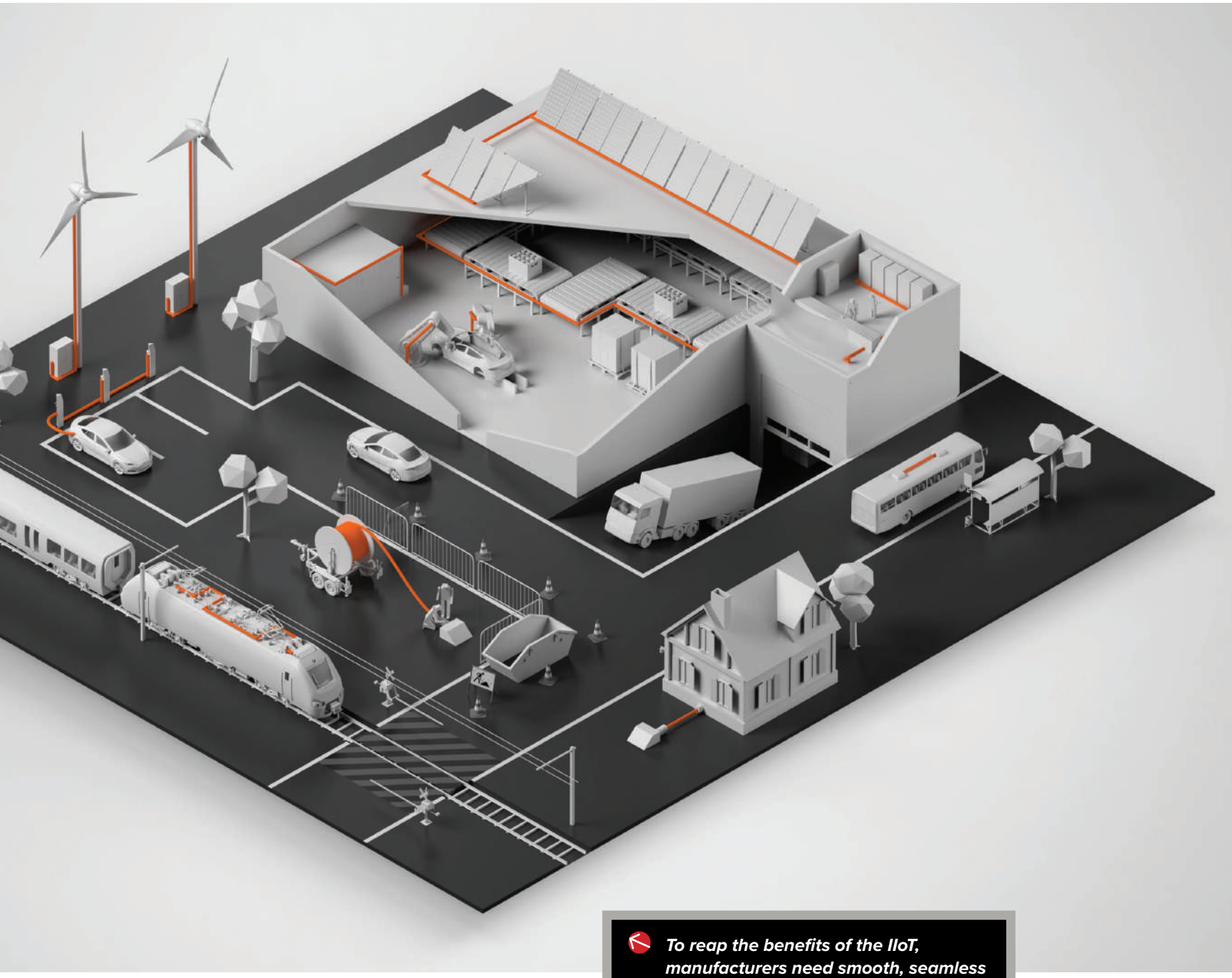
Simplifying Ethernet connectivity

A physical layer for Industrial Ethernet, single-pair Ethernet combines high data rates with a lightweight cable design, streamlining communication across automation levels.

By Sagar Patel | Product Manager
Lapp North America

With the rise of the Industrial Internet of Things (IIoT) the goal for many manufacturers is to connect all the machines, controls, actuators, and sensors in their plant. That's easier said than done, however. In reality, there are many system inconsistencies at play, making communication between the field device, control, and enterprise levels anything but easy.

Single-pair Ethernet (SPE) has emerged as this critical bridge, making the field level smarter while ensuring consistent, reliable network communication across the entire automation pyramid. SPE is a cable design that uses a single pair of twisted copper wires to transmit data at speeds up to 1 gigabyte per second (Gbps), allowing real-time, continuous data transfer to and from the



field level. It offers additional advantages including supporting cable lengths up to 1,000 meters (at 10 Mbps), minimizing space requirements and easing installation.

The following white paper takes a deep dive into this game-changing cable construction, including its features, benefits, and standardization practices — empowering design engineers to quickly and effectively use IIoT communication technology as a way to improve their manufacturing facilities.

To reap the benefits of the IIoT, manufacturers need smooth, seamless communication across all automation levels. Although Ethernet has long been the communication standard at the control level, bus systems still dominate the field level, limiting potential data flow. The solution is to implement cost-effective and space-saving infrastructure, enabling non-Ethernet field devices to communicate with the Ethernet networks above it.

LAPP's Etherline T1 Y Flex two-core cable boasts high data rates, allowing industrial Ethernet networks to integrate new, smart components.

Driving SPE forward

The SPE Industrial Partner Network consists of many electrical connection companies, including cable and connector manufacturers, as well as companies that specialize in advanced single-pair Ethernet technology. The group expects SPE to replace the current fieldbus systems at the sensor and actuator level, providing the core infrastructure for intelligent sensors and actuators in modern smart factories. The goal of this partnership is to continue to create standardized interfaces and system components, all while working closely with various international committees.

The limits of traditional network technologies

Until now, manufacturers have typically relied on bus networks to enable the flow of data from field devices. One of the most widespread bus communication methods for automation technology is PROFIBUS, a serial fieldbus technology established over 30 years ago that uses one pair of cores in a BUS cable. Later, as the industry expanded from buses to Industrial Ethernet, particularly at the control and enterprise levels, PROFIBUS and PROFINET International (PI) developed PROFINET. This Industrial Ethernet protocol uses two pairs of cores to transmit Ethernet at a rate of 100 megabits per second (Mbps). Some manufacturing operations even use Gigabit (GB) Ethernet, a transmission technology that requires four pairs of cores and provides data rates up to 1 billion bits per second, or 1 GB.

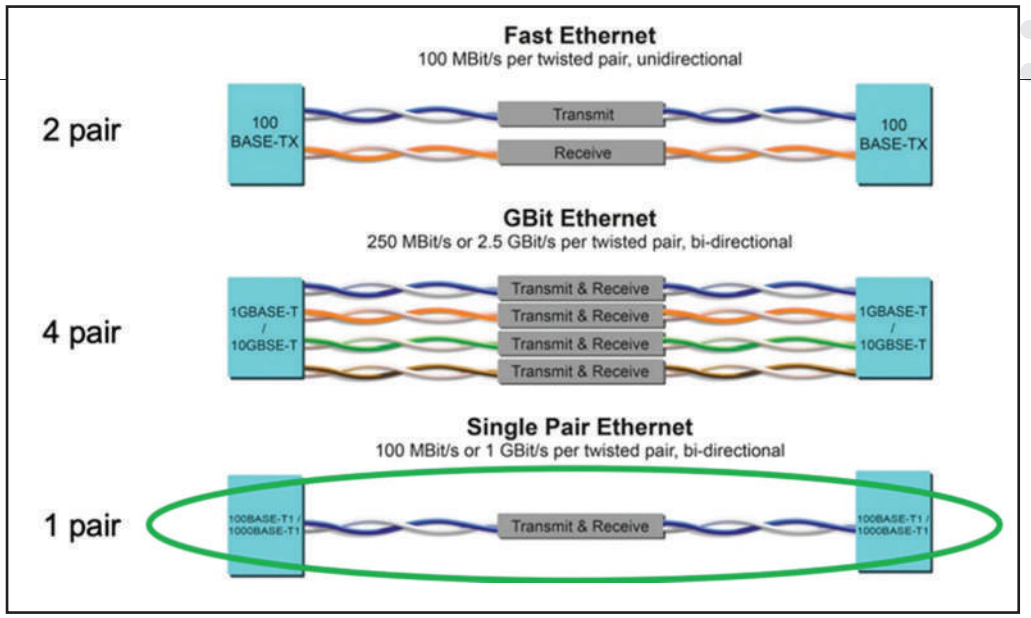
With the rise of the connected factory, bus systems can no longer handle the large data transmission rates required by the ever-increasing number of sensors in production facilities. Despite the benefits of Industrial Ethernet solutions, Ethernet is not always suitable for connecting devices at the lowest field level. Cat.5 and Cat.7 cables can be too large to efficiently connect hundreds, possibly thousands, of individual sensors spread throughout production environments.

Another challenge is connection complexity. In order to bridge the communication gap between the field device level (bus) and everything above it (Ethernet), manufacturers must install translators and gateways. In addition to driving up system costs and complexity, the field work required to install this additional hardware increases the risk of installation errors.

No more isolated networks: SPE to the rescue

A streamlined cable solution, SPE simplifies Ethernet connectivity from the sensors, up through the control and company levels, and then to the cloud — opening new application areas for Industrial Ethernet. A lightweight, efficient cable design, SPE reduces the number of cores to two, enabling 1-Gb Ethernet communication over a single pair of cores. It also eliminates the need for costly gateways between Ethernet and bus networks, reducing installation work and minimizing the chance of errors. Because the cabling itself requires less space, SPE significantly reduces component costs.

In addition to high data-transmission speeds via Ethernet, SPE can supply power to end devices via Power over Ethernet (PoE), a standard that specifies the power distribution method for use over a single twisted-pair link. PoE can provide 0.5 to 50 W of power over a twisted pair to power devices like



Note how single-pair Ethernet compares to fast (100 Mbps) and Gigabit Ethernet.

cameras, sensors, and remote input/output (I/O), and it further reduces costs by eliminating the need for additional cabling to power devices. Benefits of SPE include:

- The fact that it supports data rates up to 1 Gbps.
- Cables can be deployed up to 1,000 m.
- It's more secure with end-to-end protection down to the edge.
- It is an open communication tool no dependence on one manufacturer or software.
- SPE is a cleaner network topology, eliminating the need for costly, complex gateways.

What's more, SPE cables feature a small form factor ... and SPE offers a hybrid solution for data and power.

SPE application areas

By enabling continuous, long-length communication between the sensor level and cloud, as well as providing power supply via PoDL, SPE offers powerful applications in many industries.

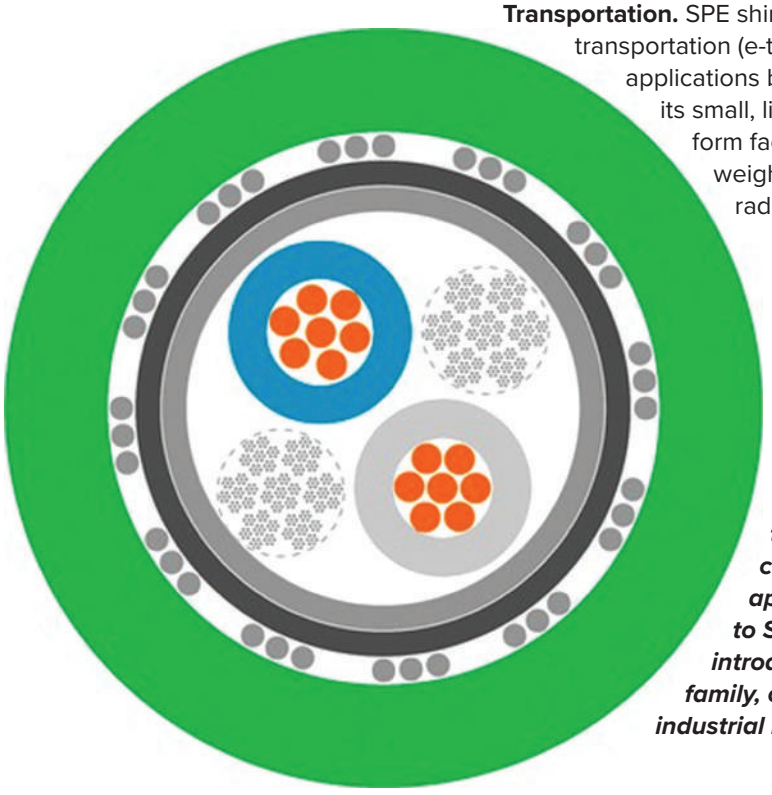
Process automation. SPE can bridge long distances in large chemical plants, where analog cables or bus networks — some with data transmission rates of just 31.25 kilobits (kbit) — are still the norm. The Ethernet Advanced Physical Layer (Ethernet-APL), an offshoot of the IEEE 802.3cg (10BASE-T1L) standard, defines additional properties for these applications, considering the use of SPE cabling in explosive areas.

Transportation. SPE shines in electric transportation (e-transportation) applications because of its small, lightweight form factor, reducing weight and bend radii by up to 55 and 30%, respectively. Compared to a cable with four wire pairs, which weighs around 4.6 kilograms (kg) per 100 m, an SPE cable weighs only 3.0 kg. Specific use cases in the transportation sector include passenger information systems, seat reservation systems, passenger counting visual (PCV) systems and closed-circuit television (CCTV).

Building automation. SPE can be used to network sensors in fire alarm systems, light or temperature sensors, access control systems, and information boards.

SPE standardization

SPE is covered by several international standards, including the Institute of Electrical and Electronics Engineers (IEEE). In addition to specifying the primary transmission method, IEEE 802.3 stipulates the transmission channel, transmission length and number of connectors. Other relevant standards organizations include the



Shown here is a cross section of the LAPP T1 Industrial Ethernet cable with one twisted pair for SPE applications. LAPP has contributed to SPE cable development with the introduction of ETHERLINE T1 product family, consisting of SPE cables for use in industrial machinery and plants.

SPE Standard	Transmission Rate	Maximum Run (Shielded)
IEEE 802.3ch	2.5/5/10 Gbps	15 m
IEEE 802.3bp	1 Gbps	40 m
IEEE 802.3bw	100 Gbps	100 m
IEEE 802.3cg	10 Gbps	1,000 m

Because single-pair Ethernet enables long-distance communication between smart sensors and the cloud, it is well-suited for many applications in process automation, building automation and transportation.

SPE benefits at a glance

- Enables Networking with Transmission Control Protocol Internet Protocol (TCP/IP) without system disruptions
- IP can address all field participants
- Suitable for real-time critical applications thanks to time-sensitive networking (TSN)
- Accommodates distances up to 1,000 m, enabling more flexibility in cabling and requiring fewer switches
- Can supply power to terminal devices via the same cable using PoDL
- Sustainable, thanks to an elimination of batteries compared to wireless systems
- Uses less material, lower weight over traditional 2- and 4-pair Ethernet
- Offers flexibility and space savings in drag chain applications and conduits
- Reduces installation errors and saves assembly time
- Improves operational reliability

International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and the Telecommunications Industry Association (TIA), all of which cooperate with IEEE 802.3.

When it comes to the cabling, several IEC 61156 standards are in progress, including IEC 61156-11 and IEC 61156-12 for 600-megahertz (MHz) data cables in permanent and flexible installations, respectively. Others include IEC 61156-13 and IEC 61156-14 for 20-MHz data cables in permanent and flexible installations, respectively.

Regarding the SPE connectors, several IEC 63171 standards are under development. The first and only standard for connections in industrial applications that has been adopted by all major standards bodies is IEC 63171-6, which covers all versions from IP20 to IP 65/67. Published in 2020, IEC 63171-6 describes the T1 Industrial Style SPE plug-in face.

This T1 industrial connector has a very robust design, including stainless steel shield plates, and a rugged core and cable gland. The interface also features a strong, stainless-steel lock to maintain a secure connection — even in harsh production environments — and a stainless-steel jacket that encloses the entire connector, minimizing electromagnetic interference (EMI). DW

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ETHERLINE T1 FD P is a shielded 26AWG cable for use in cable chains. ETHERLINE T1 FLEX is an 22AWG cable for occasional movement. ETHERLINE T1 P FLEX is an 18AWG cable suitable for distances up to 1,000 m.

	ETHERLINE® T1 FD P	ETHERLINE® T1 FLEX	ETHERLINE® T1 P FLEX
Jacket Material	PUR	PVC	PVC
Application Style	Continuous Flexing	Occasional Flexing	Stationary
Data Rate	Up to 1 Gbps	100 Mbps to 1 Gbps	10 Mbps
Maximum Run	40 m	100 m	1,000 m
Outer Diameter	4.7 mm	5.8 mm	-
UL Approvals	UL AWM 80°C, 300V	UL PLTC, CM, AWM	-
IEEE Compliance	IEEE 802.3bp	IEEE 802.3bw IEEE 802.3bp	IEEE 802.3cg

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The basics of linear bearings and friction

Some of the most important material considerations for friction in linear bearings include wear, lubrication, and surface roughness.

Miles Budimir • Senior Editor

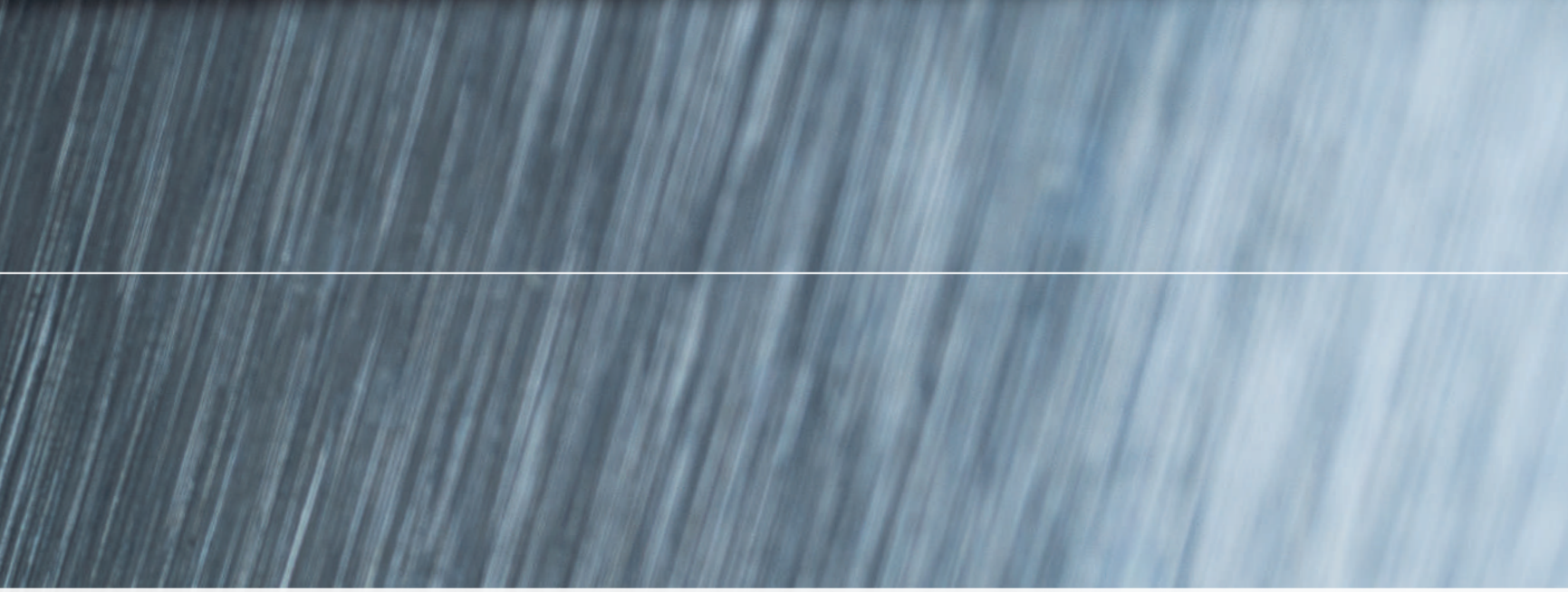
All bearings essentially have the same purpose; to enable parts to move smoothly and with as little friction as possible. One basic way to distinguish different types of bearings is whether they are involved in rotary or linear motion.

Linear bearings are used in linear motion applications. Linear bearings include mechanical components that allow relative motion between two surfaces — with one surface supporting the other and minimum friction between the two. There are two basic types of linear bearing; one that uses sliding motion (plain bearings) and one that relies on rolling elements.

Regardless of the linear bearing type, there are some common considerations when it comes to design factors involving friction. Here's a look at some of the most important considerations.

Tribology basics

The formal study of friction is called tribology and involves the study and application of the principles of friction, lubrication, and wear between two surfaces in relative motion. In linear bearing systems,



those two surfaces are the bearing element and the guide raceway.

The term "wear" generally refers to deterioration, but when discussing tribology principles in relation to bearings, it refers to material loss on the bearing surfaces. Wear is an inevitable outcome of use, caused by the load, speed, and other operating conditions that the bearing experiences. The life of a linear bearing — whether recirculating or plain type — is determined by the amount of wear on the bearing surfaces.

The primary cause of wear in bearing applications is friction. Although bearings are designed and manufactured to have extremely smooth surfaces, no matter how well the surfaces are finished and polished, they will inevitably have microstructures (also referred to as asperities), or "rough" spots, where the material dips and protrudes.

As two bearing surfaces — a raceway and a ball, for example — move past each other, the peaks on each surface collide. This not only creates friction as the surfaces interfere, but the peaks can also break and release as particulates that abrade the bearing surfaces through friction, causing premature fatigue failure.

By separating the bearing raceway from the rolling or sliding element (ball, roller, or plain bearing surface), lubrication reduces friction between the surfaces, which reduces wear and lowers the amount of heat generated. Lubrication also inhibits corrosion of the bearing surfaces and protects them against contamination.

Lubrication options for linear bearings

Bearings are typically lubricated with either oil or grease. Grease adheres to surfaces better and lasts longer than oil, making grease the more common choice for rolling element bearings, such as recirculating ball and roller bearings. And because of speed's influence on the development of the lubricating film, low-speed applications typically require grease since it provides better protection under the conditions of boundary lubrication and mixed lubrication, which are prevalent at low speeds.

Oil, on the other hand, dissipates heat better than grease, making it better for

The term "wear" generally refers to deterioration, but when discussing tribology principles in relation to bearings, it refers to material loss on the bearing surfaces.

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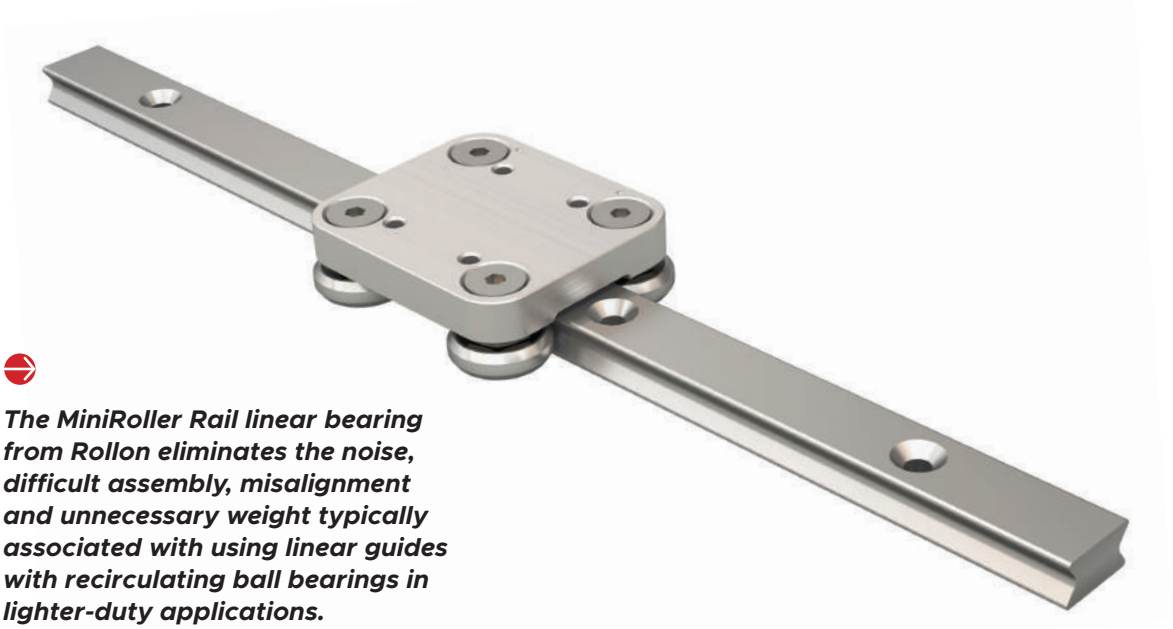

The MiniRoller Rail linear bearing from Rollon eliminates the noise, difficult assembly, misalignment and unnecessary weight typically associated with using linear guides with recirculating ball bearings in lighter-duty applications.

One of the key factors to consider when selecting shafts for linear bearings, and an important one in terms of friction, is surface roughness, which describes the microscopic asperities, or peaks, and valleys present on a material's surface.

high-speed applications where heat generation is especially problematic. Oil can also be circulated through an external lubrication system that cools the oil and filters out any debris. It also flows more readily, making it better at lubricating complex structures and surfaces. But because of its low viscosity, it may not be a suitable choice for vertical surfaces, due to its tendency to pool at the lowest available space. An oil mist can address this problem but adds cost and complexity to the bearing system.

Plain bearings are often made from, or impregnated with, self-lubricating materials, such as PTFE (Teflon), Delrin, or nylon. But the release of lubrication from these materials isn't consistent. And the sliding contact between plain bearing surfaces produces significant friction and heat. So while it's possible for some plain bearings to be operated without lubrication, the use of external lubrication can be beneficial, even for bearings that use self-lubricating materials — especially when the application involves high loads or high speeds.

Note that proper lubrication requires not only using the right type of lubrication for the bearing and its

Other options for linear bearings include bushing bearings, such as these polymer bushings from Thomson Industries, Inc. They are a reliable solution for machines where moment load is non-critical or contamination and temperature are concerns.

operating conditions, but also using the right amount of lubrication. Too much lubricant can actually increase friction and heat in the bearing and tends to trap particulates that can damage the bearing surfaces.

Surface roughness, texture, and finish

One of the key factors to consider when selecting shafts for linear bearings, and an important one in terms of friction, is surface roughness, which describes the microscopic asperities, or peaks, and valleys present on a material's surface. The ASME B46.1-2019 standard, Surface Texture (Roughness, Waviness, and Lay) defines surface roughness as, "the finer spaced irregularities of the surface texture," and states that these irregularities often result from, "the inherent action of the production process or material condition." In other words, the combination of the material's properties — such as particle size and distribution of elements in metal alloys — and the machining process determine the surface roughness of a part.

Surface roughness is most commonly expressed as an average value, denoted as Ra. The Ra value is the arithmetic average of the absolute deviations of the profile from the mean line, recorded over an evaluation length. Another specification, useful for determining how much material should be removed during machining or finishing, is Rz, which gives the average distance between the five highest and five lowest points along the evaluation length.

Three terms — surface roughness, surface finish, and surface texture — are often used interchangeably, but they actually refer to different quantities or characteristics. Surface roughness, as explained here, is a quantitative measure of surface asperities.

Surface texture is defined by the ASME B46.1-2019 standard as being made up of three parameters: lay, waviness, and roughness, of which waviness and roughness are quantifiable values.

Lastly, surface finish is a qualitative classification which, technically, applies to stainless steel materials. Guidelines for describing surface finishes are given in the ASME SA-480/SA-480M document, Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.

Surface roughness is important for linear guides, ball screws, and lead screws for several reasons, but

probably the most important is its contribution to friction. A higher (poorer) surface finish on rolling or sliding elements means more friction between those elements, and in turn, greater wear and reduced life. In fact, dynamic (or kinetic) friction between two moving components is directly related to the components' surface finish.

A poor surface roughness can also damage plastic or rubber parts that ride on metal shafts or guides. For example, both the rubber seals used on ball nuts and the plastic nuts often used on lead screws can be damaged if the surface roughness of the ball or lead screw shaft is too high.

In recirculating linear bearings, the surface roughness of the recirculation guides can create pulsations that show up as planar errors during travel. And a maximum surface roughness is sometimes recommended for the mounting and reference surfaces used for profiled linear guides in order to avoid plastic deformation of these surfaces caused by stresses from the guide mounting screws.

For plain bearings that are lubricated through the transfer of material from the bearing to the shaft (or guide), some amount of surface roughness is necessary, since the "peaks" on the surface of the guide serve to scrape off small amounts of material from the inside of the bearing. These small bits of material settle in the "valleys" on the surface of the shaft (or guide) and provide lubrication as the bearing travels back and forth. Similarly, when external lubrication is applied to plain bronze bearings, the valleys in the surface of the shaft capture and hold the lubrication to reduce friction and wear. DW

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How modularity benefits test systems

By understanding the key issues at every phase of the product lifecycle, engineers can make decisions that result in flexible, reliable, and scalable test systems. Taking a modular approach to test system development can accelerate development and mitigate risk throughout the entire product lifecycle.

By Bob Stasonis | Pickering Interfaces

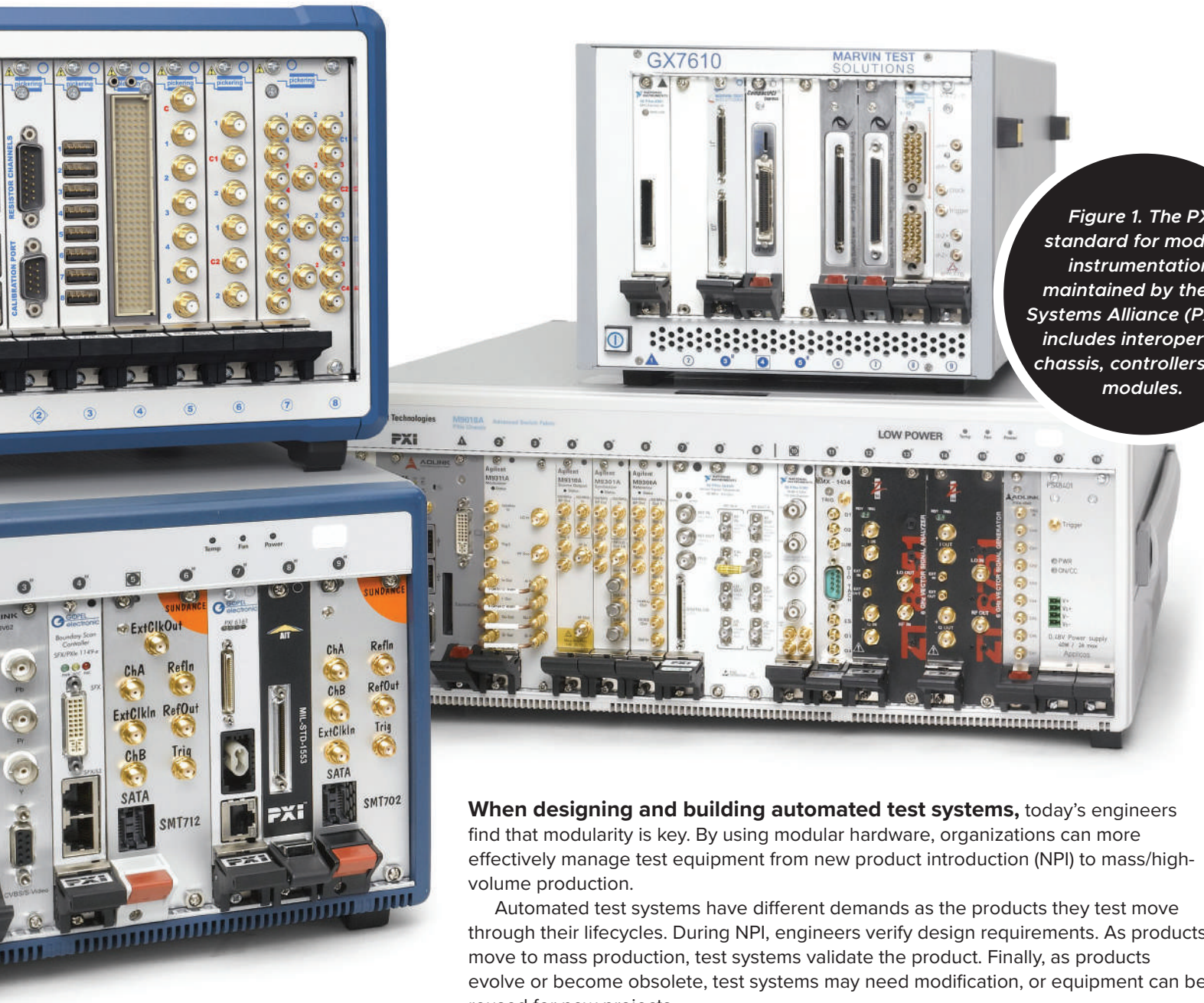

Figure 1. The PXI standard for modular instrumentation, maintained by the PXI Systems Alliance (PXISA), includes interoperable chassis, controllers, and modules.

When designing and building automated test systems, today's engineers find that modularity is key. By using modular hardware, organizations can more effectively manage test equipment from new product introduction (NPI) to mass/high-volume production.

Automated test systems have different demands as the products they test move through their lifecycles. During NPI, engineers verify design requirements. As products move to mass production, test systems validate the product. Finally, as products evolve or become obsolete, test systems may need modification, or equipment can be reused for new projects.

Modular test systems typically consist of computer-controlled chassis housing multiple instruments, power supplies, and switching modules interconnected to form complete automated testing stations. Such test systems allow for easy upgrades to support new products, and straightforward replacements of defective modules. PXI has become the dominant modular hardware platform for electronic test, measurement, and automation applications.

Why PXI?

PXI is short for the PCI eXtensions for Instrumentation bus standard. Introduced in 1997, it is an open, industry-standard, chassis-based architecture that defines how engineers can connect instruments, computers, and other devices using a common

Figure 2. The modular nature of PXI makes it easy to repair, replace or upgrade test system modules as requirements demand.

bus. PXI systems use the PCI or PCI Express buses to interconnect modules in the chassis.

Phase 1: designing test systems for new products

As products move through their lifecycles, organizations face different challenges. In the early stages of NPI, for example, there is a need to quickly and efficiently test the product to verify design requirements. This can be best accomplished by taking into consideration the following:

Bridging the gap between design and test engineers

One of the best ways to ensure an effective and efficient test system is to consider test requirements early in the design phase. Design engineers will primarily look for their designs to fulfill the product requirements without always thinking about product testability in a production environment. By bringing test engineers into discussions early, they can advise on any testability issues that may need to go into the product design.

Evaluating test equipment's ease of use and adaptability

Once the product specifications and test expectations are set, it's important to get the test system up and running quickly. Rapid development and deployment of the test system lets engineers verify the product and move forward as soon as possible.

Upon first run of a test system, issues may arise. As the debugging process takes place, erroneous connections can damage subsystems, so being able to quickly diagnose and repair failures is imperative to keep the testing process moving forward.

Paying attention to equipment cost and availability

Cost and availability are always important, but design engineers sometimes only consider the verification testing needed in product development. If the same test system design is needed for a high-volume production test, it may demand repeat purchasing of costly or scarce components, resulting in cost/time overruns in the future.

Phase 2: moving from NPI to high-volume test

When products move from the validation testing needed for NPI to production test, engineers no longer check for product design faults; they're looking for component or manufacturing faults. A well-planned NPI test system can evolve and scale to production testing if it is designed with the following in mind:

Considering available resources

Footprint, cost, test accuracy, and availability are all important when moving to a production test system. In

Modular test systems don't tie organizations to specific programming interfaces or operating systems, allowing engineers to use their preferred platform and tools.

the NPI phase, engineers are usually working with a full test bench, providing adequate space for equipment.

Minimizing product test time

For high-volume production, you must optimize the productivity of all test processes to minimize the number of test systems required to meet production demands. This entails minimizing the setup and test execution time of each system. The device under test (DUT) must quickly and reliably connect and disconnect from the test equipment so that time is not wasted between units as it moves through the test system.

Making those connections requires reliable interfacing and possibly even incorporating mass-interconnect systems for products with particularly high changeover rates. In these cases, all connections are made simultaneously through reliable, high-usage connectors in a standard streamlined interface, as shown in Figure 2.

Operation and integration requirements

To minimize any adverse impact on production, test systems must be reliable and quick to repair if a fault develops. Also, because production testers are often handed off to test technicians in different locations and even countries, they must be easy to operate and well-documented. Similarly, production testers may neec to integrate with factory management systems. Industry-standard controllers and programming interfaces will help facilitate these objectives.

Phase 3: update test systems as products change

As products evolve, support will alwa be a factor — it's inevitable that test systems will need to be modified or components will require replacement The following considerations set production test systems up for long-term success throughout the entire product lifecycle:

Minimizing the opportunity for errors

Every test system should produce the same test results, so engineers should look for quality and consistency of performance across multiple test systems. Interconnects can easily prove a failure point as DUTs are mechanically connected and disconnected.

Using industry-standard tools

When a test system moves out of NPI and into production, it must be easy to use, debug, and adapt to design changes. Industry-standard test hardware and software will provide familiarity, scalability, and flexibility, streamlining tester deployment. DW

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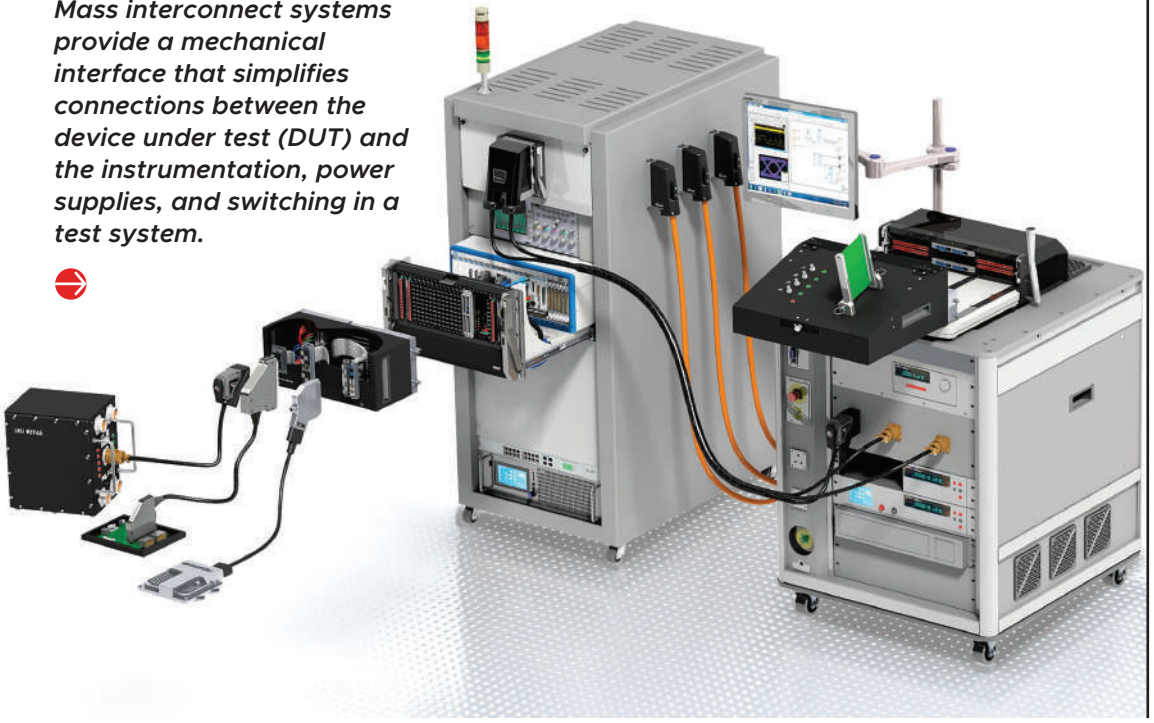
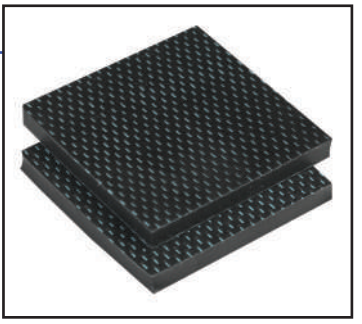


Mass interconnect systems provide a mechanical interface that simplifies connections between the device under test (DUT) and the instrumentation, power supplies, and switching in a test system.

How Sorbothane is protecting lightweight devices

from shock and vibration

Sorbothane water-jet cut shapes.



Sorbothane isolation pads.

Chances are you've encountered Sorbothane, a unique proprietary material, with or without knowing it. It might be as insoles for your running shoes (Sorbothane protects the body by absorbing up to 94.7% of impact shock) or in your smartphone or electronic device (Sorbothane is a highly reliable shock-absorbing material).

"Sorbothane was initially developed by a chemist at British Tyre and Rubber who was also an avid runner. He felt that the insoles of his sneakers were far from comfortable or effective," shares David Church, the president of Sorbothane, Inc. — aptly named after the patented material. "So, his goal was to create a solution that would act similarly to the natural pad on one's hand or heel to dissipate the energy."

The result was Sorbothane. Little did this chemist, Dr. Maurice Hiles, realize how effective or popular his invention would become. Today, Sorbothane (the company) is celebrating more than 40 years in business and supports several markets, including fitness, electronics, transportation, medical device, aerospace, and others.

"Sorbothane is applicable nearly anywhere there's a need to isolate vibration, attenuate shock, or damp unwanted noise," explains Church. "The material is classified as a viscoelastic polymer. This means it exhibits the properties of both a liquid and a solid."

As a liquid, Sorbothane will deform under load and transmit this energy in different directions. However, since the material also has elastic properties, it will return to its original shape and be ready for the next impact.

"This is critical for many applications where there are vibration or impact loads," he says. "Imagine you're repeatedly seeing an isolator compressed from the energy exerted on that pad. A viscoelastic material must have the ability to return to its original shape. But also, when it's under load, it must maintain a small amount of creep. Sorbothane is compounded to where the amount of creep, which is the tendency of the material to continue to be compressed over time, maintains its original properties extremely well."

This is, of course, important for equipment manufacturers who want to ensure product longevity. So, that isolating pad must work just as well five or 10 years down the road as it did when it was first installed, and that's something Sorbothane can offer.

"It's what makes this material so versatile. It can be used to isolate a basic microscope in a lab from ambient vibrations caused by people walking by or to isolate critical monitors on a U.S. military vessel," says Church.

And today, there's one more key feature that's proving essential for modern industry, and it's one Sorbothane delivers.

"Nearly every industry is now looking for lighter-weight materials, which creates a whole new set of conditions for engineers to tackle as they attempt to best isolate vibration in smaller, lighter, and faster products," he shares. "But this has opened more doors for Sorbothane because there's a bigger need for attenuating the vibration in electronics and portable devices — or dissipating the shock that occurs during transportation and when people accidentally drop such devices."

Interestingly, Sorbothane can be engineered to fit nearly any size requirements, with a water-resistant option available.

"The material can be molded down to a quarter-inch by a quarter-inch block or square, for example. We can also water-jet cut even smaller shapes out of sheet stocks of Sorbothane," says Church. "So, we have the versatility to provide an isolator that's extremely small to one that could be three feet by two inches thick by three feet, if necessary."

Standard Sorbothane products and sizes are available, but the company offers custom-engineered options for projects that fit outside these parameters.

"Simply provide us with the specifications of an application, and we'll do much of the work — free of charge. There are zero fees for our engineering services," he says. "Sorbothane is unique, so we always want to ensure it's used and applied properly. This also gives engineers or entrepreneurs the time to focus on other parts of their project, while we work on the ideal isolator for them."

Online Design Calculators also allow engineers to see exactly what's available envelope-wise when using Sorbothane to perform within the function of a specific application.

"There's what we call the 'perfect shape factor," says Church. "Ideally, an isolator damps 94 to 95% of the energy, but that's assuming the 'perfect shape.' Almost every project has limitations wherein the isolator must work, and that's where our Design Calculators help out."

Sorbothane recently launched a new website where visitors can ask for a quote, literature, or a material sample.

"It's always been Sorbothane's motto that we're here to protect people and help make the world better," adds Church. "We're extremely grateful to have worked with incredibly innovative companies over the last 40 years, and help make many dreams a reality."

Sorbothane Inc.
Innovating Shock and Vibration Solutions

Fastener Engineering

July 2023
A supplement of Design World

How 3D printing has the potential to transform plastic fastener production

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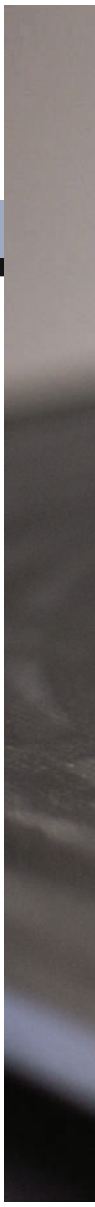

How 3D printing has the potential to transform plastic fastener production

Michelle Froese, Editor

Despite mainstream innovations in 3D printers, additive manufacturing has been primarily limited to prototypes for the fastener industry — until now. Advances in technology are transforming the speed and volume of manufacturing, specifically for plastic parts.

The latest in industrial 3D equipment uses resin material, offering automated functions capable of producing hundreds of thousands, if not millions, of parts per year. This is potentially game-changing for C-parts manufacturers in terms of production capacity and costs.

What's more: rather than compete, this type of additive manufacturing can enhance and work side-by-side with conventional manufacturing, such as injection molding.

Understanding additives

Additive manufacturing or 3D printing is the process of building an object one layer at a time based on a digital file, and it has evolved significantly since its inception in the early '80s.

"Initially, additive manufacturing was considered extremely futuristic and almost *Star Trek*-like, where there was a magic box that could somehow make things," shares Mason Fischer Paul, 3D Sales Engineer with Würth Additive Group, which supplies 3D printing and digital inventory solutions. "The technology was gate-kept for a while, and access was limited. But that's changed over time."

One reason for this change is because 3D printers have evolved, developing increased capacities and capabilities, and new methods of printing.

"There are now multiple methods of additive available using various materials and manufacturing methods," says Paul. "The ideal method depends on the parts being produced and the production expectations."

Fused deposition modeling (or FDM) is one such method, which quickly became one of the more popular and extensively used techniques. Essentially, thermoplastic materials are extruded through a nozzle tip and then solidified.

Additive manufacturing offers a streamlined and efficient method of printing many different parts, which can lead to simplified supply chains. These fasteners were printed in nylon and carbon fiber.

"FDM is commonly used for plastics, but we've begun experimenting with DLP for plastic fastener manufacturing, and it has the potential to make a big impact in the fastener industry," says Paul.

DLP or digital light processing is similar to SLA (stereolithography), an early additives invention that used a UV laser beam. But instead of a beam, DLP uses a UV light projector to rapidly produce photopolymer parts. It cures an entire layer of resin at a time, so the printing process is much faster than with SLA.

"The thing with fasteners is it's necessary to keep up with extremely high volumes, and that's where additive manufacturing has previously met limitations," Paul explains. "If, for example, you're printing three brackets, it's typically going to print layer one of the first layer, one of the second, and one of the third layer. Then, it's going to follow suit for the subsequent layers, essentially printing each, one at a time. This is not viable or efficient for high-volume production."

However, advanced DLP equipment is leading to greater throughput, which is allowing for greater part production.

"With the latest in Rapid Shape 3D technology, if it takes 40 minutes to print one part, it'll take the same 40 minutes to print 40 parts. It's now possible to crank out parts extremely fast relative to other printing methods, whether it be laser-based printing or FDM printing," he says. "And that's a game-changer for fasteners."

Rapid Shape is a tech company in the field of DLP technology that introduced the first resin 3D printer with fully automated functions to allow lights-out manufacturing processes, requiring little or no human intervention.

"By integrating a variety of smart systems, we've been able to increase production capacity, decrease human handling, and bring user safety to the forefront in resin production," shares Andreas Schultheiss, CEO of Rapid Shape.

"With the growing adoption of UV-cured resin printing, we're seeing tighter tolerances and faster production speeds that the fastener industry would benefit from," Paul adds. "By using the Rapid Shape Inline, we're

Würth Senior Sales Engineer, Darren Brubaker, operating the Rapid Shape i50 — a high-performance industrial 3D printer that's ideal for producing plastic fasteners.

The latest in industrial 3D equipment uses resin material, offering automated functions capable of producing hundreds of thousands, if not millions, of parts per year. This is potentially game-changing for C-parts manufacturers.

capable of producing between one and three million parts a year, depending on size, material, specifications, and quality assurance."

Standardizing production

Aside from volume requirements, manufacturing fasteners means certain specifications must be adhered to. This is something not yet standardized when 3D printing fasteners.

"Whenever I've toured fastener manufacturing plants, I've typically seen one machine continually running one specific part — such as a 1/4-20 x 1/2-inch bolt. So, this machine is set to produce that particular bolt to spec over and over, all day long," says Paul. "Of course, this is important to limit any deviations. You don't want a distributor to buy a million of these bolts only to find some two percent defective. Two percent of a million is a lot."

This is particularly important in critical industries such as aerospace, automotive, or the military, where a fault bolt could have devastating impacts.

"If you're manufacturing for the military, there are MIL specs. Aerospace has NASM specs, and each automotive company typically has its own specs called out where fastener threads must be within plus or minus a few thousandths of an inch, or what have you," he says. "Limiting variance is essential."

Such specifications have not yet been standardized within additive manufacturing. In part, this is because the ability to print fasteners in larger volumes was previously impracticable, given the time and cost constraints of additive manufacturing. But it's also because 3D printers were never designed to produce only one type of component.

"The organic evolution of 3D printing was always about variety," says Paul. "Generally, people invested in a printer to produce hundreds or thousands of different parts. I probably have an archive of at least 1,000 different parts now, and if I had to tool up a CNC machine to manufacture every single one of them, it would take forever."

Jacob Ayers, Lead Technician with Würth Additive Group, removing printed parts from the Rapid Shape i50 3D printer.

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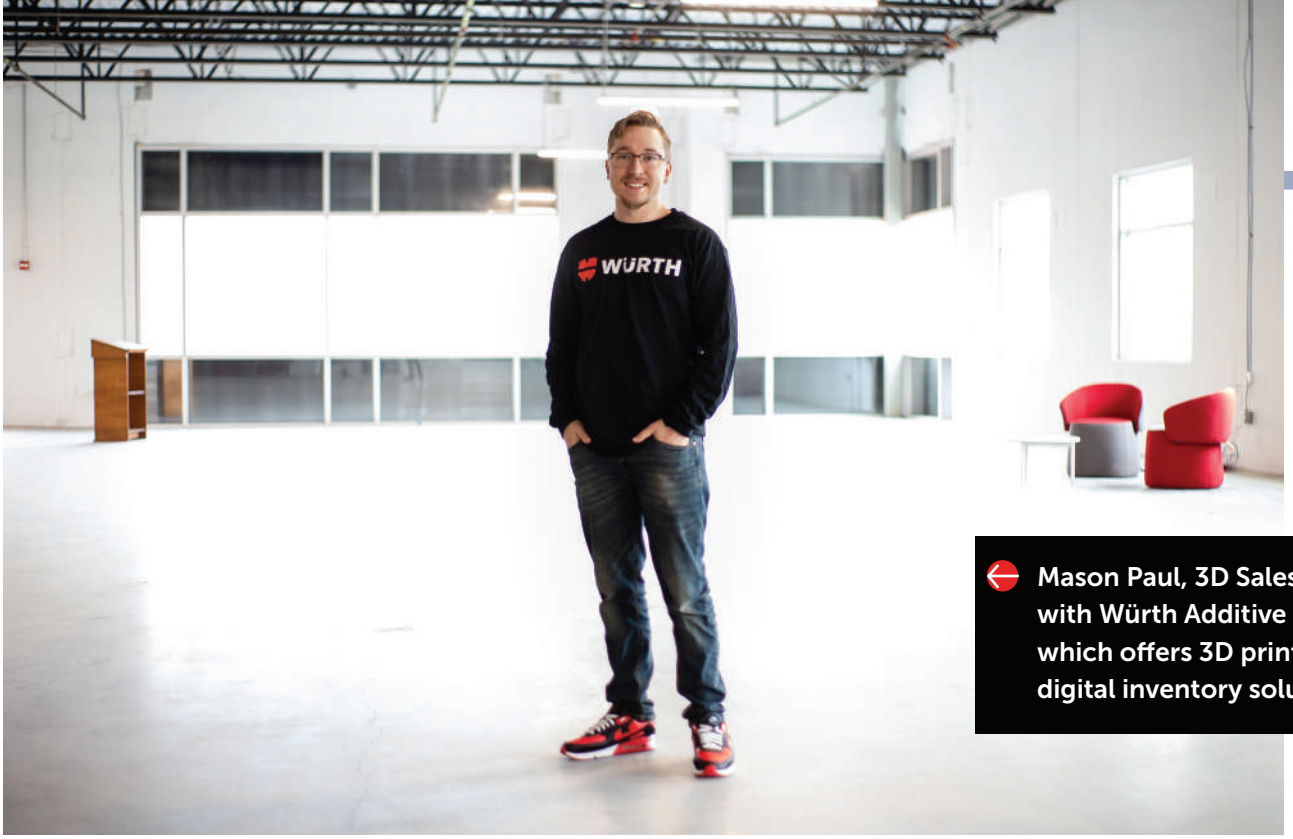

Mason Paul, 3D Sales Engineer with Würth Additive Group, which offers 3D printing and digital inventory solutions.

However, necessity drives innovation, and 3D printers are evolving to meet differing demands. Automated equipment like that from Rapid Shape means standardized 3D printed parts are becoming a necessity.

"We're committed to figuring out how to best build out standards for specific parts for these printers, so users can properly validate and archive CAD files, materials, part dimensions, and the equipment, ensuring the manufacturing is a benchmarked process and a repeatable one."

Paul says the Würth Additive Group is collaborating with its partners — like Rapid Shape (which has the equipment expertise) and Henkel (a global chemical manufacturer with the resin and material expertise) — to create standards for certain plastic fasteners.

"It's still early in the process, but we're working through different PPAPs — which are production part approval processes — to validate that a part has been printed to specification. Ideally, we want to compare with injection molding as that's one of the most common types of plastic manufacturing."

Paul refrains from using the word "compete" with injection molding because he says such manufacturers are gaining interest in 3D printing to support their manufacturing lines.

"We've asked manufacturers to map out their part SKUs, and there's typically a declining curve where the demand for certain types of fastener tapers off," he says. SKUs are 'stock keeping units,' a unique number combination used to identify and track products. "We believe additive manufacturing can serve the tail end of such a bell curve, working alongside injection molding."

This means determining which parts are in the lower percentiles of production and evaluating whether they're potential candidates for additive manufacturing. As such, they could be manufactured with a 3D printer, saving the injection-molding equipment for the parts required in higher volumes.

"In this way, additive manufacturing is in no way a threat to more conventional forms of manufacturing and serves as a way to optimize a business and tackle new markets," he says.

Paul has his team at Würth recently conducted a small in-house study on plastic fasteners to determine if 3D printing such smaller-volume parts would make a significant impact — and it certainly can.

"Smaller batch orders are going to cost a lot more, especially when considering the tooling and set-up that goes into typical manufacturing equipment. I mean, the set-up alone can cost tens of thousands if not hundreds of thousands of dollars per run," he says. "Whereas with a 3D printer, you simply need to plug it in once the material and CAD models are ready. There are no tooling charges or machine changeovers or anything like that."

Before deciding to go with additive manufacturing, however, it's important to properly evaluate the fastener type, project volume, and costs.

"I say this all the time: you can 3D print almost anything, but should you 3D print everything? Probably not. There's an ideal time to do so that's based on the part, material, cost, and overall manufacturing goals," he says. "Nevertheless, we're seeing a lot of change when it comes to breaking that barrier of 3D printing and how it's implemented. It's no longer just used for prototypes, but final production pieces. It'll be exciting to see how the evolution of additive manufacturing progresses from here." **FE**

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How to choose the proper fastener when automating

Christie Jones
Director of Marketing, Vice President
SPIROL International Corporation

Fasteners are as important in automation as the equipment itself. Choosing the ideal fastener can prevent exorbitant machine and fixture costs, decrease set-up and cycle times, and reduce the manufacturing cost of the components.

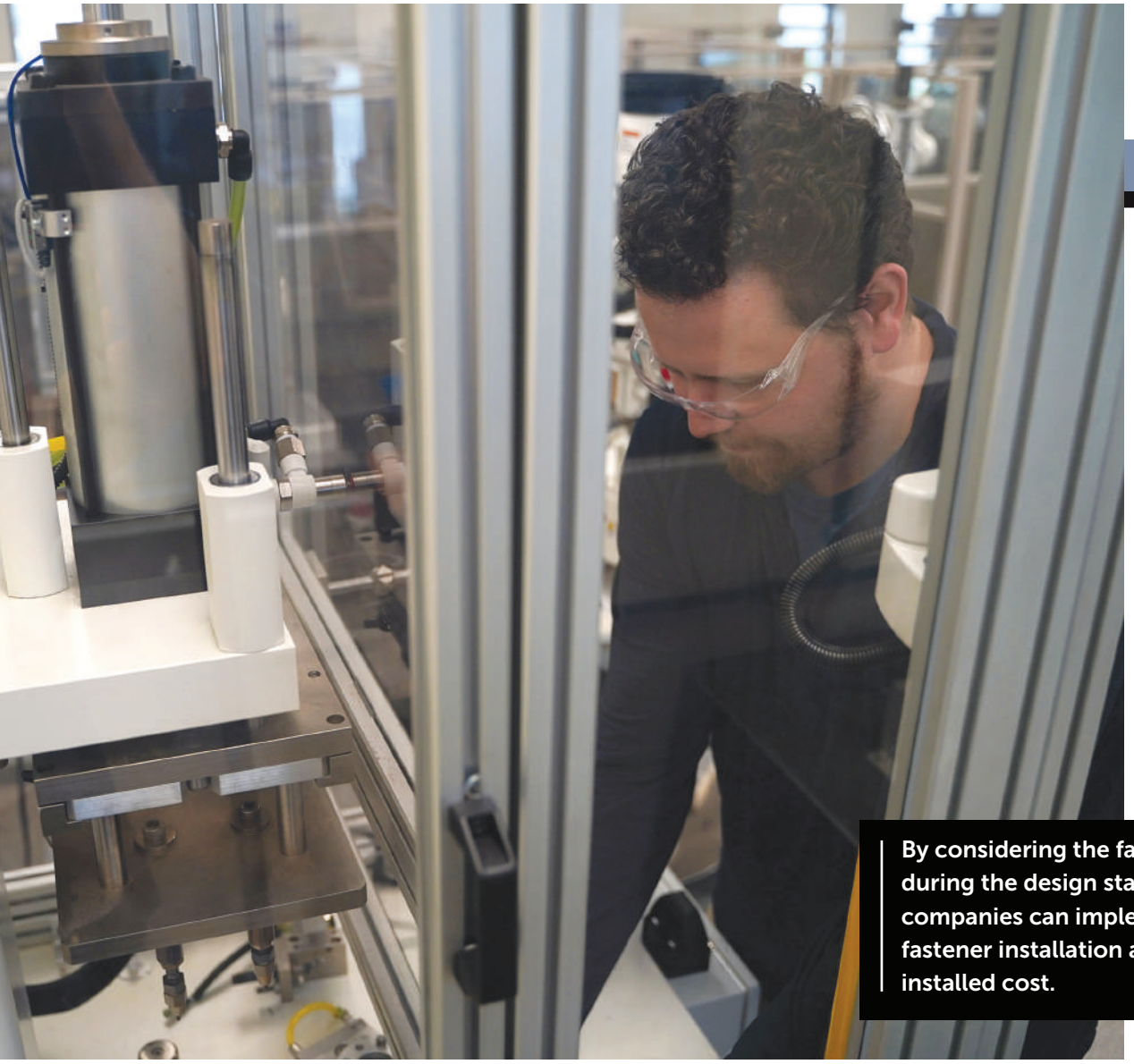
Of course, not all fasteners are easy to orient, feed, or install, and the more tooling necessary for these tasks, the pricier the equipment. It's important to select a fastener that meets the application requirements and is conducive to automation to maximize productivity and minimize costs.

The design stage of the assembly is where decisions are made that will make or break the success and ease of automation. A common mistake is letting the cost of the fastener take precedence over the cost of fastening. Money saved on the fastener can quickly be lost on intricate automation equipment — decreasing productivity via increased assembly cycle times and equipment downtime.

Ideally, companies should focus on parts with the lowest installed cost. Typically, these are permanently installed fasteners pressed into (rather than threaded into) a hole, requiring no secondary operations for retention.

There are a few additional factors to consider when automating fastener installation.

- The length-to-diameter ratio of the fastener is critical. Any part with a length-to-diameter ratio of less than 1:1 can be problematic because the parts in the feed tube can tumble and jam.



By considering the fasteners early during the design stage of an assembly, companies can implement automatic fastener installation at the lowest installed cost.

- Fasteners should be clean and sorted. Dirty fasteners cause some parts to stick in the feeder bowl and the feed tube. Improperly sorted fasteners can jam the insertion equipment. Time is money, and both are wasted if the machine must be disassembled to clear the jam.

To ensure successful automation, design engineers and assemblers should become familiar with the features of fasteners.

Consider the symmetry

Non-symmetrical fasteners are often challenging to automate, requiring end-to-end orientation. This means more costly tooling than for symmetrical fasteners.

If using conventional automating methods, headed parts should hang by the head. A good rule of thumb is to ensure a minimum 20% differential between the head and body diameter to provide enough distinction for orienting and hanging the parts. If the diameter differential can be held between 20 to 30%, it's possible to avoid additional tooling costs.

Headed parts with no consistent head diameter or inconsistent beneath the head tend to get jammed on the feed rail. Flat heads are better than round heads for automatic installation. This is because pressing a flat insertion quill onto a flat (instead of round) surface is easier while keeping the fastener straight.

The additional cost to feed, orient, and install headed fasteners make it fundamental to ensure the application requires a headed fastener before specifying one.

Non-headed, non-symmetrical fasteners must also have differential to use the typical feeding method of hanging on a set of rails. This differential can be a 20% difference between the body and feature diameter or a significant weight imbalance of at least 10% between the ends of the fastener. When put in a set of rails,

The top reasons for automating instead of manually fastening include increased productivity and reduced costs. However, many fail to realize the fasteners' impact on achieving these goals.

Choosing the ideal fastener can prevent exorbitant machine and fixture costs, decrease set-up and cycle times, and reduce the manufacturing cost of the components.

the fastener should naturally fall in one direction every time. A more complex method of orienting is necessary if this fails to occur.

Other methods include vision, laser, optical sensor, or a gaging bushing. However, using a symmetrical fastener makes it possible to save significantly on automation equipment.

Symmetrical fasteners have a continuous profile and are ideal for automating. They're the easiest to feed because they require minimal orientation. Examples include straight (dowel), grooved, knurled, and slotted spring and coiled spring pins.

Generally, a machine will deliver the parts in a straight line to the feed tube. Once oriented, these parts are typically fed in a tube down to insertion equipment.

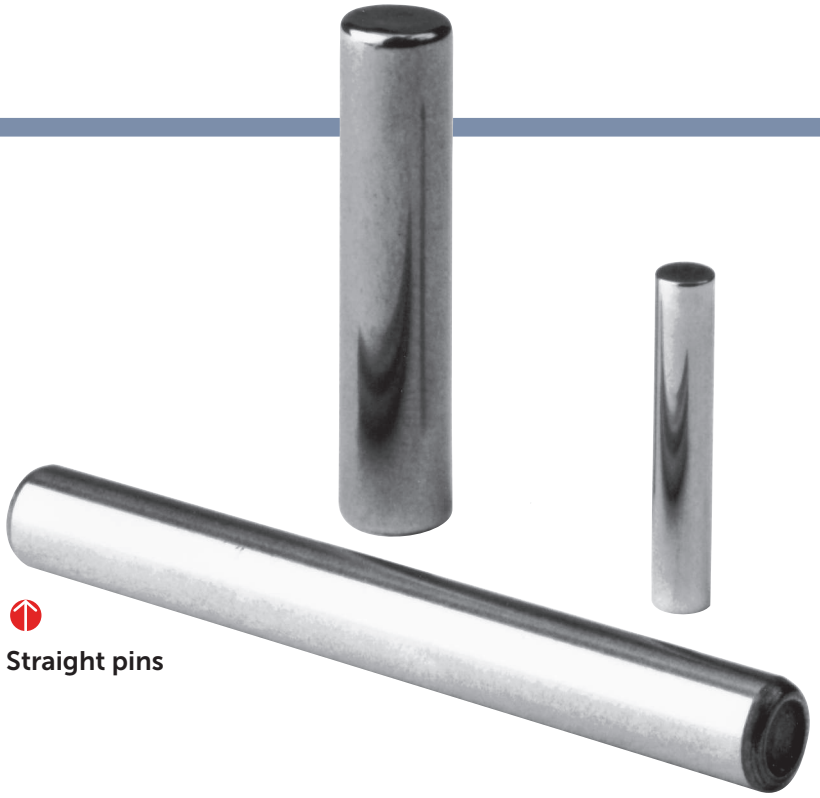
Symmetrical fasteners also have some disadvantages. For example, the straight dowel pin depends on the host material for retention. As a result, reaming might be needed to achieve the necessary tight tolerances, and the hole preparation cost can be high (The exception is when these pins are used in plastic because the holes are molded.)

Grooved and knurled pins were developed to compensate for these concerns. The diameter across the grooves and knurls is designed to be larger than the hole. So, when a hardened grooved pin is used for strength, the host material deforms — but not to the same extent as a straight solid pin.

The knurled pin is also designed to cut into the host component. But neither the knurled nor the grooved pin requires the tight tolerances of the straight solid pins. Nevertheless,

Nearly anything can be automated, providing ample time and money. By adhering to a few basic guidelines, companies can increase productivity and avoid unnecessary tooling costs associated with complex automation equipment.

- Specify fasteners with a length-to-diameter ratio greater than 1:1
- Always ensure fasteners are clean and sorted
- Use symmetrical fasteners when possible
- Avoid fasteners that must be oriented for strength
- Choose fasteners that require low insertion forces
- Consider fasteners that allow for greater hole tolerances
- If a headed fastener is necessary, design the fastener such that the differential in the head and body diameter is between 20 to 30%.



Straight pins

Slotted spring pins

insertion forces are usually much higher for all types of solid pins, which can dramatically affect the cost of the automation equipment.

Since solid pins require deformation of the host material for retention, there's the possibility of cracked or damaged components during installation.

The spring pin was developed to compensate for the shortcomings of the solid pin. When a spring pin is driven into a hole, spring action allows it to compress within the diameter of the hole. Once installed, the radial force exerted by the pin against the hole wall provides self-retention.

Since spring pins require no material deformation for retention, the installation forces are lower, and there's no host component damage. The spring pin can also absorb hole tolerances and minor hole mismatches.

There are two types of spring pins: slotted and coiled.

Slotted pins are manufactured with a gap to allow the pins to flex. Some manufacturing processes, such as the roll-forming method, result in uneven chamfers and non-square ends. The slotted pin offers an ideal way to reduce costs when manually installing the fastener, but it's not recommended for automation.

The biggest problem when automating is the slotted pin's "non-square" ends. When entering the escapement in the installation machine, the slotted pin tends to catch on the pin above it in the feed tube, preventing advancement. A gap can also cause the slotted pins to interlock and jam in the pin inserter.

Roll forming also induces the possibility of a bowed or banana-shaped part. The pins tend to stretch at the slot and contract 180 degrees from the slot. The stresses in the heat treating/quenching process also tend to distort the pins. If the pin is not straight, it will not pass through the discharge bushing.

Knurled pins

The **coiled spring pin** was developed to overcome such challenges. These pins are manufactured from strip material and rolled into a spiral spring of 1-1/2 or 2-1/4 coils. Several features contribute to trouble-free automation.

Coiled pins have a spring nature and cannot nest or interlock as there are no gaps. The square, clean-cut ends — combined with a smooth, concentric lead-in chamfer and a blended radius — eliminate sharp edges or angles that may "bite" into the hole wall, reducing insertion forces.

The chamfer concentricity assists in alignment with the host and mating holes. A coiled pin must not be oriented for strength. These attributes can significantly reduce downtime during the production process, decrease equipment costs, and yield trouble-free assembly.

The coiled pin's duty (or material thickness) can be varied to provide the optimum combination of strength and flexibility. The lighter-duty pins require less insertion force, reducing the cost of the automation equipment because a smaller cylinder or machine can be used.

In applications where this pin is appropriate, the ease of automation makes this the lowest-installed cost fastener available. **FE**

Coiled spring pins

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Ad Index

Fastener Engineering Supplement

By Mark Jones

The pizza box problem — and why it might kill Teflon

It looks innocuous in my hand, yet there are growing calls to ban it. The Manhattan Project created the technology, but, in my hand, it doesn't feel like a weapon. It feels natural, despite the very unnatural materials it contains. I'm not at all cautious as I open it. Reaching in, I grab a slice. I do love pizza.

Pizza isn't the problem, it's the box, specifically the fluorocarbons used to make the box resistant to both grease and steam. Per- or polyfluorinated alkyl substances, PFAS, make an exceptional pizza delivery device. I can't tell whether the box in my hand is PFAS-laden or not.

Tasked with handling uranium hexafluoride gas, the Manhattan Project scientists rapidly developed fluorocarbon polymers, fluids, and waxes. After the war, chemists at 3M and DuPont went wild making all sorts of new compounds. Applications exploded.

Functionalized fluorocarbons, when added to pulp even at only around 1%, make the cardboard repel both oil and water. Use in paper, certainly a decade ago, was the largest use of PFAS. Paper intended to be thrown away after a single use was, and may remain, where most PFAS get used. Its presence in biosolids and compost points to paper being a major source of widespread, low-level contamination. PFAS used to be a concern only in places where high levels were found. Concern is now everywhere. PFAS are found at low levels in more and more places, just as levels of concern have dropped from parts-per-million to parts-per-quadrillion. This is leading to suggestions that all PFAS should be banned.

Fluorocarbon polymers are themselves PFAS. The C8 materials, referred to as PFOS and PFOA, were used as processing aids in making fluorocarbon polymers. Contamination near manufacturing sites created some of the highest environmental levels and are where health impacts were first realized.

Teflon (polytetrafluoroethylene or PTFE) would be gone with a PFAS ban. So would Kynar (polyvinylidene fluoride), Viton (vinylidene fluoride and hexafluoropropylene copolymer), FEP (copolymer of hexafluoropropylene and tetrafluoroethylene), and Tefzel (copolymer of ethylene and tetrafluoroethylene). Gore-Tex (expanded PTFE), Neoflon (polychlorotrifluoroethylene and formerly sold as Kel-F), and Nafion (polyperfluorosulfonic acid). Also, I am writing this on a laptop with a lithium-ion battery containing polyvinylidene fluoride as an electrode binder. Bye-bye to all if PFAS are banned.

Manufacturers of polymers are pushing back. Polymers, they argue, are too big to cause health issues and don't decompose to make smaller, ingestible PFAS species. The hazards presented by polymers are small and the benefits are more than worth the risk. Historic manufacturing carelessly released PFAS, but that's not done anymore, manufacturers say. Emissions are controlled. Time will tell whether these arguments are persuasive and whether we'll still have these materials to use in the future.

The pizza is gone. I'm now stuck deciding what to do with the box, unsure whether it contains PFAS. If PFAS are there, it is my hand that now determines their fate. Recycle bin or trash bin are the options available. I tear the box in half. Half into the recycling, half into the trash. Faced with uncertainty and two bad options, I choose a bit of both. DW

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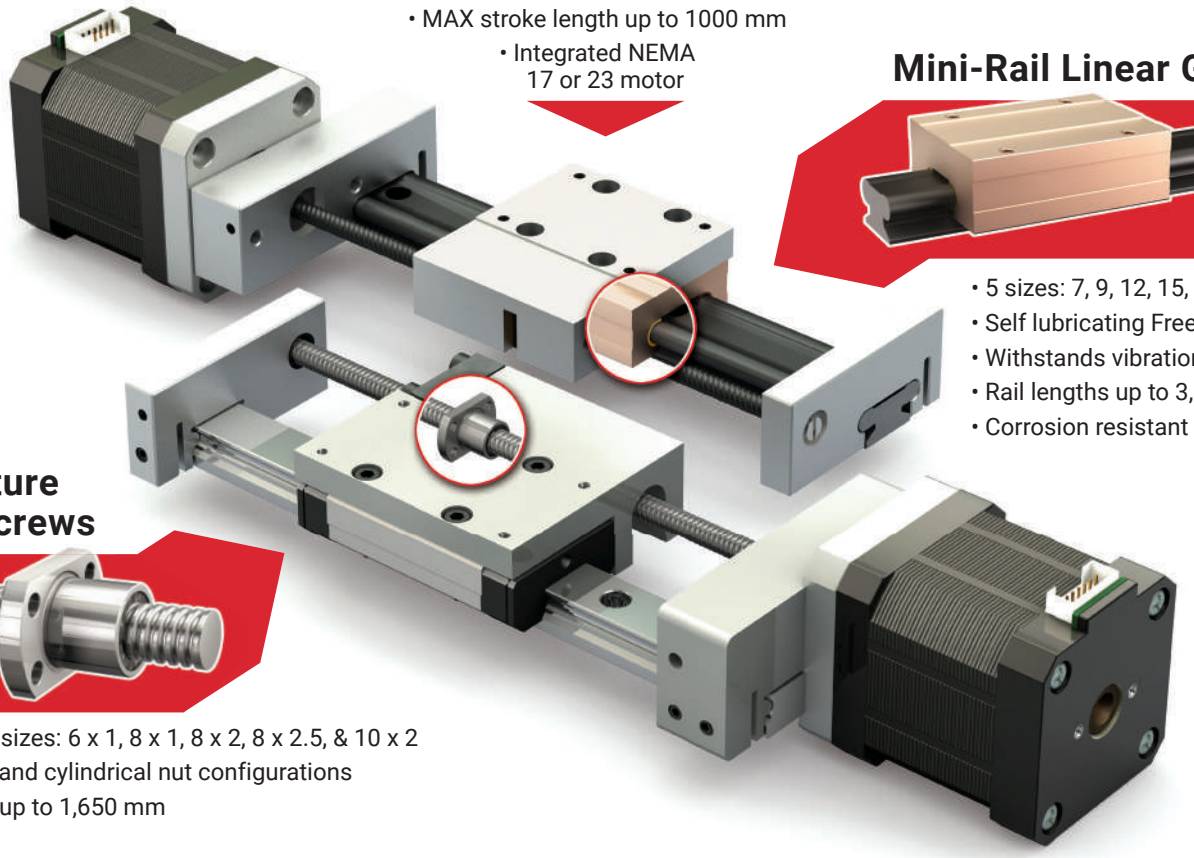

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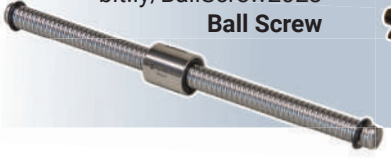

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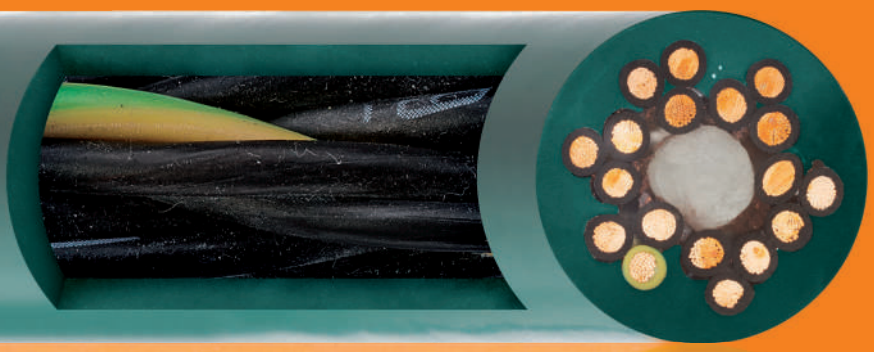

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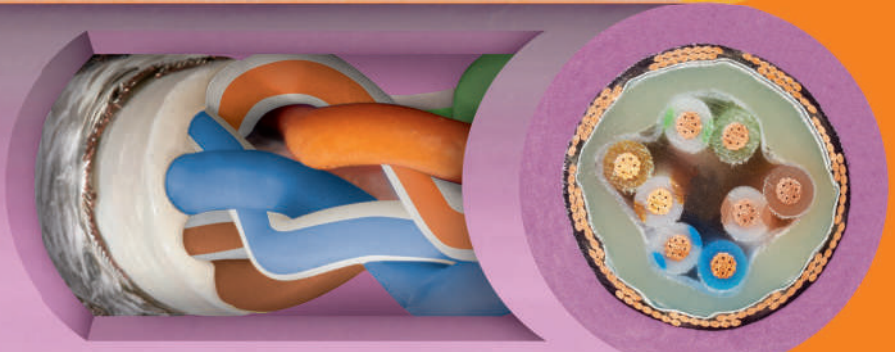

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