Robotics Benefits Wire Harness Manufacturing p. 16

EV, Battery Makers Seize the Digital Thread Advantage p. 18

How Motion Systems Can Best Leverage Servo Technology p. 26

March/April 2024

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FLUID POWER'S DESIGN POTENTIAL P. 12

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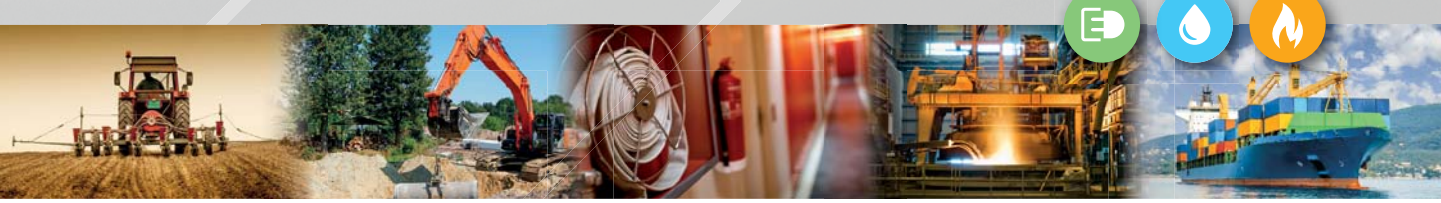

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POWER&MOTION

VOLUME 77, ISSUE 2

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SARA JENSEN
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The Growing Role of Sensors

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Integration of sensors into mobile and industrial machinery can gather and transmit a range of data to help improve the productivity and efficiency of operations as well as automate some tasks.

Sensors have become an increasingly common part of hydraulic, pneumatic and electric motion control systems, bringing a range of benefits from data collection to improved precision. As sensor technology has evolved and become more affordable over the years, its use has continued to grow.

The push toward greater levels of automation in both the mobile equipment and industrial machinery spaces are helping drive use of sensors even higher as they are a key component in enabling safe, accurate movements as well as visibility around a vehicle or machine.

Given their ever-increasing use in motion control systems and the technological advancements taking place, *Power & Motion*'s coverage of sensors continues to grow.

You can find some of this ever-expanding coverage in this issue, starting with our cover story on pg. 12 which reviews the various technological impacts of sensors on fluid power systems as well as benefits offered by inclusion of sensors and the technological advancements still needed for further industry success.

Then on pg. 20 we dive into an industry partnership which brings oil condition monitoring to mobile hydraulics systems. By integrating an oil conditioning sensor and IoT capabilities into hydraulic components, the monitoring of oil conditions and thus the performance of hydraulics can be improved.

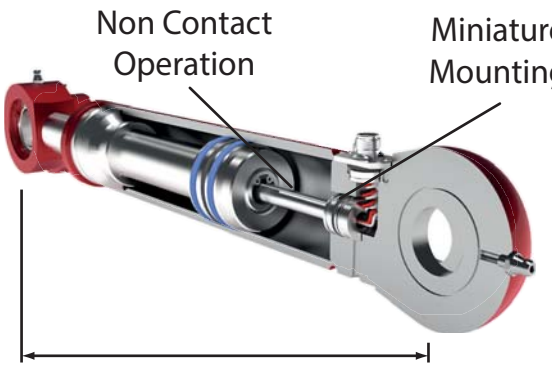
And on pg. 32 you can learn how the digitization of sensors is making them smarter — enabling more information to be collected and better analysis which will benefit predictive maintenance efforts.

If you're looking for even more sensors related content, you can download our latest e-book featuring several new articles focused on technologies and trends related to this increasingly important component. You can download it at powermotiontech.com/21282946.

Have suggestions for subjects related to sensors you'd like to see us cover in the future or want to provide input on the topic? Reach out to me any time at editor@pmtmag.com. P&M

COFFEE or TEA?

You also have a choice for hydraulic cylinder positioning



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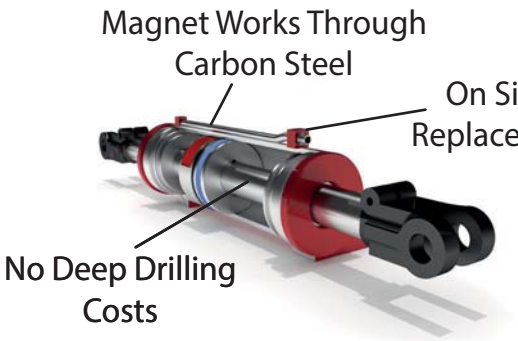
UN ECE R10 Automotive Approval



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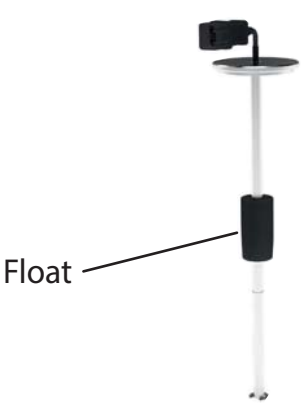

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Moog Motion Control Technology Aids Creation of High-Performance Test Rig

Use of digital hydraulic solutions enabled a test system to achieve the high forces and speeds necessary for the development of suspensions for extreme applications.

by Sara Jensen

Testing heavy-duty vehicles can be a difficult job, requiring reliable and high-performance components. When looking for a test rig capable of handling the testing needs of suspensions for armored vehicles, Piedrafita Systems — a Spain-based developer of mobility solutions — turned to Moog Inc.

The company was looking for technology which could deliver forces up to 500 kN at a speed of 8 m/s, and up to 200 Hz to assist in the development of vehicle suspension systems. Having previously worked with Moog on the design of a fatigue test bench providing 80 kN at 4.4 m/s velocity, used for development of a shock absorber, Piedrafita felt confident Moog could aid with the design of its newest test bench.

"Piedrafita asked if this new system was feasible," said Juan Carlos Molinero, project manager and engineering leader for Simulation & Test at Moog in the company's press release announcing the partnership. "After our study and performance tests, we again collaborated with Piedrafita to develop a concept that could test an armored vehicle's suspension."

Close collaboration between the companies led to Moog delivering a high-performance test system to Piedrafita which met its high force and speed requirements. The new test rig was installed in July and is being used for several projects including development of a hydropneumatic rotary suspension for armored vehicles as part of the company's SRB Project, funded by a grant from the EDIDP (European Defence Industrial Development Programme).

Custom Motion Control Components Benefit Real-World Testing

The test rig is designed to simulate the passage of an armored vehicle's tracks over undulating terrain, creating a level of vibration similar to what would be experienced in the field. Enabling this capability through the use of various Moog motion control technologies allows Piedrafita to evaluate the resistance and performance of its shock absorbers and suspensions, ensuring the vehicle will perform as desired in combat scenarios.

"Our new test system is capable of carrying out tests for 70-ton tracked vehicles, with a weight of around 5.5 tons per wheel," said Vanesa Recio, head of Communication and Marketing for Piedrafita. "Our engineers can test wheel stations under very demanding profiles for main battle tanks such as the Abrams, Challenger, Leclerc, and Leopard."

Moog technologies on the test rig include:

- a test controller
- two hydraulic actuators with digital servo valves
- hydraulic power unit (HPU) with digital pumps and power cabinet
- an accumulator bench with the required piping.

"Working with Piedrafita, our engineers designed the new test bench with a high-performance controller and customized actuators reproducing vibration up to 100 g," noted Ian Whiting, chief engineer for Moog.

The combination of force, velocity and acceleration help make the new test rig unique to

the market Moog told *Power & Motion*. To provide context of its capabilities, the company said the system combines the heavy-duty loading typically found in a high-capacity hydraulic press with the speed and fidelity of a motorsport 4/8-poster rig.

An aspect which aids the high-performance capabilities of the test system is the hydraulic actuators' digital servo valves. Moog said they are custom turbocharged versions of Moog's standard offering which enables them to achieve the 500kN, 8m/s, 200Hz, and 100g operating envelope required by Piedrafita.

As part of the design and installation process, Moog was tasked with selecting and sizing the various components for the new test rig. The company also provided training on the operation of the system to Piedrafita's staff.

Recio said the new test bench helps to reduce the time and costs associated with testing by minimizing the amount of physical testing required. OEMs can also utilize the test bench, enabling Piedrafita to provide customers with additional services which help get their vehicles in the field faster.

"The high-performance test bench minimizes costs and enables tests in a controlled manner rather than driving over a proving ground, thereby protecting a crew who would otherwise have to be on board a vehicle," he said. "Manufacturers such as General Dynamics and KNDS can also test their vehicles' suspension on our new test system." P&M

Incorporation of various Moog hydraulic motion control components, including custom digital servo valves, enables the Piedrafita test rig to achieve high levels of force, velocity and acceleration.
MOOG INC.

TTTech Industrial Achieves Certification for IIoT Cybersecurity

The IEC 62443-4-1 certification ensures the security of TTTech Industrial's IIoT related technologies.

by Sara Jensen

One of the first companies in Austria to achieve the IEC 62443-4-1 certification is TTTech Industrial— a developer of industrial automation solutions and part of the TTTech Group. IEC 62443-4-1 is an international cybersecurity certification for the industrial sector which defines the requirements and framework for secure product development and lifecycles. The company's product development processes were certified by TÜV Austria, an international testing and certification company.

Receiving this certification not only helps to ensure the security of TTTech Industrial's various technologies but also provides a prerequisite for certifying its Nerve IIoT platform according to the IEC 62443-4-2 substandard covering IT security in industrial automation systems.

According to TTTech Industrial, Nerve — a cloud-managed edge computing solution — already includes many cybersecurity features. These are being monitored and updated according to IEC 62443-4-1 and include securing all connections to the product's Nerve Management System as well as role-based access control to ensure secure access to data for different users and services.

"Industrial systems are used by different companies along the supply chain that need access to various kinds of data and services for various purposes. Our IIoT platform Nerve is at the center of this by allowing customers to collect, manage, and analyze their machine data from everywhere in the world," said Thomas Berndorfer, Member of the Executive Board at TTTech Industrial, in the company's press release announcing its recent certification. "We regularly review Nerve's cybersecurity features, and we continuously monitor potential security threats, so we can provide patches if needed, and improve our solutions' security level. The IEC 62443-4-1 certification is the first step towards the product certification of Nerve in 2024."

Opposite page: Alexander Zeppelzauer, Managing Director of TÜV Austria (left) hands the IEC 62443-4-1 certificate to Erwan Sudrat, Director of Development IoT at TTTech Industrial, who managed the certification project at TTTech Industrial (right), at the company's headquarters in Vienna. TTTECH INDUSTRIAL

Why Certification Matters

Cybersecurity has become an increasingly important topic as more systems and machines become connected and digitalized. Ensuring a safe connection means there will be no issues with performance and that collected data is only shared with the appropriate entities. This helps to prevent disruptions to production as well as compromises to IP, safety or supply chains for machine builders, suppliers and end-use customers.

"Connectivity and digitalization are vital for optimizing production and increasing efficiency, but they can also increase the risk for cyberattacks. We are committed to playing an active part in our customers' efforts to increase cybersecurity on their shopfloor," said Herbert Hufnagl, General Manager and Member of the Executive Board at TTTech Industrial, in the company's press release.

Given the importance of cybersecurity, the European Union (EU) is one of many governmental and organizational bodies developing regulations and standards related to cybersecurity, with the IEC 62443-4-1 being one example.

In January 2023, the EU put the NIS2 Directive in place which aims to provide legal measures for enhancing cybersecurity in member states. Through this directive, the EU strives to ensure:

- Member States are prepared for cybersecurity attacks by requiring them to be appropriately equipped to address them,
- cooperation among all Member States through a group established to support and facilitate information exchange and strategic copperation, and
- a culture of security across sectors vital to the economy and society such as energy, transport, water, banking, digital infrastructure and others.

The EU is also currently considering the Cyber Resilience Act (CRA) for products with digital elements. Its goal is to enhance the cybersecurity of hardware and software products introduced into the market. To achieve this, four key objectives have been set:

- ensure that manufacturers improve the security of products with digital elements since the design and development phase and throughout the whole life cycle;
- ensure a coherent cybersecurity framework, facilitating compliance for hardware and software producers;
- enhance the transparency of security properties of products with digital elements, and
- enable businesses and consumers to use products with digital elements securely.

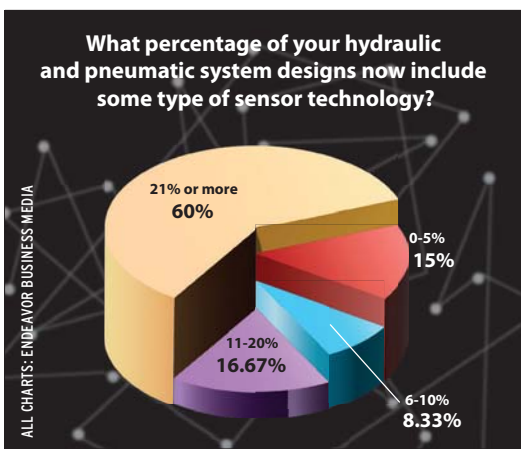
By implementing various regulations and standards such as these, manufacturers and the broader public can be better protected from cybersecurity threats. **P&M**

Sensors in Fluid Power

Bring a Range of Design Opportunities

Benefits ranging from improved precision and control to enhanced machine monitoring are possible when integrating sensors into fluid power systems.

by Sara Jensen



Integration of sensors within hydraulic and pneumatic systems continues to grow. Doing so brings a range of benefits including enhanced performance and data collection for improved maintenance and machine monitoring.

A recent survey of *Power & Motion*'s audience found a large number of fluid power system designs now include some type of sensor technology. Sixty percent of respondents said 21% or more of their system designs include sensors while another 16% said 11-20% of their systems include sensors.

This coincides with the many discussions we've had with members of the fluid power industry who are also witnessing the increased use of sensors in their hydraulic and pneumatic system designs.

There are of course several drivers for the rising use of sensors, with safer and easier operation being chief among them according to Oliver Lythgoe, Chief Marketing Officer at FÉTIS Group, who discussed the topic during a *Power & Motion* webinar. Adding more electronics, including sensors, to fluid power systems enables these goals to be achieved.

Lythgoe said the integration of sensors allows for new forms of control to enable faster and more accurate movements.

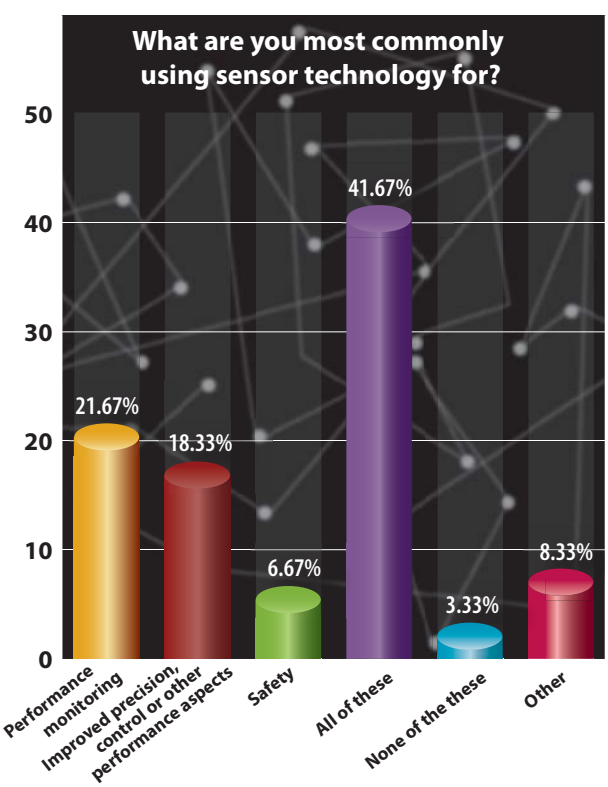
Joern Strasser, Business Manager for Speed Sensors at Rheintacho — who also spoke during the webinar — added that the more a system is controlled, the bigger the advantages which can be achieved. For those in the mobile equipment industry, autonomous driving is one of the next big technological steps manufacturers are looking to take. The measurement and data capabilities provided by sensors will be vital to enabling safe and accurate autonomous driving.

How are Sensors Being Used in Fluid Power Systems

There are a variety of sensors being integrated into fluid power components and systems to meet varied customer needs. Safety, performance monitoring, and improved precision, control or other performance aspects were among the common uses for sensors noted by respondents.

A number of respondents, 41%, indicated all of these were reasons they are including sensors in their hydraulic and pneumatic system designs.

Russ Schneidewind, OEM Sales Manager at HydraForce, said in an interview with *Power & Motion* that the company is seeing increased demand for precision in proportional control of hydraulic components. Sensors are often being used to provide the feedback necessary to achieve more precise control of hydraulic actuators and motors, he said.



The Gefran Twiist is capable of several measurements in a single unit which fits in the same space claim as other sensors in the market. GEFRAN INC.

With this increased precision not only comes better control but also improved energy efficiency, another feature for which he said there is increasing demand. Improving the efficiency of a fluid power component or system can reduce the amount of total energy required to power a machine. This is becoming an increasingly important issue to help reduce emissions output. Systems which can operate efficiently will also be necessary for electric-powered machines to ensure a longer battery life between charges.

By externally mounting its hydraulic cylinder position sensor, Rota was able to provide the required measurements while keeping the sensor protected. ROTA LIMITED

Position sensors are commonly used with hydraulic cylinders to help provide more precise movements. This can help increase the accuracy of various machine functions, as was the case when Rota Limited worked with heavy equipment manufacturer Vermeer.

The OEM had developed a special pile driver machine for solar field installations which requires a high level of accuracy when driving the piles which support a solar panel into the ground. To ensure consistent, accurate placement of these piles, Vermeer contacted Rota about using its linear position sensors on the machine.

Two position sensors were installed with hydraulic cylinders on the machine which provide x and y axis readings to allow for accurate alignment of the pile driver. Communication with the machine's CANbus allows for better calculation of the pile driver angle, helping to ensure not only accurate placement of piles but also ease of use for machine operators.

Technological Challenges and Opportunities for Hydraulics and Pneumatics

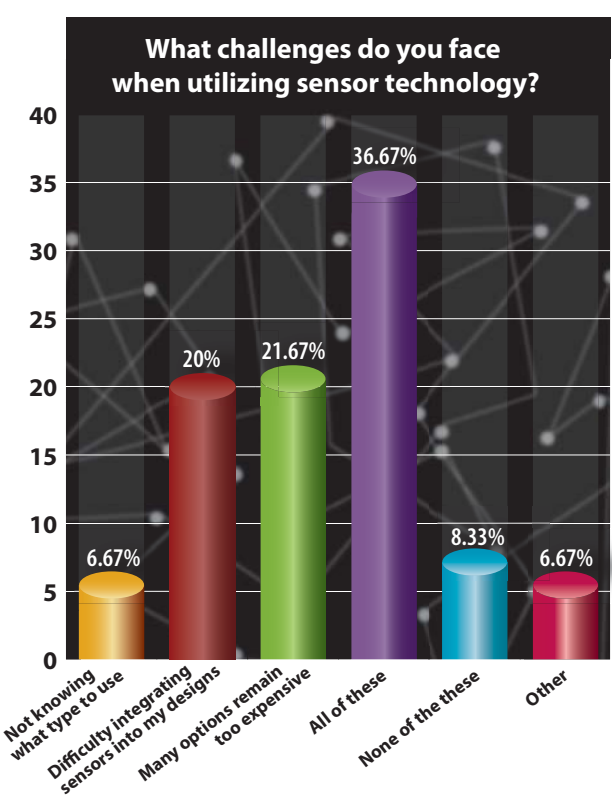
Although the use of sensors has become more common within the fluid power industry, there are still many challenges faced by the design teams utilizing them. One of the top challenges noted by 21% of survey respondents is the fact that many sensor options remain too expensive. Although their costs have come down in recent years, they can still be a costly part of a system design depending on the type of sensor required and any ruggedness or other aspects which may need to be built into it.

Another 20% of respondents said difficulty integrating sensors into their designs remains a challenge while 6% said not knowing what type of sensor to use can be challenging. Both are important aspects to ensuring a sensor meets the given application and measurement requirements.

There are several sensors available from which to choose — position, temperature, angle and more — making it important for developers of hydraulics and pneumatics to know what they want to accomplish through integration of a sensor.

When it comes to installing a sensor, it is vital to understand the application in which it will be used. In the previously mentioned Rota example, the company had originally thought position sensors embedded in the pile driver's hydraulic cylinders would be the installation method used. However, Rota found this would not be feasible with one of the hydraulic cylinders because of potential damage to the wire harnesses needed for its sensor. Instead, the company chose an independent mount sensor to keep it protected from damage while still offering the measurement data required by the application.

While there are many sensors available in the market which can be used with fluid power systems, there are also some areas in which the technology is lacking. One of the areas several respondents noted was the lack of multifunctional sensors – i.e., those capable of taking more than one measurement.



Often multiple sensors are integrated into a component or system to gain all of the data that needs to be collected. However, this can be costly and take up valuable installation space. If it were possible to use a single sensor capable of multiple measurements instead, this could help to reduce costs and space requirements for system developers.

There are sensor manufacturers working on this type of technology because they understand the benefits it can provide to the industry. In 2023, Gefran Inc. introduced its Twiist linear position transducer which is capable of providing multiple measurements in a single sensor unit. It features a specialized design to enable linear, angular, and other movements to be measured.

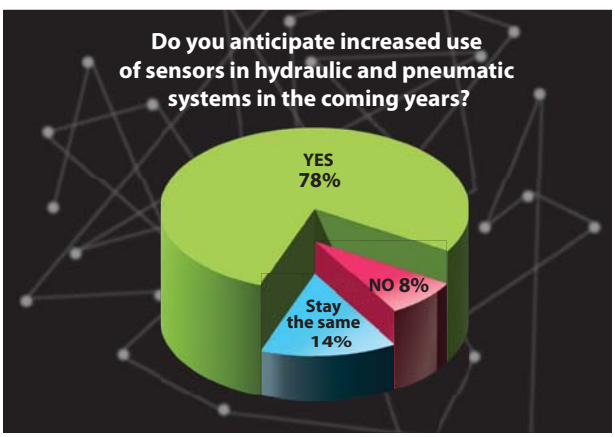
Cost and ease of integration were other areas several survey respondents noted there could be technological improvements made. Additional areas in which it was said sensor technology is lacking include oil film thickness measurements, durability and robustness, continuous fluid level measurements and the need for pressure measurements without wiring and drifting.

In the National Fluid Power Association's (NFPA) 2023 Technology Roadmap, sensors were noted as a key research area for hydraulic and pneumatic systems. It was noted in the roadmap – a document aimed at guiding future design needs — advancements in materials, wireless sensors, position detection, availability, and real-time information are ways in which sensors could help meet the needs of the fluid power industry.

With these advancements in sensor technology, fluid power systems would be better able to meet the data, safety, and energy efficiency improvements the roadmap committee viewed as vital to ensuring the longevity of the industry.

Sensor Benefits will Lead to Further Growth

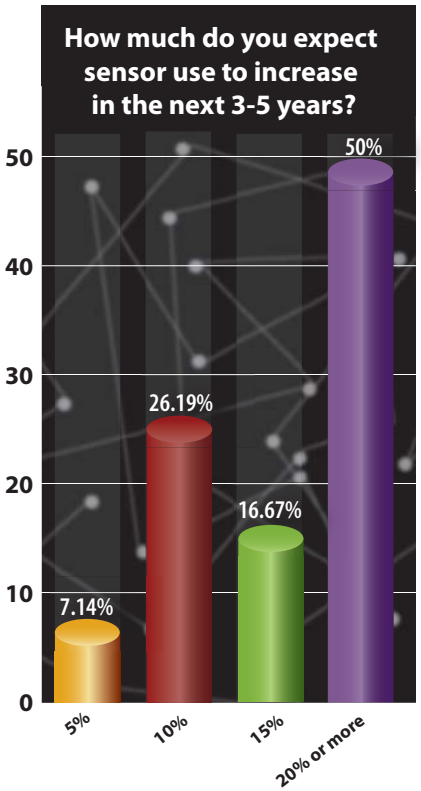
Survey respondents unanimously agreed that the integration of sensors in fluid power systems has been beneficial for the



industry. When it came to what the biggest benefits have been, however, there was a little more variety in responses.

Many respondents noted the improvements to machine and system monitoring as well as enhanced maintenance capabilities as some of the biggest benefits offered. Improved control and precision were also benefits mentioned by several respondents.

Rex Bateman, Director of Engineering at SMC Corp., told *Power & Motion* that the ability to integrate industrial networking into control products such as pressure and flow sensors is one of the evolutions taking place in the pneumatics sector which is aiding ease of maintenance. This capability makes it easier to remotely monitor systems and track performance to reduce unplanned downtime.



In general, there are a range of benefits which can be achieved through integration of sensors in fluid power systems. As such, their use will continue to grow in the coming years.

Most respondents, 78%, said they anticipate the use of sensors in hydraulic and pneumatic systems to increase over the next several years. Just 14% expect their use to remain the same while 8% do not anticipate increased use.

Fifty percent of respondents expect sensor use to increase 20% or more over the next 3-5 years, followed by 26% anticipating a 10% increase in use.

As fluid power systems and the applications in which they are used continue to advance, sensors will remain an important part of these system designs and will help bring about numerous enhancements in performance, data collection and other capabilities. P&M

Streamlining Wire Harness Manufacturing with a 5-axis Robot

The CY1000 robot reduces the manual labor required for production of wire harnesses, helping to address manufacturing and supply chain challenges.

by Sharon Spielman

In an era where streamlined manufacturing processes and cost efficiency drive success, UK-based Q5D is reshaping the future of industrial production with its CY1000 robot for automating wire harness manufacturing.

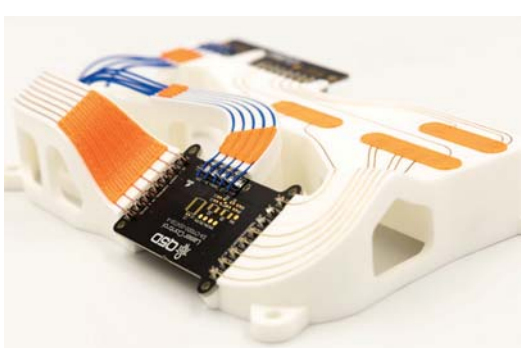
The company originated in 2020 as a spin-off from two manufacturing tech companies. Q5D leverages the expertise and intellectual property of an additive manufacturing company and a machinery manufacturer specializing in laser micro machining.

Although the underlying technology has been in existence for a longer period, the CY1000—the company's first product—launched in April 2023. Designed to automatically add components, connections and conductors to products made of metal, ceramic or polymer, the machine's development was inspired by the stagnation of the consumer 3D printing market and rapid growth observed in industrial manufacturing, according to Steve Bennington, CEO of Q5D.

"We saw that the industrial market was growing very fast," he said. "A lot of additive manufacturing is just landfill at the end, it's just bits of plastic, whereas if you could make it functional, you could add electrical conductors to it to make it so that it's as a useful part of a product that we thought…would be marketable."

This approach presented opportunities for reducing manufacturing costs and enhancing product quality compared to traditional handmade processes.

"We realized that the wiring harness world is probably the last part of the manufacturing world, which is still all or largely done by hand. …So, if you can…automate that, there are all sorts of potential benefits. …You're taking out…a huge amount of labor—and it is an astonishing amount of labor that they use to make and install wiring harnesses," he said.



By creating a systematic and organized wiring layout, the CY1000 robot streamlines the production of wire harnesses and eliminates requirements for additional standoffs and tie wraps. ALL IMAGES COURTESY OF Q5D

How Does the CY1000 Work?

The CY1000 robot is designed with linear motors. Bennington said this is the same kind of technology that is used in rail guns or monorails and high-performance machine tools. "It is essentially a motor where the stator (innards) [is] rolled out flat," he explained. "They are expensive but very fast and accurate. We are using a version with high-precision encoders to give us the precision that we need."

The machine operates by depositing existing wire (insulated or uninsulated, coaxial or twisted pair) onto a surface using a robotic system. The machine ensures fast and accurate wire laying and termination, according to Bennington, with compatibility for a range of wire gauges up to 3 mm in diameter.

He said the machine's design includes a five-axis platform capable of accommodating different wire deposition and termination end effectors. While additive manufacturing plays a minimal role in the process due to its time-consuming nature, Bennington noted that it is employed for specific tasks such as securing wires in place with a layer of polymer. "It's almost all about the wire deposition," he said.

Traditional wire harness manufacturing involves time-consuming tasks such as utilizing pin boards for wire layout and intricate connections, Bennington said, but this machine removes the need for elaborate wire routing and intricate

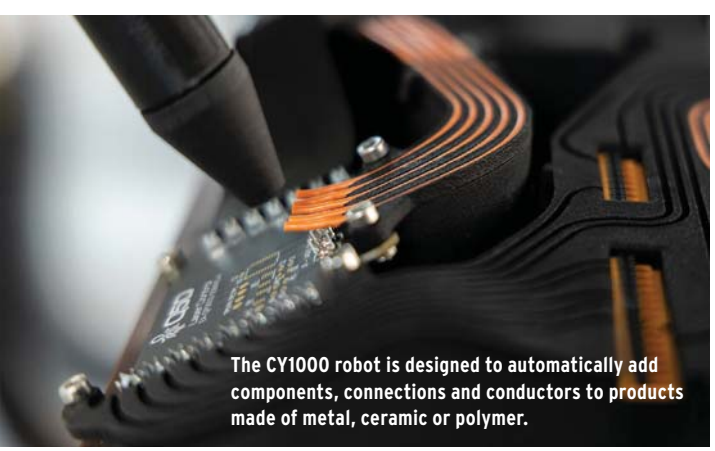
connections by using wire traps and individual wire spaces. By creating a systematic and organized wiring layout, the CY1000 streamlines the process and eliminates requirements for additional standoffs and tie wraps, resulting in significant weight reduction and cost savings.

"For example, when we're working in the aerospace sector, we tend to work mostly in the cabin," he said. "We're taking out something [like] 30% of the weight of the wiring harnesses, and that could be…5% to 10% weight of a business class seat overall…and that is all around taking out all of the stand-offs and tie wraps and all the other bits and pieces."

Solving Manufacturing and Supply Chain Challenges

When the company introduced its robot, there was an overwhelming response from the automotive sector. The automotive industry faced significant challenges related to supply chain disruptions caused by the pandemic and issues with sourcing semiconductors, Bennington said.

The challenges, coupled with the transition to electric vehicles and the need for onshoring or "friendshoring" manufacturing processes to tackle skills shortages and rising labor costs, created the perfect storm for Q5D's solution, he added.



The CY1000 robot is designed to automatically add components, connections and conductors to products made of metal, ceramic or polymer.

Automakers saw the potential for cost savings, improved quality and increased automation in the manufacturing of wire harnesses, a labor-intensive process traditionally done by hand. "They were very receptive to new manufacturing methods," he said.

While the automotive sector quickly embraced the CY1000, the company's initial target customers included manufacturers of machine tools, consumer electronics and industrial electricals, Bennington said. Q5D is actively working with customers in these fields, establishing partnerships and exploring new projects.

In the consumer electronics realm, Q5D collaborated with makers of injection-molded parts, incorporating wire guides to prevent entanglement during assembly. The company has also brought its five-axis robot to aerospace applications. While collaborating with a customer in this space, Q5D worked with a composite part, an air intake and integrated printed electronics to attract heat, which enhanced versatility and automation.

By simplifying and automating processes with tools like the CY1000 robot, Bennington said manufacturers can achieve higher accuracy and reduce product failures.

Future Growth Potential for the 5-Axis Robot

Looking ahead, Bennington said the company has plans to introduce conductive ink end effectors, which will enable the incorporation of printed electronics on a larger scale. These end effectors, initially scheduled for release in late 2023, have been temporarily delayed due to overwhelming customer demand and the need to raise additional funds to accommodate the company's growth, he said, adding that Q5D is committed to advancing its technological offerings and plans to ship the next generation of more focused and customer-centric machines by mid-2024.

As a young company, Q5D has focused on piloting machines and collaborating closely with customers. With an increasing demand for its solution, Bennington says the company is ramping up manufacturing capabilities and expanding its teams, including software development, product support and manufacturing engineering.

He mentioned working on a CAD/CAM product with Siemens NX. And as the company prepares to ship units to the U.S. and EU, it is also setting up subsidiaries in these regions to provide localized account management and service engineering teams.

Another part of the company's growth plan includes catering to diverse customer requirements. The next generation of robots will be designed to address specific needs and preferences. Customer feedback and industry insights gathered from the current model have shaped the development of more focused solutions. "The next fleet of machines [is] going to be bigger," Bennington said. For instance, "the automotive [industry] wants to get up to 2 by 4 m," he said. To meet the demands, he said Q5D will modify the frame, incorporating its robust linear motors, while keeping other features unchanged.

While the current machine is designed with an open side for robotics access, the next-gen models will have conveyor access for seamless integration within automated manufacturing processes. Bennington said this flexibility will allow the machine to be utilized as a stand-alone unit or as part of a larger production line, depending on customer requirements.

"It's interesting just to talk about these things conceptually, but it only really gels when you actually start to talk about exactly what it might be for," he concluded. P&M

Full Charge Ahead:

Trends Driving EV & Battery Makers to Embrace the Digital Thread

The digital thread connects processes, systems and equipment which can help electric vehicle and battery manufacturers better meet evolving industry needs.

by Jamie Nelson, Industry Sales Director for Auto/EV/Aerospace, Rockwell Automation

Electric vehicles will make up about half of new car sales worldwide by 2035 as the global push for net-zero carbon emissions accelerates, according to research from Goldman Sachs. But the road to an electrified future is not without its twists and turns.

The challenge for electric vehicle (EV) and battery makers is to not only accelerate production at a sufficient rate to meet this demand in the short term, but also future proof their production operations for future inevitable innovations and disruptions.

Use of digital solutions can help manufacturers more easily adapt their manufacturing processes to evolving electric vehicle and battery designs.

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For this to happen, EV and battery manufacturers need to harness the power of digital technologies across every facet of their business, spanning product development, manufacturing, operations, supply chain management and service. This forms a connected enterprise that unites and integrates information technology (IT) and operational technology (OT), resulting in a digital thread of information that spans the entire value chain. But what exactly is a digital thread, and how is it reshaping the landscape of electric vehicle production?

Digital Thread 101

The digital thread is a seamless flow of data that connects processes, systems, products and equipment across the value chain. Imagine it as a virtual string that weaves through every aspect of a product's lifecycle. It starts from the initial design and continues through manufacturing, testing, deployment and even maintenance. This thread connects all the dots, ensuring that information flows smoothly between different stages and stakeholders.

One of the key functions of the digital thread is the ability to connect processes and systems. In the past, IT and OT departments worked in isolation, using their own sets of data and tools. This siloed approach could lead to inefficiencies, errors and miscommunication. The digital thread breaks down these barriers by allowing data to flow freely between departments and systems. Feedback loops of data coupled with artificial intelligence (AI) and machine learning allow companies to blaze a path toward truly autonomous manufacturing, addressing workforce challenges and maximizing their competitive advantage.

So, why does the digital thread matter? In a word: efficiency. By maintaining a seamless flow of data across all aspects of a business, it eliminates bottlenecks, reduces errors and saves time and money.

Trends Driving EV & Battery Makers to Embrace the Digital Thread

There are several marke trends which are helping drive EV and battery manufacturers toward the use of digital solutions.

Changing Economic Conditions

In the wake of changing economic conditions, EV manufacturers are grappling with heightened scrutiny from investors. With global interest rates on the rise and capital becoming more costly, the honeymoon phase enjoyed by early success stories like Tesla has subsided.

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The digital thread allows data to flow freely between departments and systems, helping to optimize the development and manufacture of electric vehicles and batteries.

Investors are now less forgiving of delays and cost overruns. Moreover, the EV market has become increasingly crowded, pitting newcomers against established internal combustion OEMs with decades of manufacturing experience in their arsenal.

The digital thread offers a lifeline in this competitive landscape. By implementing an end-to-end digital thread, they can streamline their operations, reduce production delays and provide a more transparent view of their processes and timelines to investors. This not only instills confidence in stakeholders but also helps EV makers stay competitive in a crowded market.

Demand for Increased Battery Capacity

EVs are becoming mainstream, and customers are starting to demand more from their electric vehicles, particularly in terms of increased range. To meet this growing demand for increased range, battery manufacturers are forced to push the limits of battery capacity. This means developing batteries that can store more energy without significantly increasing the size or weight of the battery pack. Increasing capacity typically involves tweaking the chemistry, modifying cell designs, or exploring entirely new materials.

These changes require frequent product design refreshes, which, in turn, introduce a level of complexity and uncertainty into the manufacturing process, as each design iteration can disrupt established manufacturing processes and lead to potential inefficiencies or downtime. To address this challenge, battery makers are turning to predictive modeling.

Predictive modeling enables engineers to simulate various scenarios and evaluate the performance of potential battery designs virtually. By creating digital prototypes and running simulations, engineers can predict how changes in design parameters will affect battery capacity, efficiency and overall performance.

This data-driven approach accelerates the design iteration process, allowing manufacturers to fine-tune their products more quickly and reducing the time and resources required for physical prototypes and testing.

Rise of Solid-State Batteries

Solid-state batteries hold immense potential for the EV industry.

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The digital thread provides a seamless flow of data to connect all processes in the electric vehicle and battery manufacturing value chain, starting from initial design through testing, production and even maintenance.

They offer the promise to double energy densities compared to traditional lithium-ion batteries. This means EVs can store more energy in less space and with less mass, a breakthrough that has the potential to significantly extend the driving range of electric vehicles.

However, introducing new product designs, processes and materials into manufacturing facilities poses inherent risks of cost and timeline overruns.

Solid-state battery technology demands rigorous testing and simulation before physical prototypes are created. The digital thread allows manufacturers to simulate the performance of these batteries in various conditions and scenarios.

By identifying potential problems early in the development stage, EV makers can avoid costly iterations and design flaws that could delay production.

Charging Forward with the Digital Thread

In a world defined by constant change and innovation, digital enablement is not just an advantage; it's a necessity. The digital thread enables EV and battery manufacturers to not only weather the challenges of changing economic conditions, increased demand for battery capacity and the adoption of technologies like solid-state batteries, but to thrive in spite of them.

Manufacturers that embrace the digital thread are well positioned to succeed in the increasingly competitive global marketplace. P&M

Sensors Improve

Integration of oil condition monitoring sensors into hydraulic systems can provide OEMs and their customers with better insights into machine performance.

by Sara Jensen

The oil which runs through a hydraulic system plays an important role in its performance, as well as that of the machine into which the system is integrated. Monitoring the condition of the oil is necessary to ensure it continues performing as desired.

Typically, this oil condition monitoring has been done through regular oil sampling which can be time consuming. However, there is increasing use of sensors to monitor the condition of hydraulic oil. This enables more continuous monitoring and improved maintenance practices because more immediate action can be taken upon detection of any anomalies.

In 2022, Hydraforce Inc. announced it would partner with Tan Delta Systems and Elevāt, a provider of IoT (Internet of Things) connected machine applications, to enable real-time oil condition monitoring in hydraulic systems.

Through this collaboration, Tan Delta's oil conditioning sensor is integrated into manifold assemblies using HydraForce cartridge valves. With the sensor, "you have a component that can monitor continuously the condition of the oil which is really the bloodstream of vital functions on a piece of mobile equipment," said Russ Schneidewind, Director of Business Development for HydraForce, Inc., part of the Compact Hydraulics business unit of Bosch Rexroth, during the *Power & Motion* webinar "Achieve Better Hydraulic System Maintenance with Oil Condition Monitoring."

Elevāt's telematics solution enables hydraulic system information to be collected, analyzed and sent to machine owners or maintenance personnel so they can immediately perform maintenance if necessary, leading them to be more proactive than reactive when an issue is detected.

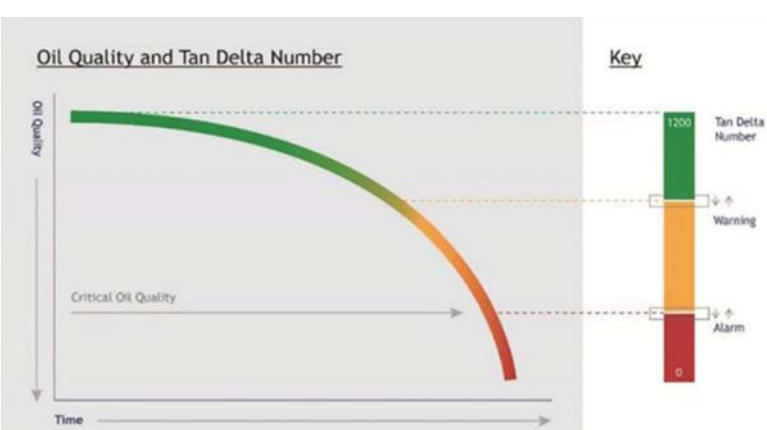
By bringing together their technologies and expertise, these companies aim to increase the use of oil condition monitoring to improve the maintenance of hydraulic systems.

Oil Condition Monitoring Sensors Provide Valuable Data

According to Chris Greenwood, CEO and co-founder of Tan Delta Systems, the company's goal is to provide intelligent monitoring and maintenance with its oil conditioning sensor. "It's all about getting the data that people need now in order to be able to manage [their] machines effectively," he said during the *Power & Motion* webinar.

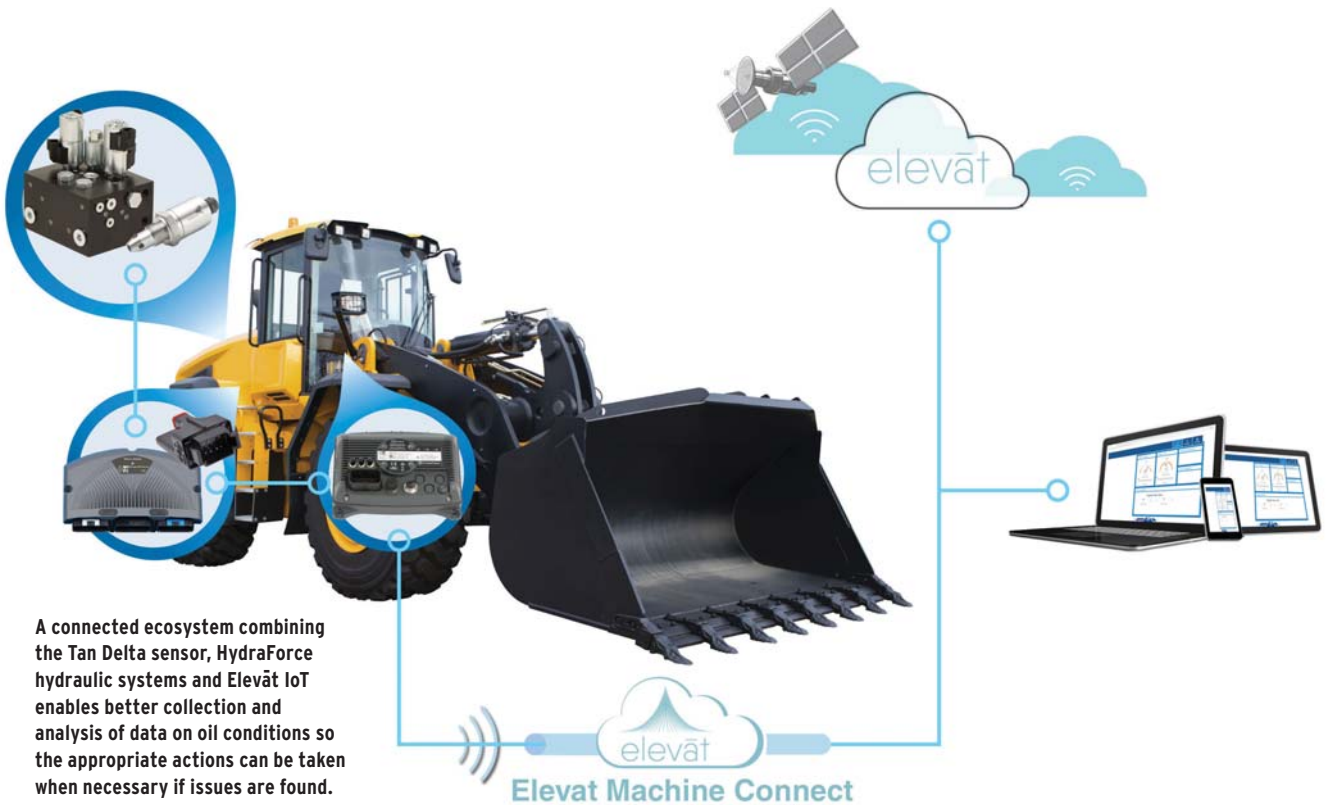
To do so, he said the Tan Delta technology looks at oil holistically — looking at every single aspect instead of focusing on one or two parameters such as particle count, relative humidity or viscosity as some other technologies do. While important factors, he said monitoring all aspects of oil condition is necessary to ensure no issues are missed.

"When you've got a machine that's running remotely, and you're relying on that data coming from the sensor, you don't want to… be in a position where it failed, but the sensor didn't see it," said Greenwood. "A key thing for us is having that accuracy, repeatability [and] sensitivity so we know whatever's going on, we're going to be able to see it and then give that back to the customer in the form of actionable data."



Real-time monitoring of oil conditions with the Tan Delta sensor enables maintenance issues to be addressed as soon as they are detected, helping to minimize unplanned machine downtime.
TAN DELTA SYSTEMS

Monitoring of Hydraulic Oil Conditions



A connected ecosystem combining the Tan Delta sensor, HydraForce hydraulic systems and Elevāt IoT enables better collection and analysis of data on oil conditions so the appropriate actions can be taken when necessary if issues are found.
HYDRAFORCE INC.

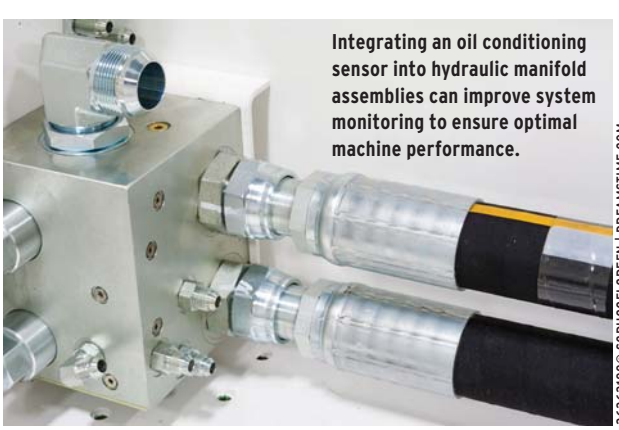
He noted that giving data is good, but if it is not meaningful, then it does not provide any value.

Some oil condition monitoring tools and techniques in the market have been lifted from the industrial sector which Greenwood said do not necessarily fit with the needs of the mobile equipment market. For instance, he said particle counting has always been a popular method of looking at hydraulic fluids but does not actually tell you anything about the fluid itself.

"It's only telling you if you've got material in the fluid," he explained. "From our perspective, if you've got material in the fluid, then you've already got an issue. So, it's now just mitigating the issue rather than preventing it in the first place."

Schneidewind said HydraForce's hydraulic systems are critical to machine operation as they are typically used as the bridge between the electronic controller and the control of all the machine functions. Therefore, it is vital to ensure the quality of the oil running through these systems.

When the company has received complaints about a product not operating as it should, he said it is amazing how many times it has been because of the condition of the oil. "Contamination is a huge problem for us because our valves are made with very precise manufacturing and loads, and



Integrating an oil conditioning sensor into hydraulic manifold assemblies can improve system monitoring to ensure optimal machine performance.
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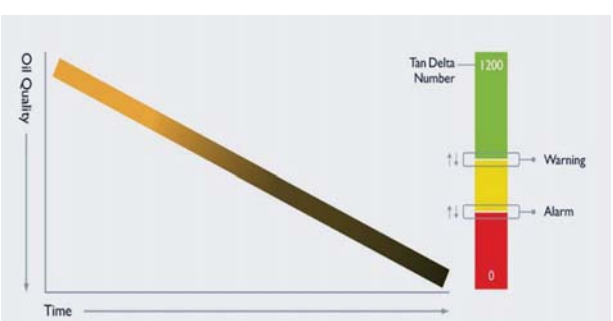
small tolerances," he said. "Sometimes when we're trying to precisely control something, we have a very small opening in the valve that we're trying to control very accurately; changes in the oil affect all of that."

HydraForce application engineers will work with a customer to determine the ideal situation for setting up the hydraulic system, but once it is in the field the company can no longer monitor it. And customers may not understand why the system is not performing as it should or what to do about it. However, integrating the Tan Delta sensor into the hydraulic system helps overcome this challenge by providing monitoring and information on what may be causing performance issues so they can be addressed.

Schneidewind said the design of the oil conditioning sensor is well suited for cartridge valve and manifold technology because it looks like a cartridge valve and threads directly into a port in HydraForce's tank line. In addition, he noted the fluid flow past the sensor is beneficial. Both aspects enable the company to create a well packaged solution for its customers.

IoT Connects Systems to Improve Data Collection and Sharing

HydraForce had been working to build up its remote access capabilities for some time, said Schneidewind, when it formed the partnership with Tan Delta and Elevāt. While the Tan Delta sensor monitors the state of hydraulic oil, the Elevāt telematics platform allows that information to be collected, stored, analyzed and sent to all interested parties.



The Tan Delta oil conditioning sensor looks at all parameters of hydraulic oil conditions to ensure no potential issues are missed.
TAN DELTA SYSTEMS

Adam Livesay, co-founder and CCO of Elevāt, said during the webinar that when the company works with OEMs or integrators, the goal is to connect the whole machine, everything from the hydraulics to the transmission to the engine and more. Sensors of various types play an important part in enabling this.

He said with intelligent solutions like Tan Delta's oil conditioning sensor, information being collected by the sensor can be shared with Tan Delta for their input which can then be provided back to Elevāt and dispersed to the OEM

The Tan Delta oil conditioning sensor easily integrates into hydraulic systems and allows for good fluid flow past the sensor to optimize its data collection capabilities.
TAN DELTA SYSTEMS

Oil condition monitoring is about getting the data people need now for effective machine management.

who can inform its customer of any possible actions to take based on the analysis provided by Tan Delta. Sharing industry expertise in this manner enables better performance insights and maintenance solutions to be achieved.

It also takes the development burden off of the OEM; instead, those who have expertise in hydraulic systems, oil condition monitoring and connectivity can work together to provide a monitoring solution that brings together their industry knowledge to ensure all aspects will perform as desired.

"We're looking at all the machine data, and we're going to be sharing it with the experts that have built these components to tell us what the health is," said Livesay. "That to us is the ultimate because we become almost like a Cisco router in essence [by collecting and sharing] the data."

Sharing all of this information between the various industry experts creates a connected ecosystem to provide the most valuable solution to the market, he said. "This is the pinnacle. This is exactly what we want with IoT moving forward, is understanding what puzzle piece we are and how do we complement each other to provide the best value for the OEM and ultimately its end user."

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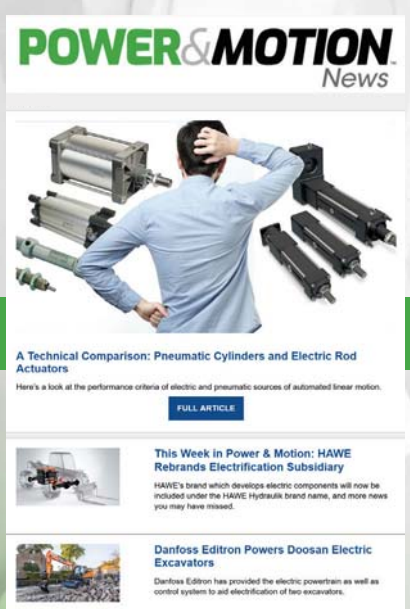

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Interest in Monitoring Hydraulic Oil is Steadily Rising

Use of hydraulic oil condition monitoring technologies within the mobile equipment industry is growing. Schneidewind said interest in this type of solution is still in the early stages, but the biggest gains are being made with high value machines such as mining equipment.

In mining, unplanned downtime can be extremely costly due to the value of the material being collected and the expense of operating mining equipment. Accessing the machines can be difficult as well because of the remote locations in which they typically work. "If you can imagine having to do regular oil sampling and sending it out to be evaluated and shipped back, by the time you get the analysis the machine could already be having some problems," said Schneidewind. "[The machine] could just go down in the middle of the work it has been doing and that would be an extreme cost to the mine."

More connected machines will lead to greater use of oil condition monitoring.

However, if an oil condition monitoring system is used it would be easier to detect issues much sooner and have alerts sent to the interested parties, minimizing unplanned downtime.

Schneidewind said there is a transition taking place in which OEMs and their customers are starting to see the value and potential cost savings associated with using these types of systems. This will help increase their industry adoption in the coming years.

Greenwood agrees there is growing interest in hydraulic oil condition monitoring. In addition to ensuring the performance of critical pieces of equipment, there is also a greater focus being placed on

High-value machines like mining equipment present a good use case for oil condition monitoring.

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ESG (environmental, social and corporate governance). Monitoring systems can help to determine when maintenance is actually needed — instead of doing so on a schedule which could reduce unnecessary waste. And by helping mitigate possible issues as soon as they occur, larger problems or damage to environments and people can be minimized.

He also noted the implications of reduced industry knowledge and service technicians, a challenge facing many market sectors. Sensors and other components enabling oil condition monitoring can help by providing the information on the possible issue at hand as well as what steps are needed to fix it – allowing those with any level of expertise to identify and address the problem so machines can get back up and running.

Elevāt's Livesay sees use of oil condition monitoring technologies expanding beyond higher value machines as more companies deploy digital strategies. He said a massive shift has taken place over the last few years in which OEMs are now looking at internal IoT use cases particularly for maintenance and warranty claims.

"The Tan Delta oil conditioning sensor is a perfect device that gives them a lot more information and data they don't currently have," he explained. "In the past, OEMs might not have had to think about how they monitor [hydraulic oil] in real time because they didn't have a connected machine."

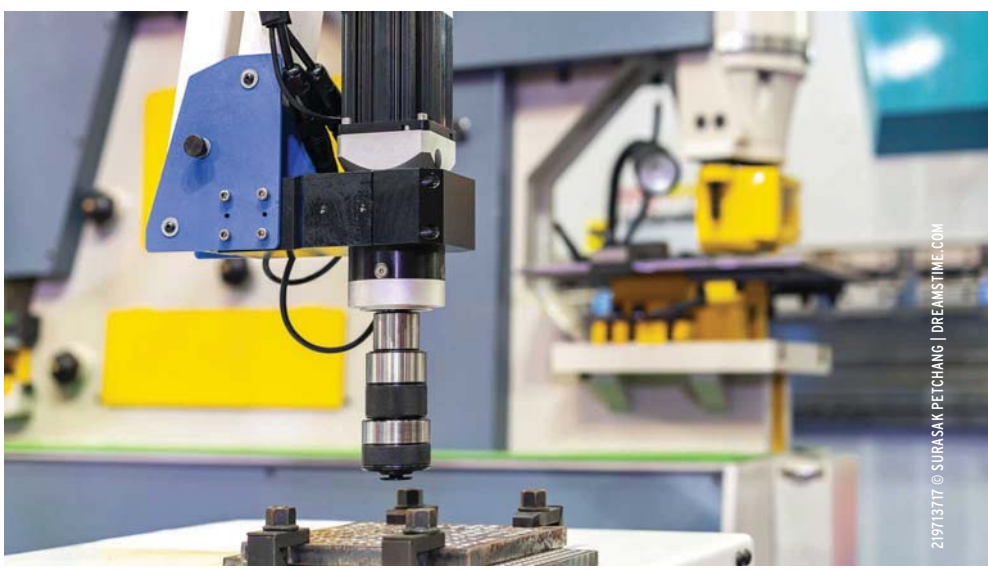
But now that machines are more connected, it is necessary to provide this information — to service tools, production lines and engineering teams. Livesay said it makes sense that if you are going to have a more connected machine then you are going to want to gather the most valuable information which is the condition of the hydraulic oil.

"As solutions like this [with Tan Delta and HydraForce] come out, and OEMs embrace smart sensing technology with better information, this is going to be a pretty big growth area over the next several years," he concluded. **P&M**

How Advanced Servo Technology can Take Motion Systems to the Next Level

As automated operations become increasingly sophisticated, the use of cutting-edge servos is paramount to enabling the creation of advanced, futureproof systems.

by Roy Kok, Thomas J. Burke



In the fast-paced landscape of motion system technologies, servos are indispensable components in applications that need to deliver accuracy, precision and dynamism. With the increased adoption of data-driven smart manufacturing applications, motion control systems are undergoing substantial changes. Shop floors are shifting from older, more basic servo products and basic analog controllers toward more responsive, efficient and advanced digital solutions that utilize multi-axis servo-motor actuators for precise position, speed and torque control.

The latest developments in sensing, artificial intelligence (AI) and industrial automation are also expanding the capabilities of motion control devices, offering new opportunities and potential for further advancement.

For example, the most sophisticated servos can seamlessly synchronize a multitude of axes to carry out complex yet highly coordinated movements while maintaining extremely short cycle times in the microsecond range. As a result, it is possible to implement cutting-edge, value-adding machines that can achieve remarkable speed while delivering consistent, repeatable, high-quality results to maximize productivity and throughput.

Use of technologically advanced servo motors incorporating intelligent algorithms, sensors and more help to improve performance and meet the requirements of today's automation systems. MITSUBISHI ELECTRIC

Integrated Intelligence Leads to Improved Motion Control

Looking at these trends, it is clear to see how the evolution of servos is marked by a distinct progression toward enhancing speed, repeatability, and data processing capabilities. Beyond faster data sharing and enhanced processing, the integration of intelligent algorithms is becoming key.

These are not just responsive—they are anticipatory, effectively mitigating disturbances, such as vibrations and harmonics, that could impede the flawless execution of motion operations. More precisely, they ensure that motion remains swift as well as remarkably precise, eliminating deviations and irregularities that might compromise the integrity of processes.

Greater speed and responsiveness for today's drives goes beyond operational performance. They support installation and startup by enhancing their user-friendliness through simplified programming, pre-coded functions as well as auto-tuning capabilities. Even more, they can effectively self-regulate. For instance, using automated position control and adjustment, the system itself can keep tabs on the required motion through closed-loop feedback systems.

Similarly, functions for servo gain adjustment contribute to reduced settling time while controlling overshoot and vibration suppression. For example, some servo drives can automatically generate all the gain values within approximately 0.3 seconds. In addition to ensuring consistent performance while minimizing downtime and maintenance, users can benefit from optimized energy use as well as quieter operations.

Machine wiring is also simplified, with a single cable to connect encoders, power and electromagnetic brakes, as well as one-touch lock connectors to avoid screw tightening. Reducing installation time, costs and the bill of materials, these features can help drive profitability and agility within a business.

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Selecting the right communication technology is necessary to ensure all desired performance attributes and data processing from servos is achieved.

Data Brings Servo Performance to New Heights

The most ambitious servo drives offer even more. They transcend basic operations, incorporating more data-based features to enhance productivity, reliability and responsiveness.

A premier example is the use of AI for condition monitoring and predictive maintenance. Thanks to embedded sensors continuously generating real-time data that communicate with prognostic models to detect wear, it is possible to identify anomalies and intervene well before critical issues occur.

In effect, users can benefit from an up-to-date accurate overview of the status of their motion system as well as leverage a setup that recommends timely actions based on the condition of the components. Therefore, they can move away from reactive maintenance or pre-set, non-indicative schedules. This means emergency shutdowns and downtime, especially unplanned, can be minimized, if not eliminated, while optimizing equipment service life, avoiding the replacement of healthy components.

This approach minimizes disruptions, enhances efficiency and significantly contributes to cost savings.

The Importance of Choosing the Right Communication Technology

As most of the functions described require high-speed data sharing, equipping servos with the right communication technology is fundamental to supporting all these groundbreaking capabilities and unlocking the full potential of motion systems. To meet modern, data-hungry applications, machine builders and end-users should favor servos that leverage high-performing industrial Ethernet technologies.

Mitsubishi Electric's MELSERVO MR-J5 series of servo drives can automatically generate all the gain values within approximately 0.3 seconds, enabling users to benefit from optimized energy use and quieter operations with minimal downtime.
MITSUBISHI ELECTRIC

What once worked at 10 Mbps is now a relic in terms of technology and capability, with forward-looking businesses relying on 100 Mbps and even 1 Gbps solutions. This increased bandwidth is fundamental to developing competitive setups for data-intensive operations.

In addition to bandwidth, using a network technology with Time-Sensitive Networking (TSN) functions is beneficial as it enables highly reliable, deterministic communications between devices sharing different types of traffic. This sets the stage for comprehensive Industrial Internet of Things (IIoT) environments where diverse data can seamlessly converge to support motion control and data-driven decision-making processes, such as predictive maintenance.

Finally, choosing servos that use an open, vendor-neutral network technology can help the creation of value-adding systems. Proprietary solutions can limit users in the specification of industrial automation components, as they may have to rely on products belonging to a single vendor's ecosystem. More interoperable alternatives grant system integrators and end-users the flexibility to choose the solutions that precisely align with their requirements.

Future-oriented servos embracing an advanced open network technology that combines gigabit bandwidth and TSN functions, such as CC-Link IE TSN, are key elements within highly competitive motion systems. By choosing drives that include these features, end-users are not just investing in machinery but advancing in their digital transformation journey toward data-driven operations that offer increased performance, efficiency and competitiveness. **P&M**

This article was written and contributed by Tom Burke and Roy Kok of the CC-Link Partner Association (CLPA) Americas, which aims to provide collaboration on industrial network connectivity worldwide.

A Shift Toward Compact Hydraulic Systems

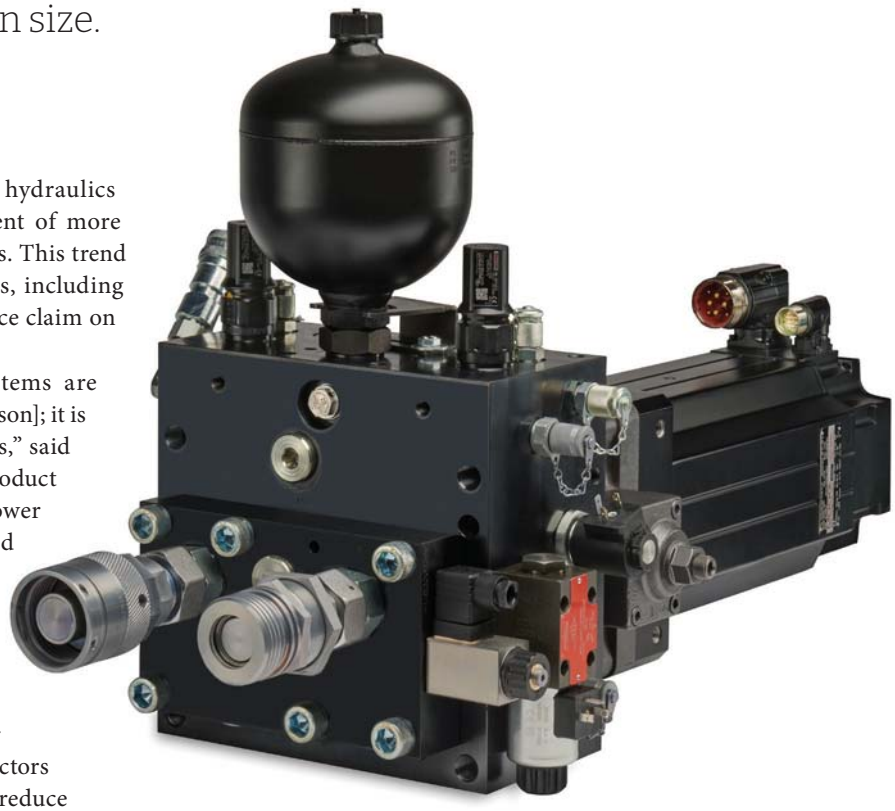
Improved efficiency and space claim are among the market factors driving development of hydraulic components and systems which are more compact in size.

by Sara Jensen

There is a growing trend in the hydraulics industry toward the development of more compact components and systems. This trend is being driven by several factors, including a need to be more efficient and reduce space claim on vehicles and machines.

"There are tons of reasons why systems are getting more compact. It is not just one [reason]; it is different things for different end customers," said Cindy Cookson, Vice President, Global Product Line Management – Industrial Fluid Power at Gates Corp., during the National Fluid Power Association's (NFPA) Fluid Power Industrial Consortium (FPIC) quarterly seminar on compact hydraulic systems held in September 2023.

Cookson said there is a technological evolution taking place in the fluid power industry, as well as cultural and societal factors and channel drivers — such as efforts to reduce emissions and evolving customer design priorities — which are all contributing to the creation of more compact hydraulic system designs.



The Moog Electrohydrostatic Pump System is comprised of a standardized manifold with hydraulic accumulator and Moog's Electrohydrostatic Pump Unit, a compact device that enables creation of a decentralized system. MOOG INC.

Why are Compact Hydraulics Growing in Use?

According to Cookson, trends related to productivity, logistics and ESG (environmental, social and governance) are among the key aspects driving the fluid power industry's technological evolution and development of more compact hydraulic systems.

On the productivity side of things, she said there is a lot of effort being made to reduce weight, particularly in the mobile hydraulics sector which can be achieved through more compact component and system designs. This is especially important for agricultural equipment because of the need to reduce soil compaction to ensure crops are not damaged, which could negatively impact a farmer's business. Weight reductions can also benefit fuel economy, leading to reduced fuel and thus operational costs for machine owners.

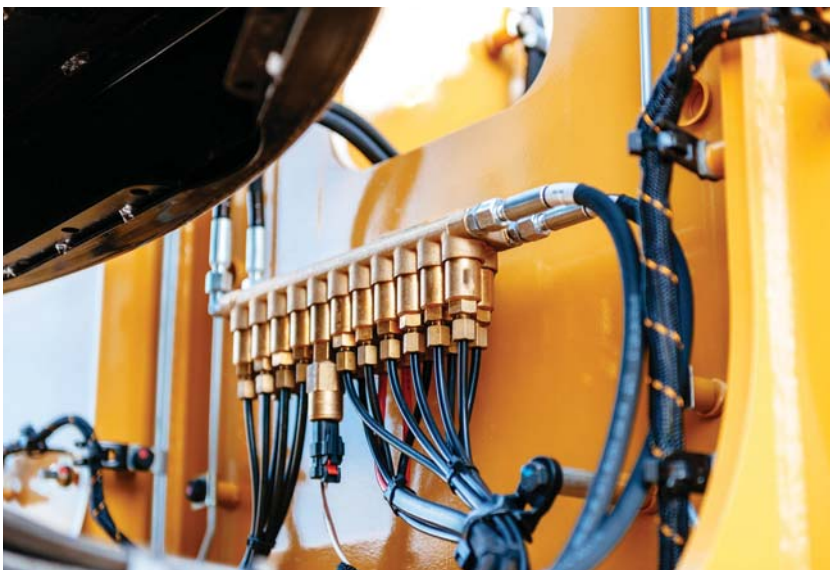
The replacement of manual labor in many industries with machines is also a driving factor, said Cookson. When thinking of places where a human may work, oftentimes the machine replacing that person will need to be equally sized which requires use of compact hydraulic systems to create a compactly sized machine as well.

In terms of logistics, ever-increasing urbanization is a key driving factor for the creation of more compact hydraulic systems. "As urbanization continues around the globe, we need equipment that can operate in tight spaces in urban environments," said Cookson. "And furthermore, as we rebuild our urban environments, you have to be able to retrofit and fit in between buildings or maybe fit in the basement of a building. You need compact equipment to do

that," which necessitates use of compact hydraulic systems.

Freight costs are a driving factor as well for both OEMs and their end-use customers. Shipping costs can be reduced with compact systems because they are lighter in weight — reducing costs of shipping the system itself as well as the machine into which it is integrated. The machine itself can also be more compact and lighter in weight, benefiting cost reductions.

Potentially even more compelling, said Cookson, are the benefits to end users who want to put a machine on a standard piece of hauling equipment, such as a trailer, without having to get a special license or permit. This can be achieved when machines are more compact in size, which again is possible with compact hydraulic systems.



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Manufacturers are developing more compact hydraulic systems to help improve efficiency and better fit into space constrained machine envelopes.

When it comes to ESG, compact hydraulic systems can provide an array of benefits as well. Whether it is reducing fuel use or emissions, minimizing how much material is used or other aspects, Cookson said compact systems can contribute to achieving all of those goals.

Bigger Hydraulic Systems are Not Always Better

When developing hydraulic systems, Cookson noted it is important to remember that bigger does not always mean better. In many cases, a more compactly sized system has the ability to provide the same performance as a larger system but with additional benefits possible such as weight reduction.

She said the fluid power industry needs to push to do more in smaller spaces. "This means we need improved system efficiencies and more accessibility in tight spaces," she said. These can help achieve the increased power density requirements many in the industry are seeking.

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Advancements in hydraulic hose designs are enabling them to become more compact so they can more easily fit into an allotted space.

Because space claim is becoming a greater concern in mobile applications, the ability to create compact systems capable of providing the same or better performance as larger systems will become more critical for those in the hydraulics industry.

As an example, Cookson noted how in the automotive sector there are insurance premiums in some regions related to the clearance around critical system components. She explained that in many cases, the more clearance there is around the engine compartment, the lower an insurance premium will be. Therefore, many OEMs are looking for ways to reduce the size of their engine compartment without having to make major changes to their vehicle platform — making way for other changes such as reducing the size of a vehicle's various components and systems.

Increased development of alternative power systems is also requiring the industry to reconsider the size of hydraulic components. Battery-electric systems, for instance, tend to take up more space due in large part to the size of the batteries, necessitating other systems become more compact. Doing so helps to offset the added weight of the batteries as well.

As no technology can yet overcome the power density of hydraulic systems, particularly in larger, heavier duty machines, hydraulics will still play a key role even as alternative power systems become more common. Cookson noted that in hybrid machines, there are actually more hydraulics used.

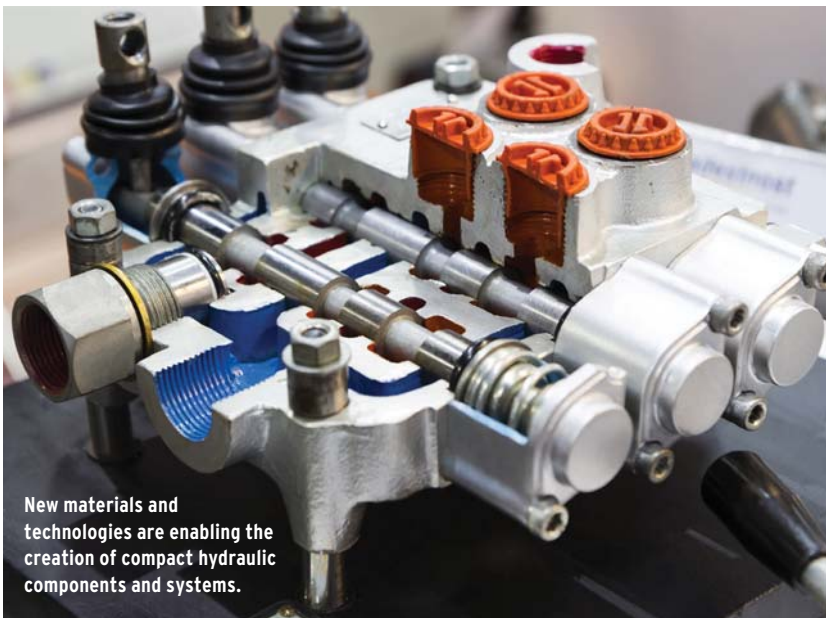
But to achieve the efficiencies desired in hybrid- and full-electric designs, it will be necessary to rethink hydraulic system architectures — which includes size considerations.

Technology Advancements Enabling Compact System Designs

Cookson said there are various technologies enabling the creation of compact hydraulic systems. Among these are advanced materials which have entered the market as well as innovative manufacturing processes.

Similarly, there are a variety of design methods which can be used to create compact hydraulic systems. During Cookson's FPIC presentation, the potential of hose bend radius and flow velocity capability improvements as a means of downsizing hydraulic circuits were mentioned.

She said there is a lot of research currently being conducted in this area, among others, to help enable the design of more compact systems. In terms of increasing flow, Cookson said there are opportunities to do so with some of the new materials that are entering the market.



New materials and technologies are enabling the creation of compact hydraulic components and systems.

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In general, though, it is important to understand the performance characteristics you're trying to achieve with your system design, various industry standards as well as ensuring the hose and other parts of the hydraulic system can fit within the installation space.

She explained that hoses are often the last component designed into a compact system, so there's often not a lot of space to route the hoses. "As the hose itself can get more compact without the inner diameter getting smaller, so you have smaller wall thicknesses, that offers a lot of value to customers because you can just physically fit the hose in the space," she said.

A greater integration of electronics with hydraulics is also enabling the creation of compact hydraulic systems. For motion control solutions, this pairing of electrical and mechanical can come in the forms of electromechanical, electrohydraulic or

> "There are tons of reasons why systems are getting more compact."
>
> — *Cindy Cookson*

"Technology developments are enabling more compact system designs."

electrohydrostatic actuation explained David Geiger, Engineering Manager at Moog Inc., during the FPIC quarterly seminar.

While each has its pros and cons, Geiger said electrohydrostatic actuation systems (EAS) bring together the best of both worlds, meeting many of the criteria which designers are looking for:

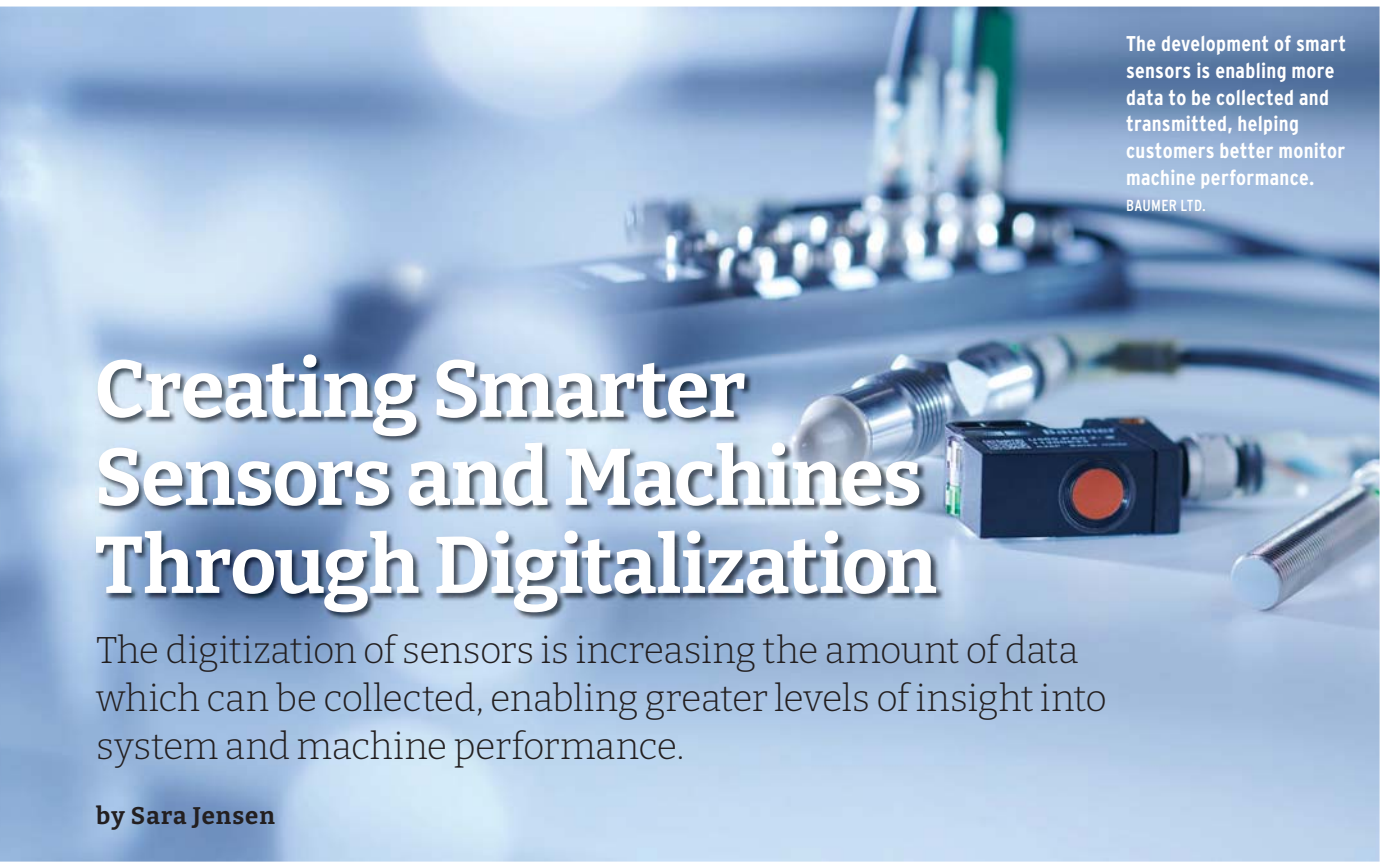
- energy efficiency
- environmental cleanliness
- low noise emission
- high forces
- no backlash.

EAS typically combines an electric motor, sometimes comprised of a servo drive and servo motor, with a hydraulic transmission — often a combination of a radial piston pump, manifold and hydraulic cylinder. Geiger explained that with EAS, you have a prime mover, such as a servo motor or any bi-directional motor, running a bi-directional pump to generation force and motion.

This technology is a key part of the company's Electrohydrostatic Pump System (EPS) which offers customers the ability to use their existing hydraulic cylinder technology. It is comprised of a standardized manifold with hydraulic accumulator and Moog's Electrohydrostatic Pump Unit (EPU) which is a compact device that enables creation of a decentralized system, eliminating the need for a hydraulic power unit and complex piping which allows space claim within a machine to be reduced.

Creation of compact systems was one of the key areas outlined in the NFPA's 2023 Technology Roadmap as a way for the fluid power industry to help meet various customer requirements, particularly in the areas of increased productivity and performance and lower total cost of ownership. To do so, the roadmap notes systems should not only be smaller in weight and size, but also able to provide increased energy efficiency and power density.

As the examples above demonstrate, development of new components and system architectures — alongside other technology advancements — will help to enable the creation of more compact hydraulic systems and the fluid power industry to achieve its future design goals. **P&M**



The development of smart sensors is enabling more data to be collected and transmitted, helping customers better monitor machine performance.
BAUMER LTD.

Creating Smarter Sensors and Machines Through Digitalization

The digitization of sensors is increasing the amount of data which can be collected, enabling greater levels of insight into system and machine performance.

by Sara Jensen

Sensors collect and transmit a range of information which can be utilized to monitor a machine's performance, potential maintenance needs and so much more. As they have become more digitized, the amount of data they can collect has increased, leading to not only smarter sensors but also smarter systems and machines.

This is enabling the transition to digitalization — the use of digital technologies to improve processes, services and more — which is taking place in various industries.

Power & Motion spoke with Kyle Lake, Product Market Manager SE-PR (process instruments) at Baumer Ltd., to get a better understanding of how sensor technology has evolved and the role it plays in digitalization.

**Editor's Note: Questions and responses have been edited for clarity.*

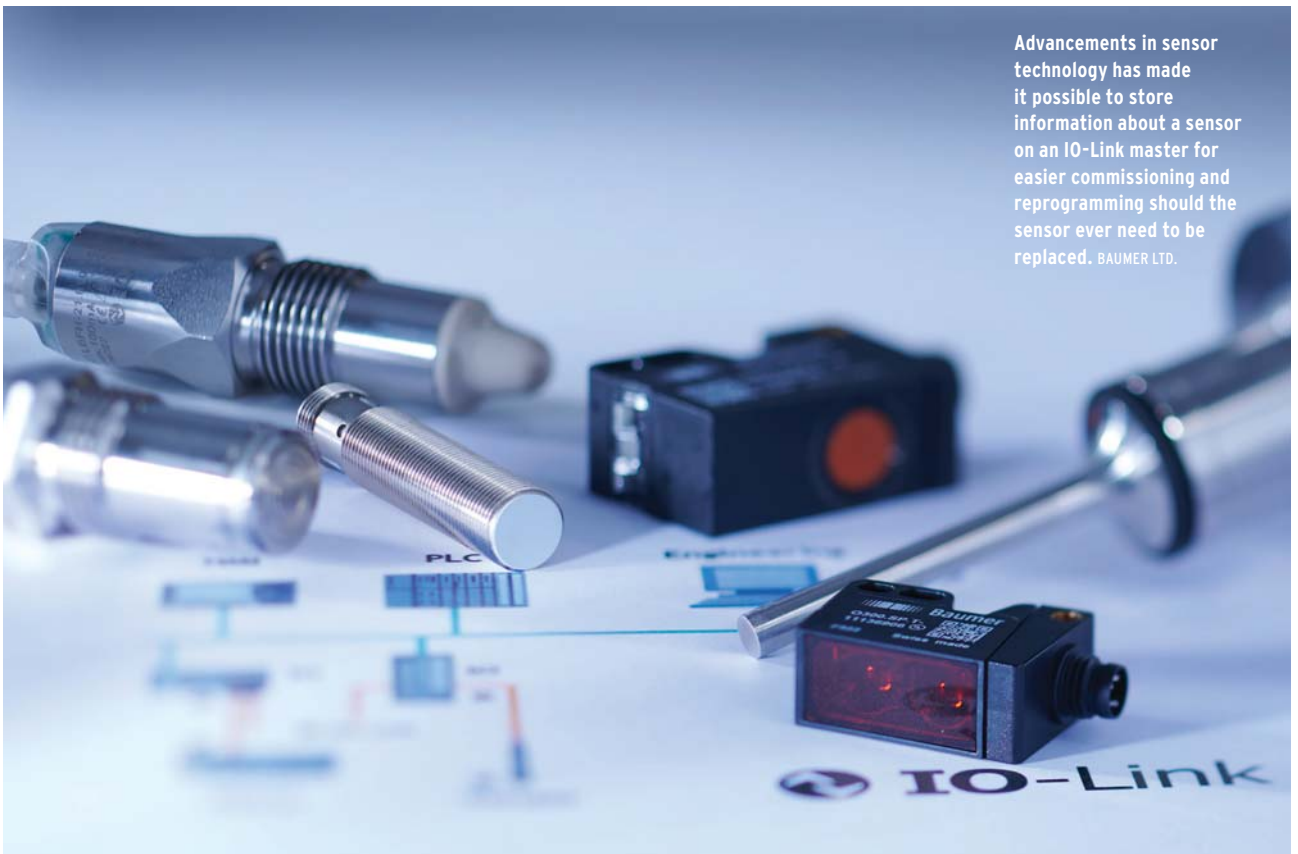
Power & Motion: It has been stated that digitalization starts with the sensor — could you explain why this is so and the types of sensors that are involved?

Kyle Lake: The idea that digitization is the access to more information quicker and easier, if a sensor can't provide that kind of information, and it typically can't via analog, it's not going to be of much use going forward. We at Baumer are looking to digitalize every sensor that we are developing now, whether that be a simple temperature measurement all the way up to absolute encoders, making that information available digitally, fast and easy so that, again, it can be used in many different fashions, not just the variable we're trying to measure, but also all the other information around the machine.

P&M: Not just sensors, but smart sensors are said to be a key part of digitalization and industrial automation. What constitutes a smart or intelligent sensor, and what benefits do they provide?

KL: We would consider something to be a smart sensor if it's easy to use as well as providing more information than a traditional process measurement. Using the temperature [measurement] example — does it give you the temperature value, whether it's in Celsius or Fahrenheit? Does it also give you how long the RTD has been running? Does it give you the temperatures it's seen in the environment it's been in? Has it seen a power surge? What are the minimum and maximum powers it's been seeing? Has it been changed, the programming or anything like that? All this information is what we consider a smart sensor.

The reason this is going to be good for automation and for applications is it gives you a better idea of how the machine is being used. Maybe it needs some additional cooling inside of one part of the machine, or the power supply isn't very clean if a customer is calling and complaining about problems or something like that.



Advancements in sensor technology has made it possible to store information about a sensor on an IO-Link master for easier commissioning and reprogramming should the sensor ever need to be replaced. BAUMER LTD.

P&M: How have you seen sensor technology, particularly for digitization, progress in recent years? What new features or capabilities have been brought to market?

KL: One of the biggest advantages of the new smart sensors is just in the commissioning of the sensors and/or machines. Because you can talk to them quicker, you have easier access to the information, you have more information to look at, [and] you can get [them] up and running faster.

In the case of the IO-Link, it could be something simple like the information about the sensor, once programmed, is stored on an IO-Link master. If a sensor is damaged and we need to hook up a new one, it automatically reprograms itself. So that means no more third shift stoppages, expensive staff on site all the time or an emergency call in to get someone there to hook up a new machine or hook up a new sensor and reprogram it.

And then with all the new information [from the sensors], we've been able to make the interface much more graphical. In the past, it was pots with a screwdriver and trying to guess "Did I turn it too much or not enough?" Then we went to things like heart or touchscreen electronics to program. Now you plug in a USB cable and you can use your keyboard and mouse; it's a very straightforward way to do it. Some of our devices have web servers on the Ethernet IP devices [which] that could be done through. [It is] very graphical, feels like you're going to a website. Or it could be software that uses the IO-Link communication to program and do different things that way.

P&M: What challenges yet exist with sensor technology, and how, if at all, is Baumer helping to overcome these with its own sensor products?

KL: The biggest challenge, and this is going to sound a little cliche because you hear it all time now, is just data. What data do we need to collect? What data do we not need to collect? And what do we do with the data?

We're trying to make sure that our sensors can provide as much raw data from the measurement itself and also the secondary data around it — the power consumption, running time, temperature spikes, dust buildup on lenses or any of those kinds of things.

We have some that will monitor the light value that's being put out and give you a quality bit that says there's dust beginning to gather; [it shows] from green to yellow to red [to indicate] how it's affecting the reading.

[It's not just about] giving you that data [and] access to the data locally, but then also how do you use that data, where do you take it. We're really working on making it accessible outside of the traditional process environment. Our new IO-Link masters have an OPC UA server built into them so you can actually export that information directly to some kind of spreadsheet, historian, whatever, gather that data and start to aggregate it and look through it and make it useful [so it is] not just numbers in a spreadsheet somewhere.

Smart sensors are those which can provide more information than a traditional process measurement.
BAUMER LTD.

"We're trying to make sure that our sensors can provide as much raw data from the measurement and the secondary data around it."

P&M: Related to the topic of data, is there certain types of data which customers are particularly interested in getting and is Baumer trying to tailor its technology to that?

KL: The quality bits are very important for customers. If it's a process that's in a dusty environment, they would like to know how often they have to clean their sensors, can they do some kind of air purge near the sensors to help clean them and keep up with [their cleanliness].

Power is another big one. People like to know how clean their power is and if they're seeing any power spikes. Power spikes aren't good for 24V devices, so if they're seeing big jumps [it could be a problem]. Ambient temperature is another one as well. If you get into high temperatures, it wears electronics quicker. So being able to see that kind of information [can be helpful]. The big buzzword is predictive maintenance — those all add data points to help you with that predictive maintenance. It's not going to do the maintenance, obviously, but it gives you some ideas and things to look at to build around [predicting maintenance needs].

P&M: How do you forsee sensor technology for digitalization continuing to evolve in the coming years? What new technologies or features do you see entering the market or are yet needed to further advance digitalization?

KL: It's hard for me to picture where the digitalization of sensors is going to keep going. If you had asked me maybe 5 years ago, I would have thought a bigger, brighter touchscreen would have been the key or the future of digitization of the sensors. And I've come to find out, it's actually going to be all internal to the sensor.We're going to keep getting more data out of the sensors. And again, that sounds cliche, but that's really what it's going to come down to. The next big step is going to be starting to interpret that data, and the software and the programs that will help with it.

When you buy a machine, will it come with a license that says we as the OEM can collect the data off the machine through a cloud and analyze what's going on with the machine and make maintenance recommendations and all those kinds of things? We've become such a subscription-based world, will you buy a warranty subscription [where] again, the OEM will monitor your machine remotely for you and you get $1,000 worth of sensors for the month, they send you those that look like they are wearing. Or is it going to be artificial intelligence (AI) built into the sensor? With all these new data points, are we going to be able to put a brain in there and it self-adjusts to keep the measurement accurate and moving in the right direction?

I don't know, but whatever the next step is, it's going to include more data and faster communications, whether or not everybody needs it or wants it. That's kind of where I think it's going. P&M

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How Connected and Software-Defined Vehicles are Reshaping System Architectures

As vehicles become increasingly connected and software driven, there are opportunities to create more streamlined system architectures.

by Sara Jensen

Advancements in vehicle technology over the past decade have led to increased levels of connectivity and the inclusion of more software-enabled features. Much of this is driven by the desire to create more efficient and automated vehicles of all types — from passenger cars to heavy-duty trucks to construction equipment.

Research firm IDTechEx is forecasting annual revenue for connected and software-defined vehicles will be worth over $700 billion by 2034 as manufacturers continue to invest in these technologies.

Connected and software-defined vehicles (SDVs) bring opportunities for new system architectures, many of which can be simplified compared to previous designs. James Falkiner, Technology Analyst at IDTechEx, wrote in a summary of the firm's market report on connected and SDVs that older internal combustion engine powered vehicles often included numerous components and kilometers of wiring.

However, he stated that the new era of vehicles can be more centralized, connected and convenient, bringing benefits to consumers and OEMs. For those in the fluid power and electric motion control markets serving various vehicle sectors, it is important to understand these new system architecture needs as it will influence their future designs as well.

What is a Software-Defined Vehicle?

Falkiner described SDV as that in which the software within a vehicle affects the user experience in some way. As the number of software-based features increases, the vehicle becomes more software-defined. These can include over-the-air updates, already a common feature in the trucking industry, or the ability to watch movies on the go.

A constant cellular connection is typically required for these vehicles as well as large touchscreens and a powerful central computing system which is connected to various components and systems within the vehicle.

In his summary, Falkiner noted that most vehicles introduced to the market over the past 5-10 years can be considered software-defined as they likely include some semblance of software-enabled features. During IDTechEx's analysis of the SDV market, it gained a deeper understanding of the various types; it created an SDV Level Guide to compare the various types available to help provide a better look at current and future designs.

The guide compares software and software-critical hardware by looking at a vehicle's connectivity level, compute power, type of displays and software systems. With each increasing level of software-enabled capabilities comes inclusion of more advanced technologies and higher levels of connectivity.

CAN-Based Systems Enable Connectivity and Streamlined Designs

The drive toward further connectivity between systems and vehicles "is allowing us access to far more data on devices than we previously had," said DJ O'Konek, Engineering Manager at Nott Co., during the National Fluid Power Association's (NFPA) December 2023 Fluid Power Industrial Consortium (FPIC) quarterly technology conference focused on connected systems and machines.

Use of CAN-based systems, including for hydraulics and pneumatics, has played a key role in enabling ever higher levels of connectivity and data collection. Many components for these systems feature integrated controllers, sensors and additional products to collect data. "This has created a lot of advantages in developing streamlined systems by simplifying the wiring since you can just have the CAN wires and power wires going out to those devices and the onboard CAN controllers can manage those devices," he explained.

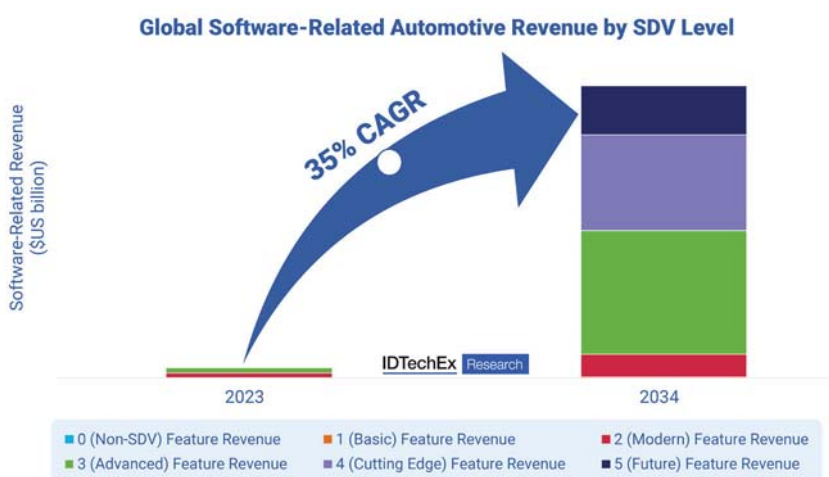
This design also provides distributed intelligence throughout the system, removing reliance on a primary controller, he said. Instead, decisions on how a component or portion of the system should operate can be made locally at each device.

The increased amount of data accessibility which is possible with CAN-based systems is allowing the creation of far more efficient systems, said O'Konek. "We can monitor all [performance] parameters far closer [to the component] than we used to," he said.

Additional safety can be built into a system as well because there are more controllers integrated into it. "We can have dedicated controls going on locally and have a redundant supervisory controller in the system," he explained.

There is also the possibility of adding error checking to the data and monitoring the outputs of most of the controllers being used within the system to see if any faults occur when connecting to the physical devices. This helps to ensure optimized performance and action to be taken faster should an issue be detected.

Creation of intelligent devices with integrated controllers, sensors, etc., is becoming common practice within the fluid power and other vehicle component sectors. Using linear actuators as an example, O'Konek said the more intelligent options now allow monitoring of rotation, torque, displacement, current draw, and linear force. "By having access to these pieces of information, we can control the force going into that [actuator's] operation to optimize for efficiency or to overcome specific limits," he said.



As more software-enabled features are added to vehicles in the coming years, there will be increasing revenue potential for automotive OEMs. IDTECHEX

Software-defined vehicles, such as that displayed by ZF at the 2021 IAA Show, present the opportunity to simplify system architectures which offers cost and installation benefits to OEMs.

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System Architectures Must Evolve to Meet Data Processing Needs

With the continued development of connected and software-defined vehicles will come the need to rethink system architectures, due in part to the vast amounts of data processed by these vehicles.

As data processing needs will greatly increase with these vehicles, Matt Via, Vice President of Sales and Marketing at HED Inc., said during the FPIC conference that OEMs will likely move toward use of zonal system architecture configurations. This will not only aid with data processing needs but also enable vehicle manufacturers to reduce the number of components required in a vehicle and thus the costs associated with producing it.

Typically, OEMs utilize a domain architecture in which vehicle controls are organized around functions and all inputs and outputs that are part of that function are wired back to that location he said. This requires at least four CANbuses to be used to move data across the vehicle. And as data needs continue to increase, so will the number of CANbuses.

Use of the Ethernet communication protocol instead could help meet future data processing needs without adding more components to already space-constrained vehicles. This will require a reorganization

of how functions are distributed from functions to locations on the vehicle, said Via, leading to an evolution from domain to zonal architectures.

"With [this] change, an Ethernet backbone is set up around the vehicle allowing controllers to share data between them. Within each zone, LAN and CAN, which are more optimized for lower speeds and lower data rate applications, are used to collect data from sensors while zonal gateways then use the Ethernet backbone to transfer aggregated data back and forth for data processing," he explained.

"The evolution from the domain to the zonal architecture will start with the alignment of the body domain, incorporating power distribution and central computing," he continued. "Over time, more and more domains around the vehicle [will be] added all using the same backbone."

Using a zonal configuration not only benefits increased data processing needs but also allows for simplification and shortening of wire harnesses, reducing space claim and production costs. Additionally, Via said that in a zonal configuration, "the software layers become more contained, allowing components to simply transfer raw data and remove multiple locations for software configurations, meaning less locations to maintain software."

All of this can help to create more simplified vehicle architectures which reduce production costs for OEMs and potential maintenance issues for end users — fewer components mean fewer failure points.

Future Market Opportunities for SDV

IDTechEx said the software-defined vehicle market is an emerging one with many OEMs in the automotive industry determining how to proceed with monetizing the features available in these vehicles as well as how they want to enable these features.

Per IDTechEx, OEMs such as Ford, Tesla and BMW are already generating revenue from software features such as connectivity, real-time traffic information and heated steering wheels.

Meanwhile, there are also automotive manufacturers still utilizing limited or sluggish onboard compute technologies and unoptimized software which is limiting the revenue potential they could see from more advanced, SVD designs.

According to Via, SVD will present revenue opportunities for OEMs in the heavy-duty equipment market as well. The ability to provide over-the-air updates in these vehicles over their lifespan will allow OEMs to build constant value for vehicles in the field, he said. The ability to fix issues with over-the-air programming can increase uptime, providing a key differentiator for early adopters of this capability.

With the amount of data collected by SVD, it will also be possible for machine manufacturers to get a better understanding of actual vehicle usage which can be used to design better machines. "Software is the future in vehicles that will drive changes to architectures and expand how connectivity is used in the vehicle," said Via.

He went on to say that in the future, SVD will also accelerate the pace at which data on vehicles is created, as well as the opportunities that can be created from data. It will provide OEMs with the chance to build customer value on existing vehicles, increase satisfaction, and lower warranty rates.

As such, it will be of paramount importance for manufacturers to focus on desired outcomes from the vast amount of data collected. "Users of data want to get an outcome that produces a better result, otherwise it's noise and expense," Via noted.

Given the many opportunities SVD can provide automotive and heavy-duty vehicle manufacturers, IDTechEx is forecasting a 35% compound annual growth rate (CAGR) for software-related revenue through 2034. P&M

[New Products]

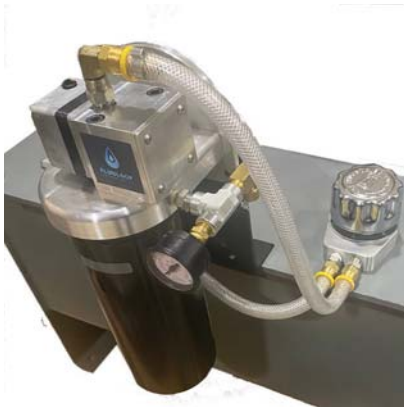
FluiDyne FM4 Series Motor

FluiDyne Fluid Power has added the FM4 Series Motor to its product line. The hydraulic motor is designed to be lightweight yet durable for use in low-speed, high-torque applications.

Features of the FM4 Series motor include:

- highly efficient design
- geroter gear set and spool valve flow distribution
- ability to be used in parallel or series systems
- ISO 9001:2000 quality

powermotiontech.com/21284518



FluidLoop Kidney Loop Filtration System

FluidLoop Technologies LLC (FluidLoop) has announced the commercial introduction of its FL-1000 kidney loop filtration system. It is designed to be a low-cost filtration system for small gearbox and hydraulic systems.

Features of the kidney loop filtration system include:

- low horsepower draw
- adjustable for use with different viscosity fluids
- circulates oil at flow rate of 0.05-0.45 gpm
- ability to be tank or wall mounted.

powermotiontech.com/21281244

Gefran Twiist Linear Position Transducer

Gefran Inc. has introduced its Twiist sensor to the market, a contactless linear position transducer capable of providing multiple measurements from a single unit.

Features of the Twiist sensor include:

- helical magnetoelectronic design
- linear, angular and temperature measurements
- compact and air-tight unit
- analog and digital outputs.

powermotiontech.com/21282004

ALT Bearings HRA-i Roller Screw

ALT Bearings (Advanced Linear Technologies) has developed the HRA-i which integrates an inverted roller screw with an ultra-high capacity roller bearing known as the Herringbone Roller Bearing (HRB).

Features of the HRA-i include:

- reduced weight and improved reliability
- need for flange and locknut eliminated
- high power density
- variety of application uses.

powermotiontech.com/21281134

Curtiss-Wright Exlar Tritex EVA

Curtiss-Wright's Exlar Tritex EVA electric valve actuator is designed to provide valve control in the process and oil & gas industries.

Features of the electric valve actuator include:

- compact design integrating servo drive, motor, and roller screw actuator
- fast valve close times in as little as 1 second
- Modbus RTU communications for remote operation and monitoring
- CSA Class 1, Division 2 (C1D2) Hazardous Location certification.

powermotiontech.com/21284820

Clippard AIV Series Air-Piloted Media Isolation Valves

The Clippard AIV Series air-piloted media isolation valves are air operated which makes them an intrinsically safe device for flow control.

Features of the AIV Series include:

- no heat build-up
- multi-functional valve stem for long life
- compact and lightweight design
- wetted areas are PTFE and PEEK for use with corrosive media.

powermotiontech.com/21284818

POSITAL Wheel-Encoder Assemblies

POSITAL offers measuring wheels and accessories which can be used in conjunction with its IXARC encoders to measure linear motion as well as speed in various applications.

Features of the wheel-encoder assemblies include:

- resolutions as fine as 0.1 mm/pulse
- measurement of speed and position directly from moving surface
- circumferences of 200 mm, 500 mm, or 12 in. available
- customizable to meet the exact requirements of each application.

powermotiontech.com/21284814

Advertiser Index

Pneumatic Designs Evolving to Meet Industry Trends

Automation, sustainability and a desire for increased intelligence are driving an evolution in pneumatic system designs.

by Sara Jensen

Increasing implementation of automation in manufacturing and other industries is helping drive the need for new pneumatic component and system designs. In relation to this, customers are looking for solutions which can aid their sustainability efforts as well as those offering data.

Power & Motion spoke with Rex Bateman, Director of Engineering at SMC Corp., about how these trends are influencing developments in the pneumatics industry and how he sees the market performing in the coming year.

**Editor's Note: Questions and responses have been edited for clarit.*

Power & Motion: What trends or market factors do you feel had the largest impacts on pneumatic component and system designs in 2023? Please explain what those trends are and how specifically they impacted the design of pneumatics.

Rex Bateman: As the labor shortage persists, the need for automation in industry continues to rise. Combatting the labor shortage requires more flexibility in automation and lower costs to satisfy the growing demand. With this rise in automation, as well as the increased global awareness and efforts towards sustainability, the need for sustainability in automation is more prevalent than ever; it is now an expectation from customers.

The sustainability movement is reducing material choice, which requires innovation from manufacturers to design lighter weight, more compact products using less material. These smaller products not only yield space and material savings, but they also decrease the payload on EOAT (End-of-Arm Tooling), thus yielding energy savings as well.

Customers are also asking for more intelligence, analytics, and integration for all pneumatics that allow for monitoring of machine output so they can spot leaks, manage downtime, and ultimately cut costs. These innovations decrease the power consumption from end users, which is a huge selling point for their own customers. In addition to the expectation to reduce power consumption on the end-user side, there is also an expectation for manufacturers to be more sustainable in the component manufacturing process.

Compact pneumatic components, like the pictured CQ2 Series Cylinder, can help manufacturers meet sustainability goals by using less material. SMC CORP.

P&M: How have you seen pneumatic component and system designs evolve in recent years?

RB: While most basic components of pneumatic systems are well-established, there are still many innovative ways to evolve these components for specific applications and solutions. One evolution of components is the production of specialized product options to support growing industries, such as the secondary battery industry where material content can affect final product quality and dry atmospheres can negatively affect the life of pneumatic components.

Another example of recent evolution is the ability to integrate industrial networking into control products such as valve manifolds, electro-pneumatic regulators, pressure and flow sensors, etc. In the age of Industrial Internet of Things (IIoT), system operators demand easy-to-maintain systems that allow remote control of components and analytics to track performance and prevent downtime. SMC's new Air Management System, the AMS Series, satisfies these demands and more.

P&M: What are some of the key features or performance attributes your company is working to include with its pneumatic components and systems, or for which customers are asking?

RB: SMC's Air Management System, the AMS Series, is a game changer for customers that are concerned with energy savings, predictive maintenance, and ease of installation. Instead of simply controlling the air pressure at a machine's inlet, the AMS Series sends data via OPC-UA that can be used to monitor the overall health of the machine and has features to automatically adjust air pressure during downtime to improve energy savings.

The AMS Series has other built-in features like wireless connectivity, EtherNet IP, and IO-Link to make installations flexible.

Read the full interview at powermotiontech.com/21276687. **P&M**

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