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March/April 2023

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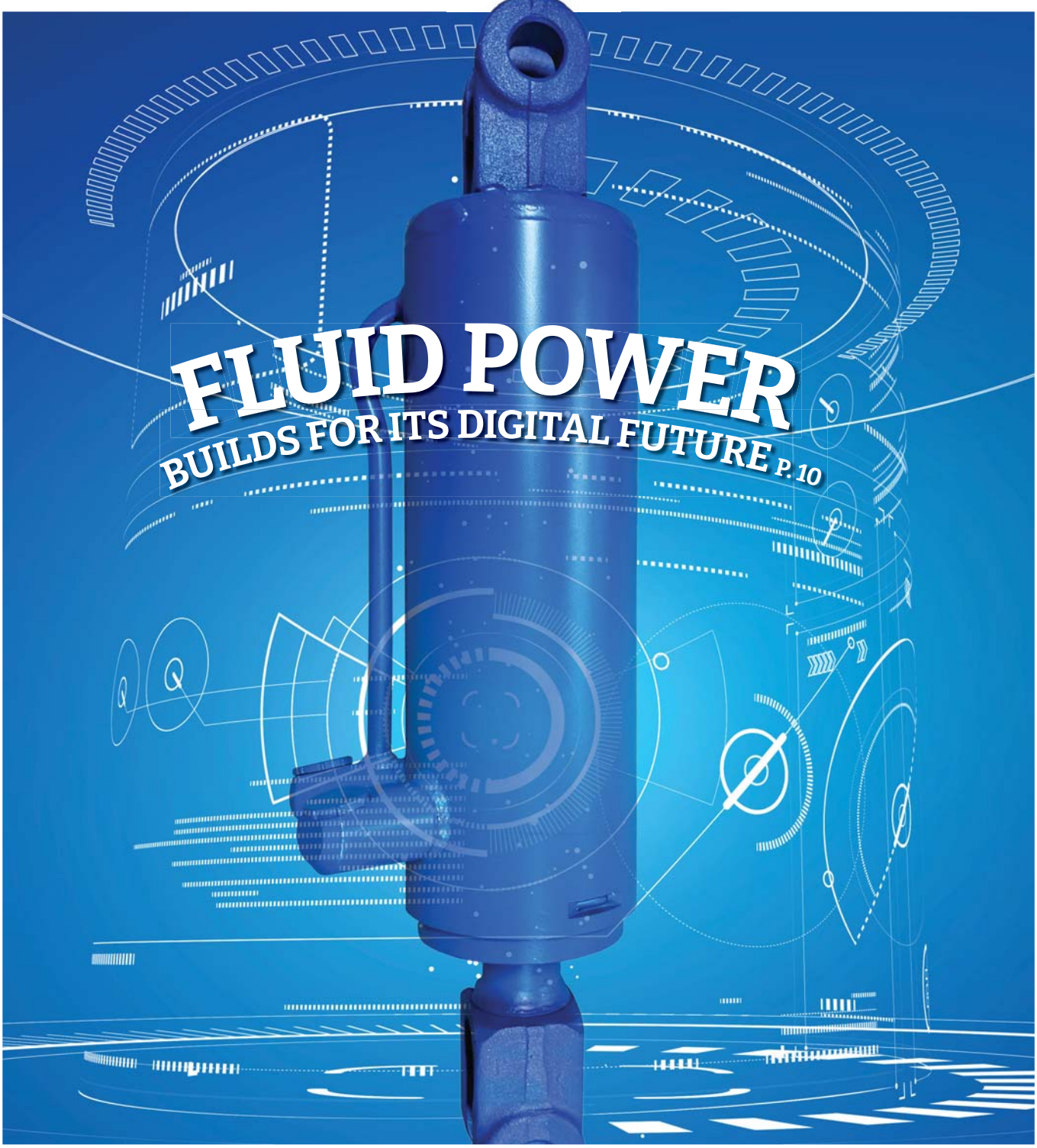

FLUID POWER BUILDS FOR ITS DIGITAL FUTURE

P. 10

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The hydraulics and pneumatics industry showcased the innovation taking place which will aid with the growing trends toward electrification, automation and digitalization.
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Hydraulic and Pneumatic Shipments Start 2023 on Positive Note

NFPA reports fluid power shipments remain on a growth trend into the start of 2023.
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Ramping Up for Hannover Messe 2023

The annual industrial event will highlight innovations in Industry 5.0, carbon neutrality and new ways to utilize technology in manufacturing operations.

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POWER&MOTION
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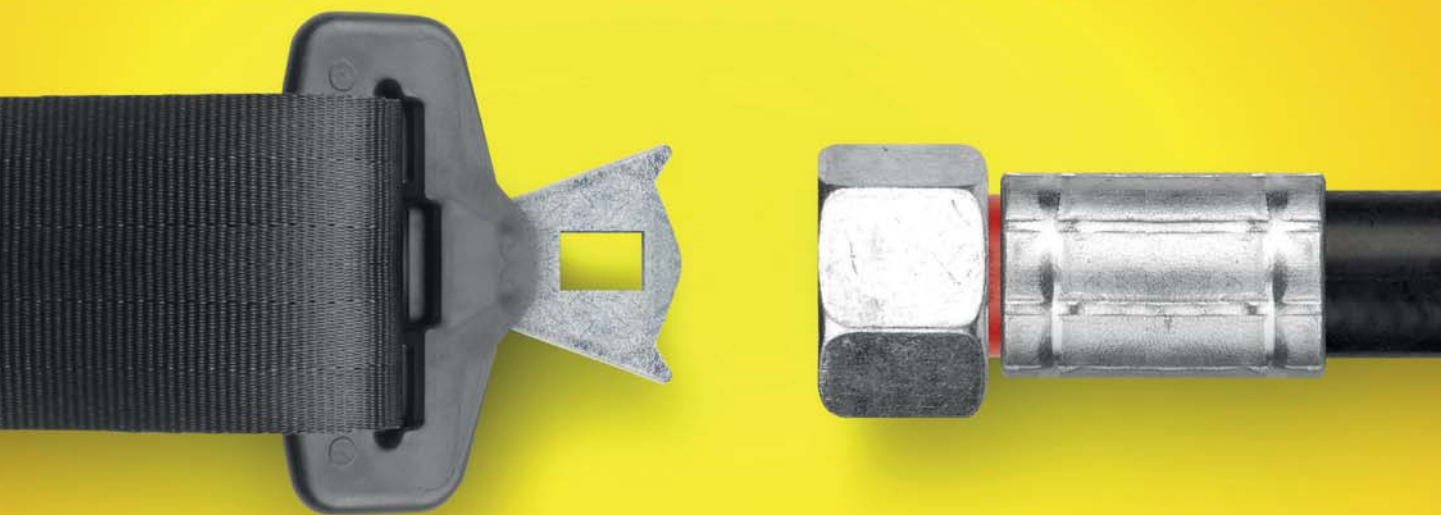

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The Continued Evolution of Hydraulics and Pneumatics

In 2023, *Power & Motion* celebrates its 75th anniversary. Just as hydraulic and pneumatic technologies have evolved over the past 75 years, so too has the publication.

The first issue was published in February 1948 and at the time was called *Applied Hydraulics*. As coverage slowly expanded to provide technical information on both hydraulics and pneumatics, the publication's name was changed to *Applied Hydraulics & Pneumatics* in 1958. Two years later in June of 1960 the word 'Applied' was dropped from the name.

And in 2022 *Hydraulics & Pneumatics* rebranded as *Power & Motion* to be more inclusive of the increasing integration of electronics, software and other advancements taking place in the fluid power and motion control industries. With this rebranding our team is working to ensure a continued focus on hydraulic and pneumatic systems while recognizing the need to cover related technologies being integrated into or impacting fluid power systems as well.

In the editor's letter of the first issue of *Applied Hydraulics* released in 1948, it was stated that use of hydraulic mechanisms for actuation and control had grown tremendously and showed further growth potential in the foreseeable future. Fast forward 75 years and hydraulics have become ubiquitous in so many applications, from large construction machinery to automobiles to manufacturing equipment and more. Even with the increasing implementation of electrification, hydraulics are still considered to offer the power density required in many applications.

A key phrase we continue to hear over and over is that it is an exciting time for the fluid power industry because of the many changes taking place and the role hydraulics and pneumatics will continue to play even as other power transmission technologies enter the market.

To highlight the ongoing evolution of the fluid power industry as well as our own publication, throughout the year we'll revisit some of the articles and topics from the past 75 years and assess just how much has advanced, and will continue to advance in the next 75 years. If you have ideas to share on the evolution of the fluid power industry, let us know! *Read an extended version of this Editor's Note at powermotiontech.com/21260817.*

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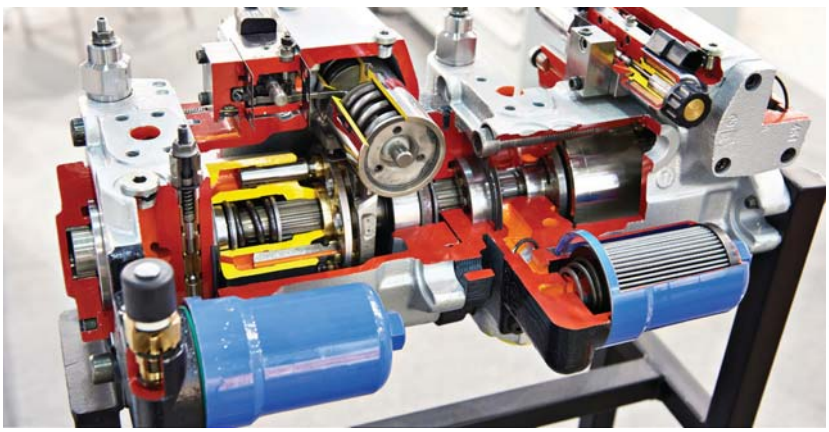
MAKELAB

NFPA Sets Customer Drivers and Strategies for 2023 Technology Roadmap

Key customer requirements will help determine future fluid power technology developments.

by Sara Jensen



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Updates to the NFPA Technology Roadmap will aid with future developments for axial piston pumps and other fluid power components.

The National Fluid Power Association (NFPA) is in the midst of its biannual update to its Technology Roadmap for the Fluid Power Industry. Through this roadmap the association provides a look at industry needs and how fluid power can potentially meet those needs, as well as research and development objectives to help meet current and future industry requirements.

In order to best determine the needs and objectives outlined in the roadmap, NFPA surveys the industry for its input. The NFPA Roadmap Committee helps to oversee the process and is led by members working in hydraulics and pneumatics. Bradlee Dittmer of NORGREN is the chair for the 2023 Roadmap Committee and Steve Meislahn of Sun Hydraulics/Helios Technologies is vice chair.

Industry Sets Development Targets

The first step in updating the roadmap was to survey the industry on technology drivers for fluid power customer markets and determine key customer drivers which will help to create a framework for the roadmap.

The association defines a customer driver as a top level performance objective that machine builders in the markets served by fluid power have for their machines, while a customer strategy is a machine-level objective or technology that is currently being deployed to help those machine builders achieve their performance objectives.

After reviewing the survey results, the NFPA Roadmap Committee determined there are four key customer drivers for the fluid power industry in the coming years:

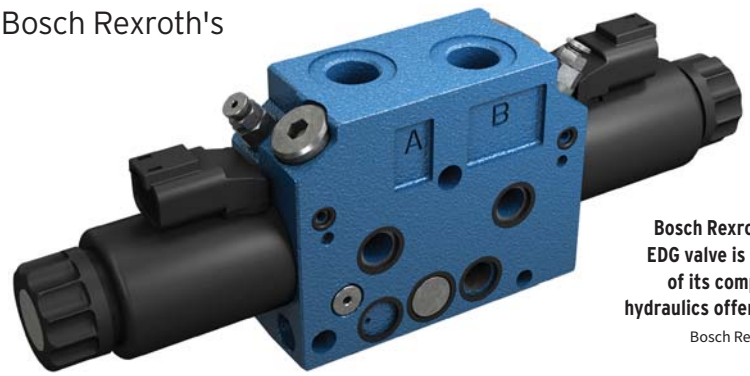
- Increased availability and uptime. Generally defined as the robustness of the machine, its ability to work continuously.
- Increased productivity and performance. Generally defined as the efficiency of the machine, its ability to do more work in less time.
- Lower total cost of ownership. Includes capital and/or operating costs.
- Compliance with regulations. Such as those pertaining to environmental, safety or other concerns.

Read the full article at powermotiontech.com/21259600. P&M

Bosch Rexroth Completes HydraForce Acquisition

HydraForce will become a part of Bosch Rexroth's compact hydraulics business.

by Sara Jensen



Bosch Rexroth's EDG valve is part of its compact hydraulics offering.
Bosch Rexroth

On Feb. 3, Bosch Rexroth completed its acquisition of HydraForce upon receiving approval from antitrust authorities. HydraForce will join Bosch Rexroth's Compact Hydraulics portfolio, helping to further expand the business unit's product offering and customer support.

The companies initially signed the acquisition agreement on July 15, 2022.

Although both companies offer various compact hydraulic products, HydraForce will bring its expertise in development of mechanical and electrical cartridge valves and hydraulic integrated circuits (HIC) which will help complement Bosch Rexroth's current portfolio.

According to Bosch Rexroth, the merger of the two companies' products will enable a broader range of offerings to meet varied customer needs as well as aid with the regionalization of supply chains—a growing focus for many companies to more easily meet customer demand.

"With Bosch Rexroth, we found a great partner who values and shares similar views on innovation, customer focus, application expertise and culture. I believe the new ownership will create great opportunities for our customers, partners and employees and lead to sustained growth," said Mike Terzich, president and CEO of HydraForce.

Managers from Bosch Rexroth and HydraForce will comprise the leadership team for the Compact Hydraulics Business Unit which will be headed by Frank Hess who currently leads the unit.

"As HydraForce and Bosch Rexroth join forces, we will combine our customer focus, application expertise and entrepreneurial know-how to achieve sustained growth above market. Together, we will continue to provide excellent support and innovations for our customers, further develop our strong relationships with partners and open great opportunities for our associates," said Hess.

Combined Expertise will aid Market Growth

The acquisition of HydraForce will enable Bosch Rexroth to expand its footprint in North America by growing its sales network and gaining access to more markets. "By acquiring HydraForce, we are expanding our presence in complementary geographies and developing a more balanced footprint in Europe and North America, while also enabling growth in Asia," said Rolf Najork, member of the board of management of Robert Bosch GmbH and CEO of Bosch Rexroth AG, in the company's press release announcing the acquisition.

HydraForce employs 2,100 people at six production sites located in the U.S., Brazil, Great Britain and China. Bosch Rexroth's Compact Hydraulics business includes approximately 1,800 employees at locations in China, the U.S., Germany and Italy.

The merger of these companies will expand the workforce and manufacturing capacity to help meet ongoing demand for hydraulic components, particularly in heavy-duty mobile equipment applications which is a strong market segment for both companies. This market is also expected to see continued growth in the coming years.

In addition, HydraForce noted in its press release announcing the acquisition the companies' regional sales structures are also complementary to one another. Bringing their sales activities together will create a well-balanced entity in North/South America and Europe, as well as support further growth in Asia Pacific, stated HydraForce in its press release.

HydraForce will also help improve global market access for Bosch Rexroth to indirect sales channels such as dealers and system integrators which benefits the company's long-term goals.

"With its diversified portfolio and international setup, Bosch Rexroth has a strong foundation. The acquisition of HydraForce expands our global market access through indirect sales channels: Sales partners and system integrators will become important target groups. In these challenging times, we are also helping to stabilize regional supply chains so that we can support our customers even better," said Hess.

Integration of the two companies has begun; customers and suppliers will continue to be served by their respective sales and purchasing teams. For now, HydraForce will operate under its own branding. The newly formed Compact Hydraulics Business Unit will operate from the current locations of Lincolnshire, Ill. and Nonantola, Italy. P&M

Understanding Digitalization and

Implementation of digital technologies is increasing in hydraulic and pneumatic systems, bringing a range of benefits and the need for more industry education.

by Sara Jensen

Digitalization is making its way into a variety of industries. But what exactly is digitalization and how can it benefit hydraulics and pneumatics?

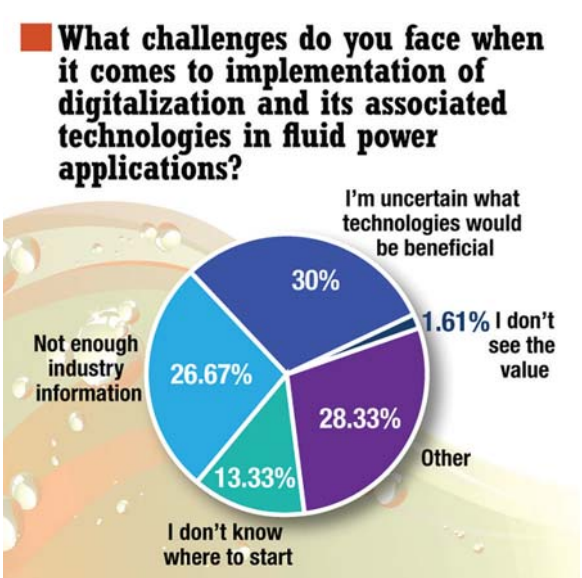
To get a sense of where the industry currently stands on the subject, *Power & Motion* surveyed its audience—looking at how much is understood about digitalization and to what extent it is being utilized in fluid power systems.

What is Digitalization?

A majority of respondents to the survey said they were either very familiar or somewhat familiar with the term digitalization, the technologies it entails and how it can be applied with the majority, 56.45% responding they were somewhat familiar.

An overwhelming majority, just over 95%, agreed that more education and information on the subject is needed within the fluid power industry.

So to aid with that, it may be important to start by defining digitalization. In a white paper from the National Fluid Power Association (NFPA)—released ahead of the International Fluid Power Exposition (IFPE) 2023 where digitalization was a key trend on display—the term is defined as leveraging digital technologies to enable or improve processes.



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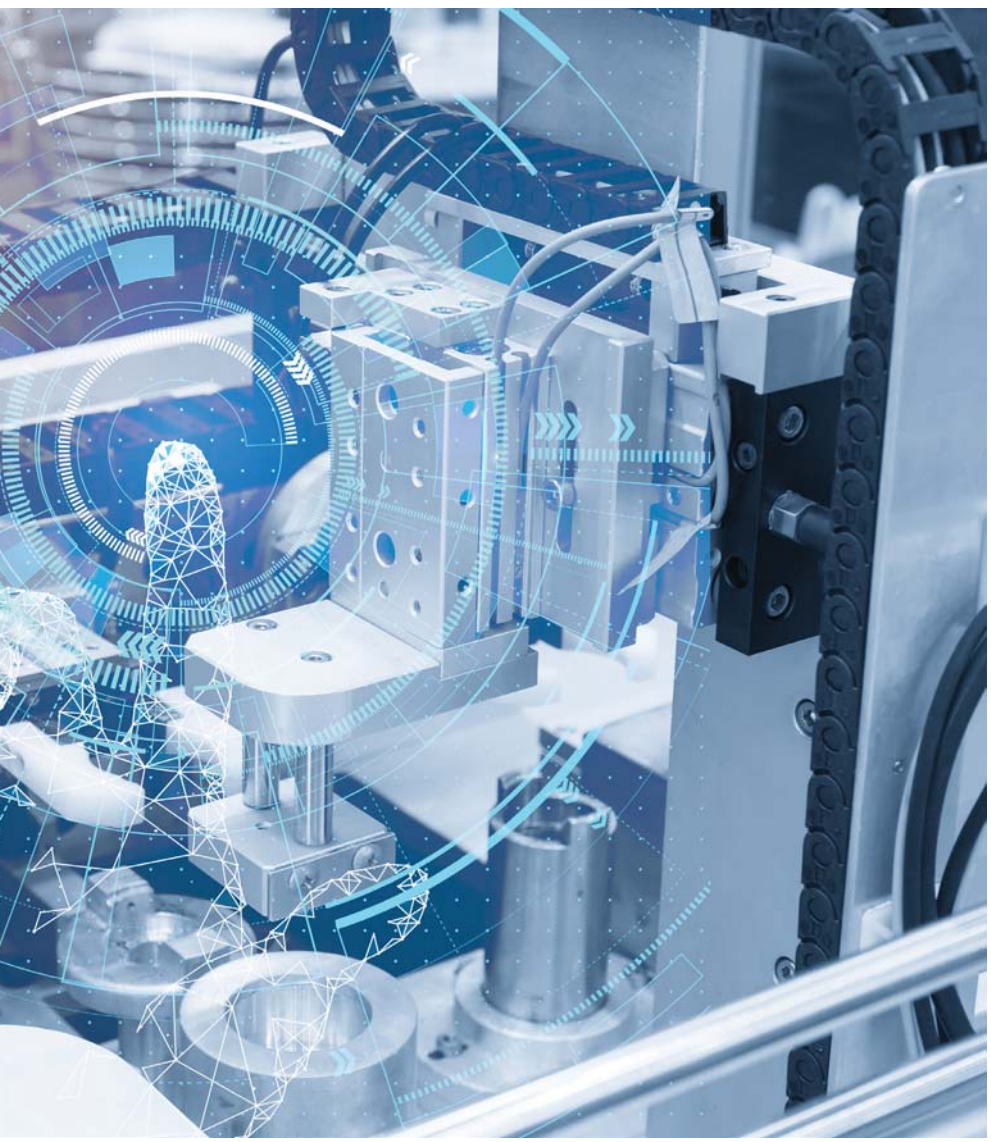
This can be achieved through use of on-board or centralized processing technologies which can help to collect, analyze and transmit information about the performance of a component or system. NFPA's white paper points to Casappa's Smart Piston Pump, displayed at IFPE 2023, as an example of digitalization in a fluid power application. The pump features an integrated electronic control unit (ECU) and sensors which help to provide enhanced digital control of the hydraulic pump, improving its efficiency.

its Use in Fluid Power



It should also be noted the term digitalization is different from digitization. The latter refers to making analog information digital which can then enable digitalization. Essentially, digitization can be viewed as the ability to collect and send data and digitalization as use of that data to improve performance or other aspects.

Kevin Vanderslice, director of sales, mobile machinery at ifm efector inc., spoke at IFPE about the digital transformation currently taking place. A key aspect for OEMs, their suppliers and end-users is understanding why digital technologies are important and why anyone should care about the data which can be collected. He said the digital revolution is happening and everyone is at different stages of implementation.

What Technologies are Involved?

Enabling digitalization is the increased integration of electronics, such as sensors, into components and systems. This allows the collection of performance data which can then be analyzed and transmitted.

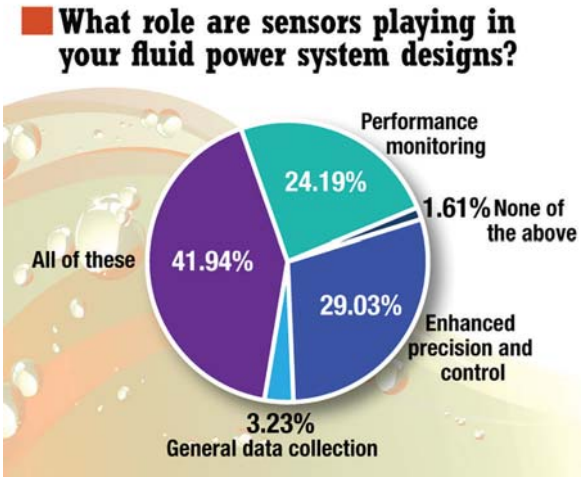
The majority of survey respondents said their fluid power systems now include sensors, with just over 35% indicating more than 50% of the components and systems they are designing have sensors included. This was closely followed by 24% responding 25-50% of their fluid power components and systems feature integrated sensors.

However, almost 23% said less than 10% of their hydraulic and pneumatic systems include sensors, indicating there is still room for growth in this area.

Of those integrating sensors into their fluid power systems, the majority are using them for performance monitoring and enhancement of precision and control. Several respondents indicated sensors are being utilized for multiple purposes as well.

In an interview with *Power & Motion*, Russ Schneidewind, OEM sales manager at HydraForce, said the company is seeing the need for increased precision and control from hydraulic components. As such, HydraForce is among those integrating more sensors into its products. Its new Innercept Digital Proportional Control solution, for instance, features an integrated position sensor and Linear Variable Differential Transformer (LVDT) to improve upon the precision and control of its hydraulic components.

HydraForce has also partnered with Tan Delta and Elevat to pair its hydraulic systems with an oil monitoring sensor and telematics. This will allow performance of the system to be better monitored and alerts sent to machine owners as needed



if issues arise. Schneidewind sees incorporation of sensors and telematics increasing within the fluid power industry to help better monitor system performance.

As Vanderslice explained during ifm's press conference at IFPE, sensors provide the data and telematics will provide the knowledge to interpret that data.

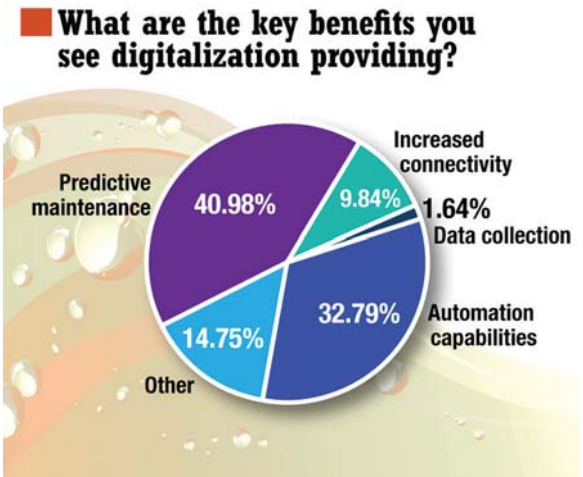
To enable these performance-monitoring capabilities, artificial intelligence (AI) and the Internet of Things (IoT) are often used to interpret collected data and transmit it to maintenance personnel. In some cases this information can be used to predict maintenance needs, helping machine owners improve their operations. Having the ability to better monitor when or if a maintenance issue will occur allows them to be proactive about maintenance needs and reduce the chances of costly unplanned downtime.

In conjunction with the rise of integrated sensors is the growing use of software which can work together with the sensors, AI and IoT to collect, analyze and transmit data. The majority of survey respondents said they have seen use of software increase in recent years and 94% anticipate its role in hydraulic and pneumatic systems increasing further in the coming years.

Challenges and Opportunities

While it is clear digitalization is making its way into the fluid power industry, responses to *Power & Motion*'s survey showed there is less clarity when it comes to implementing it.

About half of the respondents indicated the top challenges associated with implementing digitalization are a lack of industry information and uncertainty about what technologies would be beneficial. Additionally, some said the amount of



software choices and tools for configuration and programming can pose challenges as well.

Multiple respondents noted a resistance to change within the industry and the need to convince management and customers of the benefits. Current approaches not being up-to-date, the age of equipment, the amount of time needed to implement technologies and costs associated with doing so were also offered as challenges for the industry.

Incorporation of sensors and telematics is increasing to better monitor system performance.

In general, though, the majority of respondents see digitalization benefiting the fluid power industry with almost 97% indicating as such. Predictive maintenance was the top choice among the potential benefits of digitalization in hydraulic and pneumatic systems. This was followed closely by the ability to integrate automation into systems.

Energy efficiency, improved performance, failure monitoring and cost savings—likely through the ability to improve maintenance and performance—were also benefits which respondents said could be achieved through the implementation of digitalization.

The overwhelming majority—98% of survey respondents—foresee further growth of digitalization and its associated technologies in the fluid power industry over the coming years. **P&M**

Electro-Hydraulic Systems

Realize Their Full Potential with IoT

Implementation of Internet of Things technologies on mobile equipment is bringing opportunities for improvement in electro-hydraulic systems.

by Russ Schneidewind

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Forward-looking organizations are adopting emerging technologies that provide access to critical data to create a competitive advantage. Companies are using live machine data to accelerate operational efficiency, differentiate their products, improve customer service and add new revenue streams to their businesses.

The implementation of sophisticated Internet of Things (IoT) technologies on mobile assets, which was once only possible on the factory floor, opens the door for numerous areas of improvement in electro-hydraulic systems. These systems are designed for machine applications in off-highway such as farming, construction, mining, forestry and other industries.

Benefits to the users of IoT-enabled mobile machines include enhanced productivity, reliability, safety, profitability and more. In addition, these technologies can become key differentiators for original equipment manufacturers (OEMs).

Connectivity and Convergence

New IoT technology methods of gathering data, along with new business intelligence models that analyze this data, are converging to offer critical insights into the operation of mobile assets. With widespread global access to 4G connectivity and the onset of 5G—which is 20 times faster than 4G networks—machines can control an abundance of data while operating. Advancements in sensor technology, both in technical capabilities and size and form factor, are also making it easier to gather and leverage equipment data. This data is being used to optimize machine applications.

Companies across the globe are integrating data-driven products into critical functions on the machine and are developing new products that assimilate technologies into robust and compact packages. For example, controllers and remote access units are used in conjunction with hybrid cartridge valve products with integrated sensors and on-board electronics which can provide data on the performance of the controlled function.

There is a trend toward "hybrid" hydraulic products that have integrated electronic controls. In many capital intense industries, including oil and gas, construction and farming, real-time oil condition monitors can be integrated to provide critical data about the quality of the system's hydraulic fluid.

According to the Association of Equipment Manufacturers' (AEM) The Future of Building, construction companies will derive value from their data over the next 10 years by making it available to others. Sensors on construction equipment present great potential, as the equipment is on the job site 24 hours a day and can provide rich insights. As part of a robust data ecosystem, these types of insights have great value both within the equipment value chain and to external markets.

Improved Productivity

Connected devices on mobile equipment enable opportunities for productivity improvements using electro-hydraulic systems with sensing technology. These technologies provide data through telematics and can alert organizations of potential failures and avoid costly machine downtime. With these timely alerts, spare parts can be ordered and installed to avoid catastrophic failures, while project managers can schedule repairs proactively to enhance productivity further. In addition, service technicians can remotely debug or update programming in a controller, eliminating the need to visit the machine in the field, reducing cost and maximizing machine uptime and availability.

Advanced and ever-growing edge controller technology also allows decisions to be made locally, rather than in the cloud, for faster response to changing conditions on equipment, quickly leading to future autonomous capabilities.

Improved Quality

The quality of construction work on a job site or produce grown and collected on the farm is improved through data collected with IoT technology. IoT data is collected through numerous wired or wireless sensors and visual recognition technologies

such as cameras, radar and lidar. These technologies deployed on thousands of assets provide better information on ground and weather conditions, temperature, vibration, noise and other aspects allowing for data-driven business decisions.

Improved Safety

Companies and farms can also improve safety through knowledge of machine movement on the job site or farm where people work alongside the machines. Sensors placed on people working around the machines indicate their positions with respect to equipment. Autonomous assistance functions can ensure that the machines maintain a safe distance from these people.

Improved Profitability

IoT helps equipment owners avoid catastrophic failures that result in costly repairs or downtime and can also improve the asset management process. When machines are easily located and operated within their optimal work cycle, they are easily accessible so the farmer or construction company can improve profitability through the efficient use of their assets across fields or job sites.

These functions also allow for accurate asset tracking to help with theft detection. IoT uses GPS to track equipment location so owners can set alerts to notify them when a vehicle has left a job site or field to mitigate theft. Through the use of geofencing, machines can also shut down automatically when a vehicle leaves a set boundary.

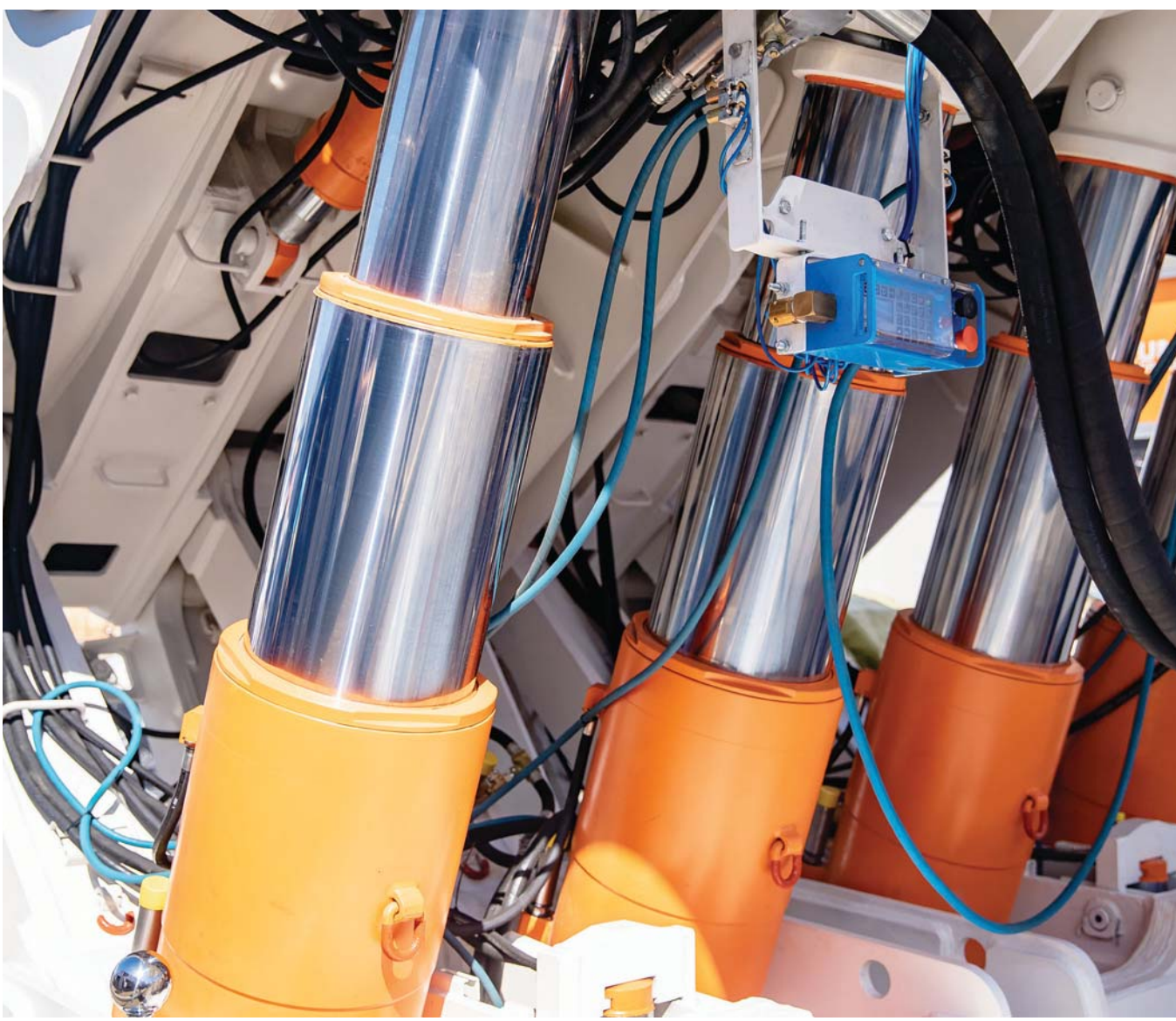
Overall, one cannot understate the power of IoT in hydraulics. The robust data collected offers opportunities for improvements across multiple business areas—not just within the hydraulics system or on the machine. This data can improve productivity, quality, safety and profitability for construction companies, farmers and other equipment owners. It can also differentiate OEMs, helping them to create a significant competitive advantage. **P&M**

This article was written and contributed by Russ Schneidewind, director of business development at HydraForce. He has more than 25 years of engineering experience. HydraForce helps smaller OEMS make use of technology by providing application engineering expertise along with a customized line of IoT solutions.

Matching a Pneumatic Cylinder's Output to the Application

Sizing a cylinder for a specific application can be challenging, as designers need to know the actual amount of force a cylinder can supply, the internal friction the cylinder will generate, the operating air pressure and several other related factors.

by Joe Malloy



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Pneumatic cylinders and actuators are much like their hydraulic and electric counterparts: Their main task is to generate enough force to move a load from one point to another. But how much force is needed in specific applications? Although calculating the theoretical force output is fairly straightforward, properly sizing a pneumatic cylinder for an application is much more challenging. Following are some simple tips that will help engineers determine the right cylinder for the task at hand.

Calculate the force. A pneumatic actuator exerts a force that can be calculated using the equation $F = PA$, where A is the pneumatic piston's usable area and P is air pressure. For example, a cylinder with a 1.5-in. bore and an extend force of 80 psi generates $(80 \times (1.5/2)^2 \times \pi)$ or 141 lb. of force. But this is the *theoretical* amount of force exerted. Several other factors work to reduce the amount of force actually applied. So, keep the following issues in mind when sizing a cylinder.

If needed, subtract the rod area. The theoretical force is the usable piston area multiplied by air pressure. If using the return stroke, or a double-rod cylinder, however, the rod area must be subtracted from the usable piston area.

Know the operating pressure. A compressor might be rated to handle a certain pressure, but the pressure the cylinder sees in operation can be much lower due to other equipment's air consumption or other air-supply restrictions. An air supply running at 100 psi may drop to 80 psi or lower during peak air use times.

Allow for internal friction. Internal friction generated by seals, bushings, wear bands and supports prevent cylinders from ever reaching their theoretical maximum force outputs. The loss in force is typically 1 to 10 psi of the cylinder's theoretical force output, depending on the type of seal. Cylinders with side loads, misalignments or specialty features have even higher levels of internal friction.

Know the true load. Unless the load is being lifted vertically and is not guided, it can be challenging to determine the true load. For example, determining force loss due to sliding friction is calculated using Friction Force = Friction Coefficient × Normal Force. Unfortunately, the coefficient of friction is often difficult to determine. And while there are tables that list coefficients of friction for various materials, there can be small variations in the coefficient's value and these small variations can make a big difference in calculating the required force.

Engineering teams sizing a cylinder for an existing application that are stymied in their pursuit of the required force should try to physically measure it. If it is a new application, carry out as many experiments as possible to prove the initial calculations.

Add speed requirements to the equation. Acceleration equals excess force divided by the total mass being moved ($A = F/m$). Total mass includes the mass of the cylinder and piston-rod assembly. But air must get into the piston quickly enough to build enough pressure to generate the required acceleration force and speed. If this is a concern, contact the distributor/supplier for help in determining the actuator's performance characteristics.

Consider the angles. When dealing with linkages or force-transfer angles, allow for force losses in angles. For example, forces in an application decrease when they work against a pin or other pivoting member instead of directly on the load.

The force transferred in an application is equal to the total force × sin(transfer angle). And the force absorbed by the pivot equals total force × cos(transfer angle). When the transfer angle is above 135 deg. or below 45 deg., more cylinder force acts against the pivot than gets transferred to the application. Transfer angles above 150 deg. and below 30 deg. should be avoided because they transfer less than half the cylinder force to the application.

Allow for future changes. It is wise for the design team to make allowances in the design to handle slight increases in performance requirements or unforeseen force losses. Adding new equipment, however, may affect the available air pressure. A regulator can reduce output forces, but it's not so easy to add forces.

Consider kinetic energy. Don't overlook the kinetic energy associated with a moving load. Cylinders can absorb some kinetic energy, but their primary task is converting pressure into linear force. Adding a shock absorber can eliminate the potential danger posed by a fast moving mass.

Test the results. Sizing a cylinder for an application without any testing can be a major mistake. Once a product is built, it can be costly to make changes such as increasing the bore size. Tandem cylinders can increase the force and extend the cylinder length, but they are less efficient than simply using a larger-bore cylinder to begin with. Unless there are strict air consumption or time requirements, it is a good idea to oversize the cylinder. P&M

Getting the Right Motor

An extended example shows how to pinpoint the right motor after first determining the loads and inertia it will see.

by John Brokaw, Norm Ellis

Engineers are constantly called on to select motors for the applications that will be able to do the task at hand and cost as little as possible over their operational lives. There are many ways to make that selection based on price, performance, manufacturer or even color. But one of the simplest and most effective methods is to determine the application's mechanical and physical requirements, establish electrical requirements that match those requirements and then find a motor that has them.

For example, if an application has limited space or needs to be lightweight, start with a motor that meets those parameters. If necessary, use mechanical means such as pulleys, gears, gear heads and speed reducers to meet the mechanical requirements.

Designers typically first settle on either an AC or DC motor or gearmotor. Gearmotors are AC or DC motors typically used for higher torque and lower rotational speed. Knowing the torque and speed requirements will help in determining if an AC or DC motor is required.

One of the mechanical limiting factors of electric motors is the bearings. Motors that use bearings will typically last longer than those using bushings. They also typically handle more perpendicular loading to the shaft (radial load), whether horizontally or vertically.

No matter how much torque the motor can generate, eventually torque falls off as speed rises or the motor can maintain the given torque only by slowing its rotation. Once

these torque-versus-speed qualities are established, engineers can fine-tune the numbers using the previously mentioned mechanical means.

An Example

Let's examine an example of a DC motor that spins at 11,500 rpm with a 1-in.-pitch-diameter pulley. This generates a linear speed of 36,128 ipm (equal to 3,011 fpm or 602 ips). Changing the size of the pulley would alter the speed or torque. However, there are applications that need slower motors with a gearbox. It's one of those immutable characteristics; as the speed rises, the load capability drops.

Suppose that DC motor will be used to power a conveyor or tangential drive system. Add in the complication that in the application, a spray tip will need to send out a fluid ounce of material over an 18 × 14-in. area using a nozzle which spits out 0.050 gallons/min or 0.1067 oz/sec at 40 psi.

To select the right motor, first find the needed speed and torque. Acceleration will then be found by establishing the time required for the move and solving for shaft speed in rpm.

To get the allotted time, divide the amount of material being dispersed by the rate of dispersion:

1 fl-oz/0.1067 fl-oz/sec = 9.372 sec.

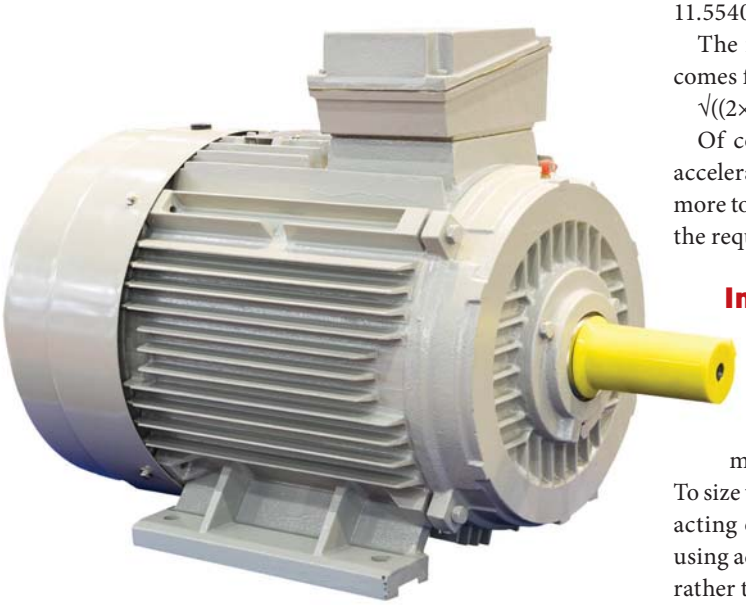
To convert that to linear velocity, divide the length of material by elapsed time:

18 in./9.372 sec = 1.9206 ips.

To find the rotational velocity in rpm corresponding to 1.9206 ips of linear velocity, convert inches/minute to inches/second and convert that to revolutions. In this example, the pulley diameter of 1.003 in. leads to:

1.9203 ips × 60 sec/min × 1 rev/(1.003 in. × π) = 36.57 rev/min or 0.6 rev/sec.

To determine the angular velocity, acceleration and time, assume the motor reaches a constant speed after the equivalent of 1 linear inch of travel. The associated arc length for a rotary system becomes 1 in./π = 0.3183 in.



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The formula for determining arc angle can be found in *Machinery's Handbook*. To use it, calculate the pulley radius:

1.003/2 = 0.5015.

Using the pulley radius and associated arc length, we get an arc angle: (57.296 × 0.3183)/0.5015 = 36.3655 decimal degrees, or 0.634 radians. (57.296 is a constant from *Machinery's Handbook*.)

To determine the final angular velocity, divide linear velocity by the pulley radius:

1.9206 ips/0.5915 in. = 3.8297 rad/sec.

To find final angular acceleration, use the equation for acceleration; $a = V^2/2\theta$

where θ = arc angle and V = linear velocity. Substituting values for the variables: (3.8297 rad/sec²)/(2 × 0.6347) = 11.5540 rad/sec².

The final angular time or time needed to reach velocity comes from the relationship: $t2 = 2\theta/\omega$. Solving for t gives:

√((2×0.6347 rad)/11.554 rad/sec²) = 0.3315 sec.

Of course, the motor must provide more torque, more acceleration rate or a shorter ramp distance is needed. The more torque available, the higher the acceleration in reaching the required velocity.

Inertia

Next calculate the load inertia. When moving objects, the load on the motor is more than just the load of the object being moved. It also includes the loads from the pulleys, belts, couplers and any other device or mechanism between the motor and object being moved. To size the motor, find the total inertia of all these components acting on the motor shaft. Sometimes it is easier to do this using actual weights (transformed into masses) of the devices rather than calculating inertia requirements.

In this example, the system consists of a 96.0 oz load, two 1-oz pulleys, and a 0.8-oz belt. Using the general equation for inertia, $I = mr^2$, where m = mass and r = distance to the rotation axis, the total inertia on the motor is:

$I = (96 \text{ oz} \times (0.5015 \text{ in.})^2) + (0.8 \text{ oz} \times (0.5015 \text{ in.})^2) + ((1 \text{ oz} \times 0.50152 \text{ in.}) \times 2) = 24.8484 \text{ oz-in.}^2$

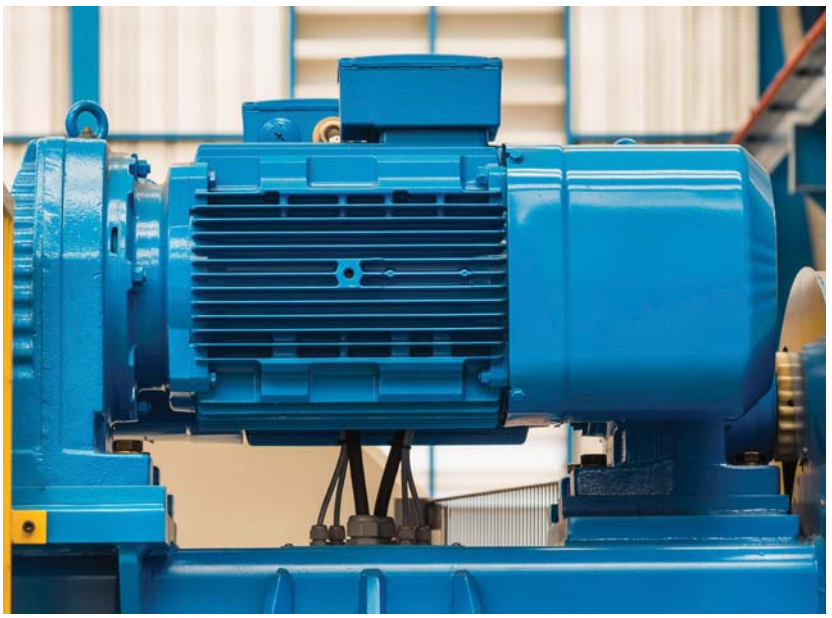
Friction

In this example, two slider rails with four carriage pads carry the load. Each pad has a coefficient of friction of 0.17. The force due to friction is calculated using $F = \mu N$, where μ is friction coefficient and N is the force perpendicular to the surface. In this case, N is the mass of the load. So, the equation becomes:

$F = (96 \text{ oz} \times (4 \times 0.17) = 65.28 \text{ oz}$

This force, in turn, is multiplied by the distance to the rotational axis:

$65.28 \text{ oz} \times 0.5015 \text{ in.} = 32.738 \text{ oz-in.}$



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To get total torque, determine the torque needed for acceleration. The initial step is to convert total inertia from oz-in.^{2} to oz-in.-sec^2. This is a simple conversion that consists of multiplying total inertia by a factor read from an inertia/torque conversion table, available from a variety of sources:

$24.8484 \text{ oz-in.}^2 \times 0.00259 = 0.0643573 \text{ oz-in.-sec}^2$.

This figure gets multiplied by the angular velocity and divided by the time needed to reach that velocity:

$(0.0643573 \text{ oz-in.-sec}^2 \times 3.8297 \text{ rad/sec})/0.3315 \text{ sec} = 0.7435 \text{ oz-in.}$

Finally, add the force needed to overcome friction:

0.7435 oz-in. + 32.738 oz-in. = 33.482 oz-in.

Thus, most of the torque for acceleration is needed to overcome friction.

The process for determining the torque needed for a constant load is similar. The only difference in the equation is that linear velocity (calculated earlier) is used instead of angular velocity, and division is by spray time (also calculated earlier) rather than acceleration time. This gives:

$(0.0643573 \text{ oz-in.-sec}^2 \times 1.9206 \text{ ips})/9.372 \text{ sec} = 0.0132 \text{ oz-in.}$

Now add the force needed to overcome friction:

0.0132 oz-in. + 32.738 oz-in. = 32.751 oz-in.

Once again, most torque goes into overcoming friction. The total torque is the sum of the torque needed for acceleration and for handling a constant load:

33.482 + 32.751 = 66.233 oz-in.

The torque needed for acceleration will not always be about the same as the torque for constant load, as in this case. Do not assume you can just double the torque for constant load and meet the total torque requirement.

Size

This example does not consider deceleration torque. It is not required when solving for maximum torque unless it exceeds the torque needed to accelerate. Another tip: Do not use holding torque to size motors. Holding torque is how much the motor will hold at 0 rpm.

Once this analysis leads to a particular motor, the designer should go back and add the motor-rotor inertia to the calculation and recalculate to verify that the total torque required lies well inside the torque-versus-speed curve. If not, the next bigger motor will be needed. As long as the required torque and speed are kept below the motor profile (with a safety margin) all other concerns are irrelevant.

When selecting a motor, determine the application's physical and mechanical requirements.

Other Factors

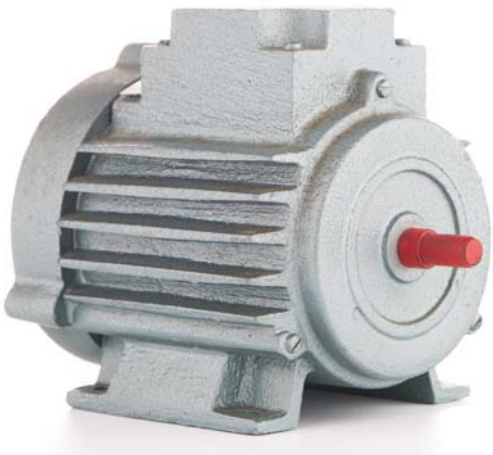
Keep in mind that side loads (radial loads) and overhang loads are set by the motor manufacturer. They must not be exceeded unless the goal is to have the motor fail prematurely. Finally, after the motor is installed, empirically measure the actual required torque to move the load and find the side load on the motor. These empirical measurements can verify calculations.

In this example, a simple fish scale could give designers a force reading in a pull test to find the amount of force needed to move the load.

It is common and prudent to include a safety factor in motor sizing to account for unseen problems. For example, calculations calling for a 66-oz-in. motor lead a designer then to choose the next size up, a 100-oz-in. motor, to provide a 1.7 safety factor. Common safety factors range from 1.5 to 2.0.

Another factor worth considering is the ratio of load-to-rotor inertia. This ratio is important if the motor must accelerate with some precision or stop quickly. It is basically a ratio of how fast a motor accelerates or decelerates its own mass. This, in turn, bears on the accuracy of the motor shaft's position.

Some motor makers recommend keeping the load-to-rotor-inertia ratio below 5:1. If there are no accuracy requirements other than for starting or stopping the motor, engineers only need to make the speed and torque requirement fall within the motor's speed-versus-torque profile and add a safety factor. If the rotor-to-load inertia ratio is too high, the motor will over- or undershoot the stop position. Or the shaft might oscillate back and forth before settling at the proper position.



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Thus, the need for precision, or the lack of it, determines whether load-to-rotor inertia is a significant design parameter. Systems with a 1:1 ratio will have the best precision. Those with a 2:1 ratio or worse will be less so.

Consider the inertia from the example and a motor having 0.00143 oz-in.-sec^2 of rotor inertia. Converting to the same units (using information from widely available tables) and solving for the ratio yields:

0.00143 oz-in.-sec^2 × 386 ips^2 = 0.55198 oz-in.^{2} Then 24.8484 oz-in.^{2}/0.55198 oz-in.^{2} = 45.

So, the ratio is 45:1.

If need be, a simple way to lower the ratio is to use a motor with more rotor inertia (bigger shaft) or add a gearhead to match as closely as possible the load and rotor inertia. Using a gearhead reduces output shaft speed and boosts torque according to the ratio value. One advantage of gearheads is they handle higher radial loading than would be possible by mounting the device to the motor shaft.

Gearboxes also affect the inertia ratio by a factor of the gearbox ratio squared. To find what gearhead size is needed, solve:

e $\sqrt{(24.8484 \text{ oz-in.}^2)/(0.55198 \text{ oz-in.}^2)} = 6.7$

This indicates a gear ratio of 6.7:1, rounded to 7:1. Recall that with gearheads, torque rises and output shaft speed drops with the gear ratio. Now size the gearhead to a motor by figuring 66 oz-in. × 1.5 (safety factor) = 100 oz-in. of output torque from the gearhead. This gives 100 oz-in./7 = 14 oz-in. from the motor through the gearbox and 37 rpm × 7 = 259 rpm from the motor.

In this case, the rpm and torque exceed requirements. The controller can fine-tune shaft speed and torque requirements to reach the final values. **P&M**

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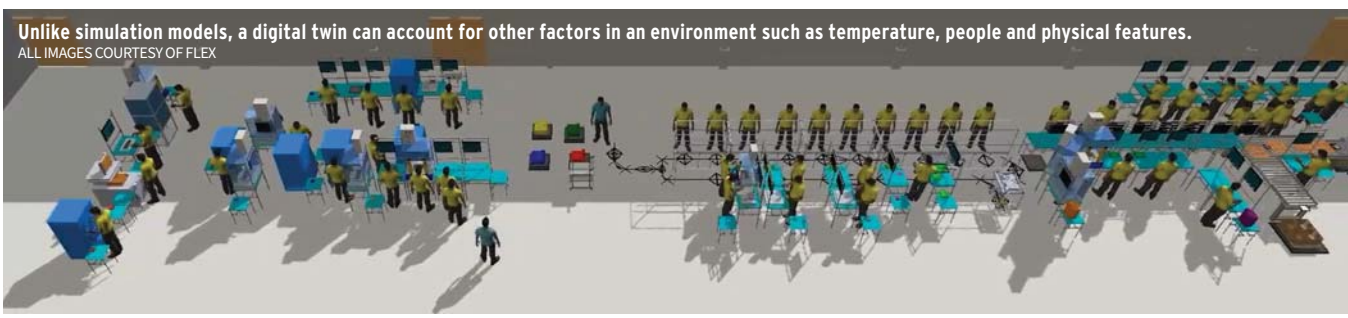
This article was written and contributed by John Brokaw, a motion control application engineer at Baldor Electric Co. and Norm Ellis, founder of Ellis & Associates.

How Digital Twins Can Increase Agility and

Digital twins can provide significant efficiencies by helping to detect issues sooner, visualize more outcomes and build better products.

by Zohair Mehkri



Unlike simulation models, a digital twin can account for other factors in an environment such as temperature, people and physical features.
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It's no secret manufacturing has been a laggard in digital transformation. In fact, more than 90% of manufacturers say that they face a variety of barriers when it comes to digital innovation. However, as organizations look to advance their operations with Industry 4.0 technology, digital twins are enabling companies to scale operations at factories across the world, detect issues sooner, visualize more outcomes and build better products.

By mapping out a complete virtualized footprint of factories, product lines and hardware, digital twins can provide significant efficiencies for organizations. To observe these outcomes, leaders must understand the basics of digital twins, how simulation feeds a digital twin, and the barriers to implementing the technology at scale.

The Basics of Digital Twins

To start, it's essential to understand what a digital twin encompasses. As the name suggests, a digital twin is an exact replica (or "twin") of a real-world asset that bridges the connection between the physical world and its virtual counterpart in real time.

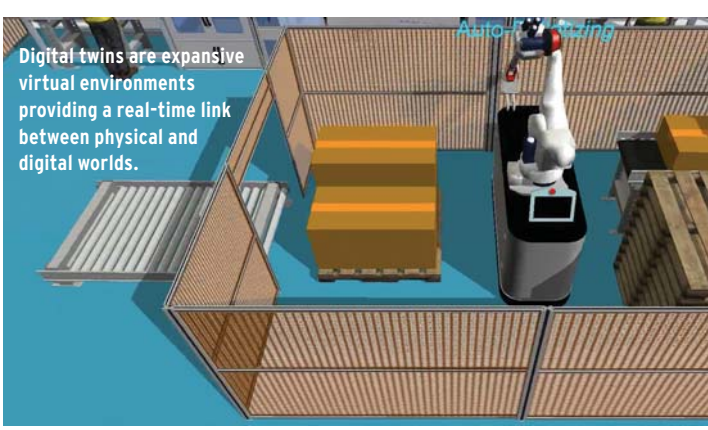
While digital twins have evolved rapidly over the past decade, the idea of modeling the physical world has been around for decades. The emergence of electronics brought the proposed concept of simulation, which has developed over time into a powerful tool for operational decision-making.

But simulation and digital twins are not the same thing–and understanding the difference is critical.

Simulation vs. Digital Twins

Every environment in the world is made up of three elements: space, time and matter. The matter can be any of the physical "stuff" in that environment. In a factory, for example, this would be the boxes, machines, materials, people and more. A simulation is created by going into these physical spaces and modeling the elements of its environment the exact same way in a digital space. This model provides a basic concept of what's happening in the physical environment.

While simulation and digital twins both use virtual model-based simulations to replicate a system's various processes, a digital twin is an expansive virtual environment, made up of a composition of technologies that develop a real-time link between physical and digital worlds.



Digital twins are expansive virtual environments providing a real-time link between physical and digital worlds.

Digital twins take simulation models a step further to replicate more complex assets or processes that interact with several components. Digital twins include other factors that simulation leaves out, like IT systems, finance programs, variables like humidity and temperature of an environment, people and physical features like pipes and walls and much more.

Digital twins use sensors attached to real-world assets to collect, communicate, analyze and use real-time data that

Bolster Operations

drives intelligent action. This continuous synchronization loop from the physical world to the digital world and back to the physical world is unlocking huge potential for even more precise and accurate modelling. With the rapid rise and accelerated adoption of digital twins, leaders in tech are working to create a more connected future, and innovation in this space is just beginning.

Why Companies Should Focus on Digitization

Factories are built with highly complex pieces of machinery that constantly interact with one another and company-wide systems. This complexity makes it difficult to understand how to drive improvements at a production site, and the impact changes have up and downstream. Traditionally, making any change at a factory was a cumbersome, time-consuming and high-cost endeavor. It requires physically moving equipment, people and lines to test and see if tweaks create meaningful increases in throughput and improvement in operations.

With the use of digital twins, companies can test out updated equipment or product configurations in a virtual environment that allows for change and optimization without the need for any physical factory involvement. This, in turn, can make potential problems much more visible before having to go through a lengthy trial-and-error process and, therefore, lowering the risk of costly miscalculations and lost time.

Lessons Learned from Digital Twin Implementation

In theory, digital twin technologies hold sheer unlimited promise and can fundamentally change industries. But a successful digital twin project needs to be about more than just providing a technological capability–it needs to align with business objectives and provide a measurable impact on top- and bottom-lines.

Therefore, it's critical that digital twin deployments fit into existing workflows and operations of a business. A digital twin does not exist in a separate realm all by itself. It is part of an ecosystem connected to existing processes, data and technology.

Moreover, good data is the basis of reliable digital twin solutions, and turning massive amounts of data into functional, real-time digital twin simulations means engaging in some serious streamlining, a task that machine learning and artificial intelligence have been working on for quite a while.

While digital twins have the potential to help drive innovation and accelerate product development, companies must be able to manage any gaps in data streams and be open to taking the necessary action to build on existing assets and processes to return real value.

A More Connected Future

Digital twins are designed to determine which input variables will make the biggest impact on specific outputs, enabling manufacturers to predict future outcomes and identify problems before they occur. There are hundreds, if not thousands, of key variables to describe the physical assets and processes within manufacturing operations.

By attaching sensors to real-world assets, data can be collected and analyzed within the digital twin to help determine when action may need to be taken to fix or adjust something.

Without simulation, this testing process can take several months to complete. Medical device manufacturing, for example, can take years, given the high stakes of a patient's well-being and the need for precise planning and forecasting. In one instance, manufacturing technology company Flex was able to create a digital twin of the factory floor and successfully accelerate and optimize the development of a Class II diabetes product in only three weeks' time.

With the right production data and information, digital twins have the potential to remove the physical restraints of production line testing, increase visibility across facilities and departments to make better decisions, faster and solve some of manufacturing's biggest challenges. P&M

This article was written and contributed by Zohair Mehkri, director of digital twin, Flex.

Filter Elements in Hydraulic Filtration: The Key to Efficient Hydraulics

Selecting the right filter for an application will ensure proper performance and efficiency of hydraulic systems.

by Simone Ortner, Dr. Anastasia Peters

Whether in wind turbines, mining, agriculture or construction, the following applies everywhere: Hydraulic systems are essential for safe and efficient operation. Hydraulic fluid filtration is a proven solution for increasing the service life of these systems and reducing downtimes. But which filter element goes with which hydraulic fluid? Some key data can help to identify the correct answer, as well as the expertise of a filtration supplier with experience and extensive industry knowledge.

Wherever fluid technology has to ensure reliable, efficient performance and motion control, it depends on filtration. In eight out of 10 cases, problems with the hydraulics in compressors, excavators or mining machinery are related to insufficient or a lack of oil monitoring and maintenance.

As the power density of hydraulic systems and components increases, efficient filtration is becoming even more important. This affects both the functionality and the service life of the hydraulic components. To benefit from the properties of the fluids used for as long as possible, effective removal of impurities—both those that are produced and those that enter from outside—is crucial. This is because the aging process of hydraulic or lubricating oil fluids largely depends on the nature and amount of contamination present.

Eaton supports system designers with a broad and specialized range of filtration products that ensure a high degree of purity and reliable operation across all industries. Application-specific filter and accessory design plays a major role in the almost endless amount of media, process variables and ambient conditions: Eaton offers more than 4,000 different filter elements, each with matching filter housings. These filter elements are available with various filter materials, in different designs and filter ratings, to help protect important system components.

The return-line, suction and pressure filter elements and elements for in-line filters are used in duplex filters for low-, medium- and high-pressure applications.

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The return-line, suction and pressure filter elements and elements for in-line filters are used in single and duplex filters for low-, medium- and high-pressure applications and are considered the industry standard in many places. In addition, there are mobile and stationary filtration systems, systems for contamination and condition monitoring, and auxiliary devices such as contamination indicators.

To find a suitable filtration solution with the right filter element, system and machine operators need to know which hydraulic fluids are being used. As a key element of the system, these fluids have to fulfill a wide range of tasks depending on the application, but this is precisely what increases the risk of declining performance due to aging.

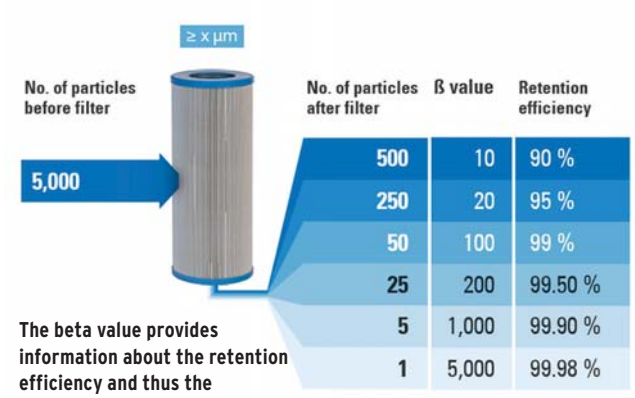
The Oil Must Match the Application

Given the wide range of applications, the selection of hydraulic and lubricating oils on the market is similar to that of the available filtration products. The hydraulic fluids differ primarily in their base oils, such as mineral oil, vegetable oil, polyalphaolefins, carboxylic acid esters, polyalkylene glycols, phosphate acid esters and silicone oils.

This means that base oils can be divided into synthetic and native oils. Synthetic fluids are compounds produced by the chemical transformation of various starting materials such as carbon monoxide and hydrogen. Examples include polyglycol oils, polyalphaolefins and synthetic esters. Native fluids are obtained without chemical transformation through distilling and refining crude oil or various vegetable oils, meaning they have a natural base.

Base oils are mixed with additives in order to make them suitable as hydraulic fluids. In this way, the basic properties of the oils, such as viscosity, susceptibility to corrosion and resistance to oxidation can be influenced. In practice, a simplified nomenclature classifies hydraulic fluids according to their intended use and properties:

- Mineral oil base H (*hydraulic fluids* mostly used for stationary hydraulics).
- Fire-resistant HF (*fire-resistant hydraulic fluids* are used in various applications and industries such as mining, the steel industry or in aircraft engines, depending on their composition).
- Rapidly biodegradable HE (*hydraulic environmental fluids* are used in mobile hydraulics, for example in agriculture and forestry).



The beta value provides information about the retention efficiency and thus the performance of a filter element.

In hydraulic systems, hydraulic fluid filtration is a must in order to maintain system performance and minimize downtimes.

And the Filter Element Must Match the Oil

Given the variety of hydraulic and lubricating oils available on the market, it quickly becomes clear that selecting the right components (support tube, end caps, etc.) and filter materials (fiberglass media, stainless steel mesh, etc.) can be challenging—especially when using unusual or highly specialized oils. The materials used, including metals, alloys, plastics and sealants, must not only withstand the environmental conditions, but also be resistant to the oil used.

What is suitable for one oil can be damaged by another, which can lead to system damage and failure in the worst-case scenario. Common problems are leakage or contamination of the oil caused by dissolving or corroding material. In addition to the base oil, the additives used for the application are critical, as these can have significant impact on the behavior of the oil toward certain materials.

Another critical factor is temperature, as fluctuations of as little as 50°F (10°C) can significantly alter the chemical resistance of the materials used. Therefore, a resistance test is usually recommended, particularly for sensitive applications. In this test, the selected materials are immersed in the corresponding hydraulic fluid for a longer period of time, under conditions similar to those of the application. In this way, the resistance of the components to the oil can be realistically and practically tested. In a further step, oil that has already been used in the application is often also used in order to be able to check effects that are associated with oil aging.

To simplify the accurate selection of a suitable filter element, Eaton has established a uniform internal specification (IS) for special filter elements in addition to the standard filter elements. The IS number indicates which filter element components are suitable for specific oils. Derived from the mineral oil used, the IS number provides users with direct and uncomplicated information about the filter elements that are suitable for the application.

A filter element consists of a support tube, around which the pleated filter media is wrapped, and two end caps. The pleated filter media with various filter and support materials are the core of the filter element. Depending on the requirements and the hydraulic filter design, different filter materials, filter ratings and types are used for surface and depth filters.

Understanding application parameters and hydraulic oils aids filter selection.

Filter materials use glass fiber fleece (VG, API, WVG), polyester (V) and cellulose (P) nonwovens and papers, and stainless steel wire mesh (G). These materials are available in various filter micron ratings, the retention efficiency of which is designated by the beta value (ß): The larger the beta value, the more particles are retained by the filter and the higher the retention efficiency. The beta value is determined according to ISO 16889 and ranges from ß200 ≥ 4 µm(c) to 25 µm(c) for fiberglass media, which act as depth filters, and from 10 µm to 250 µm for wire mesh media, which act as surface filters.

To ensure reliable, trouble-free operation, all components such as O-rings and filter element load-bearing parts should be selected and, if necessary, adapted according to these specifications. Eaton can also customize filter elements from the existing range of special

applications. For example, gaskets and adhesives can be customized to withstand extremely low temperatures of up to –58°F (–50°C).

The selection of the right filter element therefore depends on various criteria which, in addition to the requirements for chemical or physical resistance, also include the type of application, the dirt-holding capacity and the associated service life, compliance with the maximum differential pressure and the required cleanliness level of the fluid.

Achieving the Perfect Solution with Expertise

No one knows the operating conditions of a hydraulic system better than its user. Operators can quickly find filter elements that are suitable for their application using their system's key data and Eaton's specifications as reference.

Industries are diverse and every hydraulic application is different. The best way to select the correct filter element is to know the following application parameters—and preferably the technical data of the hydraulic oil too:

- What kind of system is being operated?
- Which fluid is being used?
- What is the temperature when the system is in operation and at a standstill?
- How viscous is the hydraulic fluid?
- What is the volume flow rate?
- What is the operating pressure?
- Which purity class is to be achieved?
- What impurities can occur?

Successful filtration in hydraulic applications requires industry-specific expertise due to the large number of possible filter elements and additional components. To ensure that the selected filter elements suit the intended application, system designers should ensure that manufacturers not only offer a broad portfolio of products, but also detailed advice.

Experienced partners like Eaton offer customers comprehensive support based on in-depth industry expertise. Whether mining, stationary hydraulics, mobile applications or wind power—expertise and cooperation as partners make hydraulic filtration more than a mere necessity: It ensures maximum efficiency and safety in operating hydraulic systems and thus becomes a fundamental element of the entire value chain. P&M

This article was written and contributed by Simone Ortner, engineering manager, and Dr. Anastasia Peters, development engineer, at Eaton Technologies GmbH, Altlußheim, Germany.

How to Implement AI in Fluid Power Applications

Understanding pain points to be solved and planning ahead can help manufacturers and the their customers get the most out of artificial intelligence systems.

by Sara Jensen

Artificial Intelligence (AI)–the ability of machines to perceive, synthesize and infer information–can now be found in almost all sectors and applications, including fluid power due to increased digitalization of components and systems.

As described in a white paper from the organizers of the International Fluid Power Exposition (IFPE) 2023, digitalization enables or improves processes using digital technologies such as sensors and software. These enable the collection of performance data which can then be analyzed via AI.

Why implement AI in fluid power? Frank Latino, global product manager, Electric Automation at Festo Americas, said during a *Power & Motion* webinar on the benefits of AI in fluid power that doing so can help customers improve their businesses.

He said three of the key benefits associated with deploying AI in fluid power applications are:

- improving maintenance processes,
- increasing product quality and
- lowering energy consumption.

"It is not just AI technology that is needed for this," said Latino. "We are leveraging technologies in addition to AI that include the Internet of Things and edge computing. There are also different software tools…and the combination of all of this together would provide these benefits."

As part of the webinar, *Power & Motion* conducted a Q&A with Latino to learn more about how best to implement AI in fluid power.

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

***Power & Motion*: What are the first key steps one should take if looking to implement or make use of AI and its related technologies?**

Frank Latino: One of the very first steps that you need to take is to get a really good understanding of what your pain point is and taking a look at what kind of data you think might be available to solve that pain point.

It might be good to [also] get some consultation in that area. People who are really familiar [and] work with this on a regular basis have a way of looking at certain sensors and devices, figuring out what information needs to be added to [a] system [and] taking the existing information and transforming it in a way where it is useful to solve a particular pain point.

And with that, having a good understanding of the ROI (return on investment) would be very important at that early stage; what return on investment would you get for this tool?

Early detection of anomalies with a trained AI model and notifications to maintenance can help manufacturers minimize downtime. FESTO

***P&M*: What are some of the challenges associated with implementing AI and related technologies? And how can these be overcome?**

FL: Implementing any of these solutions is not a one size fits all kind of thing. So, understanding what kind of infrastructure you have and how you can get the right quality of data out of the system is important.

All customers have different ways of consuming this data. [They] may want to report anomalies into an ERP system or an MRP system, or maybe just want a dashboard that could help them find information. Every customer has something different it wants to achieve with this, and having an understanding of the data structure and where the data has to go tend to be some of the challenges.

Bringing someone with expertise into the mix can easily help customers overcome those challenges. You can always overcome [the challenges], but sometimes just need a second set of eyes to see how best to overcome them.

***P&M*: Do you see use of AI being applicable for any type of application or industry, or are there certain ones for which it is best suited?**

FL: I think AI is suitable for most use cases. You are deploying a software tool into a system and there is always ways of connecting that tool within a system, so I think it can be used in just about any case.

If you push me harder on that question, those applications that have a higher value output might make the return on investment quicker. In most cases, though, that you are able to deploy AI there eventually will be a positive return on investment from using it.

***P&M*: We have heard over the years the amount of data that can now be collected from smarter systems can be overwhelming for people. Is there a way Festo or the industry, or possible best practices, can help people hone in on the important data?**

FL: Again, I have to say to bring in some expert help to do that. People who are experienced in this field have a way of looking at certain data and being able to transform it into [something] much more meaningful.

It is not the [quantity] of the data that you are looking at that is important. It is not like the most data makes your job easier. [Instead] it is sifting through, contextualizing and coming out with the type of data that is really valuable for a use case that you want to solve. And so again, a little bit of expertise from someone would help any end-user make a lot of headway [and] some quick wins, instead of struggling along trying on their own to find the right combination of data and so on that may not work to their expectations.

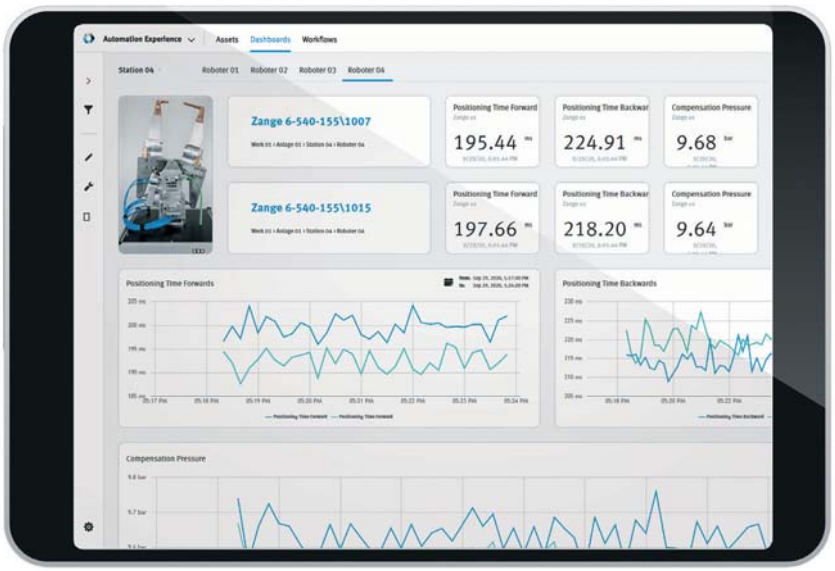
***P&M*: If you had one key piece of advice for our audience regarding implementation of AI in fluid power, what would that be?**

FL: If I was specifying a new system and even if I did not think I needed some sort of AI system to give me the best

results or give me the best business outcome for my system, I would still think of AI in the beginning and take action now to prepare for that, even if I was not planning on deploying AI early on.

For example, if you're going to spec out pneumatic cylinders, make sure you have an option that has some sort of magnet inside or something that will work with a cylinder switch, or parallel cylinder switches. So, if in the future you wanted to deploy some sort of AI system, you can easily put sensors on that cylinder. And now you will have a nice data set where you can look at cylinder switching signals compared with the valve signals and make some determination on that.

I would consider using an Ethernet network for control even if I historically hard-wired solenoid valves to a digital output module. I would maybe consider implementing a smart device with an Ethernet infrastructure; it might be more expensive upfront [but] your installation times would probably be a lot less because it is a lot quicker to install. The other benefit is that you have that infrastructure in place so if in the future you decided that you have an issue you want to address and you think AI might be the way to give you a benefit, then you have that infrastructure in place. And now you can maybe deploy another system on that infrastructure to collect certain data and be used for an AI solution.



Implementing AI and associated digital technologies enables better monitoring and maintenance practices. FESTO

So, think about it at least in your next installation, even if you don't plan on using it, think about some infrastructure and something that would support it going forward. Because we have seen some very successful use cases with our customers and [AI] could be applied to most of our customers and give them very reasonable results. **P&M**

"We are leveraging technologies in addition to AI that include IoT and edge computing."

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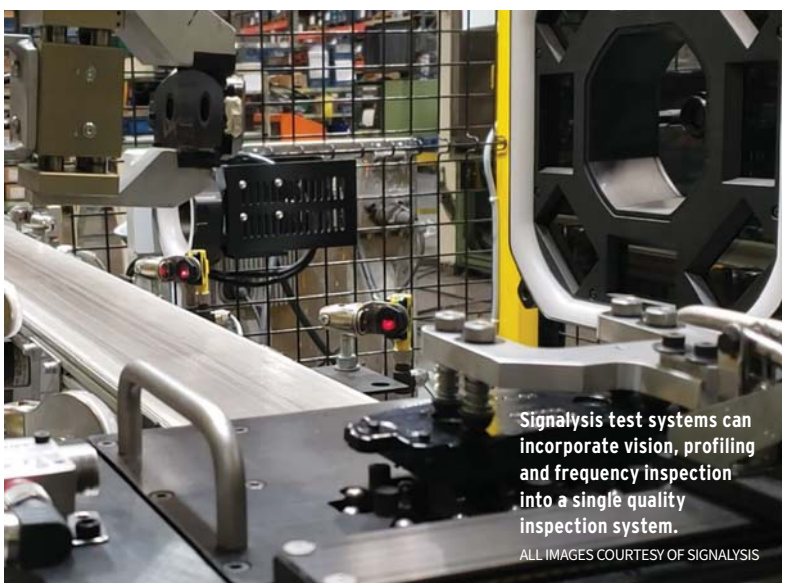
Subjective Quality Testing is Becoming a Thing of the Past

Automating product quality inspections ensures clear and objective results, reducing potential quality issues for manufacturers.

by Robert Farrell



Signalysis test systems can incorporate vision, profiling and frequency inspection into a single quality inspection system.

ALL IMAGES COURTESY OF SIGNALYSIS

What comes to mind when you look at your automobile, washing machine, lawn mower or any other product? For many, it's the manufacturer's name attached to that product. And to protect their brand, reputation and market share, those manufacturers are increasingly diligent about quality. And for an OEM, that includes all Tier 1 and Tier 2 suppliers.

Christopher Kus, project engineer and NVH expert for the Automotive Seating Business Group-NAO of Faurecia, explained that consumers rarely differentiate between the system and its components.

"Sub-system and component flaws generally create overall negative feelings toward the system as a whole," said Kus. "For example, a rattling window, unreliable ventilation fan, or noisy seat motor will result in a reputation for poor quality for the entire vehicle. Consequently, OEMs are increasingly vigilant with supplier quality."

Faurecia Seating seat systems optimize the comfort and safety of occupants while offering premium quality to its customers. By objectively quantifying quality, Faurecia is meeting and exceeding customer (and end-user) expectations.

"Throughout manufacturing there's no time for detailed laboratory quality testing. As a result, companies generally rely on a Pass/Fail or Red Light/Green Light inspection process," explained Kus. "To get to that point we take subjective, often vague, input from the customer to create objective quantifiable metrics. We begin with subjective jury evaluations to determine a rating of specific noises. From the results we can use statistical methods to choose what psychoacoustics best can be used to describe how the human ear perceives sounds of the specific source. From there statistical methods are used to create an algorithm to correlate to the rating system of the human ear subjective ratings."

Cracks, flaws and other anomalies can be identified through frequency inspection. Here a force is applied to a brake rotor to measure its resonance frequency.

The Challenge: Eliminating Subjectivity

Relying on the judgement of even the most experienced quality inspectors to determine what is acceptable (or not) as products roll off the production line creates opportunity for errors. When human emotion is involved in making critical decisions, results can vary from one inspector to the next or from one day to another.

But removing subjective interpretation from the equation is not always easy. For example, supplier requirements might call for the product to satisfy any number of specific design and performance parameters and be free of other objectionable noises. But how does one quantify what is objectionable?

Fortunately, technology has emerged that allows suppliers to inspect every part that they manufacture to identify flaws and ensure conformance to rigid specifications.

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The Answer: Automating Objectivity

Quality inspection must be repeatable, consistent, metrics-based and above all "objective." Faurecia and many other suppliers rely on automated end-of-production quality inspection technology from Signalysis, a provider of testing systems, to verify that parts are defect free.

"Automated objective testing is a break from the norm for some and there is nearly always an adjustment period."

The thorough, highly technical and systematic approach begins by gathering customer specifications. This could be anything from specific failure modes to the nondescript "other objectionable noises" catch-all.

The next step is to acquire baseline data on a sample of parts to help quantify and differentiate acceptable from non-acceptable. Ideally these test parts represent the full range for each failure mode including those that do not meet quality standards, borderline parts and acceptable parts.

Signalysis' physics-based SigQC software powers these systems and decisions. The measurement hardware (data acquisition devices, sensors, triggers and timing) along with the proper setting of measurement parameters drives the quality of the data. A robust and versatile software toolbox of functions and data management is the key to designing the perfect objective quality testing algorithm.

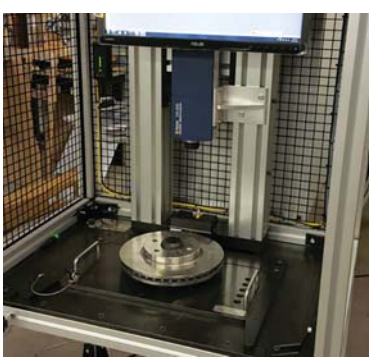
The sequence of actions used to create a production sequence is completely customized and can be made unique for any customer. A database of acceptance tests with complete description of products, test setups and pass/fail specifications is available for automatic access. As a product arrives to the test station, a bar code scanner or keyboard entry provides the information needed for automatic selection and initiation of the acceptance test. Upon test completion, the unit automatically receives a pass/fail quality grade. The data for the unit under test is displayed on screen; but it can also be to customer servers or an in-house data display program.

Implementation Challenges

Signalysis engineer Robert Cagle explained that one of the biggest challenges is that the laboratory or theoretical data is rarely the same as end of line testing, and everything else is a symptom of that. What can be calculated on paper is rarely seen in experimental data exactly as one expects it will come to fruition.

Sometimes lab data might have been collected in an anechoic chamber with microphones. This isn't conducive to the production line tester that is being developed without a sound chamber and can lead to the issue of buy-in from suppliers and OEMS. This is mainly due to the lack of understanding that what we hear in microphone data is what we are feeling from vibration data taken with an accelerometer or laser vibrometer.

"Automated objective testing is a break from the norm for some and there is nearly always an adjustment period to implement objective quality testing," said Cagle. "The massaging of metrics and tolerance limits in that transition can sometimes cause headaches and frustration. When this is the case, the user may be tempted to turn the machine off and revert to more subjective testing methods. However, the key to long-term success is to understand and trust the process. A little patience at the beginning will yield measurable quality improvements."



Quality inspection systems remove subjective interpretation. This laser vibrometer system is helping to ensure that the manufacturer is conforming to OEM frequency requirements.

The Product Lifecycle

While end of production testing is important, it's just one area where quality should be assessed. Implementing quality testing from concept through production helps to ensure that flaws are identified as the product passes through each product development stage gate. This greatly reduces the number and cost of rejected parts being tossed on the scrap pile.

But what about products with inherent flaws that do not surface until the product is in use?

Portable test systems isolate problem areas after the product reaches the final customer. This enables problems to be quickly identified and corrected while relaying vital information back to the supplier for the design of next generation products.

The Bottom Line

Today's competitive supply chain landscape is crowded with would-be suppliers just waiting for an opportunity to pounce. There is nothing more dangerous than to have the quality of one's work brought into question. When it comes to product quality, there's no place for guesswork, subjectivity or trial-by-error engineering.

Objective quality testing is rooted in science and generates results that are measurable, consistent and repeatable. When embraced the results are sustained improvements to quality, cost-reduction and, ultimately, the bottom line. P&M

This article was written and contributed by Robert Farrell, president of Farrell MarCom, LLC, and co-founder of Revolution in Simulation.

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Parker Critical Protection Hose Cover

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Key features of the CP hose cover include:

- abrasion resistance
- allows hoses to retain flexibility
- operating temperature of –40 to 275°F
- MSHA (Mine Safety and Health Administration) approved

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Rota Engineering LL Series Transducer

The independent mount LL Series transducer from Rota Engineering is designed for use in harsh environments. Its ultra-robust design enables use in these applications where monitoring by standard, in-cylinder position transducers is undesirable or not possible.

Key features of the transducer include:

- high vibration rating
- IP69K OPEN FACE M12 and Deutsch connectors
- absolute signal
- –30 to 80°C operating temperature range

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Norrhydro NorrDigi Digital Hydraulic System

Norrhydro's NorrDigi features a digital control system to optimize the movements of hydraulic cylinders. The appropriate force and speed are applied to provide the performance needed without consuming an unnecessary amount of energy.

Key features of NorrDigi include:

- stores energy in accumulators
- four-chamber hydraulic cylinder design
- data gathering capabilities to aid maintenance
- electronic control provides improved productivity and efficiency

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Thomson Electrak XD Linear Actuator

Linear motion control solutions provider Thomson has introduced the Electrak XD linear actuator. The high-capacity, high-performance electric linear actuator is designed to provide a cost-effective alternative to hydraulic cylinders.

Key features of the Electrak XD include:

- load handling up to 25,000 N (5,000 lb.), depending on configuration
- operating speeds of up to 75 mm/sec (3 in./sec.)
- up to 1,200 mm of stroke
- brushless motor technology

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Bosch Rexroth Smart Flex Effector

The Smart Flex Effector from Bosch Rexroth is a sensor-based compensation module designed to provide robots and Cartesian linear systems human-like sensitivity, aiding with factory automation applications. Due to its sensitive touch, the position of work pieces is precisely recorded and passed to the robot control unit for active compensation.

Features of the Smart Flex Effector include:

- load handling of up to 6 kg
- new application possibilities
- ability to recognize positional deviations

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EXPECT A SUPERIOR STANDARD

Technology Partnerships Enable Optimized Pairing of Batteries and Fluid Power Systems

Vanguard's Brett Engelland and Nick Moore discuss the benefits of Battery Technology Partners to better integrate fluid power components with electrification solutions.

by Sara Jensen

Engine manufacturer Briggs & Stratton expanded into the electrification space in 2019 with the introduction of its first Vanguard Commercial Lithium Ion Battery pack. Since then, the company has introduced new battery pack sizes as well as formed various industry partnerships.

Included in these partnerships are those with hydraulic and pneumatic component manufacturers and system integrators. Known as Battery Technology Partners, Vanguard works with these companies to supply its battery technology while also providing its expertise in developing power systems for various machine applications.

Power & Motion spoke with Brett Engelland, director of sales for Electrification, and Nick Moore, director of product management for Electrification at Vanguard, about how the company works with its Battery Technology Partners and the benefits of doing so.

***Power & Motion:* Vanguard has formed several Battery Technology Partnerships recently with companies specializing in fluid power engineering and system integration capabilities. What is driving the increase with these types of industry partners?**

Brett Engelland and Nick Moore: Many OEMs want to start their electrification journey but don't necessarily have the resources in-house to execute an electrification project. These OEMs know the future is moving toward electrification and that they need partners to help them integrate a total solution—battery, motors, controllers, wiring, etc.—into their application. This is where a Vanguard Technology Partner shines.

The Vanguard swappable battery pack is one of many options available from the company, and allows users to easily swap it out for another fully charged battery as needed.
VANGUARD

Like electrified solutions, fluid power systems are complex, so the engineering resources a Technology Partner is able to offer an OEM are essential to navigating the entire process and finding the best solution for that particular application.

***P&M:* What is the value…in partnering with those who specialize in developing and integrating fluid power systems?**

BE/NM: Our Technology Partners in the fluid power engineering space have an extensive understanding of the OEM's requirements and challenges. Often, the Technology Partner has been working with the OEM for years on hydraulic applications. An OEM's electrification project will go much more smoothly when working with a partner who knows and understands what they need. Vanguard and the larger industry share the goal of bringing more electrification options to core applications, and these partners help accelerate that transition.

***P&M:* How does the company see battery technology and fluid power systems working together, and what benefits can be achieved?**

BE/NM: Some of the benefits we've realized through our Battery Technology Partners include the opportunity to improve efficiency and emissions performance for OEMs and to help them get ahead of changes in the legislative landscape.

Emissions control, specifically, is an area of importance since we are seeing an increasing demand for zero-emission equipment designed for indoor construction work. While there are solutions that can eliminate the fluid systems altogether, in many cases, the best operating systems will still require functionality that only fluid power can deliver.

***P&M:* From Vanguard's perspective/experience, what special considerations need to be taken into account when bringing together batteries and fluid power systems?**

BE/NM: In most cases, there are many different ways to solve a problem that allows a machine to do the work required of it. There is a wide range of fluid power system components that can be paired with electrical systems.

Our goal will always be to help our customers and their stakeholders to find the solution that makes the most sense for their needs—whether that's fully electric or a hybrid solution. In many cases, properly combining battery and fluid technologies can yield significant improvements to the overall functionality of a machine. P&M

Read the full Q&A at powermotiontech.com/21260724.

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