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The Continued EVOLUTION of Mobile Hydraulics

Credits: Moog, Bosch Rexroth, Hawe, Danfoss

HYDRAULICS remain an important part of construction equipment, mining machinery and other mobile applications because of the power density they provide. Even as electric options come into play, hydraulics in one form or another will still be required.

Sara Jensen,
Executive Editor,
Power & Motion

With automation, electrification and other major industry trends driving the design of vehicles and machines, new requirements are being placed on hydraulics as well. Hydraulic components and systems need to be more efficient, offer enhanced control and be more connected to other systems.

These and the other drivers being placed on hydraulic system designs are helping to make it an exciting time for the industry. In this eBook you'll find a collection of articles which look at the design trends taking place within mobile hydraulics as well as guidance to help ensure optimized system designs.

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CHAPTER 1:

The Future of Hydraulic Systems in Mobile Machinery

SARA JENSEN, Executive Editor, *Power & Motion*

Efficiency, automation and other major industry trends present continued development opportunities for hydraulic systems used in mobile applications.

Hydraulic components and systems have played an important role in the functionality of excavators, tractors and other mobile applications for many years. And according to 93% of respondents to a Power & Motion survey, they remain a key technology of choice in mobile machines and vehicles.

The power density of hydraulics continues to be unmatched in many applications by electric alternatives. While some examples exist of hydraulics being replaced by electric systems, for now they are limited and in more compact machines.

However, this does not mean hydraulics are not evolving to meet various industry and OEM requirements. Quite the opposite in fact; a common phrase heard time and time again from those working in the fluid power sector is that it is an exciting time because of the many technological developments taking place in the industry today.

Major Industry Trends Driving Hydraulic System Designs

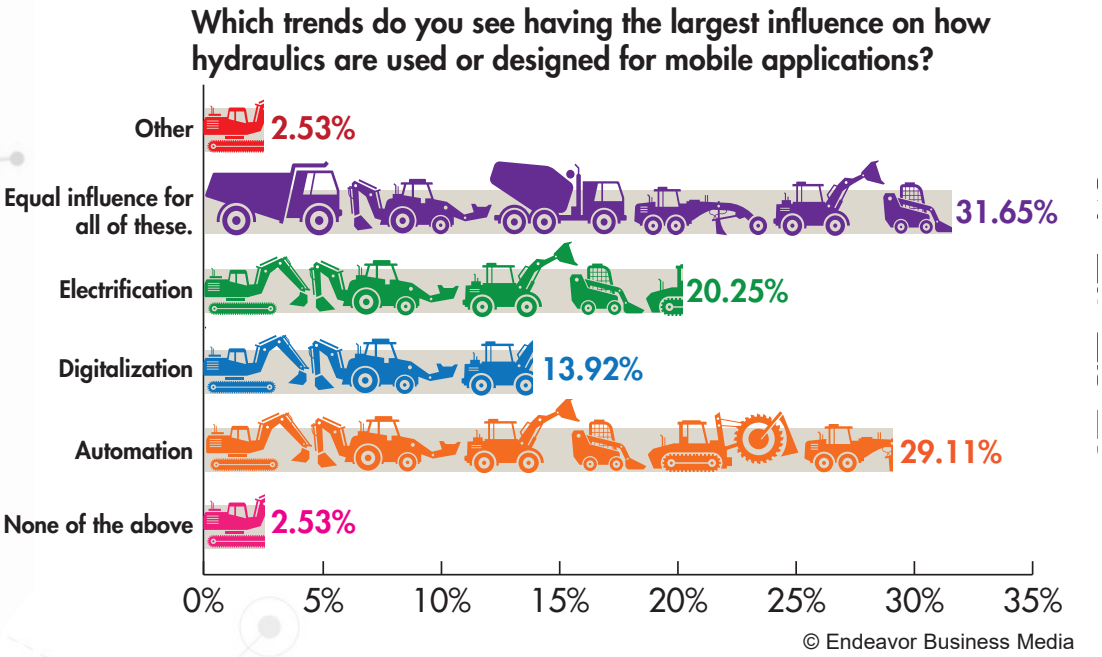
Several factors are influencing how today's hydraulic components and systems are designed. Ken Baker, CEO of Bailey International, said digitization, which includes the addition of sensors to products, and efficiency are the trends he sees most influencing hydraulic component designs.

He said efficiency is a particularly significant one because of customers' emphasis on reducing their energy consumption which leads to cost and emissions savings.

Jeff Herrin, Senior Vice President, Research & Development at Danfoss Power Solutions, agreed that efficiency is a key driver because there is a greater focus on the environmental impact of machines and their components which is shaping how hydraulics are designed.

These and many of the other influencers on hydraulic system designs are related to the

major trends impacting a number of industries, including fluid power and mobile equipment – automation, digitalization and electrification. The majority of respondents to *Power & Motion's* survey said they are seeing equal influence from all three of these trends on their hydraulic systems used in mobile applications, followed closely by 29% saying automation is having the largest influence.



Christopher Griffin, Business Development Manager - Electrification, Motion Systems Group at Parker Hannifin, told *Power & Motion* that hydraulic systems are getting smarter and more connected which will aid in achieving higher levels of autonomy as well as monitoring of machine performance and maintenance requirements.

Herrin also noted this growing trend, indicating that to make machines smarter it is necessary to develop intelligent components. This will enable full autonomy and lower levels of automation, such as automating a specific machine function, which he said is just as valuable.

With the move to smarter and more automated systems, Herrin said the control system for hydraulics will almost always be software driven. In addition, controls are moving away from the centralized design traditionally utilized to being component based which will offer more flexibility for optimizing machine performance.

The majority of survey respondents, 81%, agreed with Herrin that hydraulic system architectures are changing. One respondent noted this is being driven by the need for greater controllability though digital interfaces, improved modularity, greater total system performance as well as the implementation of software-defined performance.

READ MORE: How Connected and Software-Defined Vehicles are Reshaping System Architectures

Other respondents also noted the change to system architectures being driven by the need to improve efficiency. Additional drivers include the need to reduce machine com-

plexity and the integration of other technologies such as electronics and artificial intelligence (AI).

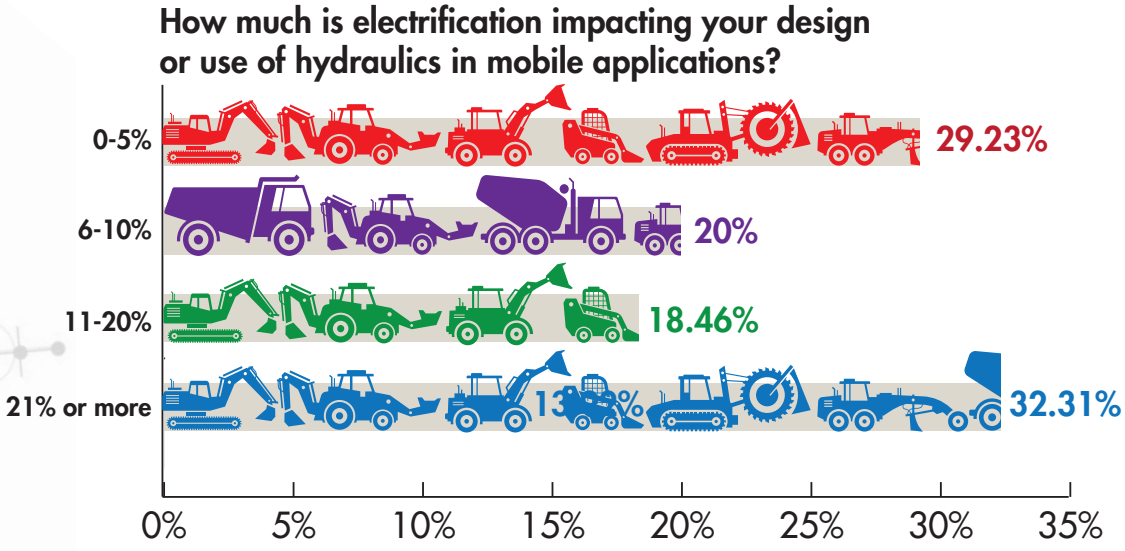
Hydraulics Remain Technology of Choice Despite Increased Electrification

Electrification is another major trend impacting hydraulic system development, with 20% of survey respondents indicating as such, but how much continues to vary. Of those who said it is impacting their design and use of hydraulics in mobile applications, 32% said it is having an impact of 21% or more but was followed closely by 29% saying 0-5% of their designs are impacted.

Baker, Herrin and Griffin all agreed electrification is influencing the mobile hydraulics industry and like the survey respondents indicated it is in varying degrees. Baker said his company is starting to see increased use of electrical prime movers such as electric direct-drive systems or ePTOs (electric power take-offs) but this remains in the early stages for Bailey's mid-market customer base.

Herrin, on the other hand, said Danfoss is seeing a rapid increase in customer inquiries for hydraulic system optimization for hybrid- and full-electric vehicles. He said the industry is moving into the second wave of electrification in which early adopters are now able to focus on optimizing hydraulic systems. Initial developments were focused on replacing hydraulic motors with electric versions in propel applications as many OEMs did not have the capacity to optimize systems.

Automation is a key development area for Danfoss and many other hydraulics companies. By enhancing hydraulic system control, higher levels of autonomy can be achieved. Danfoss Power Solutions

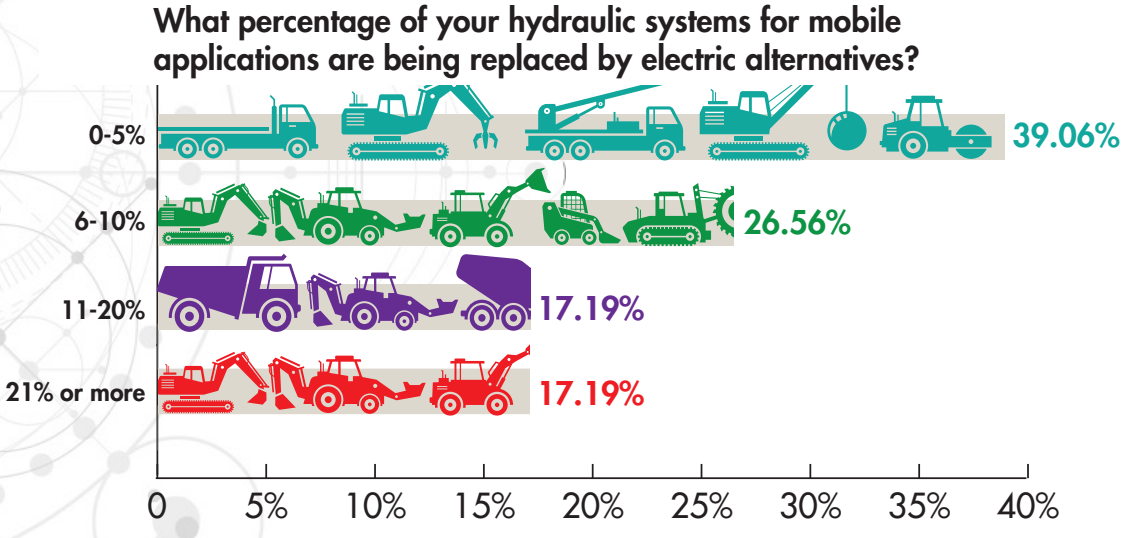


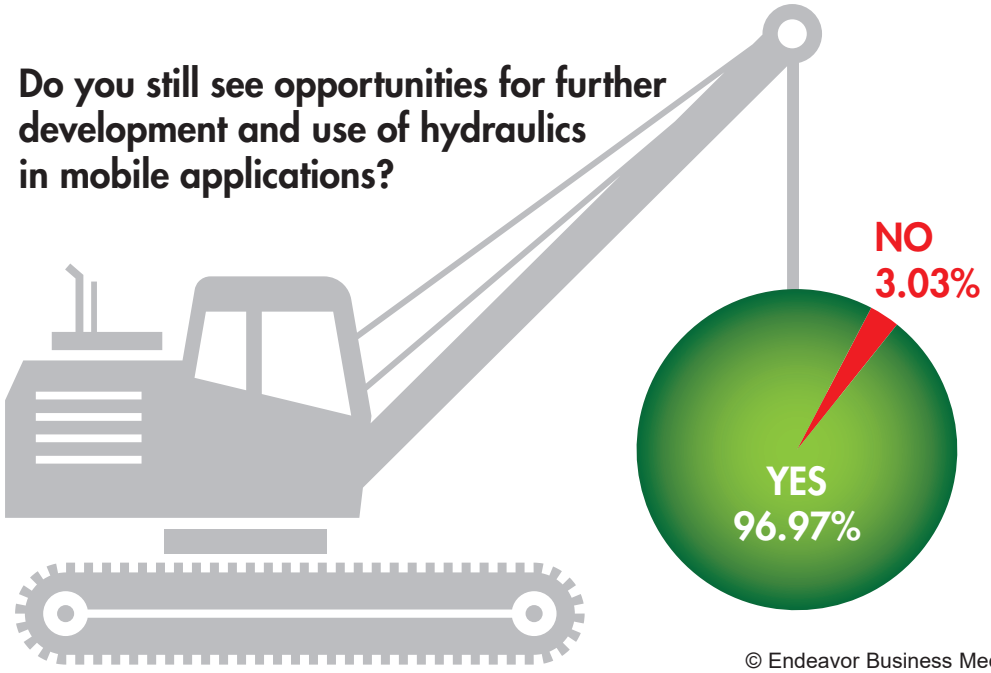
READ MORE: 5 Factors Driving Uptake of Electric Construction Equipment

As electrification progresses – both in the form of electric powered machines and greater incorporation of electric technologies – there continues to be the question as to whether or not electric alternatives will replace hydraulic systems in mobile applications. The general consensus is that there are some instances in which it makes sense, such as rotary applications like wheel drives said Herrin, but the power and force provided by hydraulics remains greater than what can be achieved by electric noted Baker.

Most survey respondents appear to be in agreement, with most indicating 10% or less of their hydraulic systems for mobile applications are being replaced by electric alternatives.

In those instances where electric is replacing hydraulic, reasons noted by survey respondents include reduced maintenance, weight, and thus fuel, savings, lower noise





emissions, and the push to electrify driven in many instances by government regulations. Improved ease of use, energy efficiency and control were also indicated as reasons some applications are making the move to electric in place of hydraulic.

The important aspect to remember though is that it is some applications because as one respondent said "just because automobiles have become a successfully converted technology, doesn't mean that every hydraulic application can equally be converted. Electrification makes sense in some areas, but in many applications the same robustness, durability, and effectiveness just isn't there yet."

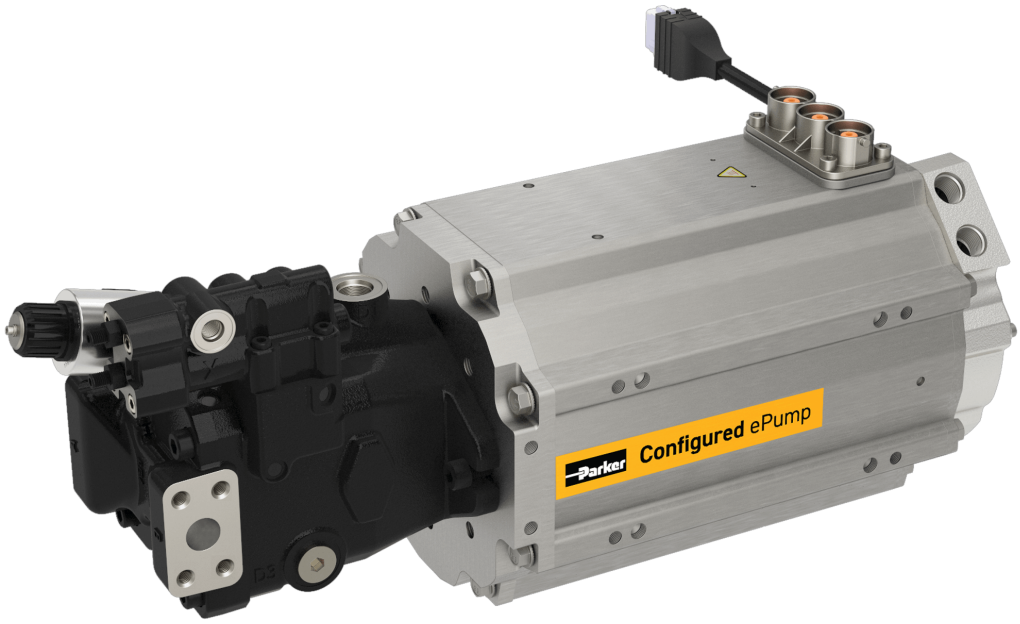
This same sentiment was expressed by Baker, Herrin and Griffin as well. As Griffin put it, there are many electric solutions for hydraulic applications but there are pros and cons to utilizing them. All-electric systems offer efficiency and control advantages but can be more costly, especially when getting into higher force and power requirements. He said they also get heavier in these instances.

He went on to say there will be applications in which all-electric motion systems make sense but there will not be a complete replacement of hydraulics in the mobile machinery market in the foreseeable future.

Survey respondents agreed that hydraulics used in mobile applications are not going anywhere with the majority, 83%, indicating as such. In conjunction, most – almost 97% – see continued development opportunities for mobile hydraulics as do Baker, Herrin and Griffin.

Herrin noted potential opportunities include achieving higher speeds and efficiency in hydraulic pumps and motors without negatively impacting power density. It will be important to get these components to a point where they are comparable with electric options, he said, while maintaining the inherent strength of hydraulics.

Read "Mobile Hydraulics: The Trends and Technologies Shaping the Industry" for Baker, Herrin and Griffin's extended, in-depth responses on the trends currently influencing mobile hydraulics.



Parker Hannifin's Configured ePump brings together hydraulic and electric technologies to meet the needs of hybrid- and full-electric mobile machines.

Parker Hannifin

The National Fluid Power Association's (NFPA) 2023 Technology Roadmap points to several areas in which fluid power manufacturers can focus their development efforts to not only meet evolving customer requirements but also maintain the relevancy of hydraulics and pneumatics used in an array of applications including mobile machinery.

Although there are many new technologies and design challenges coming into play, it is clear there are also many opportunities for the use and advancement of mobile hydraulics.

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HydraForce

CHAPTER 2:

Hydraulic System Redesign Enables Performance Improvements for Agricultural OEM

MEGAN TOLLEY, PR & Marketing Coordinator, *Hydraforce Ltd.*

HydraForce collaborated with SaMASZ to redesign the hydraulic and electronic control systems for a tractor mounted disc mower, enabling new performance features and implementation of ISOBUS.

HydraForce recently partnered with SaMASZ, a manufacturer of agricultural equipment, to design a new tractor mounted disc mower using improved hydraulic systems and ISOBUS technology to increase efficiency, sustainability, and improve ergonomics for machine operators.

Prior to HydraForce joining the project, the original design of the SaMASZ mower consisted of a controller, operator panel, and four individual hydraulic blocks, connected with hydraulic hoses. The combination of four blocks made the mower vulnerable to hydraulic leaks and damage; assembly of the hydraulic system required ongoing expertise, resulting in a longer manufacturing process.

In addition, the machine's conveyor belts were controlled by the hydraulic system, leading to high service costs due to continuous oil and filter changes and the requirement of an oil cooling system.

Due to these collective issues, SaMASZ partnered with HydraForce to redesign the mower's hydraulic and electronic control system, allowing the OEM to take full advantage of HydraForce's hydraulic expertise.

New Hydraulic System Enables Compact Design and Enhanced Capabilities

Partnering with SaMASZ provided the opportunity for HydraForce to design a dedicated manifold to house multiple cartridge valves which would result in a more versatile compact hydraulic system as well as provide additional hydraulic features, such as a transport latch, side guards and hydropneumatic suspension with breakaway functionality to lift the mower and avoid obstacles in the field.

HydraForce designed three custom hydraulic manifolds, each of which is used for a different function on the SaMASZ tractor mounted disc mower. HydraForce

To create the hydraulic solution, HydraForce designed a set of three custom hydraulic manifolds, providing SaMASZ with the ability to customize machines according to users' individual equipment and machine capabilities.

Each hydraulic manifold holds a different function for the machine, and by flanging each block together it eliminates the possibility of hose or fitting leakages, resulting in a more compact hydraulic solution.

The function of the main manifold is to operate the machine actuators by controlling the general functions of the mower, including the hydraulic breakaway system, and the lifting and lowering of conveyors, protective side guards, and transport safety devices. This manifold is also responsible for the folding and unfolding of the machine back to the transport position as well as the raising and lowering function between the headland and working positions, all of which help to protect the mower against external damage.

READ MORE: Trends Impacting Agricultural Equipment Component and System Designs

The secondary (optional) manifold is offered by SaMASZ as part of the standard machine equipment and is responsible for controlling the front mower. Its function is to allow users to raise and lower the front mower when working or preparing the machine for transport, which provides the possibility to set the pressure in the hydraulic system of the front mower.

The third and final manifold is responsible for driving the conveyors by using oil from the machine's load-sensing system. Use of this third manifold as a flanged section also makes it possible to replace it with another attachable conveyor drive system.

"The newly developed hydraulic system has given us the possibility to drive the conveyor belts from the tractor's load-sensing system, resulting in zero requirement for an oil tank

The main manifold developed by HydraForce controls general functions of the SaMASZ mower including lifting and lowering of conveyors. HydraForce

on the machine and no need for additional oil cooling," explained Krystian Gotlib, Manager of Hydraulic and Control Section in the R&D Department at SaMASZ.

"Another advantage of the new solution is the ability to automatically adjust the pressure in the hydraulic suspension system so that pressure of the cutter bars on the ground remains the same, regardless of the height of the hitch or the unevenness of the meadow," he said.

Electronic Control System Improves Machine Performance and Compatibility

As part of the redesign, HydraForce also provided SaMASZ with a new electronic control system which added new features to improve the overall implement control while offering

HydraForce developed a new electronic control system for the SaMASZ mower which allowed implementation of ISOBUS, providing operators with the ability to choose all of the implements' functions from a virtual terminal leading to improved ease of use. HydraForce

With the new electronic system developed by HydraForce, it was possible to receive ISOBUS certification which ensures the SaMASZ disc mower will work seamlessly with various models of agricultural tractors, ISOBUS terminals and other external equipment. HydraForce

even more customer value to SaMASZ as the equipment manufacturer could purchase the complete solution from one supplier.

This new electronic system facilitated the implementation of ISOBUS, a standardized communication protocol used by agricultural and forestry machines.

The electronic system was developed in house at HydraForce in Europe & the United Kingdom and is the company's first ISOBUS project. Incorporating ISOBUS has allowed SaMASZ to extend its portfolio with a new control solution by providing operators with the ability to choose all of the implements' functions from a virtual terminal.

READ MORE: Increased Demand for Electronic Controls Driving Hydraulic System Designs

For those operators who already use ISOBUS compatible tractors, it is not a requirement for them to have an additional control panel which provides savings for end users. Whereas for those customers without an ISOBUS compatible tractor, SaMASZ offers ISOBUS-certified virtual terminals. The implement also presents the ability to map functions to an AUX-N joystick, allowing easier and more comfortable control for the operator.

The SaMASZ KDD 911 STH ISOBUS received ISOBUS certification by the AEF (Agricultural Industry Electronics Foundation), allowing the mower to be listed on the official database — a tool which can be used by farmers and dealers to compare the compatibility of different manufacturers of ISOBUS machines.

"By obtaining the AEF certification, our customers can be assured that the KDD STH/WTH mower set works seamlessly with various models of agricultural tractors, ISOBUS terminals and other external equipment to meet the relevant standards," explained Gotlib.

The mower is the first of its kind in the SaMASZ portfolio to be equipped with this type of hydraulic and electronic control system which has made the brand more attractive to

the wider global market.

"The provision of a complete hydraulic and machine control solution by HydraForce has reduced costs and saved time, both during the project and in the machine's implementation," said Gotlib.

"The high level of expertise within HydraForce has provided a smooth and seamless development of the entire control system for the mower, and the team's engineering knowledge of load-sensing and ISOBUS control, coupled with the ability to implement and link these systems, proved to be an invaluable benefit."

Working with HydraForce enabled SaMASZ to add new features whilst still maintaining the optimum performance that farmers have come to expect from the SaMASZ brand. The SaMASZ KDD STH ISOBUS was officially released to the market at the end of 2023 and promises an efficient and comfortable solution for the agricultural market.

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Price Engineering

CHAPTER 3:

Hydraulic Reservoirs: Is it Time to Rethink Their Size?

SARA JENSEN, Executive Editor, *Power & Motion*

Reconsidering the size of your hydraulic reservoir can lead to cost, weight, space and even environmental savings.

Hydraulic reservoirs have traditionally been large in size to mitigate heat buildup and prevent air from getting into hydraulic oil, both of which can cause performance issues. However, the weight, size and cost associated with using large hydraulic reservoirs can present challenges.

"They might be great for reducing air and increasing efficiency, but they add complexity and cost," said Marcus Herrera, Application Engineer, Advanced Systems Team, HYDAC International during a presentation he gave as part of the National Fluid Power Association's (NFPA) June 2024 quarterly technology conference.

Re-evaluating the size of hydraulic reservoirs, also referred to as a tank, can help to overcome these challenges as use of a smaller reservoir makes it possible to reduce the amount of materials and oil required, leading to cost and weight savings.

Why Larger Hydraulic Reservoirs Have Been the Rule of Thumb

The status quo in the hydraulics industry for many years has been to use a large hydraulic oil reservoir. There are several reasons for this, including the need to supply enough oil for components such as hydraulic cylinders and mitigating thermal expansion — when oil gets warm, it expands and so space is needed to accommodate this.

Herrera said there are also some common thoughts in the industry as to why more oil, and thus a larger reservoir, is better. One is that the more oil that is in the reservoir the cooler it will be as hot oil running through a machine can negatively impact performance.

Another common thought is that the longer oil sits in the tank (referred to as dwell time), the less air there will be going into the hydraulic system which can be detrimental to its performance. Herrera said air in the system is just like any other contaminant as it can cause increases in temperature and noise, change oil viscosity and more.

He said historically to keep air out of the system the mentality was to use a good tank

Large hydraulic reservoirs have been the norm for many years as the industry implemented design features to mitigate heat and air buildup. 197702004 © Kittisak Jaitieng | Dreamstime.com

design which meant using the rules of thumb that were always used:

- lowering the tank turnover rate to increase dwell time
- include baffles to prevent sloshing
- placement of the return and suction lines – don't put them next to or pointed at one another.

However, all of this has led to the creation of larger hydraulic reservoirs which may not be the best option from a size, weight and cost perspective.

READ MORE: Fundamentals of Hydraulic Reservoirs

Smaller Hydraulic Tanks Offer Several Benefits

Moving away from the larger sized hydraulic oil reservoirs commonly used in machines can offer a range of benefits.

Operational and production costs can be lowered when using a smaller reservoir due to the reduction of steel, plastics and oil used in the manufacture and use of a tank — benefitting end-use customers and the manufacturers producing and installing them. Using fewer materials aids sustainability efforts as well.

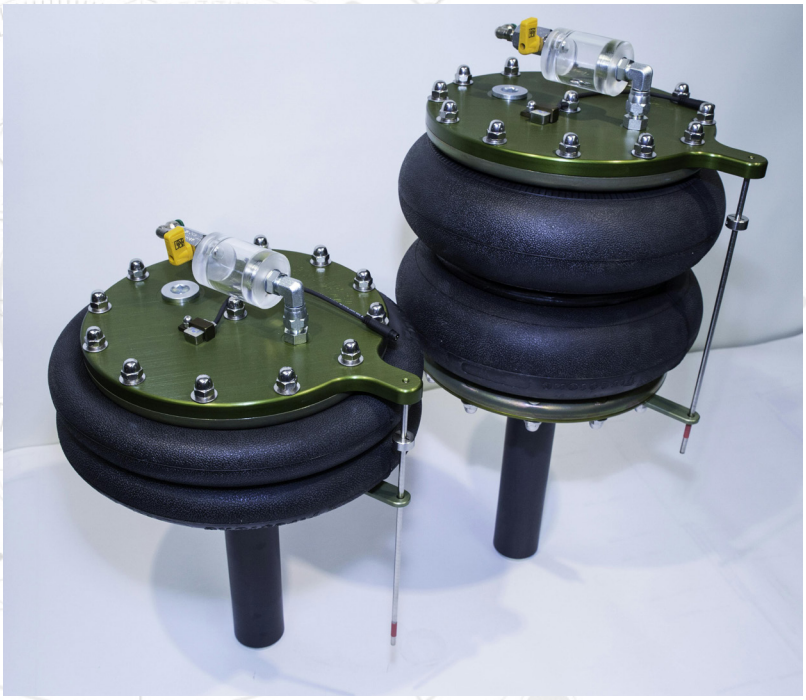
As Tom Price, President, Price Engineering, a SunSource Company, noted in an interview with Power & Motion, oil is not getting any cheaper. High quality oils and biodegradable options are expensive as well. Smaller reservoirs such as Price Engineering's Cyclone Hydraulic Reservoir reduce the fluid volume and space required for oil, leading to cost savings of sometimes several hundreds of dollars he said which can greatly benefit a machine owner's bottom line.

READ MORE about the Cyclone Reservoir in the article "A New Approach to Hydraulic Reservoir Designs."

Less oil in the reservoir means harmful environmental impacts are minimized as well should a leak occur. Hydraulic oil spills are not only damaging soil and waterways but also expensive to clean up, so if it possible to reduce their impact by using a smaller reservoir, all parties involved can benefit.

The Cyclone hydraulic reservoir from Price Engineering is about 10 times smaller than the traditional 20-gal. versions mounted on many machines, helping to reduce space claim in machinery. Price Engineering

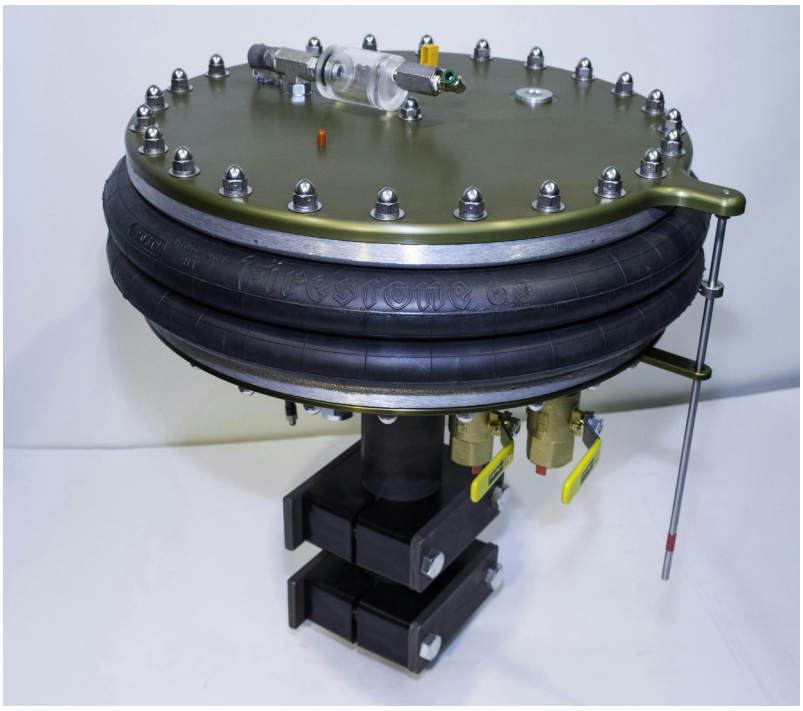
Carl Seguin, fluid power systems engineering and business development consultant at Smart Reservoir, said his company's variable volume reservoir (VVR) is so small that if a leak occurs there will not be as much spilled into the environment. Additionally, the VVR will alert operators if a leak is detected so they shut the machine off immediately. With traditionally sized reservoirs, operators may not know about a leak and so will continue using the machine and thus wind up spilling large amounts of hydraulic fluid into the environment.



When a smaller hydraulic reservoir is utilized, it requires less real estate within a machine which can benefit an OEM's design. Mobile equipment in particular is becoming more space constrained due to the number of components they now contain, requiring some systems such as the hydraulics to be more compact when possible.

In addition, an oil tank which is smaller in size reduces the overall weight of a machine. This can help to reduce the machine's energy and fuel use, leading to further cost savings. More efficient

The Smart Reservoir variable volume reservoir is a compact hydraulic oil reservoir which can help to save on space and weight within machines. Smart Reservoir



The variable volume reservoir is smaller than traditional reservoirs and therefore does not contain much oil which helps minimize environmental contamination should a hydraulic system leak occur.

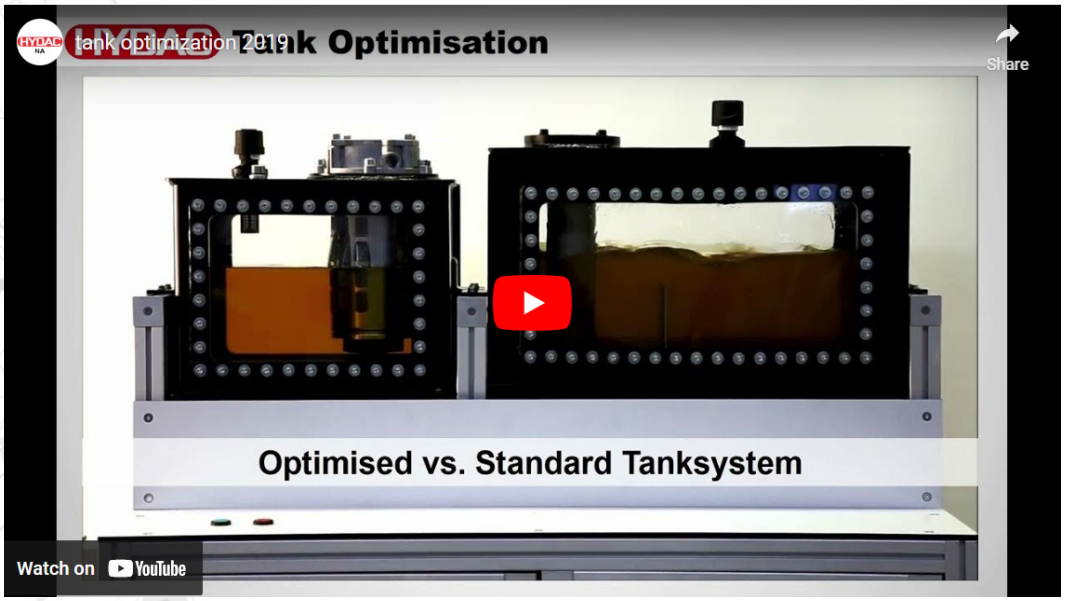
Smart Reservoir

machines also produce fewer emissions.

Weight reductions will be increasingly important for the transition to electrification as the more efficient a machine is, the less battery power required. Batteries also add a lot of weight, so if that can be mitigated in other areas the machine design can be better optimized.

Seguin said the hydraulic reservoir is often forgotten about when developing electric-powered machines. Reservoirs are typically large square boxes with too much oil in them and so if looking to develop a so-called green machine it is necessary to consider the size of the reservoir and how much hydraulic oil is being utilized.

"You want to optimize everything," he said when it comes to developing electric machines and so "you should optimize your reservoir as well."



READ MORE: Variable-volume reservoir solves weight problem

Better Optimized Oil Reservoirs Improve Material Use and Performance

To help customers understand how they may be better able to optimize the size of their hydraulic reservoirs, HYDAC offers as part of its engineering and consulting services a Tank Optimization Platform.

As Herrera explained during his NFPA presentation, this service includes simulation and field testing as well as consulting on what an optimized hydraulic reservoir might look like. "Through our tank optimization platform, we hope to give advice, provide solutions [and] optimize the tank," he said. "And the advantages that people end up getting from this is not only savings in oil and in this tank design to reduce space and complexity, but also an environmentally sustainable solution."

The simulation portion of the optimization process looks at five main aspects of a reservoir design:

- Flow
- Deaeration
- Sloshing
- Thermal
- Structural.

Through these simulations the company can help customers see how adjustments to tank designs can negatively or positively impact their performance. For instance, Herrera said some customers want to know what would happen if they used a steel tank versus a plastic tank and how that could affect oil cooling rates. Through thermal simulation, HYDAC can show how the oil and tank will interact based on the chosen material.

In one example he showed, HYDAC was able to reduce the oil in a tank 48% which led to a 40% reduction in the steel used to produce it. Simulations helped demonstrate that with this smaller tank design the turnover rate is better, the space within the tank is used more efficiently and less air gets into the system.

Although it doesn't make hydraulic reservoirs, HYDAC offers this service to help customers understand what is possible by better optimizing their tank designs. "At the end of the day we hope that we can visualize the benefits before we go out to the field," said Herrera.

Once all simulations are run and it is determined a hydraulic reservoir is a good candidate for a more optimized design, it is taken into the field for testing.

Herrera said HYDAC has worked with customers in a range of industries to help them better optimize the size of their hydraulic reservoirs, enabling them to achieve weight, cost and emissions savings. "The concept isn't just based on HYDAC, really the concept is optimizing a [tank] and going over those things we thought were rule of thumb [and would] never change. Maybe we should spend some more time looking into these areas and see how else we can optimize not just the hydraulic side of things but also the tank," he concluded.

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CHAPTER 4:

Choosing the Right Material for Soundproofing and Vibration Control in Hydraulic Systems

DAVE GIGUERE, Product Specialist, *Nott Company*

Mitigating noise and vibrations from hydraulic systems through proper material selection can optimize performance, safety and more.

Vibration and noise control are crucial in many industries, but what do they entail exactly? In hydraulic systems, where precision and reliability are paramount, managing vibrations and reducing noise levels are crucial tasks.

Vibration control strategies in hydraulic systems focus on minimizing mechanical oscillations that can disrupt equipment performance and compromise system stability. Methods such as damping, isolation, and active control mechanisms are employed to effectively mitigate vibrations.

Noise control in hydraulic systems aims to diminish overall noise levels generated during operations. This is achieved through specialized soundproofing techniques, installation of active noise cancellation systems, and other tailored approaches.

Understanding the specific applications of vibration and noise control within hydraulic systems is essential for optimizing conditions and ensuring long-term efficiency.

The Beneficial Impacts of Hydraulic System Vibration and Noise Control

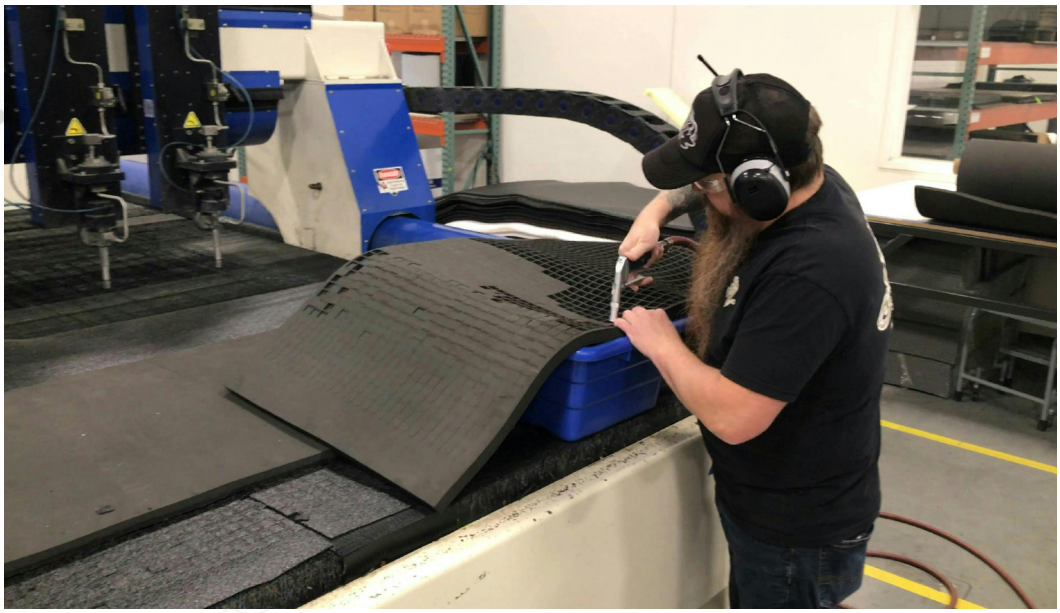
Effective soundproofing and vibration control measures not only minimize noise but also optimize hydraulic system efficiency. By dampening vibrations that can affect performance, these measures enhance operational reliability and extend the lifespan of critical components.

Additionally, a quieter working environment improves operator comfort, reduces the risk of noise-induced fatigue, and enhances overall workplace safety.

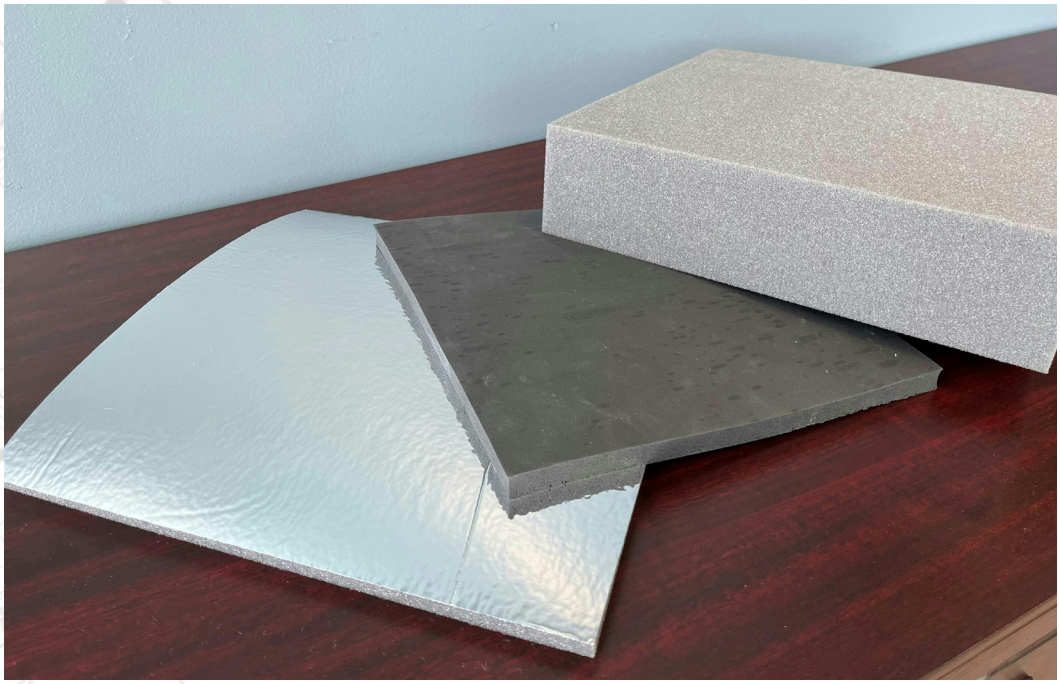
Proper Soundproofing and Vibration Control can Prove Challenging

Choosing the appropriate soundproofing and vibration control solution presents significant challenges, primarily influenced by the complexity of the system and environmental factors.

1. System Complexity: The intricate nature of the system itself poses the primary challenge in selecting suitable solutions. Factors such as spatial constraints within the



Damping, isolation, and active control mechanisms can help to mitigate vibrations in hydraulic systems. Nott Company



Foam is one of the many materials that can be used within a hydraulic system to help reduce noise and vibrations. Nott Company

system and the surrounding environment can greatly impact the choice of materials and methods used for soundproofing and vibration control.

2. Material Compatibility: Ensuring compatibility of materials is crucial. It requires evaluating whether the selected materials can endure exposure to chemicals, moisture, varying temperatures, and other environmental conditions without compromising their effectiveness or durability.
3. Cost Considerations: Balancing cost with performance benefits is essential in determining the most appropriate solution. It's vital to achieve improvements in system performance while managing costs effectively to ensure the solution provides long-term value.

Ensuring the compatibility of selected materials for noise and vibration control is crucial to overall hydraulic system performance.
Nott Company

READ MORE: How to Reduce Noise in Hydraulic Systems

Common Misconceptions When Designing Noise and Vibration Control

Misconceptions surrounding sound and vibration control solutions in hydraulic systems often include the belief in universal solutions that fit all applications, despite the diverse operational requirements of these systems.

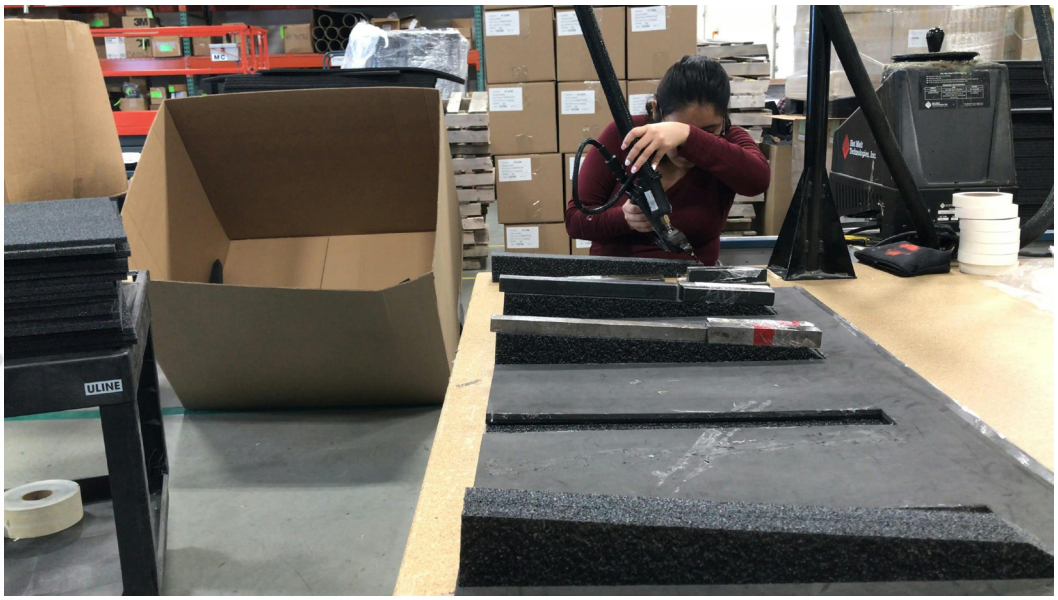
Tailored solutions are necessary to address specific challenges effectively. Additionally, while these solutions aim to minimize disturbances, complete elimination of noise and vibrations is typically impractical.

The primary objective remains to be significant noise reduction to optimize operational conditions and equipment performance.

Key Considerations for Material Selection to Minimize Vibration and Noise

When selecting materials for soundproofing and vibration control in hydraulic systems, several critical factors must be considered:

- Acoustic Properties: Assess the material's ability to absorb or reflect sound waves effectively within hydraulic assemblies.
- Vibration Damping: Evaluate materials that can effectively reduce vibrations and prevent their transmission through hydraulic components.
- Compatibility: Ensure materials are compatible with hydraulic fluids, resistant to environmental factors such as chemicals and moisture, and capable of withstanding varying temperatures.



Dampening vibrations that can affect performance enhances operational reliability and extends the lifespan of critical hydraulic components. Nott Company

- Durability: Consider the longevity and durability of materials under continuous hydraulic operation.
- Ease of Installation: Choose materials that facilitate straightforward integration within hydraulic assemblies, minimizing downtime during installation.
- Cost-Effectiveness: Balance initial investment with long-term benefits in operational efficiency and maintenance savings.
- Regulatory Compliance: Verify adherence to safety and environmental standards applicable to hydraulic systems.

READ MORE: Clamp down on noise and vibration from hydraulic tubing

Effective management of vibrations and noise in hydraulic sytems is not just about meeting regulatory standards; it's about optimizing performance, enhancing reliability, and creating safer, more comfortable working environments.

By navigating the complexities, addressing misconceptions, and selecting material with meticulous care, industries can ensure their hydraulic systems operate at peak efficiency while mitigating potential disruptions.

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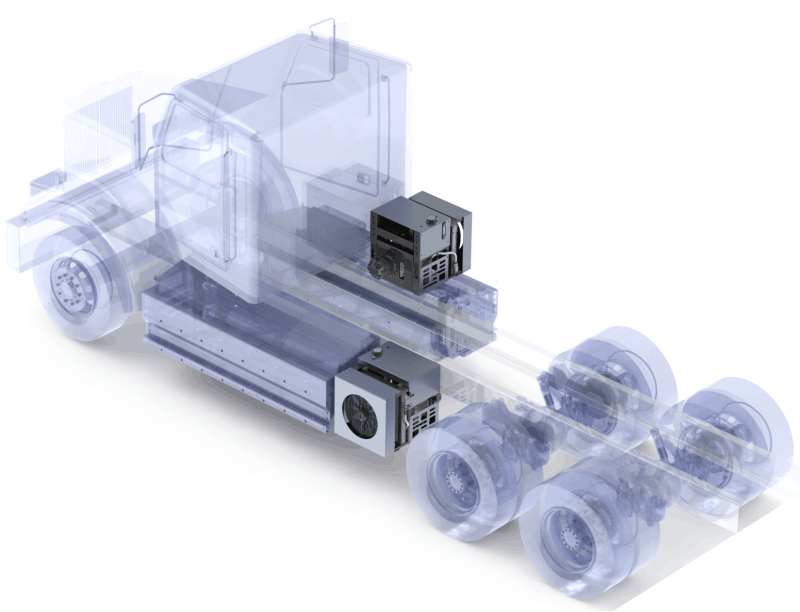

ProDrive PTO & Hydraulics

CHAPTER 5:

ePTOs Enable Continued Use of Hydraulics in Electric Vehicles

SARA JENSEN, Executive Editor, *Power & Motion*

Development of ePTOs is on the rise to power the hydraulic systems that will remain vital to the operation of many electric vocational vehicles.

Power take-offs (PTO) are an important component on many vocational vehicles, such as dump trucks, as they help drive various systems including hydraulics. Like many other industries, there is a push to electrify these vehicles which is increasing development of ePTOs (electric power take-offs) to power the hydraulics that will still be used on many electric vehicles.

The PTO is used to transmit power for the operation of auxiliary functions of a hydraulic circuit or system which has traditionally come from the engine and transmission, said Brad Gulick, Aftermarket Commercial Product Manager at Eaton.

But with the engine now being replaced by a battery-electric powertrain, a PTO capable of harnessing the electric power supplied by the batteries is required – hence the rise in companies developing ePTOs.

Leandro Girardi, Vice President Aftermarket North America at Eaton, said there is a huge push from municipalities, governments and new legislation targeting reductions in carbon as well as noise emissions. Electric vehicles are seen as a method for curbing these emissions; he said the expected growth for electric vocational vehicles is from 35-50% per year. As such, companies need to be prepared to supply the required technologies for these vehicles such as ePTOs.

How Does an ePTO Work?

Unlike a traditional PTO which takes power off a transmission, driveline or other place where rotational energy occurs, ePTOs get power from the vehicle's power distribution unit (PDU) said Parker Chelsea during a presentation on ePTO technology at The Green Truck Summit 2024.

The PDU is connected to the batteries to send power to the drivetrain, air conditioner and other auxiliary functions. An ePTO can also gain power from the PDU and transmit

it to an inverter – where direct current (DC) input power is output as alternating current (AC) – a motor and a hydraulic pump which then drives the vehicle's hydraulic systems the company explained.

Amir Ghajari, P. Eng, Business Development at ProDrive PTO & Hydraulics, said that in ePTO setups power is taken as DC from batteries and then transformed to mechanical power if required. He also noted that any means of electrical or electromechanical power take-off can be considered as an ePTO.

"If this DC output is used to power a dedicated electric motor coupled with any kind of auxiliary equipment such as a hydraulic pump, then it would be an electromechanical power take-off."

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Considerations for the Design and Integration of ePTOs

There are several aspects which need to be taken into consideration when integrating an ePTO. Gulick said a key one is understanding the parameters of the hydraulic system.

If the application is a bucket truck, only so many gallons per minute (gpm) will be required for its operation whereas a crane truck will require more flow, so it is important to properly size the PTO to the truck and its operational needs he said.

Other aspects which need to be considered include the operating voltage utilized on the vehicle. Gulick said when Eaton first entered this market, voltages were in the range of 680-720V and now they are around 800V. "We're seeing a big shift [in voltages] and the reason they're going up is they're looking at bigger hydraulic systems," he said.

ePTO systems can harness electrical energy from batteries to power hydraulic systems on electric vehicles.

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He explained that the hydraulic pumps on many of these trucks are getting bigger to add more functions. Instead of one or two hydraulic circuits there are now four or five to drive a crane, air compressors, outriggers or other accessories. "I think [OEMs] are getting more comfortable with the room on these vehicles and they can add more," he said. "They can get the weight down on the vehicle and add more functions…run with hydraulics."

Understanding how the ePTO will interface with other electronics and systems on a vehicle is important as well, requiring close collaboration between the ePTO manufacturer and vehicle OEM said Ghajari. "Since we are going to draw power…going to drain the batteries, they [OEMs] want to know more," he said. "They want to understand how much current we're taking [and] how long we're going to use it.

"They want to know exactly how we are going to operate, and we need to know exactly what they're providing us to not go above their limitations," he added.

A typical ePTO system is comprised of an electric motor, inverter and hydraulic pump.
Eaton Corp.

Related to this is the connectors and cabling that will be utilized. Parker Chelsea said while it may seem these components are simple to source off the shelf, there are many options available today and it is important to be intentional about the ePTO design as well as what it is plugging into.

OEM Collaboration Key to Success

Ghajari said ePTO systems are more complicated and contain more parts than a traditional power take-off, so there is more integration and OEM involvement required. The additional parts in an ePTO system also means there is more space required, necessitating collaboration to ensure proper packaging on the vehicle.

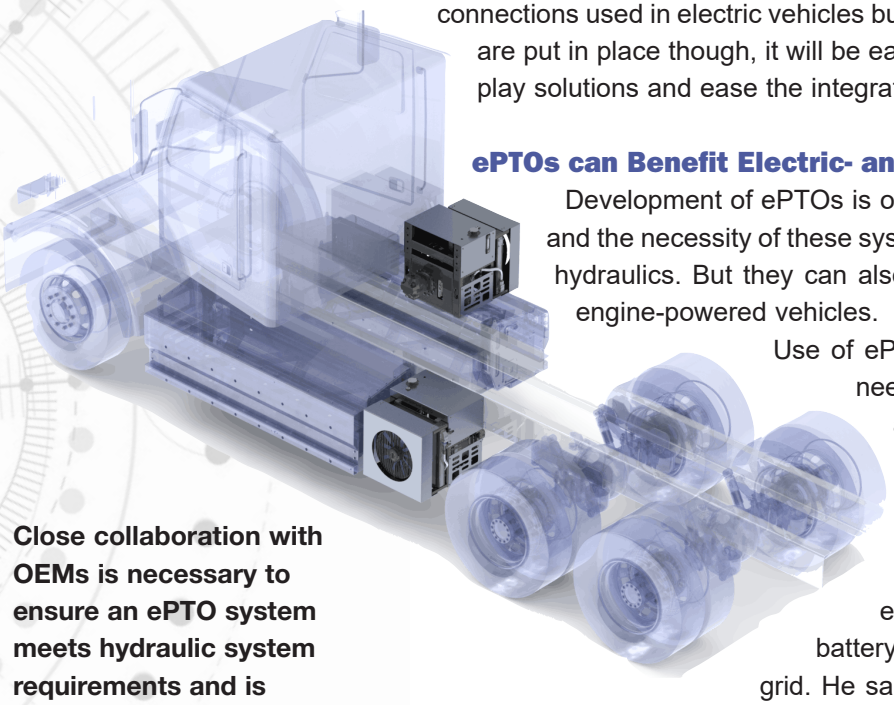
He said ProDrive is working to simplify ePTO designs but there are some technological restrictions. For instance, electric motors and inverters above 20 kW require a separate cooling system. Here again it will be necessary to collaborate with OEMs to determine how to address this additional cooling need.

There are some approaches in the market under development; in Europe, some OEMs are increasing their cooling power 10 kW which then provides enough cooling for the ePTO as well. Another possible consideration is for PTO manufacturers to package the motor, inverter and cooling into a single standalone unit, but again Ghajari said there are technology restrictions associated with this approach such as cooling the inverter. Electric motors have reached a point in which they can be oil cooled but it is not currently possible to reach good efficiency levels with just oil cooling an inverter, he said.

Gulick noted that ePTO technology is so new and changing so rapidly that sometimes Eaton must make changes midway through the development process. In one example he shared, the company had an ePTO design ready to go that would be packaged right behind the cab of the truck but then the customer said it needed to bump out its frame rail, requiring a complete change to the packaging.

Because of the increased complexity associated with ePTO systems and the varying requirements of vehicle manufacturers, Ghajari said most ePTOs are developed on a case-by-case basis. The lack of standard interfaces used throughout the industry necessitates this as well. He said everyone is doing things differently which has made it difficult for PTO manufacturers to offer plug-and-play solutions.

Differing interfaces between vehicle manufacturers means companies like ProDrive must adjust software and sometimes hardware as well which not only increases complexity but costs as well. SAE is working on a standard to have more conformity for the interface



Close collaboration with OEMs is necessary to ensure an ePTO system meets hydraulic system requirements and is packaged appropriately for a given vehicle application. ProDrive PTO & Hydraulics

connections used in electric vehicles but those are still under development. Once those are put in place though, it will be easier for PTO manufacturers to create plug-and-play solutions and ease the integration process for all parties.

ePTOs can Benefit Electric- and Diesel-Powered Vehicles

Development of ePTOs is on the rise due to the growth of electric vehicles and the necessity of these systems for powering their auxiliary equipment and hydraulics. But they can also be used in conventional internal combustion engine-powered vehicles.

Use of ePTOs on a traditional vehicle can eliminate the need for idling, helping to reduce noise, emissions and fuel use. This can benefit a vehicle's use in confined spaces or noise-sensitive areas while also reducing operational costs for vehicle owners.

Ghajari explained that when used in an engine-powered vehicle, the ePTO has its own battery system which is charged by the engine or the grid. He said this setup is much more efficient than using a transmission-based PTO as you would need to keep a 300-400 hp engine running to supply the 10 hp demanded by a traditional PTO which is extremely inefficient.

He noted utility trucks are an application in which the use of an ePTO is becoming popular for both electric- and diesel-powered vehicles. For diesel options, it is typically a standalone package consisting of a battery, onboard charger and a hydraulic pump. On these trucks the ePTO is used to move the bucket which Ghajari said does not require much power to operate. Noise, emissions and cost savings can all be achieved by using the ePTO to operate the bucket instead of the engine.

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The energy and cost savings benefit associated with using an ePTO in engine-powered vehicles is driving growth for these systems, said Ghajari.

ePTOs used in electric vehicles offer several advantages as well. In terms of energy management, he said electric motor does not have to run all the

ePTOs can be used on diesel-powered vehicles, eliminating the need to idle the engine to run certain functions which saves on fuel costs and emissions. Eaton Corp.

time which helps to improve efficiency. The electric motor's ability to instantly speed up enables immediate use of the hydraulic system, enabling operators to remain productive.

In addition, it will no longer be necessary to have several variations of speed ratios because desired speeds can be set electronically. This will aid OEMs in developing different variants of their trucks as they will be able to use the same PTO and just modify the electric motor software as needed.

Going forward, Gulick and Girardi see ePTO demand continuing to grow for both retrofit and new build applications. The retrofit options will help those who want a more immediate solution to aid their emissions reduction efforts.

In addition, those who choose to retrofit will have the opportunity to become more comfortable with hybrid and electric vehicle technology and assess if it is the right solution for their application.

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