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MOBILE ROBOT USE CASES GROW AS TECHNOLOGY ADVANCES

Improvements in sensor, GPS and other automation-enabling technologies are making robots a more viable option.

PAGE 30

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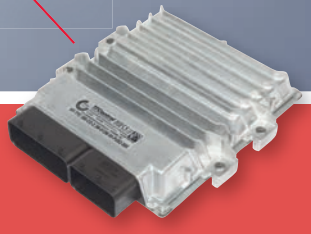

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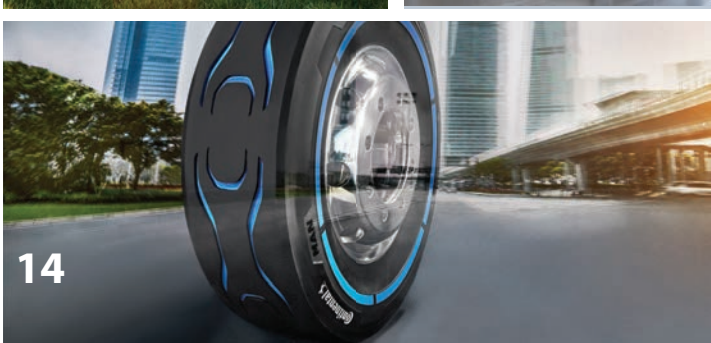

IN EVERY ISSUE

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Selecting an Electric Compressor for Off-Road Vehicles

Performance, displacement and voltage are all important factors to take into consideration when determining the correct electric compressor for an application.

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Push for ELECTRIFICATION, Emissions Reductions Continues

MANWOLSTE | ISTOCK / GETTY IMAGES PLUS

We're halfway through the year—hard to believe isn't it—which means it's time for our annual "E" issue in which we spotlight the latest trends and technologies related to engines, emissions, electrification and efficiency. Although we cover these topics all year long, bringing them together into a single issue continues to signify their importance to our industry.

This year, you'll find electrification is a key theme in many of the articles, demonstrating the continued push of component and equipment manufacturers to create more efficient and environmentally friendly products. On pg. 24 you'll find our overview of new battery technologies while on pg. 14 we look at how autonomous and electric vehicles may impact tire designs in the future. As always, you can keep up with all of the latest news, articles and videos related to electrification on our dedicated channel at *www.oemoffhighway.com/trends/electrification*.

While the current global health crisis continues to present many challenges for the industry—see pg. 12 on news of Stage V deadline extensions—it has not seemed to hinder society or manufacturers' desire to continue their efforts to reduce global carbon emissions. Shortly before we began production on this issue, the California Air Resources Board (CARB) announced its new clean trucks initiative, which was soon followed by 14 other states announcing they would look into enacting their own clean vehicle rules. You can read more about this on pg. 10.

For even more "E" issue coverage, be sure to check out the digital exclusive content in the TOC.com portion of the Table of Contents which directs you to even more articles and related information on our website.

Coming in October is our annual State of the Industry issue in which we speak with executives in the off-road equipment industry about the trends they are seeing and their thoughts on the coming year. *How do you see these "E" industry trends progressing in the coming years? Are there related "E" issue topics we should be covering? Let us know!*

IN THE NEXT ISSUE

OCTOBER ISSUE

- Market Forecasts
- Industry Consolidation Trends
- Shifting Business Models for OEMs
- Operator Interface Design Trends

+ State of the Industry Q&As

editor@oemoffhighway.com
@OEMEditor

PHOTO BY GEROLD HINZEN ON UNSPLASH

EQUIPMENT DEMAND EXPECTED TO REMAIN LOW IN 2020

U.S. Construction Machinery New Orders through April 2020 were down 12.2% compared to the previous year. Demand will likely be limited into late 2020. U.S. Farm Machinery and Equipment Supplies were down 3.2% in April and steep decline is anticipated due to global macroeconomic decline negatively impacting machinery exports.

Europe Agricultural and Forestry Machinery Production through April was down 10.4%. Further decline is anticipated due to shifting consumer demand, labor disruptions and COVID-19 shutdowns negatively impacting the industry and reducing demand for new machinery.

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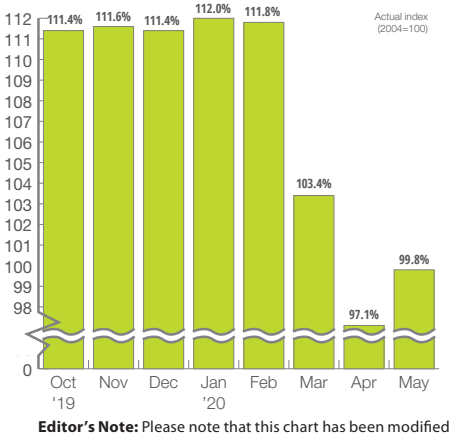
U.S. Leading Indicator:

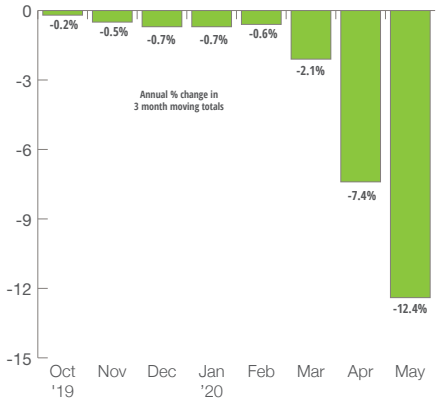
- The U.S. Leading Indicator ticked up in May, with the best-ever April-to-May percentage change in the 62-year data history.
- Tentative rise in the U.S. Leading Indicator suggests U.S. Industrial Production could transition to business cycle rise in early 2021.



Editor's Note: Please note that this chart has been modified on the Y-axis to show the trend more easily.

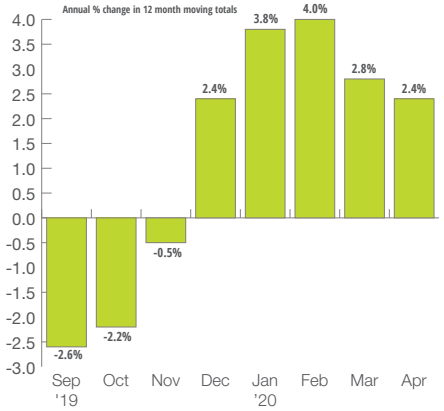
U.S. Industrial Production:

- U.S. Industrial Production during the 3 months through May was down 12.4% from 1 year ago. Monthly Production in April and March posted the worst declines on record, suggesting that overall decline in Production this year will be severe.
- Shutdowns and stay-at-home orders may be lifted in more states moving into the second half of the year. This is expected to result in a rebound in U.S. industrial activity in the latter half of this year.



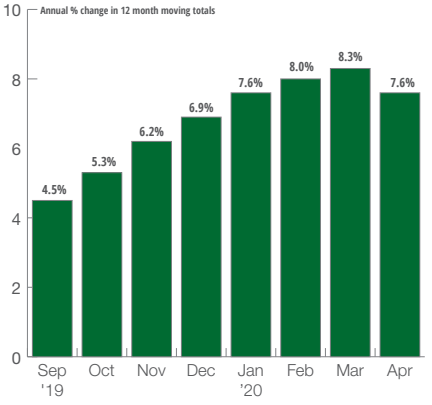
U.S. Private Nonresidential New Construction:

- U.S. Private Nonresidential New Construction during the 3 months through April totaled $113.7 billion, up 2.4% from 1 year ago.
- Construction site shutdowns and labor disruptions in municipalities across the U.S. are hindering rise in Construction. Expect quarterly Construction to decline through at least this year.



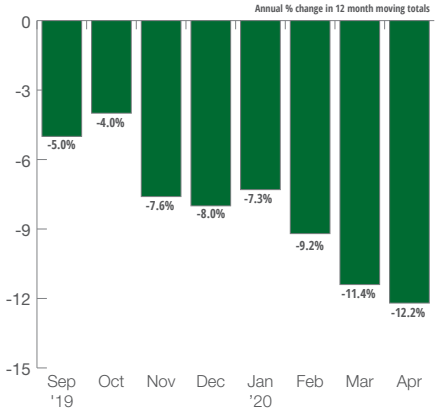
U.S. Total Public New Construction:

- Annual U.S. Total Public New Construction totaled $335.4 and was up 7.6%. The annual Construction rate-of-change tentatively transitioned to decline in April.
- Funds typically allocated for public construction may be allocated toward the more immediate needs generated by the COVID-19 shutdowns.



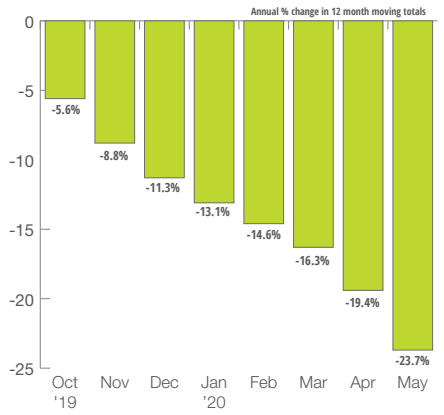
U.S. Construction Machinery, New Orders:

- U.S. Construction Machinery New Orders in the 12 months through April were down 12.2% compared to the same time last year.
- The impact of COVID-19 is reducing demand for U.S. Private Nonresidential Construction. This suggests that there will be limited demand for construction machinery into late 2020.



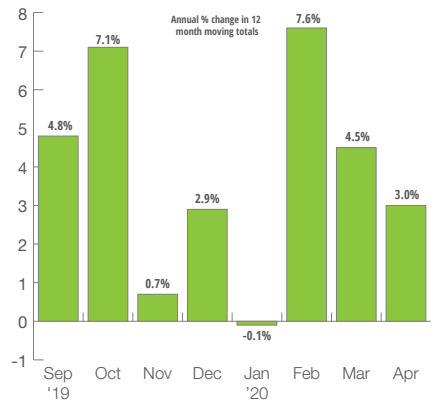
North American Rotary Rig Count:

- The North American Rotary Rig Count averaged 940 in the 12 months through May, down 23.7% from 1 year ago.
- U.S. Crude Oil Futures Prices are expected to trend below year-ago levels this year. Producers will be less incentivized to increase production at these low prices, which will keep the Rig Count relatively low this year.



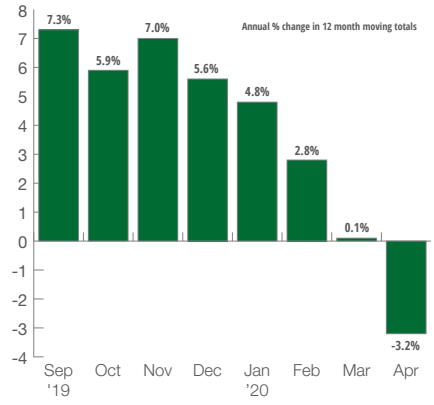
U.S. Defense Industry, New Orders:

- U.S. Defense Capital Goods New Orders during the 12 months through April were up 3.0% from 1 year ago. April New Orders were down over 50% from March, largely stemming from the defense aircraft segment.
- The recent multi-billion dollar contract for Raytheon, as well as rising U.S. Defense Capital Goods Shipments, suggests that this period of weakness will be relatively brief.



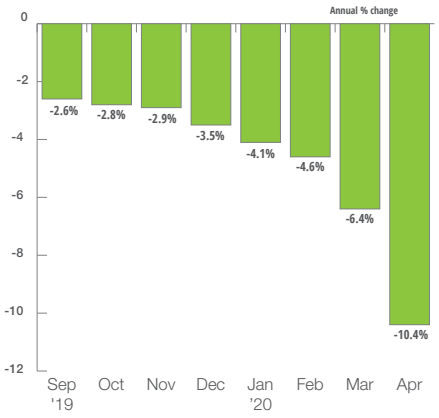
U.S. Farm Machinery Production:

- Supplies during the 12 months through April were down 3.2% from 1 year ago. The March-to-April percentage change was the second-worst in the data history, which dates back to 1964.
- Global macroeconomic decline is contributing to decline in U.S. Exports of Farm Machinery and Equipment (down 22.3% during the 3 months through April). This suggests steep decline in Supplies will persist this year.



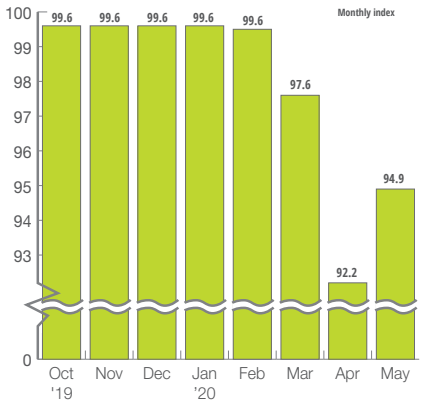
Europe Ag & Forestry Machinery Production:

- Europe Agricultural and Forestry Machinery Production during the 12 months through April was down 10.4% from 1 year ago. The ITR Checking Points™ system signals further business cycle decline is likely during the next two to three quarters.
- Shifting consumer demand, labor disruptions, and COVID-19 shutdowns will negatively impact activity in the European agriculture sector this year, reducing demand for new machinery.



Europe Leading Indicator:

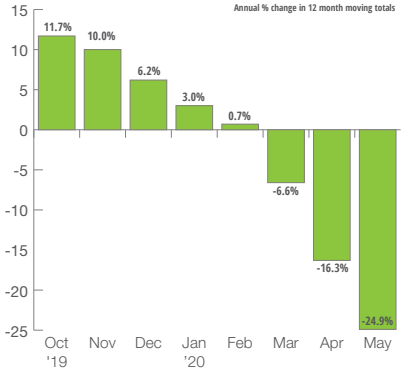
- The Europe Leading Indicator tentatively transitioned to rise in May.
- Should the Leading Indicator April 2020 low hold, it would suggest an early-2021 business cycle trough for Europe Industrial Production.



Editor's Note: Please note that this chart has been modified on the Y-axis to show the trend more easily.

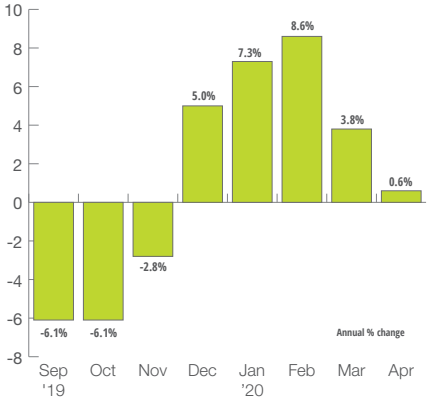
U.S. Heavy-Duty Truck Production:

- Annual U.S. Heavy Duty Truck Production was down 24.9% in May. Uncertainty and cash flow concerns have businesses delaying orders of heavy trucks until the arrival of a more stable economy.
- Annual Production is expected to decline for the remainder of the year as companies adapt to the economic fallout of the COVID-19 shutdowns and low fuel prices.



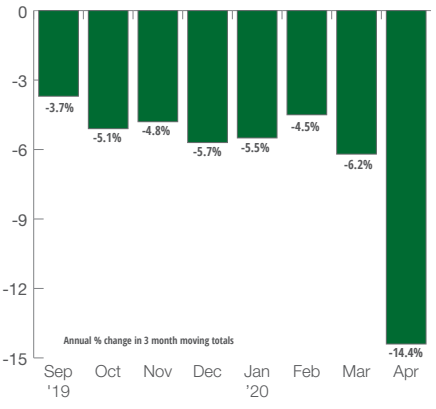
China Diesel Bus Production:

- Annual China Large Diesel Bus Production in April was 0.6% higher than 1 year ago. Production will likely fall below the year-ago level imminently.
- Though China Industrial Production is coming back on line, expected decline in the global industrial sector this year could lead to reduced need for new and replacement buses.



Germany Industrial Production:

- Germany Industrial Production during the 3 months through April was down 14.4% from the same 3 months 1 year ago. The March-to-April percentage change was the worst on record.
- Decline in the Eurozone Purchasing Managers Index suggests further decline in Production is likely this year.



States Band Together to Bring Electric Trucks to ROADWAYS

California and 14 other states have put in place rulings that will accelerate market adoption of zero-emission trucks.

VOLVO TRUCKS NORTH AMERICA

Electric vehicles like the VNR Electric demonstrate what is feasible currently in the market and will help California and other states meet their emissions reduction goals.

At the end of June, the California Air Resources Board (CARB) adopted the Advanced Clean Trucks (ACT) rule requiring all new trucks sold in California be zero-emission electric vehicles by 2045. Soon after the ruling, 15 U.S. States and the District of Columbia signed a memorandum of understanding (MOU) which set a goal of achieving full electrification of medium- and heavy-duty vehicles by 2050. The memorandum also set an interim sales target of 30% zero-emission trucks by 2030 for truck manufacturers.

States which signed the MOU are: California, Connecticut, Colorado, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington.

"No package delivered by a diesel truck is worth dirty air, asthma and climate change. It's time to shift past the old ways of thinking and move toward a clean environment with trucks that don't pollute. Clean electric trucks can clear the air and help stave off the worst impacts of climate change. That's the delivery we are all waiting for. This plan will play a major role in realizing that goal. We applaud the states involved for charting a path for zero-emission electric trucks to clean up our roads," said Morgan Folger, Clean Cars Campaign Director for Environment America, in a statement issued after the MOU was announced.

Matt Casale, Transportation Campaign Director for U.S. PIRG, said, "Getting to school or commuting to work shouldn't include a daily dose of toxic pollution or increase the chances that people will get sick. These states' commitment to 100% zero-emission school and transit buses, along with other heavy- and medium-duty trucks, will help slash lung-damaging pollution and save lives. The sooner we get more electric buses and trucks on the road, the healthier our kids and communities will be."

What the new ACT rule entails

The new ACT rule is part of CARB's efforts to create a holistic approach to accelerate a large-scale transition to the manufacture and adoption of zero-emission medium- and heavy-duty vehicles (Class 2b to Class 8).

According to CARB's fact sheet on the rule, there are two major components of it which include a sales requirement for manufacturers as a well as reporting requirement for fleets:

- Zero-emission truck sales - Manufacturers who certify Class 2b-8 chassis or complete vehicles with combustion engines would be required to sell zero-emission trucks as an increasing percentage of their annual California sales from 2024-2035. By 2035, zero-emission truck/chassis sales would need to be 55% of Class 2b–3 truck sales, 75% of Class 4–8 straight truck sales, and 40% of truck tractor sales.
- Company and fleet reporting - Large employers including retailers, manufacturers, brokers and others would be required to report information about shipments and shuttle services. Fleet owners, with 50 or more trucks, would be required to report about their existing fleet operations. This information would help identify future strategies to ensure fleets purchase available zero-emission trucks and place them in service where suitable.

By adopting this ruling, California aims to meet its air pollution reduction goals including a 40% reduction in greenhouse gases (GHG) by 2030, an 80% reduction in GHG by 2050 and a 50% reduction in petroleum use by 2030.

"California is an innovation juggernaut that is going electric. We are showing the world that we can move goods, grow our economy and finally dump dirty diesel," said Jared Blumenfeld, California's Secretary for Environmental Protection, in CARB's press release announcing the new rule.

"For decades, while the automobile has grown cleaner and more efficient, the other half of our transportation system has barely moved the needle on clean air," said CARB Chair Mary D. Nichols. "Diesel vehicles are the workhorses of the economy, and we need them to be part of the solution to persistent pockets of dirty air in some of our most disadvantaged communities. Now is the time – the technology is here and so is the need for investment."

In the coming months, CARB will also consider two complementary regulations which will support the ACT rule. The first sets a stringent new limit on NOx (oxides of nitrogen), requiring new trucks that still use fossil fuels to include the most effective exhaust control technology during the transition to electric trucks. There is also a proposed requirement for larger fleets in the state to transition to electric trucks year over year.

Jacobs Vehicle Systems says it supports CARB's new initiatives. "Jacobs has been working with our customers and industry partners for years to develop solutions to improve engine combustion and aftertreatment efficiency to be ready to respond to these new regulations," said Steve Ernest, Vice President of Engineering and Business Development for Jacobs, in a press release from the company. "We have the technology to help engine and vehicle makers meet these new limits and improve fuel efficiency while doing it."

"California is proud to be joined by 14 other states and the District of Columbia in a push for clean, zero emission trucks," said California Gov. Gavin Newsom in the press release announcing the MOU. "Our efforts in California will be magnified through the efforts of this multi-state coalition to reduce emissions and improve air quality. By working together, we can move toward a cleaner future."

"The electric vehicle industry is primed for tremendous growth," said D.C. Mayor Muriel Bowser. "We cannot afford to miss this opportunity to place clean transportation technology and infrastructure at the center of the nation's economic recovery."

Read More

Read the full article at www.oemoffhighway.com/21139798 to learn more.

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EU Extends Stage V Transition Deadlines by 12 Months

Deadlines have been extended for the production and market introduction of off-road equipment with transition engines.

by Sara Jensen

On July 17, the European Parliament signed into law an amendment to the original Stage V emissions regulations for off-road equipment. The amendment—Regulation (EU) 2020/1040—confirms a 12-month extension of transitional provisions for certain categories of engines and is applicable retroactively from July 1, 2020.

Deadlines for the production and placing on the market of off-road equipment fitted with transition engines <56 kW (75.1 hp) and ≥130 kW (174.3 hp) were initially set for June 30 and December 31, 2020. However, as the COVD-19 pandemic began to negatively impact the global economy—including the equipment manufacturing industry—many began to call for an extension of the original deadlines put in place by Regulation (EU) 2016/1628.

Several European associations for the mobile off-road equipment industry, including—CECE, CEMA, EGMF, EUnited Municipal Equipment & Cleaning, Europgen and FEM—first sent a joint letter to the European Commission in March asking for a moratorium on the application of 2020 and 2021 deadlines listed in Regulation (EU) 2016/1628 on exhaust emissions from non-road mobile machinery (NRMM) and 2018/985/EU for agricultural vehicles.

While manufacturing and procurement of these engines was already

The Stage V transition deadlines have been extended for some categories of engines.

FPT INDUSTRIAL

complete, the challenges created by the pandemic—supply chain and manufacturing disruptions caused in part by government-directed lockdowns—made it clear it would be difficult for manufacturers to get the engines into their machines and on the market in time to meet the deadlines set out in the original regulation.

After hearing from the industry and debating the topic, the European Parliament adopted text on July 10 to extend the deadlines by 12 months, and published it in the Official Journal of the European Union a few days later. The NRMM sector welcomed this extension, including the retroactive application of the legislative amendment, providing the necessary legal certainty to manufacturers. This was made necessary by the delayed decisions of the European Commission in presenting the legal proposal and a slight delay in the adoption phase.

Commenting on the initial vote to extend the deadlines, CEMA Secretary General Jérôme Bandry said, "The Parliament's vote was vital to prevent further economic damage caused by the COVID-19 pandemic to our manufacturing industries and protect thousands of qualified jobs that depend on them."

Bandry continued, "Neutral from an environmental perspective, this measure will not soften the stringency of the European legislation. Instead, it will give our industry the necessary time to install transition engines already acquired in machines, place them on the market and be compliant with ever more demanding requirements. On the opposite, inaction would have led to unnecessary waste of raw materials and resources, in addition to the financial costs."

In a joint statement, the NRMM industry associations said they warmly welcome the positive conclusion of this extension process. They also noted the political success obtained by the united NRMM industry allows machinery manufacturers to avoid economic damage and unnecessary waste of raw materials and resources since the transition engines were already built in 2018 and would otherwise have to be scrapped.

NRMM and tractors fitted with transition engines between 56 and 130 kW are not affected by this extension and retain the applicable 2021 deadlines. However, the sector is calling on the European Commission to continue to monitor the effect of COVID-19 on the industry and conduct a timely assessment of this impact regarding upcoming deadlines, submitting a new report to Parliament and undertaking new legislative actions as appropriate.

Head to the Web

Read more on the topic at www.oemoffhighway.com/21139224.

CONTINENTAL

LEFT: The Conti e.MotionPro concept was developed for an electric truck from MAN.

BELOW: ContiPressureCheck features a sensor embedded in the tire to monitor tire performance and issues alerts on an in-cab display.

The Impact of Autonomous and Electric Vehicles on TIRE DESIGNS

Unique requirements of autonomous and electric vehicles will bring about the need for new tire and wheel solutions.

by Sara Jensen

With autonomous and electric vehicles continuing to become more commonplace, their designs are impacting many components and systems including the tires. Research firm Smithers released a report earlier in 2020 examining the impact of autonomous vehicles on tires. It found tire materials and components, tire retail and tire marketing will be the most affected.

Smithers' report went on to note tires for autonomous vehicles will:

- place a greater emphasis on durability, over handling and other performance criteria;
- accelerate the adoption of smart tires with sensing and reporting functions;

- see more use of low maintenance or planned tire monitoring platforms to manage fleets of shared AVs;
- demand lower weight tires to extend mobility, especially for electric vehicles.

Continental says with the trend toward automation, the impact of the driver on driving behavior and operational processes will become obsolete. As such, tire designs will need to evolve to account for these changes in driving behavior.

"Electric and autonomous vehicles are becoming more popular due to operating efficiencies," says Ron Tatlock, Manager – Training & Engineering at BKT USA, Inc. "Designing tires for optimum tire and vehicle performance on electric and autonomous vehicles will help owners maximize the efficiencies and control the cost of operation."

Special considerations based on vehicle type

Aaron Dahl, Chief Engineer Americas at GKN Wheels, says it is important to note design challenges raised by electric vehicles and those by autonomous vehicles are different and therefore require different solutions. Dahl says autonomous vehicles in general require wheels and tires that provide increased durability, strength, and longevity whereas the challenge with electric vehicles comes in the application of torque and the different demands this imposes on wheels and tires.

Julian Alexander, Product Line Manager Material Handling at Continental, notes the different requirements required by both vehicle types places great demands on tire manufacturers. Forklifts, for instance, are already electric and are quickly becoming more automated. Tires for these vehicles must be robust, heat resistant and durable, especially if automated Alexander says, because they are able to run 24 hours a day, 7 days a week which can create a lot of wear. However, electric vehicle tires must have as low a rolling resistance as possible. Alexander says these requirements are contradictory, making it integral for a tire manufacturer "to keep close relationships with the customers to understand their specific needs [and] keep coming up with the right fit for their vehicles."

Tatlock says lower rolling resistance is an important feature for electric vehicles to help preserve the stored electrical energy on a vehicle—decreased rolling effort of these tires leads to a reduction in the amount of energy needed to move the vehicle. Minimizing the amount of energy used by the tires helps to ensure the vehicle can operate as long as possible before recharging is necessary.

Design considerations to minimize tread wear from tire to surface slippage when the vehicle begins to move is also integral for electric vehicles, says Tatlock. This is because electric drivetrains are capable of nearly instantaneous torque at the full motor power, eliminating motor ramp up or drivetrain slippage. The full torque of the drive motors is thus instantly applied to the tires which can increase the amount of wear they will experience over their lifetime. "Also, tire casings must be robust enough to handle this unthrottled torque," he adds.

Lower rolling resistance is an important feature for electric vehicles.

Tire slippage between tire and rim as well as tire and ground surface must be taken into consideration due to the increased amount of torque being placed on the tires of electric vehicles, says Gianpietro Bramè, Global and European Chief Engineer Wheels at GKN Wheels. This is already a common problem in the agriculture industry due to the increasing size and horsepower rates of equipment. As such, GKN Wheels developed its Profi-Grip wheel rim which has demonstrated the ability to eliminate tire slippage. "We are therefore confident that we have the experience, expertise and necessary tools to respond both to tire

In the future, the design of and technologies used in machinery, including tires, will be even more tailored to their working environment.

CONTINENTAL

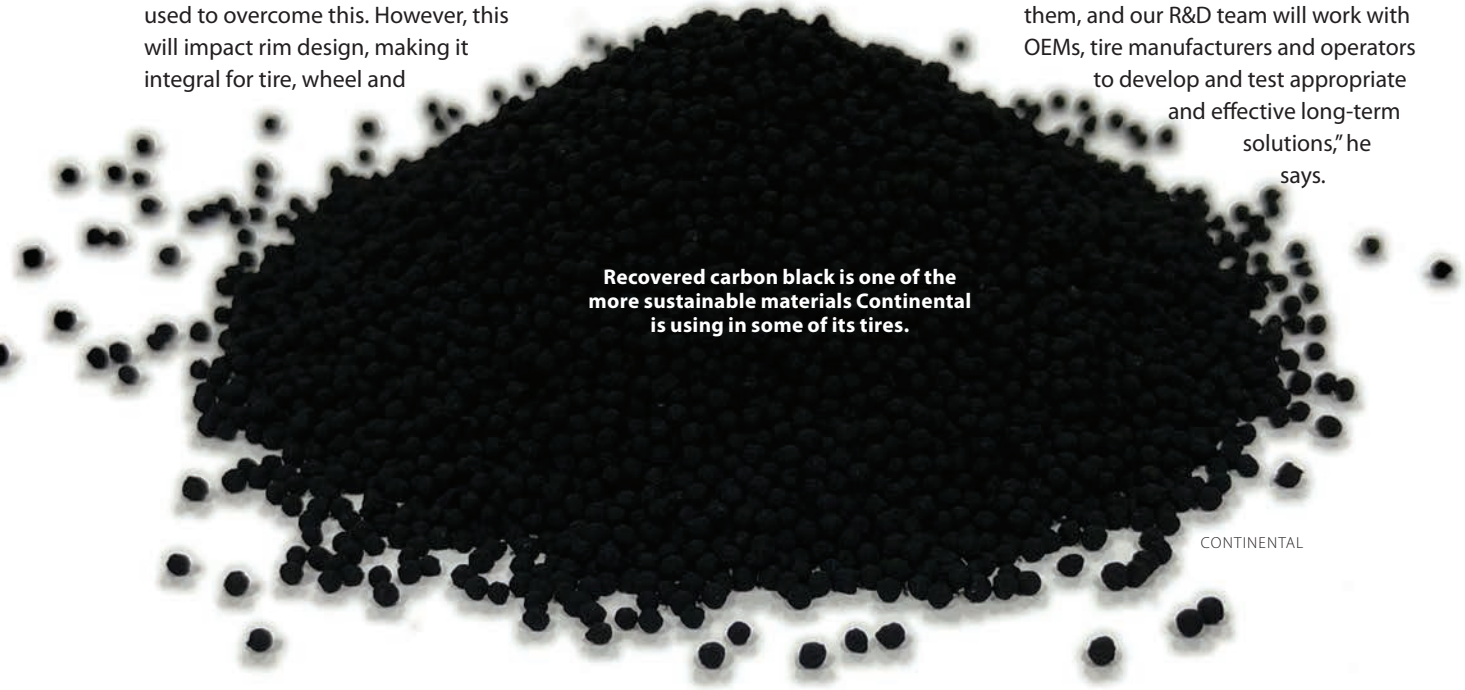
CONTINENTAL

More monitoring tools will be necessary to ensure optimal performance of tires in various applications.

slippage, and to completely new challenges that the use of electric vehicles may present," says Bramè.

Dahl says tire slippage will likely be an issue for electric vehicles in the construction industry as well. Both Dahl and Bramè say wider tire bead designs may be one of the methods used to overcome this. However, this will impact rim design, making it integral for tire, wheel and equipment manufacturers to work together to achieve the right design for an application.

Dahl notes wider tires and larger diameter wheels to help spread the torque could also be a solution to overcoming tire slippage. Increased torque application associated with electric vehicles may lead to challenges with bolted joints and disc designs, as well, which he again notes GKN Wheels has the knowledge and experience to overcome. "It is possibly too early to know with certainty what all the challenges are which lie ahead in these sectors, but we are prepared to meet them, and our R&D team will work with OEMs, tire manufacturers and operators to develop and test appropriate and effective long-term solutions," he says.



Recovered carbon black is one of the more sustainable materials Continental is using in some of its tires.

CONTINENTAL

Tatlock says autonomous vehicles will require robust compounding and overall designs with extra protection for tire sidewalls and tread. "The autonomous vehicle may not drive around a rock or other tire hazard or avoid hitting the [side of a] wall as consistently as a good operator," necessitating a more durably designed tire. And because autonomous vehicles are running continuously, a special design may be required to lower heat generation and retention to avoid heat related damage.

Reliability and assurance of long-life performance are critical requirements in the design of wheels and tires for autonomous goods vehicles (AGV), says Bramè. "Standard wheels are simply unable to cope with this extraordinary operating environment and so our

More Sustainable Tire Materials

Manufacturers have been researching alternative material options for tires for several years. The goal is to find options other than rubber—which is a non-renewable resource and often subject to price fluctuations—which are better for the environment without compromising performance.

Julian Alexander, Product Line Manager Material Handling at Continental, says tires of the future will need to be made of recyclable and biodegradable materials. As such, the company is already using a recycled carbon black material for its solid tires for forklift and industrial trucks. Also known as pyrolysis carbon black, the material is recovered by pyrolysis of used tires which reduces material consumption and CO_2 emissions.

The company has also been investigating the use of Russian dandelion and has opened a research lab dedicated to farming and extracting it.

Michelin introduced its VISION concept tire in 2017 which is an airless, connected, rechargeable and organic wheel and tire. It uses bio-sourced and biodegradable material, and can have its tread 3D printed. Michelin announced the following year its goal to manufacture all tires using 80% sustainable materials and that 100% of all its tires will be recycled by 2048.

Watch and learn more about these and other tire material research projects at www.oemoffhighway.com/21046635.

CONTINENTAL

Tires for forklifts which are both autonomous and electric will need to meet contradictory requirements of high durability and low rolling resistance.

experienced R&D team worked closely with OEMs, tire manufacturers and port authorities to develop a solution to meet their needs, developing a wheel better able to cope with the increased stresses and so have significantly more resilience to fatigue," he says.

This solution, the Infini-Forge wheel, is manufactured through a hot induction forming (HIF) process which makes the wheel 50% stronger and last 50% longer compared to conventionally manufactured, multi-piece wheels. The HIF process allows material to be placed where it is needed, and taken out where it is not, leading to an increase in rim strength without a significant increase in weight.

"Whereas traditional wheels would have a lifespan of some 37,000 hours in these challenging applications, AGV Infini-Forge wheels, with customized geometry, have demonstrated in field tests a lifespan in excess of 90,000 hours and so are considered to be a structural component of the machine," explains Bramè.

In some sectors, like agriculture, the use of autonomous vehicles is more complicated due to the varied and less predictable environment in which the machine is working, says Bramè. Duty cycles are not necessarily as repetitive as those of other applications, such as port or surface mine operations, and he says it is unlikely farmers will require 24/7 operation. As such, the challenges for agricultural autonomous vehicle tires and wheels may be different.

"Although we have a good understanding of what the issues are likely to be in [the off-road equipment] sectors, to fully understand each market's requirements, we will continue to work closely with OEMs, tire manufacturers and end users to make sure we develop solutions that are right for each of them and put the solution through its paces in field tests," says Bramè.

Smarter tires will be essential

Reinhard Klant, Product Line Manager Earthmoving at Continental, says autonomous equipment in the earthmoving sector is often operated in a convoy to increase efficiency and enable smooth processes. However, if one of the vehicles breaks down due to an issue with a tire or other system it will not only stop the entire fleet but also increase the risk of a collision. As such, it will become increasingly more important to use monitoring tools such as sensors which can send alerts to other vehicles as the problem occurs and thus prevent possible collisions.

The company's ContiEarth tire range is one example of how intelligence is already being added to tires to improve operations. An integrated tire sensor alerts the equipment operator when pressure and temperature of the

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GKN WHEELS

The Infini-Forge wheel is manufactured through a hot induction forming process which makes it 50% stronger and increases its lifespan 50%.

tire deviates from the norm. This helps to increase efficiency and safety by allowing fleets to better plan for maintenance and avoid costly downtime.

Dahl agrees the next stage of development for tires and wheels will be creation of more monitoring tools such as sensors capable of detecting cracks. "This technology will be invaluable in ports, but will also help unlock the potential for autonomous vehicles in sectors such as underground mining, where the risk of a vehicle failing 3 mi. (4.8 km) underground is an obvious barrier to their introduction in these environments," he says. "Clearly if preventative maintenance can be accurately predicted, then vehicles can be taken to the surface at the right time, rather than waiting for a failure to occur."

Continental says that in the future, the design of and technologies used in machinery will be even more tailored to their working environment. Demands for a more sustainable world will also continue to increase. Because of this, tires of the future will be intelligent, sustainable and environmentally friendly. "The tire of the future will therefore need to be as efficient as possible in order to save fuel and emissions," says Continental. "At the same time, it will have to be made of recyclable and biodegradable materials." *(See sidebar, pg. 17.)*

In general, manufacturers agree that traditional tire and wheel designs will not be able to meet the requirements demanded by autonomous and electric vehicles, so new solutions will be needed. "Rather than being completely new designs though, these new [tires and] wheels are likely to be evolutions of existing technologies, both product and process, building on the benefits of proven solutions in use globally to respond to the needs of these new machines," agree both Bramè and Dahl.

"BKT expects to see more of these vehicles appearing in more diverse applications as the technology and ingenuity of equipment designers continues to grow. We are ready for the challenge," concludes Tatlock.

Electro-Hydraulic Actuators Offer Ability to Handle HEAVY LOADS in TIGHT SPACES

Compared to hydraulic cylinders, electro-hydraulic actuators can offer many benefits including increased load handling and a more compact installation space.

contributed by Matt Palmer, Product Line Specialist – Industrial Linear Actuators at Thomson Industries Inc.

System designers have long given hydraulic cylinder-based motion control systems first consideration in applications requiring handling of loads upwards of 3,000 lb., mostly because of the high power density of the cylinders themselves. But when the designer factors in the large space required for the intricate infrastructure needed to achieve that power, that power density becomes much less attractive.

Now, however, thanks to technology that builds hydraulic motion control into an envelope smaller than a conventional electromechanical unit, designers and end-users can enjoy the power conversion advantages of hydraulic fluids without the expense, rigidity and need to clean up after conventional hydraulic cylinder-based systems.

THOMSON INDUSTRIES

The Thomson H-Track electro-hydraulic linear actuator handles force up to 4,800 lb. and features the smallest mounting envelope in its class.

Electro-hydraulic linear actuators are fast becoming the motion designer's choice over hydraulic cylinders for a wide range of heavy load handling in outdoor equipment, military and many other applications.

Structural differences

A hydraulic cylinder-based motion control system converts electrical energy into motion using an assembly involving oil reservoirs, electric motors, pumps, oil filters, relief valves, and directional valves. The speed desired and the size of the cylinder dictate the size of the pump needed, which then determines the size of all other components. The higher the required speed, the higher the cost of the system and the greater the operating space needed.

An electro-hydraulic system, in contrast, embeds the equivalent of that infrastructure into an envelope that is about the same size as a conventional electromechanical actuator (Figure 1). An electric motor rotating clockwise turns gears that pressurize the hydraulic fluid. Valves open to draw fluid from both the reservoir and head side, and control delivery to extend the rod. On retraction, the motor runs counterclockwise, reversing the operation, and returning the fluid to the reservoir and the opposite side of the piston. For loads of up to 4,800 lb., miniaturizing that infrastructure has significant advantages over hydraulic cylinders in power density, maintenance requirements, location versatility, cleanliness and cost, while handling comparable shock loading (Figure 2).

Load capacity

By replacing the gear and lead screw assemblies of conventional electromechanical actuators with a compact hydraulic system, electro-hydraulic actuators can move loads up to 4,800 lb. Loads of this size have typically been relegated to hydraulic cylinder-based systems. This load range is more than 1,000 lb. greater than the capacity of a conventional electromechanical actuator.

Power density

For raw power density, electro-hydraulic designs have a distinct advantage. While the electro-hydraulic actuator and hydraulic cylinder may not be too much different in size, the support infrastructure needed to operate the hydraulic option consumes significant space.

Cleanliness and safety

Electro-hydraulic actuators also have an advantage in cleanliness and safety. External leaks at pipe and hose fittings of hydraulic cylinder systems occur over time due to vibration and other factors. When these leaks happen, the cylinder leaks a film of oil into the plant environment with every stroke.

Internal leaks present an even greater maintenance challenge. Leaks inside the pump, pressure controls, directional valves and cylinder convert pressure and flow to heat or wasted energy, which will reduce actuator speed. In industrial settings, leaks also cause odor and present slipping hazards.

	Hydraulic Cylinder-Based Systems	Electro-Hydraulic Actuators
Max Load Capacity	>21 kN (4,800 lbs.)	21 kN (4,800 lbs.)
Power Density	High	Highest
Cleanliness & Safety	Low	High
Additional Maintenance	High	None
Location Versatility	Low	High
Shock Handling	High	High
Cost - Initial	High	Low
Cost - Expanding Existing Unit	Low	Low
Cost - Lifecycle	High	Low

Figure 2: Comparison of hydraulic cylinder-based systems and electro-hydraulic actuators.

Location versatility

Because they don't need an elaborate support infrastructure, electro-hydraulic actuators make it more effective to move control closer to the point of application. Hydraulic cylinders are far less than ideal for any application that is hard to access. If a cherry picker vehicle designer wants motion control to tilt the bucket, for example, it would be far easier to run electrical wire up to the boom than hydraulic fluid transport tubing. This solution also removes potential concerns about fluid dripping into the environment.

Shock loading

Historically, hydraulic technology has been better able to handle sudden shocks. However, embedding this technology into electro-hydraulic actuators gives them shock-loading benefits on par with hydraulic cylinders.

For new application designs requiring handling of loads up to 4,800 lb. and speeds up to 4 in. per second, electro-hydraulic actuators have significant advantages over hydraulic cylinder-based systems in power density, cleanliness of operation, versatility and lifecycle costs.

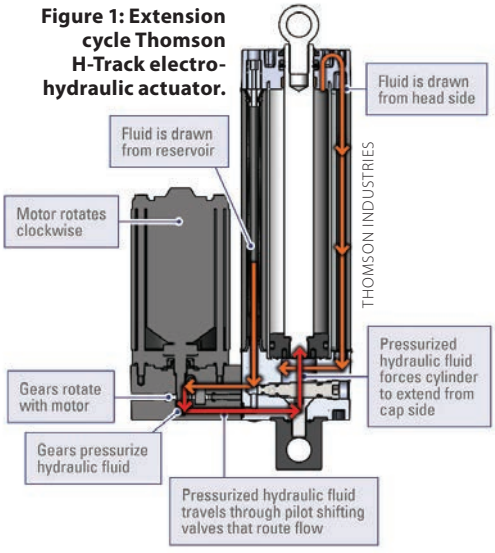

Figure 1: Extension cycle Thomson H-Track electro-hydraulic actuator.

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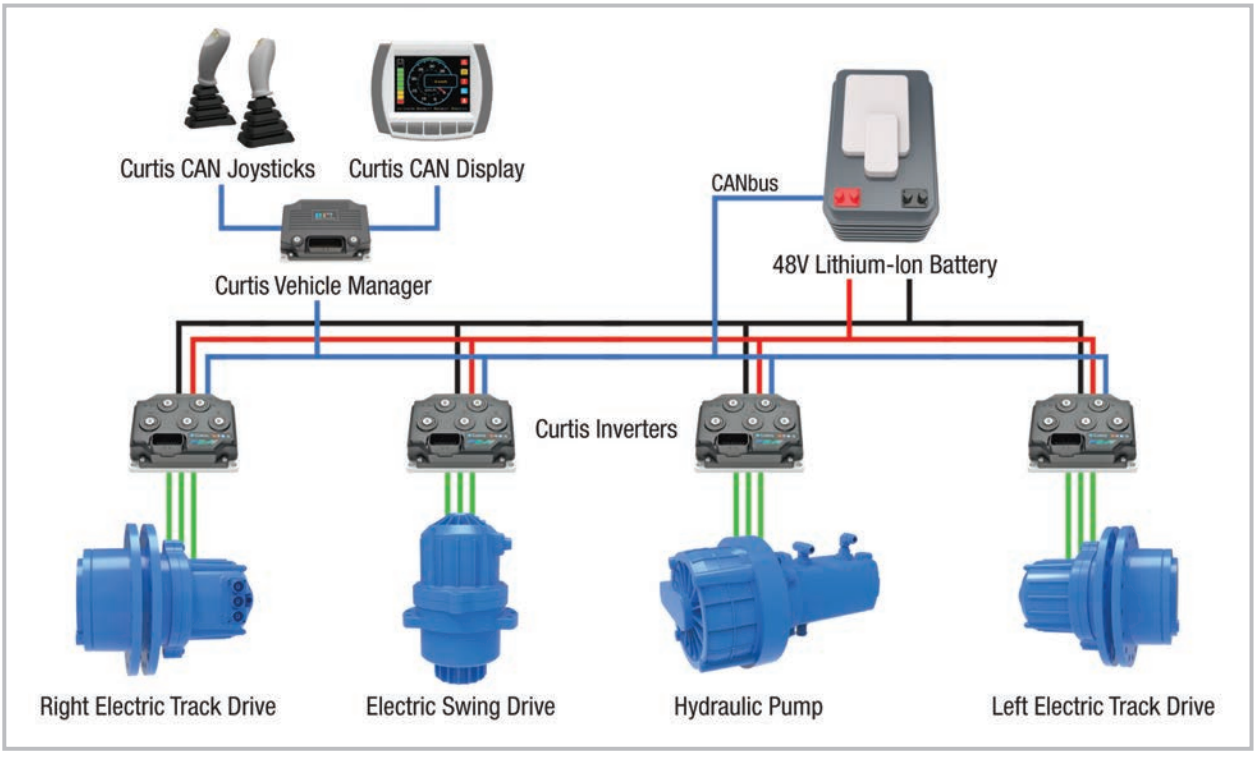
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Left Electric Track Drive

Advancements in Battery Systems are Increasing

The first demonstration of the Vanguard battery is on an ARGO J8 unmanned ground vehicle.

RIGHT: The Vanguard battery comes with the battery management system as well as the controller and charger, offering a complete package for OEMs.

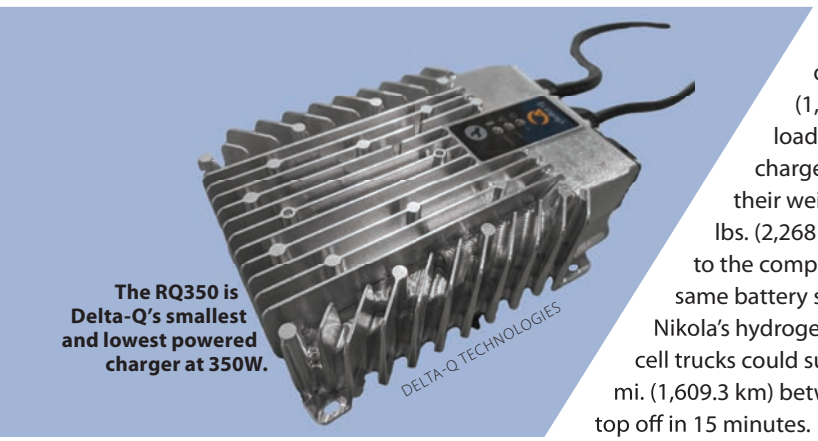
Continued developments in battery technology are bringing about higher power capabilities and additional use cases in the heavy equipment industry.

by Sara Jensen

As electrification continues to advance in the heavy equipment and vehicle industries, so do the battery technologies available to power them. With these new batteries have come increases in power output as well as new applications in which they are employed.

Nikola Motor Co., for instance, announced in November 2019 it was introducing a new battery technology with energy density of 1,100 watt-hours per kg on the material level and 500 watt-hours per kg on the production cell level. The prototype of this battery removes binder material and current collectors, enabling more energy storage within the cell.

Use of the battery in Nikola's battery electric trucks could enable them to drive 800 mi. (1,287.5 km) fully loaded between charges, and reduce their weight by 5,000 lbs. (2,268 kg) compared to the competition if the same battery size was kept. Nikola's hydrogen-electric fuel cell trucks could surpass 1,000 mi. (1,609.3 km) between stops and top off in 15 minutes.



The RQ350 is Delta-Q's smallest and lowest powered charger at 350W.

Mourad Chergui, Product Manager at Delta-Q Technologies, says battery technology has reached a point at which it allows heavy equipment to have the same duty cycle—typically an 8-hour shift—as traditional power sources.

CASE Construction Equipment's recently introduced fully electric backhoe loader, the 580 EV, is powered by a 480V, 90 kWh lithium-ion battery pack which supports most common 8-hour workday applications on a single charge.

Advancements like these show battery technologies are overcoming many of the concerns regarding range associated with electric vehicles and equipment.

More manufacturers enter the battery space

Development of electric powered equipment and vehicles will continue to increase in the coming years. As such, over the past several years many

BRIGGS & STRATTON

component manufacturers have begun diversifying their product portfolios to include batteries.

Webasto—probably best known for its heating and cooling products—introduced in November 2019 its commercial vehicle (CV) Standard Battery System. Designed for scalability and configuration flexibility, the battery pack provides 35 kWh of energy and allows up to 10 packs to be combined to provide enough power for larger equipment applications.

BRIGGS & STRATTON

The Vanguard Commercial Lithium Ion Battery pack was developed specifically for the 0.5-20 kWh power range.

Josh Lupu, Director of Marketing at Webasto, says the company started investing in high voltage technology around 2010 due to the increased interest and future growth it was seeing in regards to hybrid and electric vehicles. "We created the high voltage heater. That was our first entry into e-mobility or the electric powertrain," he says. "That was the start of Webasto diversifying into non-combustion powertrains."

In 2016, the company started developing charging stations and acquired a charging station company in 2017, which is also when it started developing the CV battery system. It is a nickel rich NMC (nickel manganese cobalt) prismatic cell battery. Webasto chose the NMC chemistry because it provides high energy density as well as a long life. "We have a lifetime of 3,000 cycles or 8 years," says Lupu. "This means if you fully discharged the battery if it was at 100%, and then fully charge it back up to 100%, you could do that every day for 8 years."

He says in reality that is not how people will use the battery; no one usually fully discharges and recharges it, but it's been verified that it can withstand that type of use. "It's very robust and made for extreme use cases," adds Lupu.

Briggs & Stratton is one of the latest engine manufacturers to announce its entry into the battery development market. "We've identified that there's a gap in the marketplace of people that are powering units anywhere from 0.5 kWh up to 20 kWh," says Christine Davison, Senior Manager Marketing, Engines & Power at Briggs & Stratton. "We believe there's a big opportunity there."

She says there are some manufacturers offering lead acid batteries in that power range, but not lithium-ion technology. The company wanted to offer a

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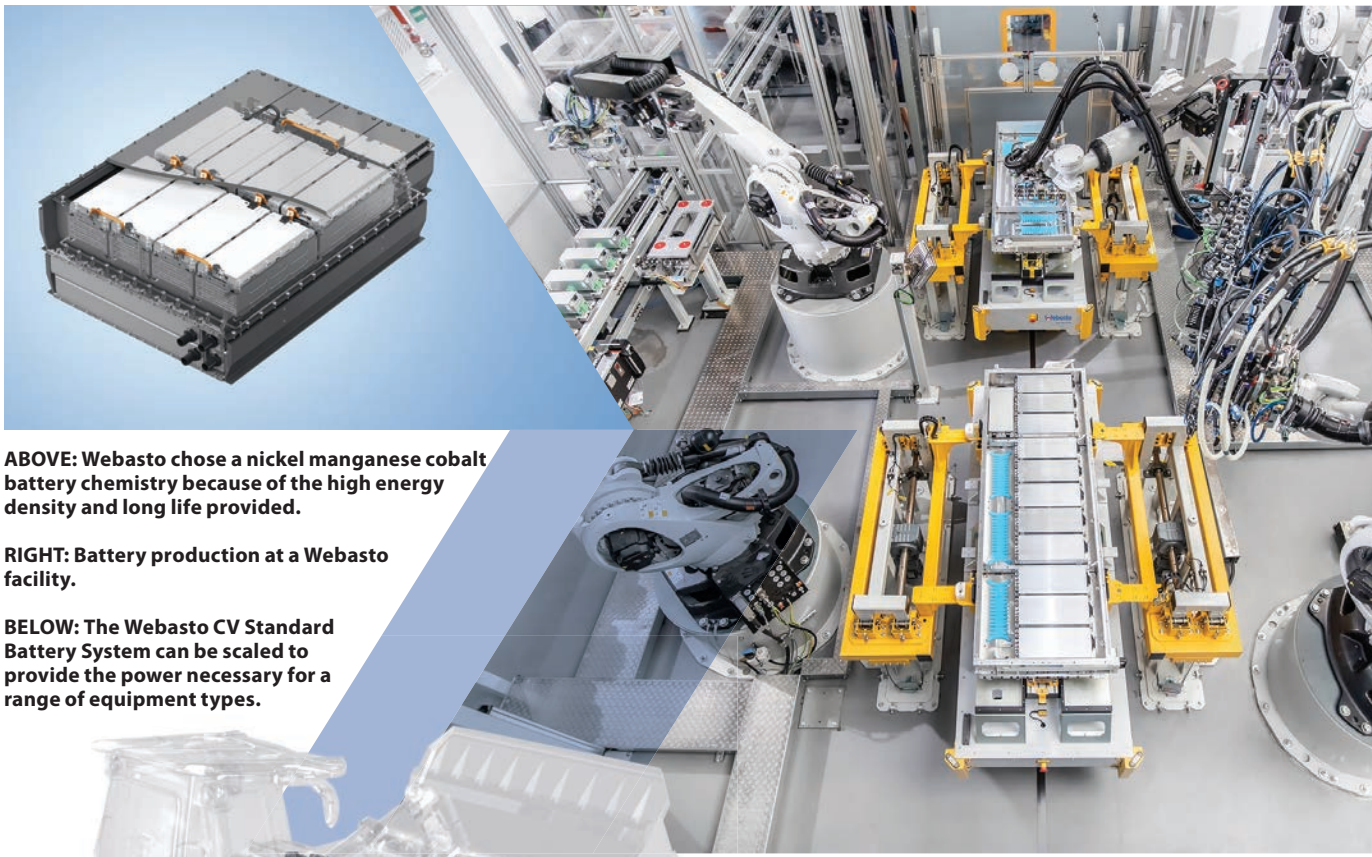


ABOVE: Webasto chose a nickel manganese cobalt battery chemistry because of the high energy density and long life provided.

RIGHT: Battery production at a Webasto facility.

BELOW: The Webasto CV Standard Battery System can be scaled to provide the power necessary for a range of equipment types.

WEBASTO

flexible lithium-ion solution for this power range, and so developed the Vanguard Commercial Lithium Ion Battery pack.

In addition, the company saw where the markets it serves were heading in the coming years and wanted to position itself to be more agnostic about the types of power systems it offers.

Key markets it is looking at for the battery pack include construction, agriculture and traditional outdoor power equipment such as lawn mowers. Equipment that would be used inside a building would benefit from using it to protect the health and safety of workers as there would be no exhaust fumes emitted as would otherwise be the case with a gas engine.

Davison says the system is customizable to an application. "Although we first launched with a 5 kWh 48V pack, as we move forward, and as more products and more customers are being developed, those packs can be customized to an application."

She notes that an advantage of Briggs' technology is that it only uses the power that is needed for a specific application. "You're not using anything extra, you're not paying for power you don't need, which is a huge advantage for the OEMs we will be working with," says Davison.

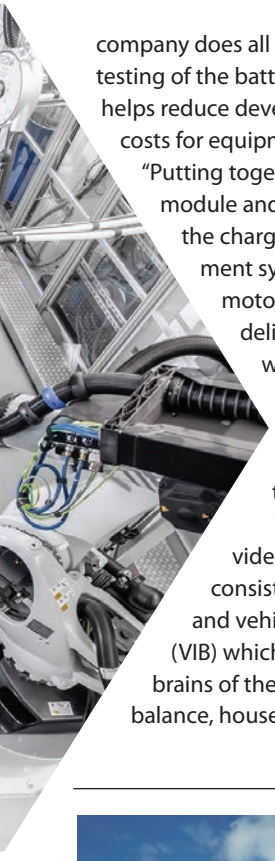
A complete, modular system

Creating a system which is modular and can be customized to an application is beneficial for OEMs looking to develop electric vehicles. Having the ability to choose how many battery packs to use in a machine based on its power needs helps ease their design process.

Lupu says Webasto's is a plug and play system which reduces development time, cost and resources for OEMs. "We've had several customers want to use this system because they can have one supplier, one battery pack that they can use across their full product line. They can use one [battery pack] on this piece of equipment, two on another piece of equipment, and 10 on yet another, which significantly simplifies their R&D."

Providing a complete system is also a key aspect. Davison says the Vanguard battery comes with the battery management system—which ensures all components work together properly and safely—as well as the controller and charger.

In addition, she says Briggs & Stratton is able to help OEMs with the design and integration of the battery. The



company does all of the assembly and testing of the battery system which helps reduce development time and costs for equipment manufacturers. "Putting together the battery cell module and integrating it with the charger, battery management system, controller and motor is really where we deliver value because we're bringing that whole system together to work," in the OEM's application, says Davison.

Webasto also provides a complete system consisting of the battery and vehicle interface box (VIB) which Lupu says is the brains of the system; it will load balance, houses the charging interface, constantly monitors the cells and keeps everything in a safe operating range. Proprietary software developed in-house by Webasto is used in the VIB to recognize how many packs are hooked up and if they're being run in parallel or series.

Lupu says the same box and packs can be run at 400V if connected in parallel or at 800V if connected in a series. "That's significant because it allows the manufacturer to be flexible in their design process."

It also prepares OEMs for the future because Webasto knows voltages will start to increase in the coming years. Right now, 400V is the norm for high-voltage electric powertrains. But Lupu says that in the near future it will rise to 800V, with many manufacturers already developing systems in this power range. "When you do that,

Diversifying Power Options

While electric powered systems continue to advance, many in the heavy equipment industry agree that traditional diesel- and gas-powered engines are not going away any time soon. "We believe gas engines are going to be around for a really long period of time," says Christine Davison, Senior Manager Marketing, Engines & Power at Briggs & Stratton.

Battery technology is still in its infancy, she says, and there are many challenges yet to overcome, such as run time and quick charging capabilities.

But like many companies, Briggs & Stratton also knows there is a need to diversify power source options. "The beauty of what Briggs & Stratton does is we can provide products that complement each other to help customers get their jobs done," says Davison. Customers could have some machines in their fleet which use engine power and others operating on battery power to meet their various needs. "So, it's kind of a one stop shop from a power [perspective]."

"When an OEM converts from a lead acid to a lithium battery, the vehicle and battery is much lighter"

Mourad Chergui, Product Manager at Delta-Q Technologies

CASE's electric backhoe-loader is powered by a 480V, 90 kWh lithium-ion battery pack that can be charged by any 220V/ three-phase connection.

you're able to achieve more power with less current, which means you're running cooler, can use thinner gauge wire and can charge the system faster," he explains.

The VIB has provisions for both the standard 240V AC , level 2 charging (J1772) and DC fast charging, says Lupu. "It is completely up to the manufacturer which they choose to use in their application."

Webasto's battery is liquid cooled; coolant paths within the battery enclosure use a 50/50 water glycol mix to cool it. Lupu says manufacturers can choose to use one of Webasto's many battery cooling systems, one of which was developed specifically for the CV Standard Battery. It is an all-in-one heating and cooling system capable of cooling the battery system with a capacity of 5 kW. Liquid heating capacity is in the range of 7-10 kW and provided by the company's high-voltage heater. Sensors continuously monitor the temperature of the battery cell and command the use of heating or cooling to keep the system in a safe operating range.

Integrated battery charging

In talking with OEMs and end users, Chergui says there is a drive toward having less maintenance on batteries. As such, they are wanting higher power levels, faster charging as well as the ability to utilize public charging infrastructure.

Regarding charging technology, he says the trend is moving toward integration of battery chargers into a piece of equipment. On-board charging makes it easier for end users to charge the machine anywhere instead of having to go back to a home base and charge for several hours overnight, which Chergui says is typical with lead acid batteries. "I would attribute [the shift] to the emergence of lithium battery applications which require higher input rates," he adds. "Having the equipment on board is definitely the way to go."

Growing use of lithium batteries lead Delta-Q to develop its latest charger, the RQ350, which is the company's smallest and lowest powered charger at 350W. "When an OEM converts from a lead acid to a lithium battery, the vehicle and battery is much lighter," explains Chergui.

The lithium battery is 20-30% more efficient, and thus smaller than its lead acid counterpart which allows the charger to be smaller and more compact, as well. Because of this, their use in various off-road applications—particularly compact equipment—is growing.

Development of the RQ350 came about due to increased conversion to lithium-ion batteries which could use a smaller charger.

DELTA-Q TECHNOLOGIES

Chergui notes the lawn and garden segment, particularly mowers, is rapidly adopting battery technology. He says in the last 3 years the company has seen a huge shift from gas to electric in this segment which helped trigger the company to develop its latest chargers.

Global emissions regulations and efficiency improvements will continue to drive development of electric power systems—and thus battery technology—in the coming years. "We're going to see a lot more normalization of electrification and a lot of the components are going to be driven toward [becoming] a commodity item," says Kevin Rhodes, Chief Engineer of Electrification at AVL. "That's important because right now, a lot of things have to be custom made."

He believes a lot of components such as chargers and inverters will become standardized as power levels and use cases become more normalized. This will help drive down costs. He believes it will be the same with battery technology, which is currently a large cost driver of an overall electric powered system.

Rhodes says more battery chemistries will continue being developed and more manufacturers will get into the battery space. "I think right now is really a great time to get into that space because it's just going to continue moving very rapidly. And if you're not getting on board with it right now, as a company, you're going to be left behind to some extent, and you really need to at least be advancing your knowledge of that and be ready for the changes that are going to be coming in the next 5, 10, 20 years," he concludes.

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Mobile Robot Use Cases Grow as TECHNOLOGY ADVANCES

Robots are becoming more commonplace in the off-road equipment market as sensor, GPS and other automation-enabling technologies continue to improve.

by Sara Jensen

Development and use of robots is increasing in heavy equipment markets including agriculture, construction and mining. The often smaller, autonomously operated machines can help improve safety and productivity on job sites as they are able to maneuver over a variety of terrain and obstacles that might otherwise be difficult for larger machines or humans.

According to IDTechEx Research, robots and artificial intelligence (AI) will drive a deep and transformative change in the agricultural world during the coming decades. This is due to their ability to take over tasks such as weeding, planting and collection of agronomic data.

Fendt's XAVER platform, for instance, uses small robots operating in swarms and a cloud-based solution to plan, monitor and accurately document precise planting of corn. The position and planting time of each seed is accurately recorded which allows subsequent operations in the plant cycle—such as fertilization—to also be performed in a precise manner.

In November, Trimble and Hilti announced they would integrate their construction management software solutions, GNSS technology and reality capture devices with Boston Dynamics' Spot Robot platform. According to the companies, doing so provides consistent output, delivers improved efficiency on repeatable tasks and enables up-to-date as-built data analysis.

"Utilizing robots for routine tasks in hazardous environments to improve safety, efficiency, and data capture consistency is part of our digital transformation vision," said Aviad Almagor, Senior Director for Mixed Reality and Brain-Computer Interface (BCI) at Trimble in the press release announcing the partnership with Hilti and Boston Dynamics. "We are excited for this latest collaboration and looking forward to the potential integration of our hardware and software solutions with the Boston Dynamics Spot Robot to enhance field-oriented workflows, reduce [the] amount of rework and facilitate on-site tasks."

Sandvik Mining and Rock Technology recently announced its partnership with Exyn Technologies Inc. to use aerial robot systems to help improve autonomous mining capabilities. The companies will use the robots to map and visualize underground mines that might otherwise be difficult to survey or inspect. Data collected by the aerial robots will be combined with Sandvik's OptiMine technology to provide an accurate picture of a mine's environment and the processes which take place within it. Eventually, the companies aim to apply and generate 3D views and perceptions of underground spaces autonomously.

"For the first time, customers will be

YANMAR

Yanmar has helped develop two prototype agricultural robots, one for grapevines and the other spinach.

Boston Dynamics' Spot Robot with a Trimble X7 3D Laser Scanning System, a high-speed laser scanner with integrated imaging, automatic calibration and registration technologies as well as survey-grade self-leveling.

TRIMBLE

able to map the entirety of their underground operations, even in dangerous GPS denied environments, while making mining safer and improving productivity. Through this partnership, we hope to empower efficient decision-making for customers and drive towards the vision of fully autonomous mining operations," said Nader Elm, CEO and Co-Founder of Exyn Technologies, in the press release announcing the partnership.

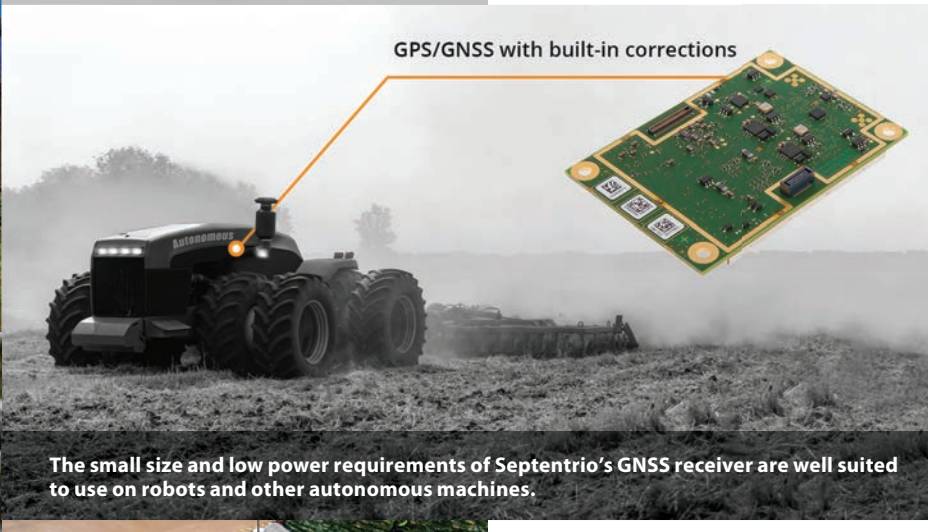
HONDA

Honda's 3E-D18 features GPS and sensor based autonomy for navigation in all environments.

Technology enables reliable operation

A variety of technologies are utilized to enable robots to operate, including various sensors and GPS systems. For its agricultural robot concept, Continental is using camera-based, multispectral or thermographic sensors which the company says are particularly important if the robot is being used to monitor plant growth or soil conditions.

Yanmar has also recently developed an agricultural robot concept as part of the SMASH (Smart Machine for Agricultural Solutions Hightech) project in Europe. The organizations involved are working together to develop a modular robotic platform employing the latest information communications technology to examine crops and soils, analyze gathered information and provide clear, actionable information to farmers to support crop management.



SEPTENTRIO

The small size and low power requirements of Septentrio's GNSS receiver are well suited to use on robots and other autonomous machines.

Through its ongoing research into advanced agricultural robotics, Yanmar is taking on the challenge of showing the possibilities and potential benefits of increased precision farming techniques in the future.

YANMAR

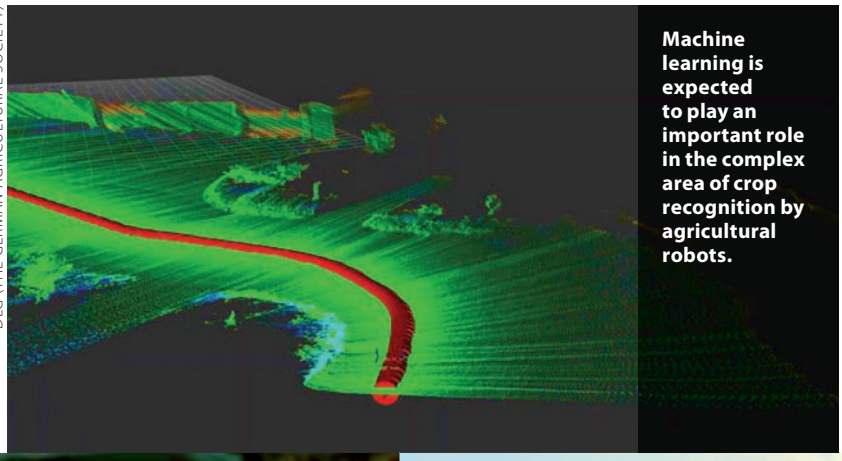
The robot consists of electronics, wires, sensors, cameras, GPS receivers, and multiple electric motors—all of which enable its operation in all types of field conditions. Among Yanmar's tasks within the project are development of control systems for the machine's multipurpose robotic arm for mobile manipulation, sensor integration for positioning technologies, and autonomous navigation and software development for the control of the system's mobile base.

"SMASH is not a single machine, but a series of different devices including a robot, base station, drones and field sensors that together provide vital information to help farmers. A farmer could program the task that he wants SMASH to carry out, and while he is involved in other activities, this machine could move autonomously, monitoring crops, detecting and treating diseases, and saving the farmer or his workers significant time out in the fields manually checking crops," explained Manuel Pencelli, Modelling and Control Engineer at Yanmar R&D Europe, in the press release announcing the project.

Septentrio's recently introduced AsteRx-m2 Sx OEM board is a GNSS receiver designed to provide high-accuracy positioning in a variety of applications, including small robots. The receiver includes built-in GNSS corrections, ensuring high accuracy and reliability. Building this technology into the GNSS receiver simplifies use for manufacturers as they do not have to subscribe to a correction service or worry about where they will get the GNSS corrections from, says Gustavo Lopez, Market Access Manager at Septentrio.

Security and signal reliability is an important factor, especially as the construction, agriculture and other industries move toward robotics, says Lopez. While there may already be existing low-cost GPS chipsets available in the market, he says they may not be reliable enough or "offer the resilience or security you might need for autonomous robotics applications, especially when the machines become bigger."

The reliability provided by Septentrio's multi-signal systems can be especially beneficial for robots working in agricultural applications as it ensures there is no loss of GPS signal which might otherwise be caused by crops or other objects as the machine moves through a field. Lopez says the small size, low power draw and reliability of the mosaic GNSS module, AsteRx-m2 Sx and Septentrio's other receiver



DLG (THE GERMAN AGRICULTURAL SOCIETY)

Machine learning is expected to play an important role in the complex area of crop recognition by agricultural robots.

HONDA

The Honda Miimo robotic lawn mower navigates through an intelligent combination of controls, timers and real-time sensory feedback.

Use of high-precision geo coordinates enables the solar-powered robots from FarmDroid to seed and weed with 8 mm accuracy within and between rows, which means manual weeding is significantly reduced and in some cases not necessary.

DLG (THE GERMAN AGRICULTURAL SOCIETY)

technologies is also beneficial for robotic and other machine applications. "The seamless integration of GNSS corrections is a game changer in the market as it makes the integration of high accuracy as transparent as possible for newer robotics applications," he says.

With the growing development of robots and other autonomous vehicles, sensor fusion is becoming increasingly more important. "One of the elements of sensor fusion linked to robotics is [related to] positioning," says Lopez, such as through the combination of GPS and inertial measurement units (IMU). Combining GPS and IMU technology creates inertial navigation which allows for more robust positioning information even in difficult operating conditions. "Sometimes due to the environment, you might not be able to track GNSS signals," he explains. "If you have an inertial measurement unit, you can improve reliability and availability of the solution."

Having the IMU technology also enables orientation of the vehicle to be determined in addition to its position. This is particularly beneficial when integrators want the robot to focus on a specific trajectory or on an implementor task requiring a sense of direction, says Lopez. He notes Septentrio's AsteRx-i product line combines high-end GNSS receiver technology with industrial-grade IMU to provide both reliable positioning and vehicle orientation information.

Lopez says Septentrio is working with customers to provide them with robust GNSS/INS sensor fusion for their applications. This enables the manufacturer who is developing the robot or other machine type to focus on the customer application side, creating a piece of equipment that will meet the end customer's use case.

Future market growth

Lopez says it is an explosion right now with different robotic companies entering the market, and there are certain applications in which use of robots will continue to increase. Agriculture, construction, mining, logistics and delivery are all areas where interest and use of robots is increasing.

IDTechEx projects the market value for these machines in the logistics, warehousing and delivery markets alone will reach $290 billion by 2040. Meanwhile in the landscape industry, robotic motors are anticipated to achieve a market value of $2 billion by 2029. Both figures demonstrate the growing appeal of these machines in various applications.

"People are really focused on efficiency," he says. "Also, people are wanting to do things in a cheaper way, so they are looking into robotics."

The safety benefits of using robots for certain tasks has been particular-

ly brought to light by the COVID-19 pandemic. Use of mobile robots has enabled successful disinfection, monitoring, surveillance, and handling and delivery of materials during the global health crisis. ABI Research says these proven use cases will propel the overall mobile robotics market to a value of $23 billion by 2021.

Because the pandemic caused many people to have to stay at home, or take extra precautions to ensure their health and safety, robots were able to step in and help with the workload and demonstrate the many capabilities they offer.

As robotics technology advances, so will GPS and other systems utilized to enable the operation of mobile robots. Lopez says the number of GNSS signals will continue increasing which will make it important for integrators to choose receivers which can track them. He notes that some of those new signals will start transmitting corrections and authentication to help prevent jamming and spoofing—which can hinder security of a system. Receivers themselves will continue to get smaller and smaller, and costs will come down as use of the technology grows. "It will definitely be quite interesting how the technology will be changing," he says.

Manufacturers who partner with navigation technology providers and developers like Septentrio will be better able to create robotic and other autonomous machinery for heavy-duty applications, says a report from ABI Research. The analysis firm notes that advanced mobility enabling autonomous navigation will empower robotics vendors in construction, mining and elsewhere. While in 2018, 28.7% of commercial robots' shipments had some degree of autonomous navigation, in 2027 the percentage will be 79.3%.

"Construction robots may be involved in specific tasks, such as brick-laying, painting, loading, and bulldozing; we expect hundreds of AMRs (Autonomous Mobile Robots) in the next 2 years, mainly doing haulage," said Rian Whitton, research analyst for ABI Research in a release announcing ABI's market research on the topic. "These robots help to protect workers from a hazardous working environment, reduce workplace injuries, and address labor shortages."

As off-road equipment industries like construction and mining "continue to strive for cost efficiency and workplace safety, task-specific autonomous mobile robots hold the key to the future," Whitton concluded.

Head to the Web

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Agricultural Robots and AI: A Question of When and Not If
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Septentrio AsteRx-m2 Sx GPS/GNSS Receiver
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Increased Technology Integration Improves PRODUCTIVITY IN THE FIELD

By including more advanced technologies, one OEM has automated many machine functions which combine with increased capacity to improve harvesting operations.

by Sara Jensen

CLAAS of America has launched the all-new LEXION 6000 Series straw walker combines. These new machines feature a variety of advanced technologies which work together to provide increased harvesting efficiency and productivity. Two new models are included in this series, the LEXION 6900 and 6800.

The company says it set out to increase throughput, reduce downtime, elevate operator convenience and maintain straw quality when developing the combines. They feature more power and capacity, as well as smart technology that takes the guesswork out of harvest adjustments, says Erin Atkins, Marketing Specialist at CLAAS.

Available with tires or tracks—specifically the company's TERRA TRAC system—the LEXION combines can achieve road speeds up to 25 mph (40 kph) to decrease the amount of time it takes to move from field to field.

A clutch-engaged drive system is utilized on the new combines which makes for smoother, quieter operation than previous engaging systems. New on these machines is a four-link rear axle which provides a tighter turning radius for improved maneuverability through fields. There is an option for a POWERTRAC rearwheel drive, a planetary drive system that offers a lot of tractive power, says Patrick Arnold, Product Specialist at CLAAS.

The combines are built on the company's 67 in. (170.2 cm) chassis, meaning crop comes into the feeder house at 67 in. wide and maintains that same width throughout the machine which helps to improve harvesting productivity. The feeder house is available with a belt feeder conveyor and a chain; it operates more quietly which helps to improve comfort for operators.

Advanced technology integration

According to Arnold, the core of these machines is the APS SYNFLOW WALKER threshing and separation system. It features an accelerator drum which balances crop flow and optimizes the capacity of the threshing cylinder. Because of this, Arnold says the crop feeds more evenly into the threshing cylinder, even in wet conditions and produces higher centrifugal force for more effective separation and can achieve higher throughput. Up to 25% more acres per hour can be harvested than the LEXION 670.

As crop flows through the system, it first engages with the APS cylinder and then the main threshing cylinder which helps to improve threshing capacity. The threshing cylinder measures 30 in. (76.2 cm) in diameter,

up from 24 in. (61 cm) on the previous machine, to help improve crop flow and grain quality. After that is a new separation cylinder which aids with capacity improvements as it actively separates the crop before it goes onto the straw walker.

Straight-line crop flow through the APS allows for smooth acceleration of the crop material through the threshing area. It also provides smooth transition of the crop between cylinders in order to use less power and deliver less stress and twisting on the crop mat that can over thresh grain and deteriorate straw quality.

Underneath the APS system is a new JET STREAM cleaning system to enable the machine to better handle the increased harvesting capacity. As material comes off the straw walker return pan, it's hit by a cascade pre-cleaner which blows most of the straw and chaff out the back of the machine before it touches the upper sieve. This helps to keep the machine clean and operating efficiently.

The addition of DYNAMIC POWER to the system aids with the combine's fuel efficiency benefits. DYNAMIC POWER automatically adjusts engine output to harvest conditions, for 10% more savings when the combine does not need to run at peak load.

Like many of the company's combines, the new LEXION series features CEMOS AUTOMATIC which automatically makes real-time, in-field adjustments in response to crop conditions. The company says the system is capable of doing so with more precision and speed than a seasoned operator, resulting in minimal grain loss. "By utilizing existing machine components and sensors, CEMOS AUTOMATIC allows operators to gain up to a 10% increase in machine throughput, up to a 32% cleaner grain sample and improved grain retention up to 58%," says Greg Frenzel, Product Specialist at CLAAS. It does so "by continuously and autonomously making machine adjustments and optimizing machine performance."

Operators have the ability to fine tune threshing settings to ensure optimal straw quality, further aiding with customers' farming operations. "High straw quality can add many benefits to machine performance that are not normally considered," says Frenzel.

He explains that straw quality is typically compromised in the threshing area because that is where the most aggressive action happens in a machine. This means separation and cleaning are affected by the straw quality created in the threshing area. Small pieces of straw and high levels of chaff make separation and cleaning more difficult. "By maintaining high quality straw, separation and cleaning are able to work more efficiently, leading to higher throughput and cleaner grain samples," says Frenzel.

Larger grain tanks and faster unload rates aid with the combines' productivity gains. The standard grain tank size has a 385 bushel capacity, and customers have the option of choosing a 425 bushel capacity tank. With these larger tank sizes farmers can harvest longer before unloading, thus increasing productivity.

Auger size increased from 12 to 18 in. (30.5 to 45.7 cm) in diameter to hold higher capacities of crop. The loading tube on these combines unloads at a rate of 5.1 bushels per second, further improving productivity says Arnold.

New in-cab features aid operator comfort

Within the cab, the 6000 series includes many of the same features as the CLAAS 8000 and 7000 series machines. Among these are the new CEMOS touch monitor and updated armrest control system.

The CEMOS monitor features a large touchscreen display which enables operators to easily see machine functions and change settings. Menus can be customized to show information of most value to the operator.

On the armrest is a new operator panel with push-button controls for certain machine functions as well as quick-change toggles allowing operators to easily change machine functions such as the threshing drum and concave. Radio controls with Bluetooth are included on the armrest, as well.

A CMOTION handle on the armrest is similar to those used in previous generations; it allows operators to easily access machine controls without much hand movement, aiding with their overall comfort. New to the CMOTION handle is a favorites menu which allows users to customize up to seven different functions which can be controlled with the toggle switch on the front side of the handle.

Various in-cab controls make it quick and easy to switch between the types of crops being harvested, increasing productivity for farmers. These include:

- dual range threshing speed adjustment,
- residue management speed adjustment, and
- residue size control to adjust particle size.

According to CLAAS, these in-cab adjustment features can reduce the amount of time needed for crop conversion by over 50%.

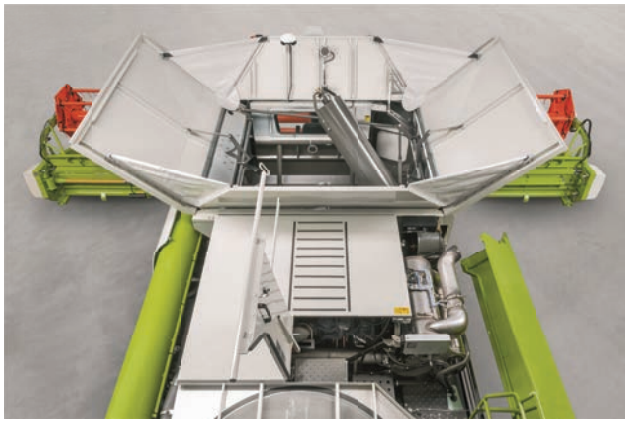
Just to the side of the armrest is a new auxiliary mounting post that has been positioned so operators can easily see the full width of the header while still ensuring accessibility to information on the external monitors mounted on the post.

Behind the operator seat CLAAS has put a new grain tank window that is larger to make it easier and more comfortable for operators to view crop as it enters the grain tank.

An updated PROFICAM system and windshield wipers on the right- and left-hand doors add to the visibility enhancements CLAAS has made on these new LEXION combines. The ergonomic steering column can easily be adjusted, allowing operators to fine tune its position to ensure comfort and help reduce fatigue.

DYNAMIC COOLING pushes fresh, cool air into the engine compartment to prevent overheating.

A larger grain tank capacity enables farmers to harvest longer in the field.



A split engine cover makes it easier to do maintenance on the engine and grain tank.

Easier maintenance and reduced downtime

Convenience features included on the machine to aid maintenance and ensure optimal machine performance include an automatic lubrication system. It continuously provides grease to 74 different points around the machine.

The engine cover on the new LEXION combines splits open to provide easy access to the grain tank. The grain tank has been increased to a capacity of 8,000 bushels per hour and incorporates a yield mass flow sensor which is more accurate and easier to calculate.

Opening the engine cover allows for easy access to maintenance points such as coolant and oil. In the 6900 model there is a 12.8L MAN engine with up to 466 hp (348 kW) and in the 6800 model a 10.7 L Mercedes-Benz engine offering up to 402 hp (299 kW). Both include the new DYNAMIC POWER feature which Frenzel says optimizes fuel and power consumption to give power when necessary while saving on fuel consumption when not as much power is needed.

The CLAAS DYNAMIC COOLING package is also included which pulls in fresh, clean air from the top of the machine. This helps increase maintenance intervals and prevents dirt from being pulled into the air filter. Instead, air is pulled into the engine compartment and pressurized to keep the engine running cooler and cleaner. This also creates an air blanket which is pushed down into and outside of the side panels of the combines to keep dirt kicked up by the tires from getting into the machine and causing potential performance issues.

"LEXION combines have built a reputation for delivering increased harvest efficiency and productivity, saving fuel and grain," concludes Blake McOllough, Product Manager – Combines at CLAAS. "Designed with efficiency in mind, the LEXION 6000 Series straw walker combine does that and more with new cutting-edge technology to keep operators harvesting acres in record time."

How to Implement the Right Cab for Electric Work Trucks

Several factors should be taken into consideration when implementing electric-capable cabs for work trucks which will be utilized in the construction industry.

contributed by Cal Kanowitz, Marketing and Dealer Development Manager, Marion Body Works

Work trucks serve an important purpose on any construction site. Whether it's transporting equipment and materials or acting as a mobile office, they must be equipped to handle the unique needs of each operation and user.

Today, manufacturers are racing to fulfill a relatively new demand among work truck buyers: electric work trucks. The electric work truck market has become a crucial battleground for manufacturers, with a wide variety of designs and prototypes being presented as the next big thing.

As a manufacturer just getting into the electric market, it can be difficult to know where to begin. However, there is one aspect of any electric work truck that will help you determine the overall design and functionality of the vehicle: the cab. While the cab is often overlooked, it's a critical starting point when developing a new vehicle. This is especially evident in the electric work truck market, which has brought on many new engineering challenges.

To help overcome these challenges and meet buyers' needs, there are some factors to consider for electric-capable cabs.

Find the right OEM

Since cabs are often outsourced, it's important to find an OEM with the

MARION BODY WORKS

When implementing electric-capable cabs for work trucks, find an OEM with the engineering capabilities needed to complete the cabs with limited outsourcing to avoid additional costs and quality issues.

engineering capabilities to take on electric-capable cabs. Ask about the OEM's history with manufacturing both regular and electric-capable cabs so you understand the types of jobs it's successfully completed. Once you know what your customer is looking for in work truck design and performance, the right OEM can help you build the proper cab.

Before you get started, make sure you have a clear understanding of your OEM's entire manufacturing process and its ability to overcome customization challenges. Look for an OEM that provides regular access to its engineering team, as this will increase your knowledge of its processes and give you the ability to collaborate on the project. Electric-capable cabs are still relatively new to the work truck market, so your OEM will have to put more time toward design and engineering.

Work with an OEM that has a lean process in place and is capable of delivering a cab as complete as possible with limited outsourcing. This will help prevent additional costs, longer lead times, and quality issues that could negatively affect the performance of the finished truck.

Other qualifiers to look for in an OEM include a low warranty claims percentage, repeat customers, certified welders, and certifications like ISO 9001:2015. OEMs are not required to share all of this information with you, so finding one that is open about its operation and processes will give you confidence in the partnership and the end product you're receiving.

Electric cab design

Once you've selected an OEM, it can get to work manufacturing a cab of your design or developing an entirely new design based on input you give the engineers. The cab will be the most important piece of your electric work truck, as it must be designed and manufactured to allow optimal vehicle performance and safety.

The cab must house the electric engine components while maintaining a high level of safety and functionality. Torque, acceleration, hauling capacity, vehicle maneuverability, and body type will all be determined by the cab and its compatibility with what's under the hood.

Because there is no block engine between the operator and a potential collision, the cab must be built to withstand the impact.

Because there is no block engine between the operator and a potential collision, the cab must be built to withstand the impact. Aluminum cabs that are reinforced with custom, heavy-duty extrusions at connection points on the truck's roof, doors, curves, and corners will help keep the operator safe.

Another design consideration is the overall look of the truck. In general, the construction market still wants trucks that look like trucks. These buyers are used to the old-school feel and look of a regular truck, so there's a fine line between offering a new design that stands out and offering something that is too radical. If you manipulate the cab and front end of a truck too much, it can lose its appeal to these buyers.

Vehicle performance with an electric cab

Your cab design must also avoid jeopardizing the performance of the truck. Much like the overall look, the construction market expects the same, if not better, usability and performance out of electric work trucks. Because of the amount of time spent in work trucks, they have to provide comfort and efficiency for the operator.

An electric cab offers drivers more interior space and a quieter ride because of the electric motor. The electric cab also makes for an overall lighter truck, which provides a number of benefits. Drivers will experience better acceleration and braking for increased safety, and a lighter truck also allows for greater hauling capacity when weight restrictions are a factor. Work truck operators can even save on maintenance and replacement costs, as a lighter truck puts less pressure on tires, weight springs, and the vehicle frame.

What's next?

The electric work truck market is growing, but it has yet to fully arrive. Major industry leaders are putting a lot of time and resources into the development of electric trucks, but they are not mass producing them. This has opened the door for smaller builders and manufacturers to develop electric prototypes and sell the vehicles while maintaining their overall capacity.

It's important to keep up with changes in the industry, but as you work toward electric trucks, be sure to do your research and work with partners that understand the process of implementing electric-capable cabs. Be aware that starting from ground zero will mean high up-front costs because of the additional design and engineering time required to make your vision a reality. However, once the design is figured out, a good OEM will be able to produce the cab in a similar timeframe as any other cab.

It's hard to say what this market will look like in 10 years, but as you dive into the world of electric work trucks, always remember that operator safety and comfort start with the cab that surrounds them. Do your due diligence when designing and manufacturing electric-capable cabs for your work trucks to make sure your buyers get vehicles that are safe and efficient.

About the Author

Cal Kanowitz is the Marketing and Dealer Development Manager at Marion Body Works where he guides brand strategy and promotion. Kanowitz has worked at Marion for over 4 years.

2020

NFPA/FPIC REGIONAL CONFERENCE
Virtual Event
Sept. 3, 2020
nfpahub.com/events

WASTE EXPO
Virtual Event
Sept. 14-17, 2020
www.wasteexpo.com

HDMA HEAVY DUTY DIALOGUE
Virtual Event
Sept. 15, 2020
www.hdma.org

FARM PROGRESS SHOW
Virtual Event
Sept. 15-17, 2020
www.farmprogressshow.com

SAE COMVEC TECHNOLOGY CONNECTION
Virtual Event
Sept. 15-17, 2020
www.sae.org/attend/comvec

NTEA TRUCK PRODUCT CONFERENCE
Virtual Event
Sept. 22-24, 2020
www.ntea.com/truckproductconference

EIMA INTERNATIONAL DIGITAL PREVIEW
Virtual Event
Nov. 11-15, 2020
www.eima.it/en

BAUMA CHINA
Shanghai New International Expo Center
Nov. 24-27, 2020 | Shanghai, China
www.bauma-china.com/en

2021

WORLD OF CONCRETE
Las Vegas Convention Center
Jan. 19-22, 2021 | Las Vegas, NV
www.worldofconcrete.com

EIMA INTERNATIONAL
BolognaFiere
Feb. 3-7, 2021 | Bologna, Italy
www.eima.it/en

NFPA ANNUAL CONFERENCE
Arizona Bitmore
Feb. 23-25, 2021 | Phoenix, AZ
nfpaevents.com

NATIONAL FARM MACHINERY SHOW
Kentucky Exposition Center
Feb. 10-13, 2021 | Louisville, KY
www.farmmachineryshow.org

GREEN TRUCK SUMMIT
Indiana Convention Center
Mar. 9, 2021 | Indianapolis, IN
www.ntea.com

THE WORK TRUCK SHOW
Indiana Convention Center
Mar. 9-12, 2021 | Indianapolis, IN
www.ntea.com

MID-AMERICA TRUCKING SHOW
Kentucky Expo Center
March 25-27, 2021 | Louisville, KY
www.truckingshow.com

HANNOVER MESSE
Hannover Fairground
April 12-16, 2021 | Hannover, Germany
www.hannovermesse.de/en/

INTERMAT
Parc des Expositions Paris-Nord Villepinte
April 19-24, 2021 | Paris, France
www.imexmanagement.com/shows/intermat-2021

ACT EXPO
Long Beach Convention Center
May 3-6, 2021 | Long Beach, CA
www.actexpo.com/

HILLHEAD
Hillhead Quarry
May 7-9, 2021 | Buxton, United Kingdom
www.hillhead.com

GREAT LAKES LOGGING & HEAVY EQUIPMENT EXPO
UP State Fairgrounds
Sept. 9-11, 2021 | Escanaba, MI
www.gltpa.org/gltpa/Expo.asp

THE BATTERY SHOW
Suburban Collection Showplace
Sept. 14-16, 2021 | Novi, MI
www.thebatteryshow.com

ELECTRIC & HYBRID VEHICLE TECHNOLOGY EXPO
Suburban Collection Showplace
Sept. 14-16, 2021 | Novi, MI
www.evtechexpo.com

NORTH AMERICAN COMMERCIAL VEHICLE SHOW
Georgia World Congress Center
Sept. 28-30, 2021 | Atlanta, GA
nacvshow.com

MINEXPO INTERNATIONAL
Las Vegas Convention Center
September, 2021 | Las Vegas, NV
www.minexpo.com

GIE+EXPO
Kentucky Exposition Center
Oct. 20-22, 2021 | Louisville, KY
gie-expo.com

Global Health Impact

Editor's note: *Due to the global health crisis, many events in 2020 have been postponed, canceled or gone virtual. Every attempt has been made to provide the most up to date information on those events listed; information is current as of the time of printing this issue. Be sure to montior our events page and individual events' websites for updates. You can also read more about those events going virtual at oemoffhighway.com/21123406 where we also continue to provide updates on changes to events.*

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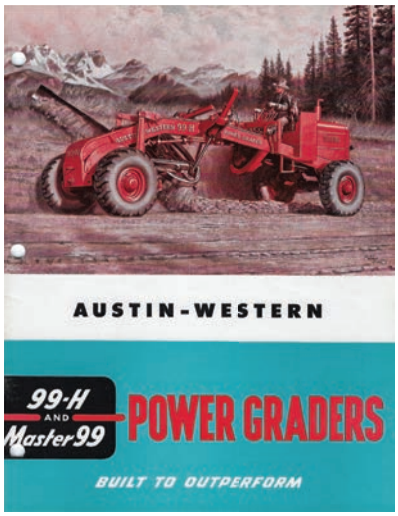

The Austin-Western 99 series was the first motor grader with all-wheel steering, all-wheel drive, crab steering and fully hydraulic blade control.

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The Austin-Western 99 Motor Grader

Improved steering capabilities and hydraulic blade control helped to advance motor grader designs.

by Thomas Berry, Archivist, Historical Construction Equipment Association

In the last installment, we looked at the Caterpillar Auto Patrol (*learn more, 21136300*). Introduced in 1931, it was the first purpose-built motor grader, as well as the first with fully power-operated blade controls and one of the first with pneumatic tires.

The next major innovation in motor grader design came in 1937 when the Austin-Western Road Machinery Company rolled out the Model 99. Descended from the Austin Manufacturing Company and Western Wheeled Scraper lines of graders that dated to the late 1800s, the Model 99 was the first to incorporate three more major breakthroughs.

One was all-wheel drive, and another was all-wheel steer. Until the 99 was introduced, all motor graders operated like the wheel tractors that powered the earliest motor graders, with the front axle providing the steering and the rear axle(s) the traction. The 99's powered front axle helped pull the blade through a heavy load and keep the machine moving through rough terrain. Besides a turning radius that was greatly improved over conventional graders, steering at both ends made it the first grader with what we now call crab steering, as well as easier and more precise steering.

Sales literature for the first version of the Austin-Western 99 motor grader.

These two features had many benefits. The 99 was the first motor grader with identical front and rear tires, cutting maintenance costs and improving handling. More weight was on the front end, keeping the blade and optional scarifier against the load better than with an unpowered front end. It could work a windrow more efficiently, with control against the tires riding onto the windrow, plus better blending of the windrowed material. It applied superior power against the resistance of side-draft on the blade. When plowing snow, it had steadier power on a front plow, and was easier to control in winter conditions. The operator could set the steering to keep the front axle where it could provide the best traction and the rear in the best position for optimum power behind the load, and he could blade in reverse under full power and control.

It was also the first motor grader with fully hydraulic blade control rather than mechanical or manual controls. The hydraulics applied consistent power to all blade motions. With very little effort, the operator could precisely manipulate the blade without moving the circle or interrupting forward or reverse motion, making possible such tasks as moving the blade around obstructions without stoppage or spillage. Combined with a wide degree of oscillation of the axles, the 99's power and controls enabled it to do exceptionally heavy ditching and slope work.

Besides a scarifier, vee snow plow and snow wing, the 99 was offered with a range of other attachments. These included an elevating grader, windrow loader, slopeboard, front blade, rear roller, front or rear disc harrow for roadmixing, and a circle-mounted sweeper.

Austin-Western initially built the 99 with a single rear axle, but later introduced a tandem drive version. The single-axle machines were called Pacers, and the tandems Supers. Several versions of gas- and diesel-powered 99s were offered, with the last being discontinued in 1959, and it and its contemporaries were replaced by the 100 series that was built as late as 1980.

The Historical Construction Equipment Association (HCEA) is a 501(c)3 non-profit organization dedicated to preserving the history of the construction, dredging and surface mining equipment industries. With over 3,800 members in over a dozen countries, activities include publication of a quarterly educational magazine, Equipment Echoes, from which this article is adapted; operation of National Construction Equipment Museum and archives in Bowling Green, OH; and hosting an annual working exhibition of restored construction equipment. The 2020 show has been postponed to August 27-29, 2021, in Concordia, KS. Annual individual memberships are $35.00 US within the USA and Canada, and $45.00 US elsewhere. HCEA seeks to develop relationships in the equipment manufacturing industry, and offers a college scholarship for engineering and construction management students. Information is available at www.hcea.net, by calling 419-352-5616 or e-mailing info@hcea.net. Please reference Dept. OEM.

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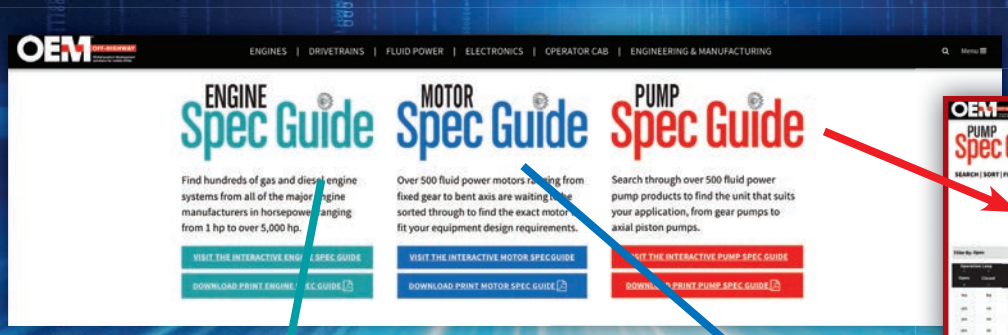

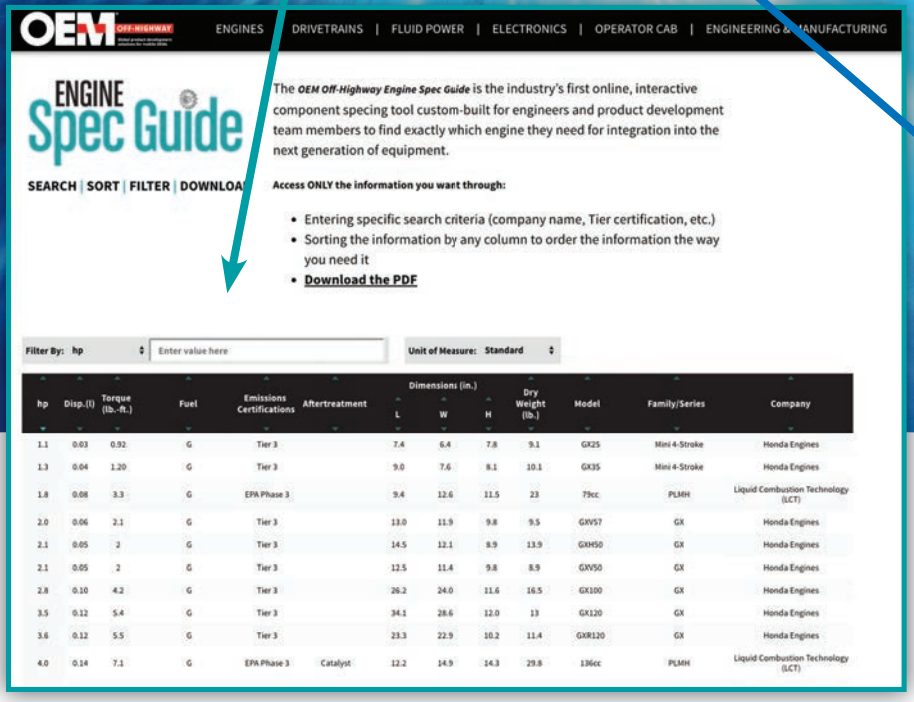

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