POWER&MOTION

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A compendium of articles
from *Power&Motion*

SENSORS: NEW TECHNOLOGIES AND TRENDS

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SENSOR TECHNOLOGY continues to advance, bringing with it new capabilities and application uses. As such, sensors have become a common part of many hydraulic, pneumatic and electric motion control systems.

Sara Jensen,
Technical Editor,
Power & Motion

Within this ebook you'll find articles which examine how sensors are being used in fluid power systems and what future growth opportunities there may be, new sensor technologies, as well as example use cases for this increasingly important component.

CONTENTS

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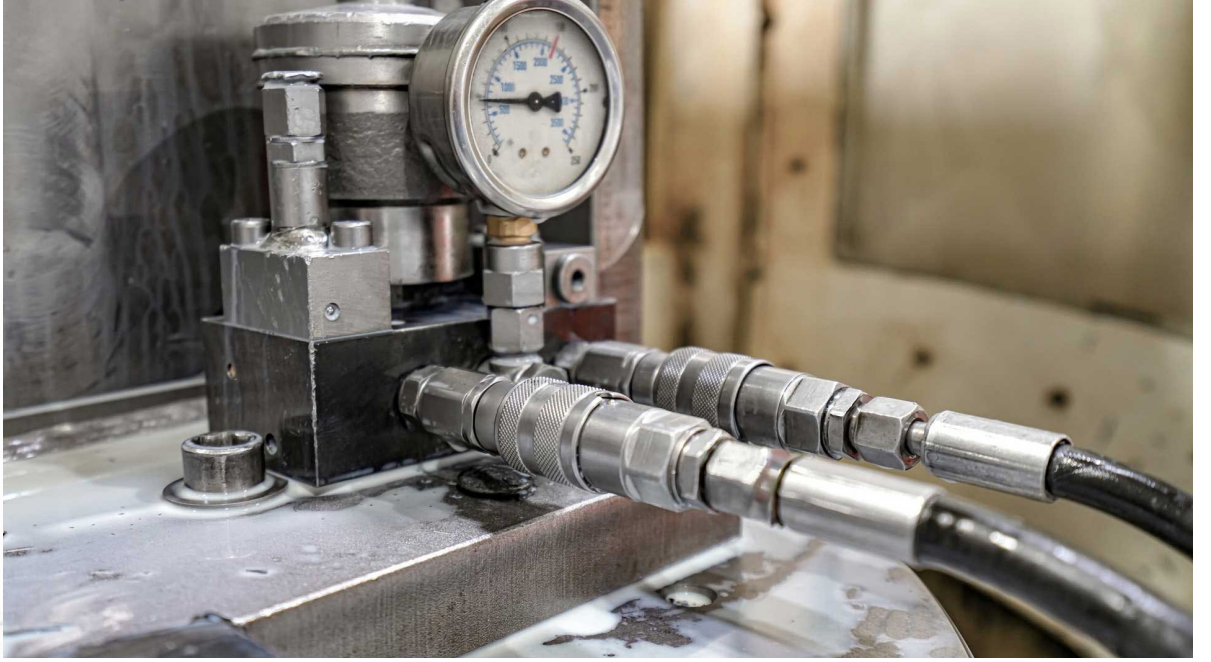

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CHAPTER 1:

Sensors in Fluid Power Bring a Range of Design Opportunities

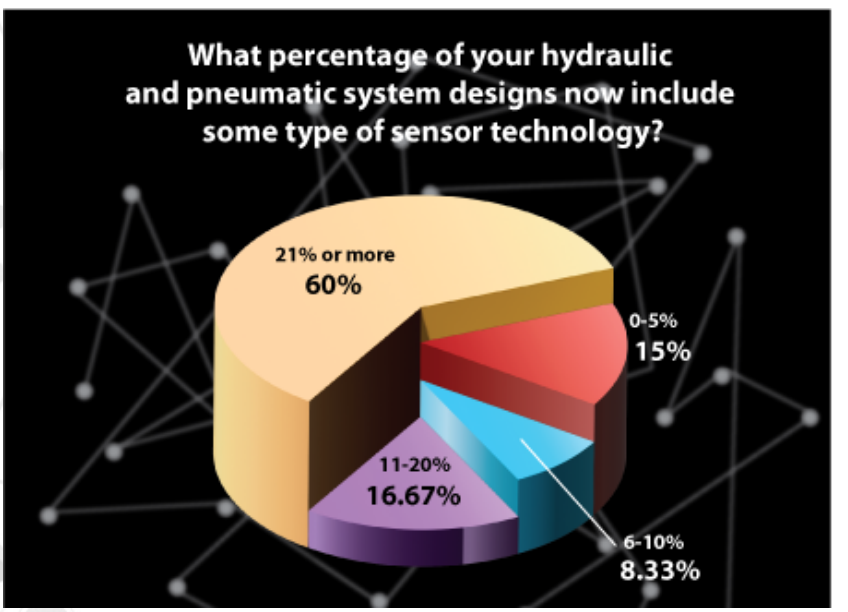
SARA JENSEN, Technical Editor, *Power & Motion*

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

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

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

This coincides with the many discussions we've had with members of the fluid power



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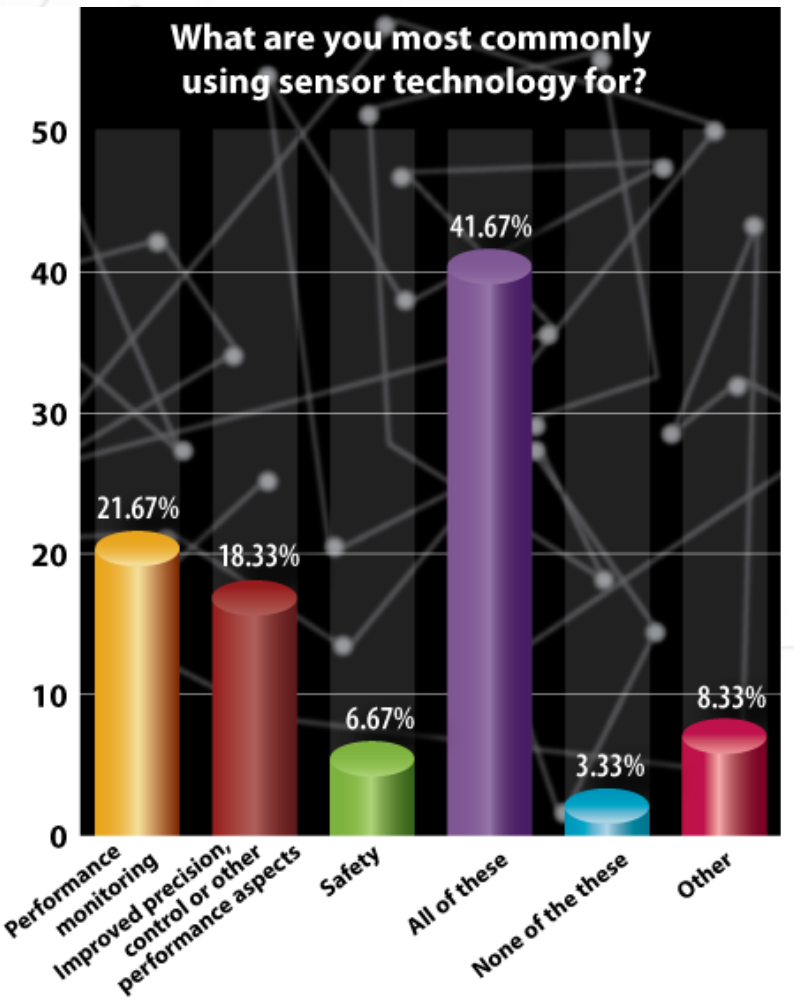
industry who are also witnessing the increased use of sensors in their hydraulic and pneumatic system designs.

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

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

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

Read "Sensors and Software in Motion Control: Key Benefits to Consider" for more on Lythogoe and Strasser's insights on the use of sensors in fluid power systems.



How are Sensors Being Used in Fluid Power Systems

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

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

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

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

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

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

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

Read more about the use of Rota's sensors in the Vermeer pile driver in the article "Hydraulic Cylinder Sensors Aid Pile Driver Accuracy."

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

Technological Challenges and Opportunities for Hydraulics and Pneumatics

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

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

There are several sensors available from which to choose – position, temperature, angle

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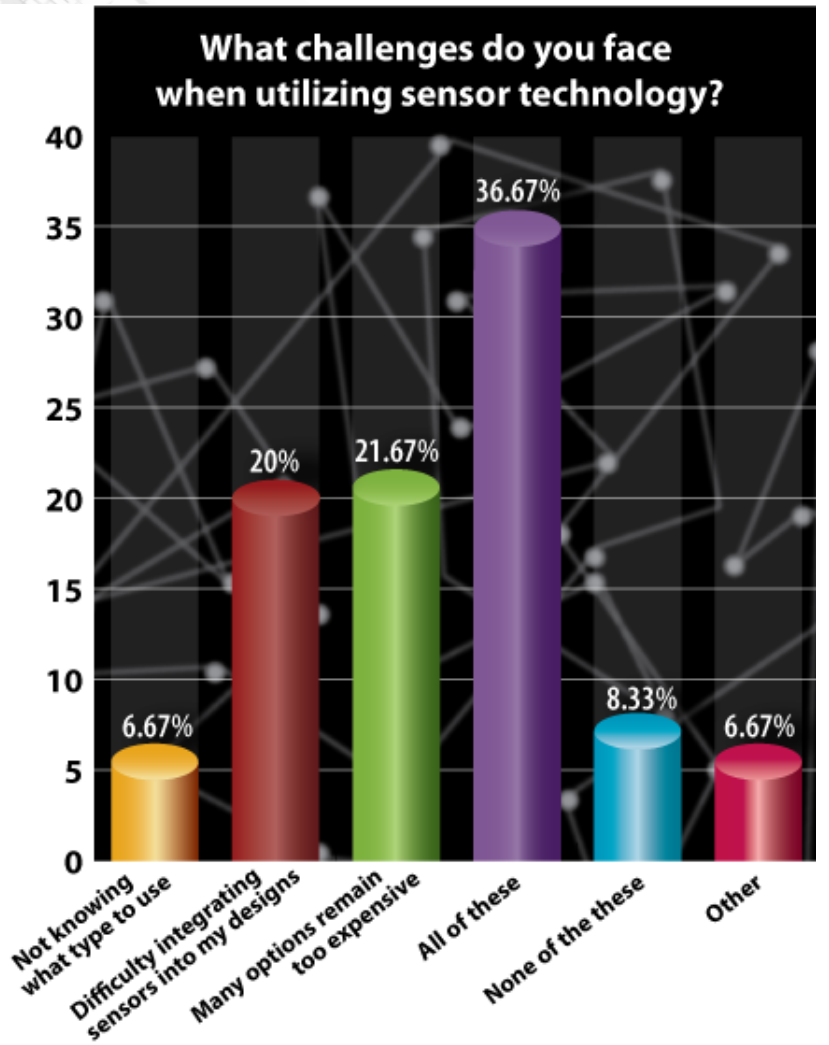

and more – making it important for developers of hydraulics and pneumatics to know what they want to accomplish through integration of a sensor.

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

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

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

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

Cost and ease of integration were other areas several survey respondents noted there could be technological improvements made. Additional areas in which it was said sensor

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

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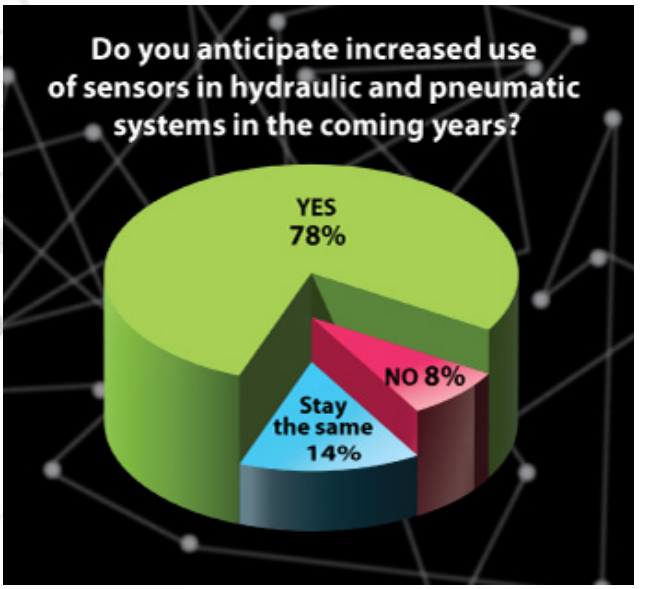
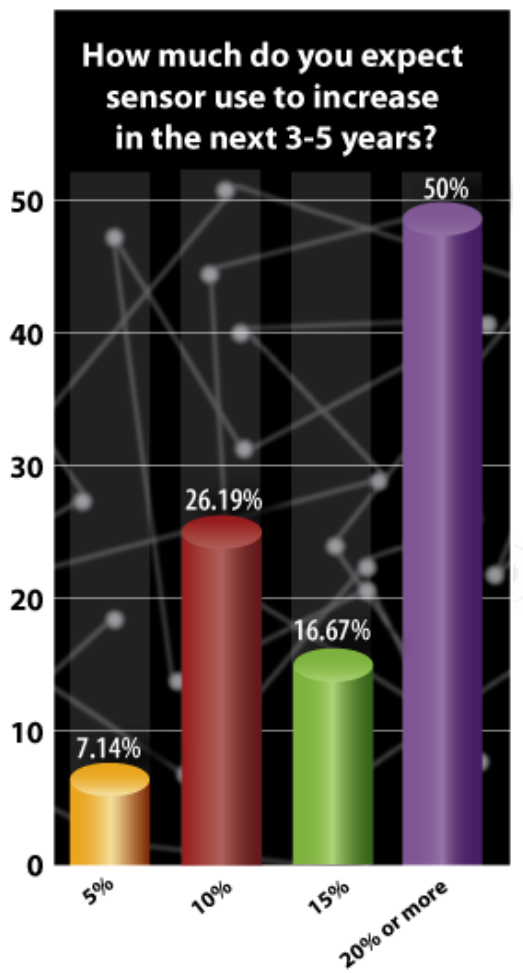
technology is lacking include oil film thickness measurements, durability and robustness, continuous fluid level measurements and the need for pressure measurements without wiring and drifting.





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

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

Read *"Assessing Future Design Needs for Hydraulics and Pneumatics"* to learn more about the 2023 Technology Roadmap and the areas future developments for fluid power should be focused.

Sensor Benefits will Lead to Further Growth

Survey respondents unanimously agreed that the integration of sensors in fluid power systems has been beneficial for the industry. When it came to what the biggest benefits have been, however, there was a little more variety in responses.

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

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

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itor systems and track performance to reduce unplanned downtime.

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

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

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

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

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☞ **BACK TO TABLE OF CONTENTS**

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Gefran Inc.

CHAPTER 2:

New Sensor Design Enables Multiple Measurements in a Single Device

SARA JENSEN, Technical Editor, *Power & Motion*

The Gefran Twiist linear position transducer is designed to provide multiple measurements in a single unit for mobile and industrial hydraulic systems.

Today's hydraulic systems often include an array of sensors which monitor various parameters. However, there is an increasing need for simpler, more compact systems – leading many to rethink how hydraulic and sensor components are designed.

Enter the Gefran Twiist, a contactless linear position transducer for mobile and industrial hydraulics capable of providing multiple measurements in a single unit.

According to Ron Akers, business development manager for fluid power at Gefran Inc., the company spent about 10 years researching and developing the sensor in partnership with the engineering department at the University of Brescia in Italy, where the company is headquartered.

"Throughout the research and development period, they discovered a new way to configure a potentiometer type of product into something that can pick up multiple variables to measure," he said. "What that means is you can pick up a measurement on linear movements and different angular movements all in real time."

Twiist utilizes a helical magnetoelectronic design to simultaneously take multiple measurements; besides position data, the sensor can also measure temperature, velocity, acceleration, and tilt angle.

Consolidating several sensor types into a single unit allows manufacturers to purchase fewer sensors, helping to lower costs and simplify designs.

READ MORE: A Shift Toward Compact Hydraulic Systems

What Makes the Twiist Sensor Different from Other Technologies

The Gefran Twiist sensor is different from standard potentiometers and transducers in that its measuring tape is wrapped in a helical position inside the device said Akers. This was done so that when the magnetic measuring device inside the sensor moves across the sensing tape it will change the polarity of the electrons inside the tape at different positions, enabling it to pick up linear and angular movements as well as other measurements.

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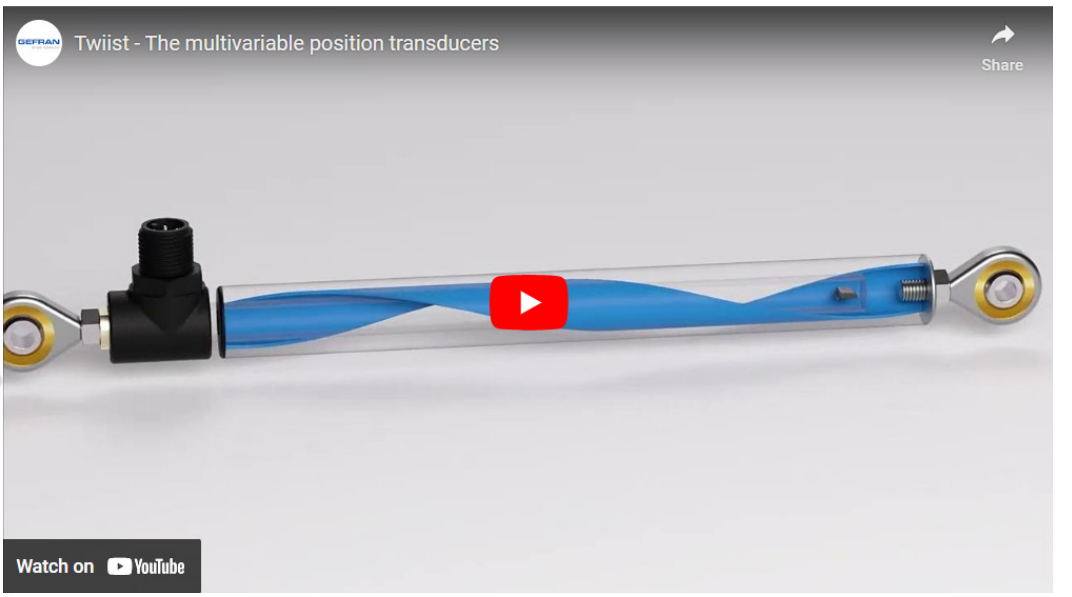

An integrated CPU collects and analyzes sensor data which can be used to ensure machines are performing as desired as well as some predictive maintenance.

By using a helical magnetoelectronic design, Gefran believes Twiist overcomes challenges associated with other sensor types in the market. Commonly used magnetostrictive and LVDT (linear variable differential transformer) sensors are capable of providing accurate linear position measurements but have limited mechanical flexibility and are quite expensive, said Ann Thomson, marketing manager at Gefran Inc. Meanwhile, potentiometric technology is more affordable and offers mechanical flexibility but there is a lack of development for communication protocols used with these sensors.

Twiist, on the other hand, is less expensive than magnetostrictive and LVDT sensors and is mechanically self-aligning which makes it a flexible and easy-to-install option. It also features a more robust design than potentiometric sensors as it is resistant to wear, water, dust, shock and vibration. This ensures long-lasting use in a variety of mobile and industrial hydraulic system applications.

The sensor is similar in look and shape to a standard potentiometer. Akers said developing it around the potentiometer platform, which is intended for linear movement, makes it easier to install because Twiist resembles a common sensor in the market and therefore is familiar to those who will be using it. If multiple sensors were instead used, there would be different shapes, mounting and other considerations to take into account which can make installation more difficult.

In addition, the Twiist sensor is available with analog and digital outputs to suit a range of application needs. Models with CANopen fieldbus and IO-Link outputs can digitally transmit

Unlike standard potentiometers and transducers, the Twiist sensor's measuring tape is wrapped in a helical position inside the device which allows it to collect both linear and angular movements. Gefran Inc.

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measurements for process variables – such as position, speed and inclination – up to 1,000 times per second which helps to provide consistent monitoring of machine performance.

Read more about the design and features of the Twiist sensor.

The Benefits of Using a Single Sensor for Multiple Measurements

By incorporating several measurements into a single sensor device, Twiist enables the creation of more compact and simplified designs. For the latter, Akers noted the amount of wiring needed in a machine is reduced when using fewer sensors which not only helps to simplify designs but also minimizes the amount of labor necessary to build a system or machine, providing additional value to a manufacturer.

With fewer components to install, the time it takes to build a hydraulic system or full machine can be reduced as well, further reducing costs for manufacturers and helping them get product to market faster which continues to be an area of focus for many.

A reduction in system components also means fewer failure points, improving maintenance for end-use customers. This also makes it easier to troubleshoot a system or machine because there are not as many components to test in order to determine what issue may be occurring said Akers.

Incorporating multiple sensor measurements into a single device helps to consolidate parts, reducing purchasing costs as well as installation space. Gefran Inc.

System designers can also benefit from using a single sensor device like Twiist. For those who may be programming a machine, he said the various measurements provided by the sensor can be put into a software device so the information can be viewed in real time and used to help program a machine if desired.

It also opens up opportunities for controls engineers who can utilize information gathered by the sensor for different formulas. “Now they can calculate accelerations, speeds of different movements; it can even analyze vibration of the machine if they want it to,” explained Akers. “It opens the door for many different opportunities.”

A Wide Range of Use Cases Possible

Akers refers to Twiist as a crossover style of sensor because it can be used in numerous mobile and industrial hydraulic system applications. Construction machinery and material handling equipment are some of the target mobile applications he sees for the sensor.

In forklifts, for instance, Twiist can provide the fine positioning required for the mass tilt and side shift features of the forks. It can also be used as part of an auto-leveling feature which allows machine operators to essentially push a button and have the machine take

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care of placing the fork at the exact level needed. This helps to ensure accuracy of material collection and placement as well as improve productivity by reducing an operator's cycle time. "For the operator, when they are picking up material, they don't have to think about [whether or not] the fork is level as it goes into the material and picks it up," said Akers. "Every second they can save on their cycle times…is more profitable for the business and efficient for the machine."

As the sensor is based on the concept of a potentiometer, it is beneficial for steering control in different types of vehicles. Akers explained the sensor can measure the position of a vehicle's front axle like a traditional potentiometer. With its additional measurement capabilities, it can also determine how a vehicle's suspension acts as it maneuvers over various terrain. "That can be used by the software to keep the carriage of the vehicle level," he said, helping to keep operators as well as any possible cargo comfortable and safe.

Thomson noted additional application uses for the Twiist sensor include controlling stabilization footings in area platforms; monitoring position and vibration for mining, fracking, and drilling; as well as measuring position and inclination for the arms on agricultural sprayers.

The Gefran Twiist is the same size and shape as a traditional potentiometer, making it easy to install in mobile and industrial hydraulic applications. Gefran Inc.

Industrial use cases for the sensor include:

- bending rolls parallelism control in metalworking machines,
- control of abrasive wheel positioning in marble and stone processing machines, and mechanical dancer position control feedback in packaging and labeling machines.

She said the sensor is also able to provide feedback control in hydraulic and pneumatic cylinders, benefiting both sectors of the fluid power industry.

Technological Progress for Sensors in Fluid Power

During his career, Akers has witnessed the technological evolution of hydraulic components over the years, including improvements in and increased use of sensors. "Now they [sensors] are more perfected for hydraulic pump control by controlling the flow of oil to be more on demand versus having the pump run at full capacity at a constant rate," he said.

This helps to conserve power for reduced energy or fuel use, leading to increased efficiency which everyone is looking for these days in both industrial and mobile applications. And as the mobile sector moves more toward electric-powered alternatives, efficiency will be vital to provide desired battery range.

Many of the technological advancements taking place in the industry, including greater use of sensors, come from the mobile hydraulics sector catching up with what has been happening in the industrial market. Akers said it seems engineers from both sides of the hydraulics

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The Gefran Twiist is a contactless linear position transducer for mobile and industrial hydraulics capable of providing multiple measurements in a single unit. Gefran Inc.

industry are talking with each other more to share ideas and those from the industrial space are being brought into the mobile equipment market to help achieve greater efficiency and other aspects.

Data collection and how that can be used to improve performance, maintenance or even future designs is part of this evolution as well.

Going forward, Akers sees more wireless and Bluetooth communication being utilized to help reduce the amount of wiring within machines. He said that type of technology should work well as long as there is no outside interference which could negatively impact the signals.

Further consolidation of components and systems are possible as well, such as putting data storage on a device, to help reduce the number of components necessary in a machine as well as the overall size of a system – which can lead to smaller, more efficient machines.

Artificial intelligence (AI) will likely play a greater role in the future as well to help with equipment diagnosis. This capability is already available in some capacity but is still in its early stages – and only likely to become more advanced and offer new opportunities in the coming years.

READ MORE: How to Implement AI in Fluid Power Applications

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☞ **BACK TO TABLE OF CONTENTS**

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CHAPTER 3:

Creating Smarter Sensors and Machines Through Digitalization

SARA JENSEN, Technical Editor, *Power & Motion*

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

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

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

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

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

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

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

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

KL: We would consider something to be a smart sensor if it's easy to use as well as pro-

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viding more information than a traditional process measurement. Using the temperature [measurement] example – does it give you the temperature value, whether it's in Celsius or Fahrenheit? Does it also give you how long the RTD has been running? Does it give you the temperatures it's seen in the environment it's been in? Has it seen a power surge? What are the minimum and maximum powers it's been seeing? Has it been changed, the programming or anything like that? All this information is what we consider a smart sensor.

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

Smart sensors are those which can provide more information than a traditional process measurement. Baumer Ltd.

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

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

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

And then with all the new information [from the sensors], we've been able to make the interface much more graphical. In the past, it was pots with a screwdriver and trying to guess 'Did I turn it too much or not enough?' Then we went to things like heart or touchscreen electronics to program. Now you plug in a USB cable and you can use your keyboard and mouse; it's a very straightforward way to do it. Some of our devices have

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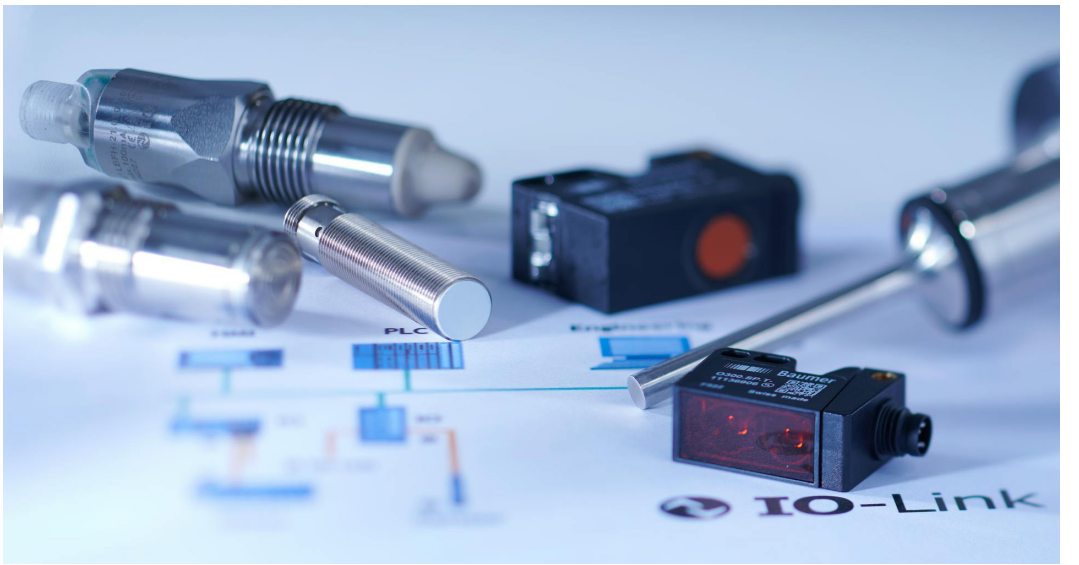
web servers on the Ethernet IP devices [which] that could be done through. [It is] very graphical, feels like you're going to a website. Or it could be software that uses the IO-Link communication to program and do different things that way.



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

READ MORE - Understanding Digitalization and its Use in Fluid Power

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

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

We're trying to make sure that our sensors can provide as much raw data from the measurement itself and also the secondary data around it – the power consumption, running time, temperature spikes, dust buildup on lenses or any of those kinds of things. We have some that will monitor the light value that's being put out and give you a quality bit that says there's dust beginning to gather; [it shows] from green to yellow to red [to indicate] how it's affecting the reading.

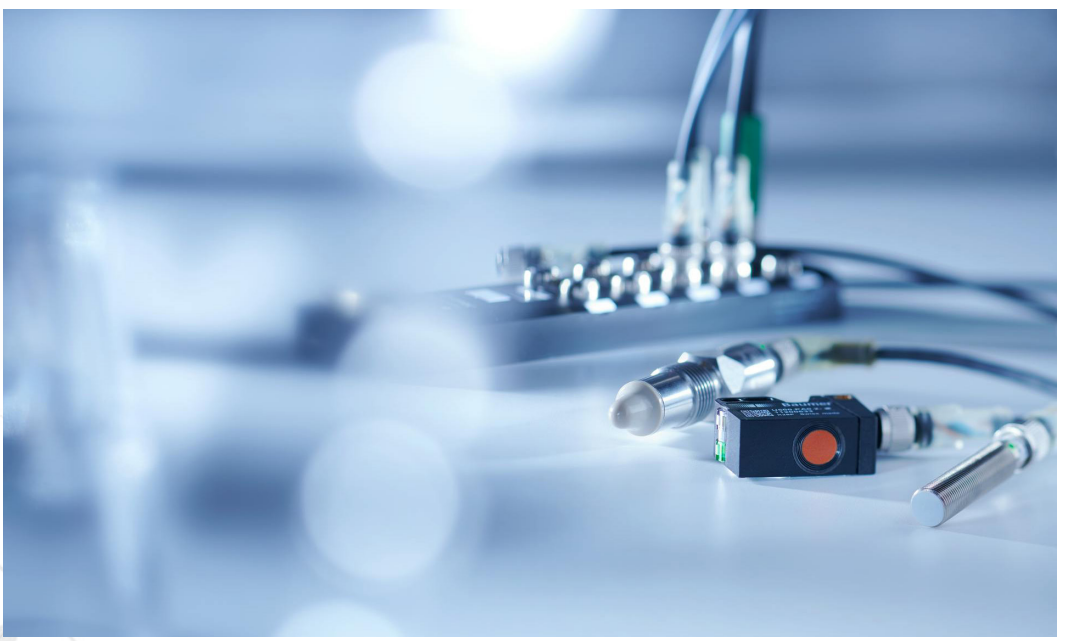
[It's not just about] giving you that data [and] access to the data locally, but then also how do you use that data, where do you take it. We're really working on making it accessible outside of the traditional process environment. Our new IO-Link masters have an OPC UA server built into them so you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

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

KL: The quality bits are very important for customers. If it's a process that's in a dusty

environment, they would like to know how often they have to clean their sensors, can they do some kind of air purge near the sensors to help clean them and keep up with [their cleanliness].

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



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

READ MORE - Sensors and Software in Motion Control: Key Benefits to Consider

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

KL: It's hard for me to picture where the digitalization of sensors is going to keep going. If you had asked me maybe 5 years ago, I would have thought a bigger, brighter touchscreen would have been the key or the future of digitization of the sensors. And I've come to find out, it's actually going to be all internal to the sensor.

We're going to keep getting more data out of the sensors. And again, that sounds cliche, but that's really what it's going to come down to. The next big step is going to be starting to interpret that data, and the software and the programs that will help with it.

When you buy a machine, will it come with a license that says we as the OEM can collect

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the data off the machine through a cloud and analyze what's going on with the machine and make maintenance recommendations and all those kinds of things? We've become such a subscription-based world, will you buy a warranty subscription [where] again, the OEM will monitor your machine remotely for you and you get $1,000 worth of sensors for the month, they send you those that look like they are wearing.

Or is it going to be artificial intelligence (AI) built into the sensor? With all these new data points, are we going to be able to put a brain in there and it self-adjusts to keep the measurement accurate and moving in the right direction?

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

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☞ **BACK TO TABLE OF CONTENTS**

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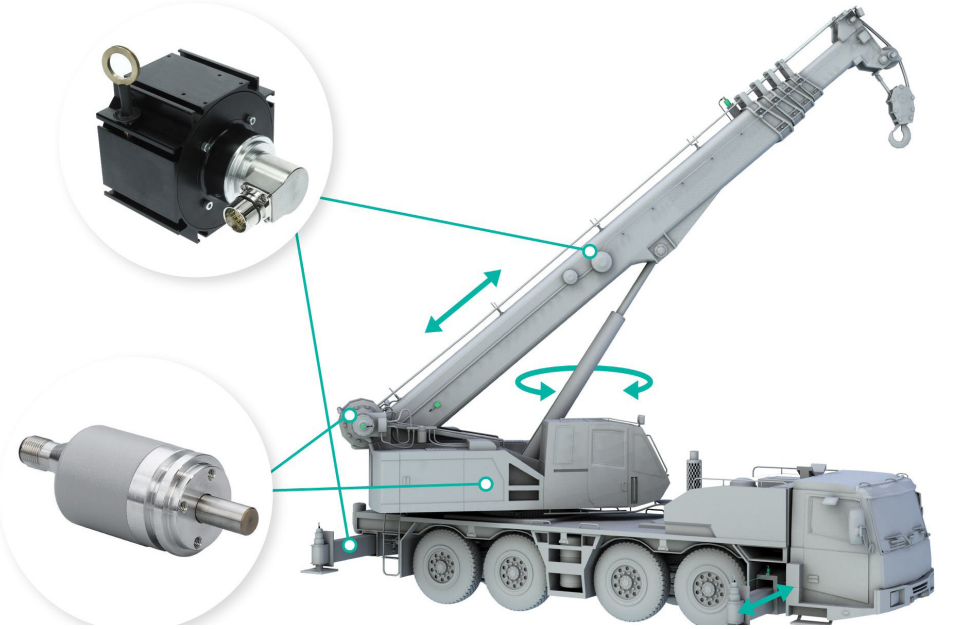

Fraba Inc.

CHAPTER 4:

Why TMR is Becoming a More Desirable Sensing Technology

SARA JENSEN, Technical Editor, *Power & Motion*

The high level of sensitivity and other benefits provided by tunnel magnetoresistance are making it a preferred technology for various types of sensors.

A variety of sensing technologies are available in the market, enabling sensors to detect position, temperature, speed and more. Magnetic sensing is a commonly used option, with Hall effect and magnetoresistive being two of the major types.

Hall effect is likely the most well-known technology as it has been around for a long time and is used in various types of sensors. However, major developments in magnetoresistive technologies over the years have made it a popular option as well.

The most recently developed technology, known as tunnel magnetoresistance (TMR), is gaining ground as an alternative to Hall effect. TMR is comprised of two ferromagnetic layers which are coupled and separated by a very thin non-magnetic, non-conductive insulation layer through which electrons will tunnel, explained Christian Fell, General Manager, Fraba Inc.

It is a robust design with a high level of magnetic sensitivity, leading to improved sensing capabilities which can benefit many applications.

The Benefits of TMR Sensors

According to Fell, use of TMR is increasing in the magnetic sensing market because of the many advantages it can provide versus other technologies. Among them is the fact this technology is less susceptible to temperature fluctuations which helps to ensure its performance in various operating environments.

TMR is also known for its low power consumption, bidirectional sensing capabilities and high-voltage isolation to help assure safety.

"The big advantage of TMR over all of the other [magnetic sensing] effects is just the size of the effect," he said. "Larger effects mean a better signal to noise ratio, more sensitivity…better accuracy and higher resolution."

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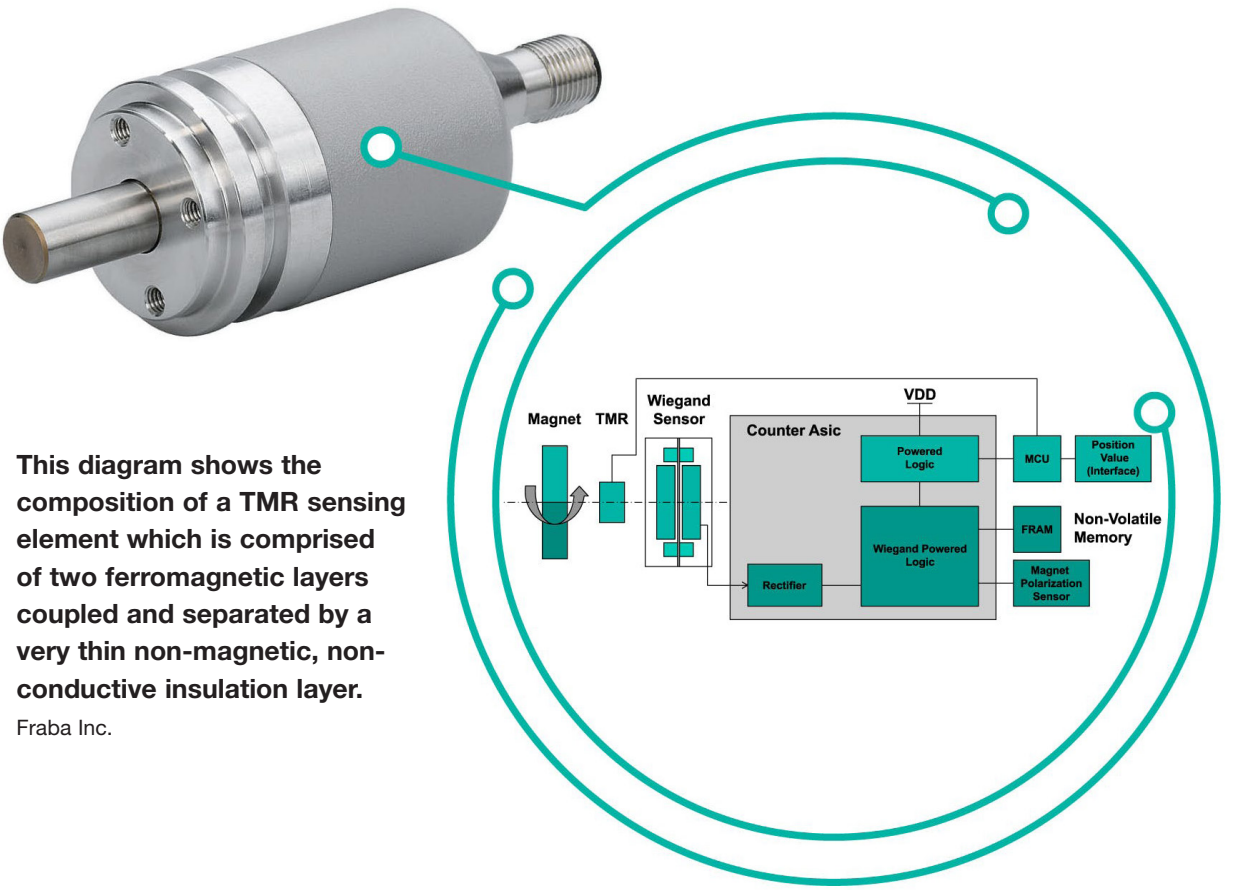

This diagram shows the composition of a TMR sensing element which is comprised of two ferromagnetic layers coupled and separated by a very thin non-magnetic, non-conductive insulation layer.

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Read "What's the Difference Between TMR and GMR Sensors?" from Electronic Design, an Endeavor Business Media partner site to learn more about how TMR differs from other magnetoresistive sensor technologies.

From Fraba's perspective as a developer of position sensors, the larger effect provided by TMR enables the creation of higher quality sensors. "In our case, it's all about resolution and accuracy of the sensor," said Fell.

A higher resolution and level of accuracy means improved detection of an object's position. Depending on the application, this could be vital to ensuring the safety of a machine or overall operation.

He went on to say that with TMR, it is possible to get close to the higher resolutions currently possible with optical sensors. This creates a broader market in which magnetically based position sensors can be used, including applications previously reserved just for optical sensors.

Rotary encoders, for instance, are increasingly using magnetic sensing instead of optical sensing, said Fell due in part to the reduced size and cost of magnetic sensors. Their widescale use in automotive and various other applications have helped to bring down costs while their compact size eases installation and costs as well.

Magnetic sensors are also known to be more rugged and robust, he said, benefiting their use in harsh operating conditions such as off-highway machinery. Inclusion of position

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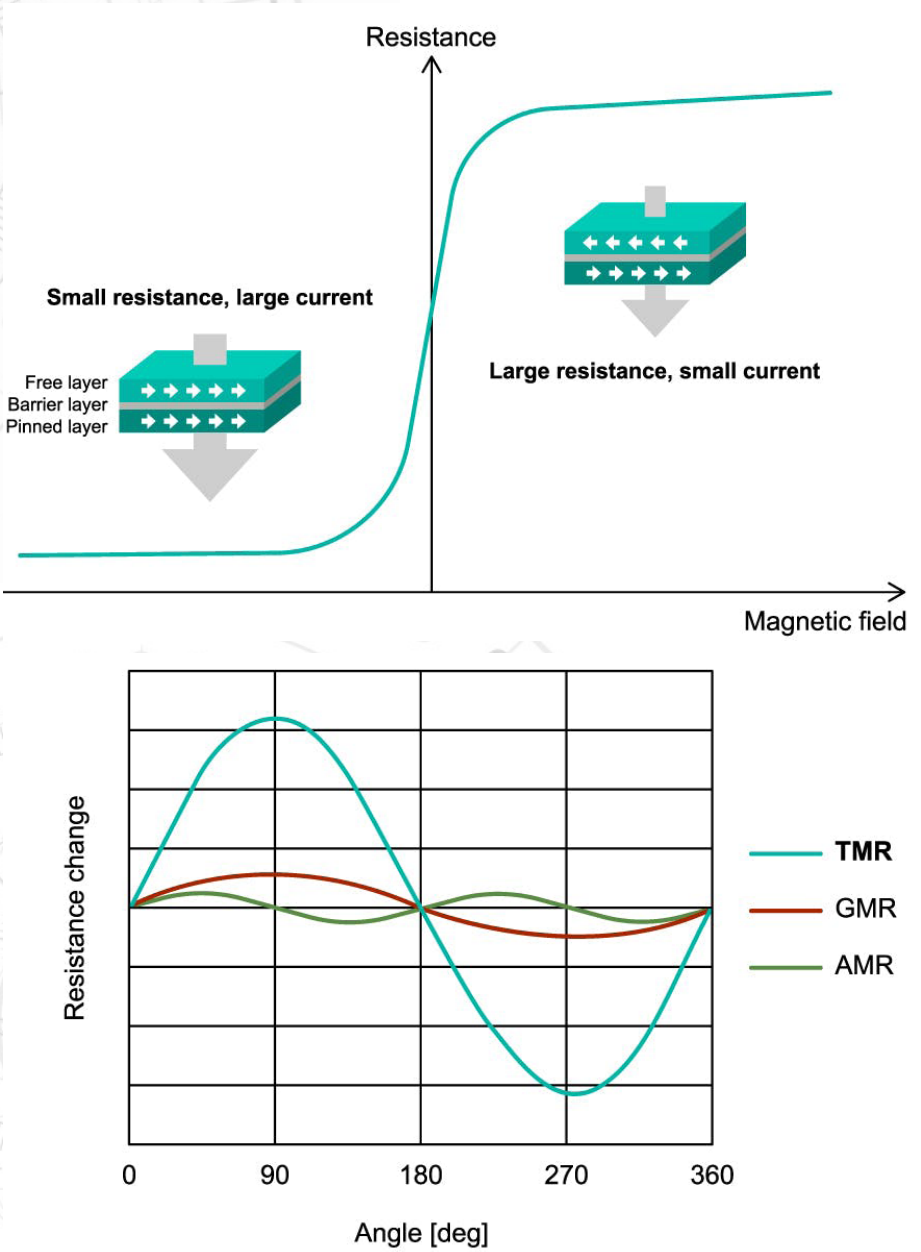
sensors on heavy equipment such as excavators and dozers is increasing; while optical sensors could be used for position sensing, they are more susceptible to the shock, vibration, condensation and other elements common in the outdoor environments in which most heavy equipment operates. Therefore, magnetic sensors are a better option.

Fell said Fraba decided early on to use TMR technology for its magnetic based sensors. "We believe in doing our own data processing in the sensor," he explained. The raw signals provided by TMR sensors enable the company to do this.

By doing the signal conditioning and data processing itself, Fraba gains more flexibility in its sensor designs. It can develop the algorithms necessary to achieve higher resolutions for quicker and more accurate position sensing.



In this diagram, you can see how TMR compares to other magnetoresistive sensing technologies. Essentially, TMR is able to provide a larger effect for a better signal to noise ratio and more sensitivity which leads to improved sensing accuracy. Fraba Inc.

Read "Sensors and Software in Motion Control: Key Benefits to Consider" to learn about the increasing use of sensor technologies in fluid power and electronic motion control systems.

Future Growth Potential for TMR

With TMR technology, sensor manufacturers can create higher performance systems which have a smaller form factor and are more cost efficient, said Fell.

These are important aspects to end use customers. How a sensor will solve a customer's measurement problem is the most important criteria, but form factor, reliability and cost are also driving factors when choosing a sensor, he noted. TMR makes it easier for sensor manufacturers to meet these criteria.

Allegro Microsystems, a manufacturer of sensor integrated circuits, has invested in TMR technology over the last several years because of the many benefits and application uses it sees. When it acquired Crocus Technology, a developer of TMR sensors, in August 2023, the company said the greater application use and forecasted growth of the TMR market as key reasons for the acquisition.

Automotive and industrial applications are expected to be among the key drivers for this market growth in the coming

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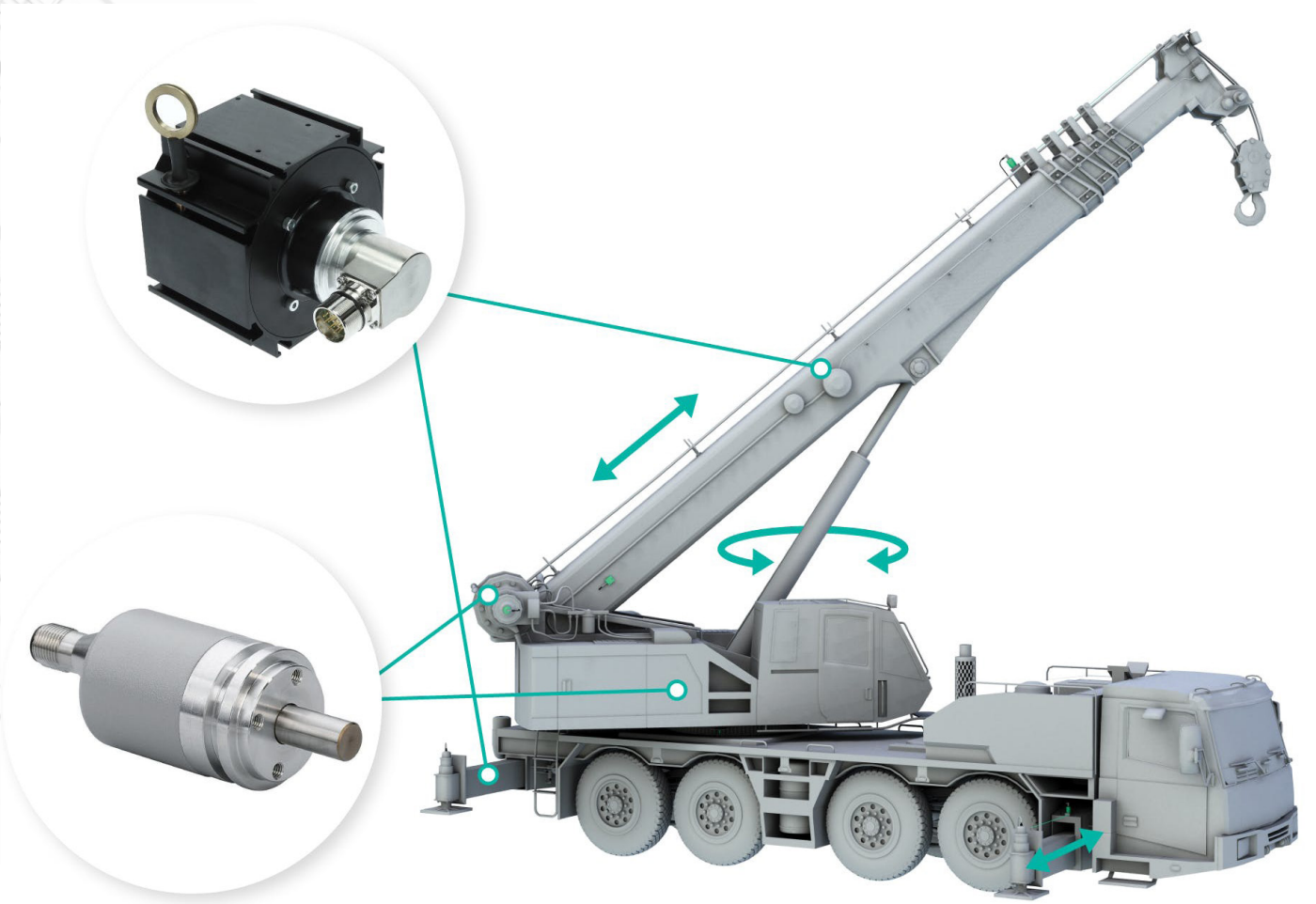

TMR technology is well suited for use within hydraulic systems on heavy-duty machines because it is robust and less susceptible to temperature fluctuations.
Fraba Inc.

years, aided in part by the transition to electrification and automation where the company is seeing greater use of TMR technology. The sensing accuracy, temperature resistance and compact size of TMR sensors are just some of the reasons they are being used in these applications.

Automation in particular requires a high level of accuracy to ensure vehicles and machines move as desired and in a safe manner. The better a sensor is at determining position, sensing objects or providing other necessary data, the greater the accuracy and safety which will become increasingly more important as higher levels of automation are achieved.

Fell concluded that TMR is still a fairly new technology. As such, further technological developments are likely to occur in the coming years which will improve its capabilities even more. This will help to bring down the cost of TMR sensors as well as enable an even broader range of applications in which they can be used.

Watch our interview with Fell, "Sensors Benefit Automation of Construction Equipment" to learn more about the role sensors play in automation.

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☞ **BACK TO TABLE OF CONTENTS**

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Rheintacho Messtechnik GmbH

CHAPTER 5:

Speed Sensors Provide Better Monitoring of Electric Drive Systems

SARA JENSEN, Technical Editor, *Power & Motion*

The ability to integrate speed sensors within an electric drive system enables more immediate and accurate collection of performance data.

Integration of speed sensors within electric drive systems has become standard practice to ensure efficient and optimized performance — enabling longer battery life and electric vehicle run times.

Unlike a combustion engine, the system's electric motor can provide immediate torque – and thus movement for vehicles and mobile machines – even at slow rotational speeds. Therefore, it is important to integrate speed sensors which can detect close to zero speed or even real zero speed to ensure safety and performance, said Wolfgang Sexauer, Head of Sales & Marketing at Rheintacho.

He said there are other possible physical measurement solutions which could be used, but they only work at a higher rotational speed. Because electric motor speed has a direct impact on overall system performance, it is important to gain speed information right away, necessitating use of a sensor instead of other measurement solutions.

Why Speed Sensors are Beneficial

Electric motors are known to get extremely hot due to the speeds at which they operate. Testing conducted by Rheintacho found temperatures inside an electric motor can reach over 150 C (302 F). When higher temperatures are reached, the performance of electronics in the system can be negatively impacted.

Sexauer said once temperatures of 150 C or above are reached, there is a need for special components and other design features to ensure the desired performance is achieved. Optimal operating temperatures are around 80 C (176 F).

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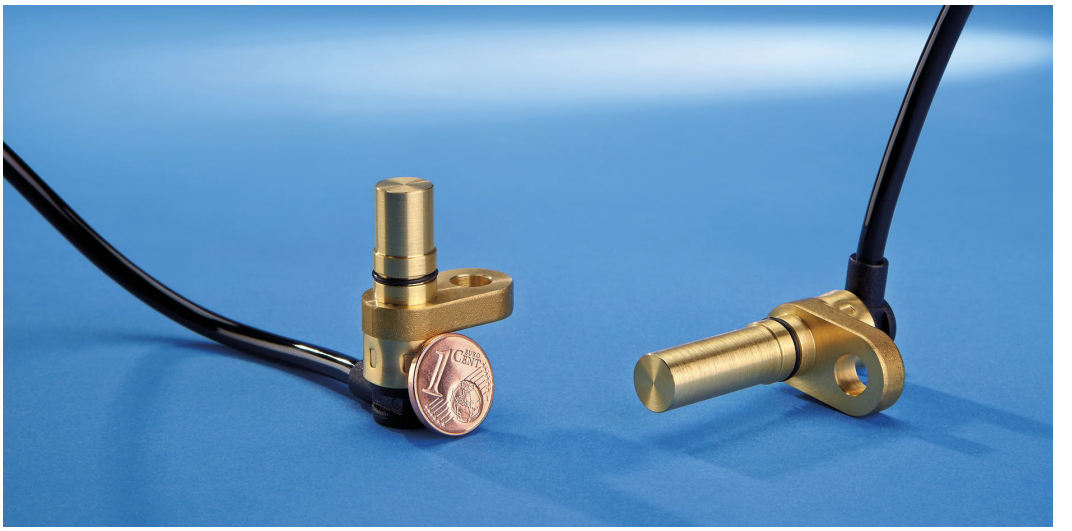

The compact design of Rheintacho's speed sensors allows for easy integration into electric motors and drive systems for collection of performance data.

Rheintacho Messtechnik GmbH

He also noted, that due to different driving situations, there are changing temperature situations inside an electric motor. This puts significantly more stress on all components than operating at a constant (high) temperature. As such, choosing the right components and the right designs are key to precise, long-term operation which is necessary to achieve the emissions reduction and other benefits posed by transitioning to electrification.

Integration of speed sensors can help with the implementation of autonomous driving functions as well. Joern Strasser, Business Manager for Speed Sensors at Rheintacho, said use of speed sensors is becoming mandatory to aid with control of these systems.

The speed signals produced by these sensors can be used by autonomous driving systems to determine if the vehicle is moving as desired, helping to ensure safe operation.

READ MORE - Sensors and Software in Motion Control: Key Benefits to Consider

The Importance of Choosing the Right Sensor

According to Strasser, two-channel sensors are the most commonly used type in electric drives. These sensors provide both rotational speed and direction measurements to provide a better picture of motor, and overall system, performance.

He noted that the more information you get from a sensor, the more you can ensure optimal motor performance.

The video on the next page from Rheintacho demonstrates the information which can be gained from its various speed sensors in an electric motor application.

For its speed sensors, Rheintacho uses Hall effect technology. Strasser said the company chose this sensor technology because it provides a sustainable and secure signal. It is also a more durable technology, enabling a sensor to withstand harsh operating conditions. This is beneficial because in an electric drive system, the speed sensor is located within the electric motor. A robust design is necessary to ensure the sensor performs as needed in this difficult operating environment.

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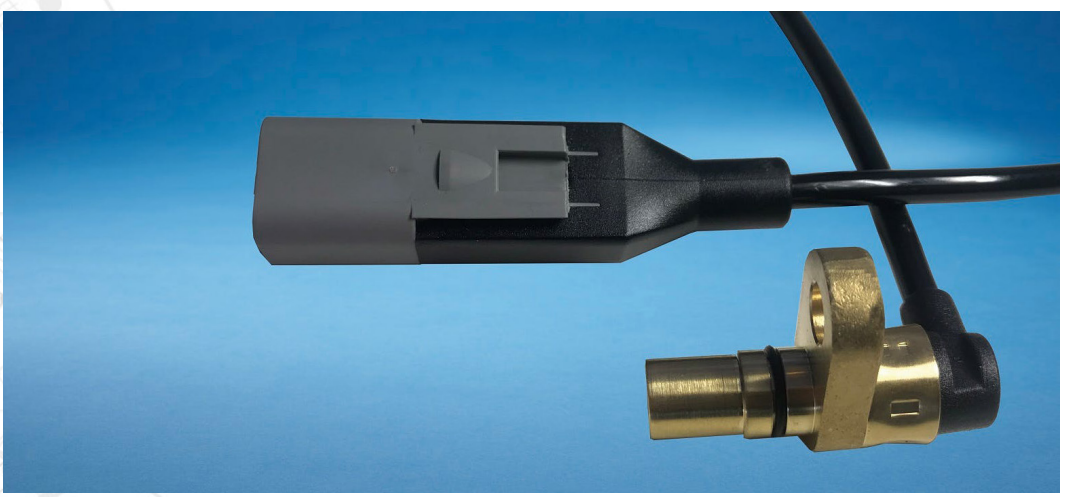
Sexauer said that when using magnetic-based sensors like Hall effect, it is important to take into account the magnetic fields within the electric motor which could disrupt signals produced by the sensor. Temperature can also be a factor which influences the magnetic field.

It can be difficult to calculate and model how a sensor and electric motor will interact with one another and so sometimes it may be necessary to conduct real-world testing to ensure the sensor and motor will work well together. He said sometimes a customer will conduct this type of testing on its own and other times it will collaborate with Rheintacho to do so.

In either scenario, Rheintacho will do its part to ensure the speed sensors it provides perform as desired for customers. Strasser explained that the sensor is not a component operating on its own but part of an overall system, requiring all components "to be adjusted well to each other so you get the best performance out of them."



The speed signals collected by speed sensors helps to ensure electric motors are performing at optimal temperatures and can be used by autonomous driving systems to ensure safe operation. Rheintacho Messtechnik GmbH

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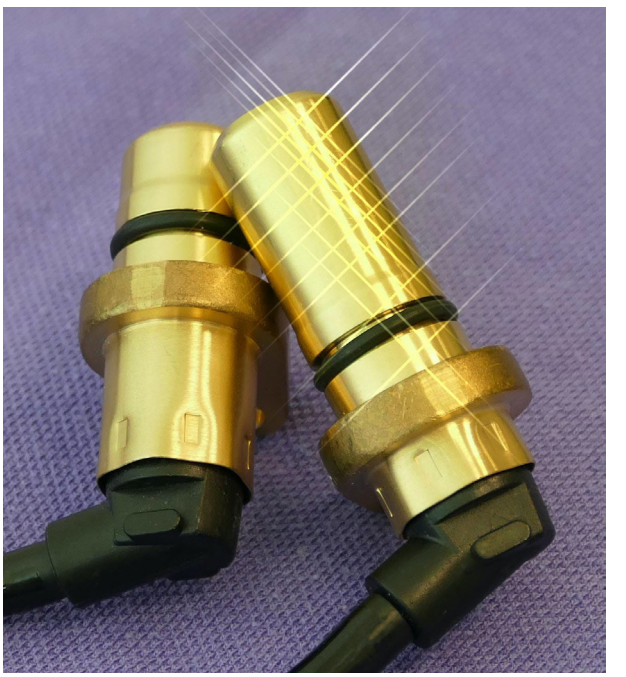
Each manufacturer prefers to have its own unique solution to which the speed sensor must be appropriately tuned, making any degree of coordination between Rheintacho and its customer an important part of the process. Because the company has its own testing facility, he said customers can send their design information to Rheintacho who will then determine the best method for integrating the sensor to ensure no signal failures.

More Sensing and Growth Opportunities in the Future

Going forward, Strasser sees the creation of customized solutions becoming more commonplace. This trend has already begun but will continue to grow to meet ever-evolving customer needs. As such, he does not see the company having many standard products but instead product groups from which customized solutions can then be developed.

He also expects sensors to become more complex in the coming years. This will likely be due to the implementation of new safety regulations which could bring about the need for four-channel sensors capable of also providing position and possibly even acceleration measurements.

Temperature is another measurement which could be included in future speed sensors. Given the effect temperature can have on system performance, this would help further improve monitoring capabilities for customers. And by including all of these measurements into a singular device, it would help to cut down on installation costs for customers – as well as space, which is at a premium in today's vehicles, especially electric vehicles.



Rheintacho is developing customized sensors capable of detecting speed, direction and temperature. Rheintacho Messtechnik GmbH

Sexauer noted that today, some customers are integrating two Rheintacho sensors into a single electric motor to get all of the signal measurements they desire. "But customers would be much [happier] if we could offer a technical solution to integrate those into one sensor," he said.

Both Strasser and Sexauer anticipate further growth for the speed sensor market in the future because of the many benefits they can provide. Sexauer said that when he started with Rheintacho about 20 years ago, there were predictions speed sensors would not be used for electric drives because there are other ways to measure speed and customers would therefore not want to spend the money on a sensor.

However, this has not been the case. In fact, use of speed sensors has only increased over the years and will likely continue to do so as use of electric drives also increases. Continued advancements in sensor technology have helped it remain the measurement solution of choice.

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Sexauer said the other measurement method is also not as affordable because of the sophisticated electronics required. And from a safety point of view, he said it is more valuable to detect movement at the actual place of the movement which is possible with a speed sensor.

Aldo Lopez, Business Development Manager for North America at Rheintacho, agreed with his colleagues' predictions for the future. He believes the many changes taking place in the company's various customer markets will be beneficial for the sensor industry, particularly the transition to more automated and electrified vehicles.

"I think the amount of sensors will increase…to fulfill all of the autonomous [vehicle] requirements," he said. "All of the safety requirements for autonomous vehicles will demand companies to implement two or three times more signal sensors than they are using currently with conventional vehicles."

With the many market opportunities and technological advancements anticipated in the next 10 years, Strasser concluded that "it will be a very challenging and interesting decade for us."

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☞ **BACK TO TABLE OF CONTENTS**

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