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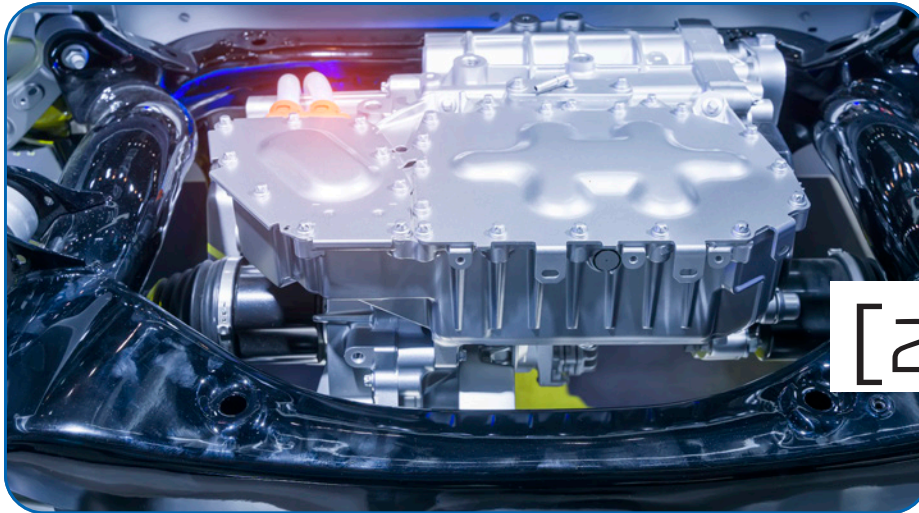
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APRIL 2021



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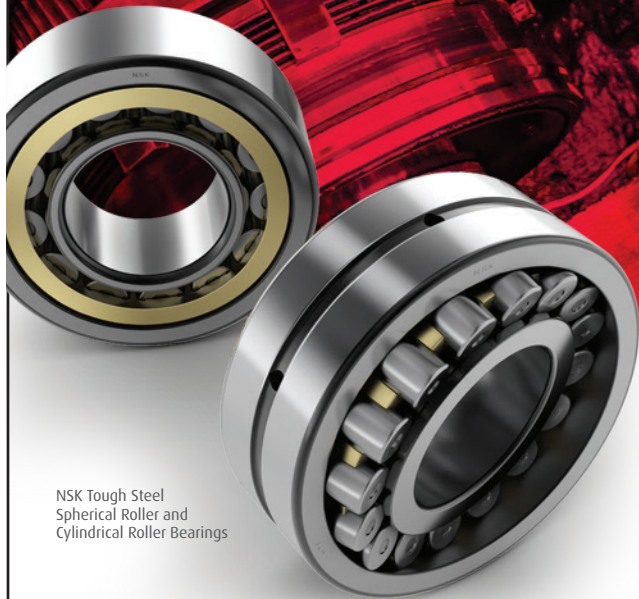
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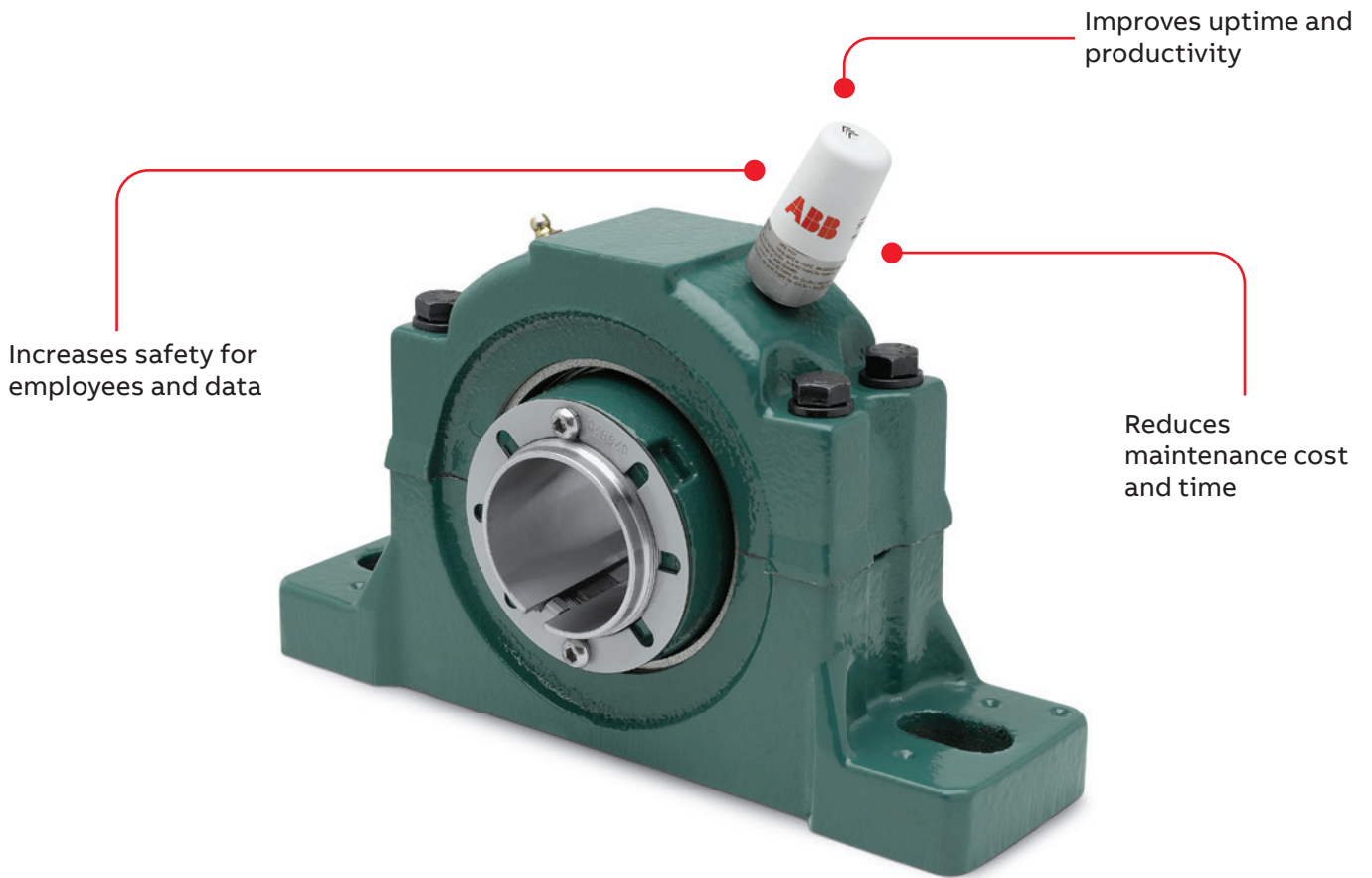
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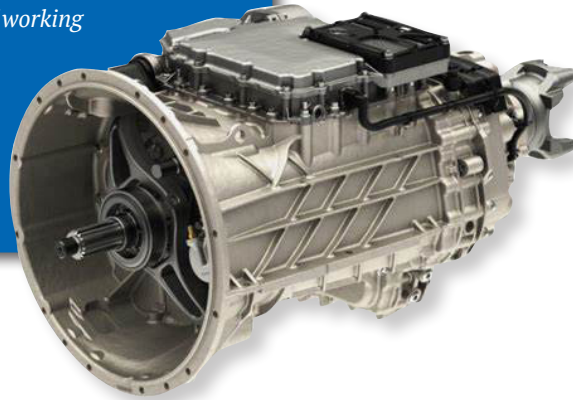
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**PTE Videos**  
**Eaton Endurant XD Series**

Development work continues on the new Eaton Cummins Endurant XD series automated transmission. To ensure this product is capable of working in the toughest environments, the company tests the transmissions at the Eaton Proving Grounds in Marshall, Michigan. Learn more here:

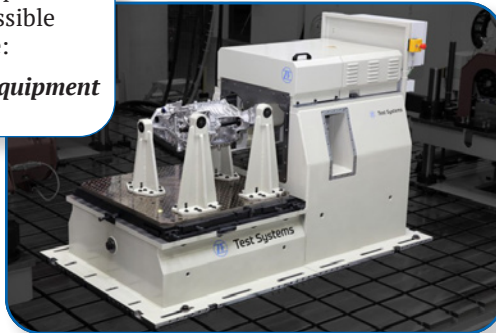
*Eaton Cummins Endurant XD (powertransmission.com)*



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*A Cut Above the Rest | Power Transmission Blog*



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# Turning the Corner

I went to pick up a pizza the other day and had a hard time finding a spot in the restaurant's lot.

I was a little surprised by this, because I personally haven't eaten in a restaurant in about a year. But there were lots of people inside, eating at tables — acting almost as if life were normal.

I know that at least part of this comes from the fact that people are just fed up with COVID. Some are ready to get on with life regardless of the risks. Another part of this is the local authorities and state governments pushing to get the engines of the economy going again. In some places, we're opening up whether we're ready or not.

Although some would argue that things are opening up too fast, and this rush to normalcy is ill-advised, it's beginning to feel like more than that. Kids are going back to school. Friends and families are visiting each other. People are getting vaccinated.

And that's a big deal. Every single person I've heard from who's gotten vaccinated feels safer. They don't even have to tell me. You can hear the hope in their voices and see the relief in their facial expressions. Their overwhelming fear is gone, and it's being replaced by a sense of hope and an eagerness return to living.

Don't get me wrong. COVID isn't beaten yet. In many areas of the world, it's still an overwhelming crisis. Even in places where it's starting to feel more normal, people are still getting sick and dying from this disease. The war isn't over. But for the first time in a long time, it feels like we might be winning.

Of course, when things finally do return to normal, it's not going to be the same normal we remember from before 2020. In fact, a lot of things will never be the same—like the way we work, collaborate with teams. For example, meetings held via Zoom are never going away. We've figured out how to be productive, even from a distance.

A case in point was the recent AGMA/ABMA Annual Meeting, which was held virtually via an online platform. Although it had fewer participants than some of the previous annual meetings, it gave the gear and bearings industries the opportunity to meet with, learn from and network with peers. All the participants I talked to were glad they participated, and they were universally impressed with the ease of using the platform. It was easy to meet new people as well as connect with old friends, customers and colleagues.



Online platforms like this are a great addition to our productivity toolbox, and I'm confident we'll continue to find ways to use them again in the future.

But even though we've learned a lot about holding meetings and collaborating online, there's still something to be said for going to a place, meeting people in person and giving them your undivided attention.

And those days are coming again. Real, in-person events are coming back.

Over the summer, you'll start to see more trade shows, seminars and educational opportunities cropping up. Maybe you won't be ready to hop on an airplane in stay in a hotel room by July. It will probably be some time before many of your companies even allow you to travel for business. But by next fall, we're expecting trade shows to really start to pick up again.

We're particularly excited about the upcoming Motion+Power Technology Expo, which will be held—live and in person—in St. Louis, September 14–16. If things keep going the way they are, it promises to be one of the first shows that has the real potential to be productive for both exhibitors and visitors alike.

We're going to be there, along with our sister publication, *Gear Technology*. We'll be talking to exhibitors, getting feedback from subscribers and learning about the latest technologies related to the field of mechanical power transmission. Will we still be wearing masks? Maybe. And yeah, there's a good chance we'll still be social distancing and using hand sanitizer. But this show is going to happen, and we believe it's going to be a productive three days for anyone who joins us.

So keep your calendars open for mid-September. It will be good to see you again.



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# SEW-EURODRIVE

## OFFERS CONTACTLESS ENERGY AND DATA TRANSFER SYSTEM

Although robotic systems are sometimes limited by constraints in automation and drive technology, this issue can be easily minimized. Application-specific automation from a single source enable machine builders to develop new, commercially beneficial solutions for customers. To demonstrate, consider the case of a gantry robot that uses contactless energy and data transfer instead of fixed wiring runs and cable carriers.

Gantry robots are a tried-and-tested solution for intra-logistics material flows within a machine or application. They are commonly used to detect products automatically, grip them securely and quickly, and take them to their destination. This type of robot is useful in many industries, and can be used for a wide range of product sizes and weights, and distances to be covered. Oftentimes, the lengths of power and communication cables and cable carriers limit the flexibility and adaptability of an existing machine to a new production scenario. Adding contactless energy and data transfer opens up new production scenarios, and has largely consigned cables to the past.

### Less noise, enhanced dynamics, greater flexibility

The illustrated solution demonstrates contactless energy and data transfer combined with intelligent software and reliable mechatronics to create a fully integrated solution. What immediately catches the eye about this gantry is the drive concept used to move the gantry robots on the rail: contactless energy transfer. As a result, multiple robots can move freely on the same horizontal stretch, greatly increasing the flexibility of this gantry robot application. This regularly leads to overlapping sections between robots—ultimately offering a great deal of freedom in terms of machine design and operations. Logistics processes of this kind would not be

as easy to implement with cable carriers, because of the additional area that carriers use along the entire distance of the system. In addition, cable carriers generate noise, are subject to wear, increase inertia, and have an overall negative impact on both dynamics and energy efficiency due to the friction they generate. Another benefit of contactless energy and communication transfer is that there are no longer

of the primary energy supply to the robot with a DC link voltage of 100 V. The typical travel profiles of a gantry robot, which involve alternating acceleration and braking phases, led to the idea of retaining the regenerative energy generated during braking within the process instead of dissipating it via resistors. The energy storage unit absorbs this braking energy and additionally functions as a booster when



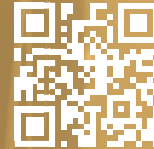
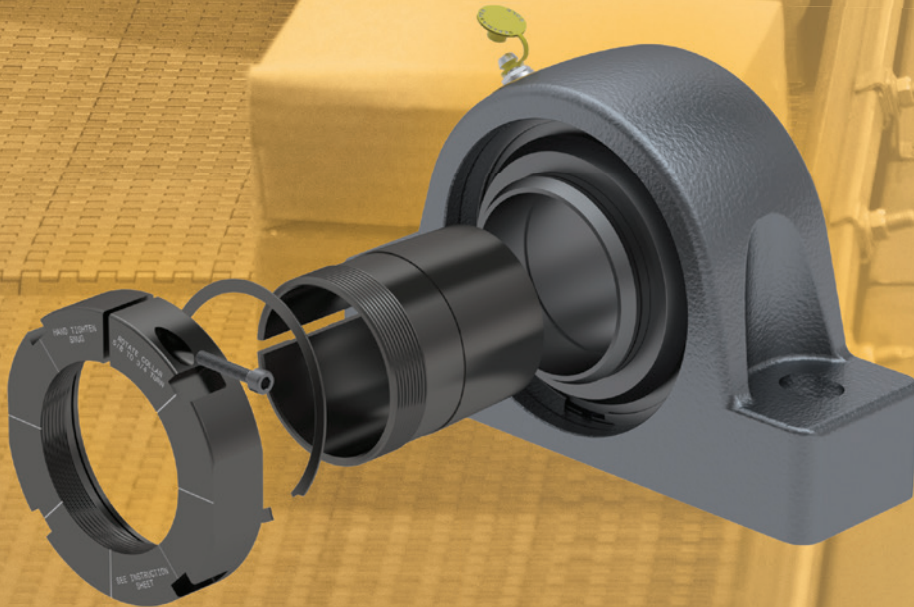
any restrictions regarding installation space, cable breakage or limited cycle rates—issues all associated with cable carriers and moving cables. The clever innovation is made possible by a contactless inductive energy transfer system, including a decentralized power supply module. Depending on the design, this module delivers a transmission power of between 5 and 11 hp.

What is exciting about this logistics solution is that throughout the entire load cycle, the robot consumes less than 0.7 hp via the pick-up—even though the horizontal axis alone requires more than 5 hp of acceleration. The short-term energy requirements are met by the energy storage unit, a double-layer capacitor package that takes care

the gantry's drives accelerate at 20 ft/s<sup>2</sup>. The design is so effective that the contactless energy transfer and storage solution only has to compensate for the system's mechanical efficiency losses, which amount to around 0.7 hp. Unlike the familiar DC link connection of multi-axis applications, which is located in the central control cabinet, each unit is enabled to store energy independently. This makes it easy and convenient to scale this type of system.

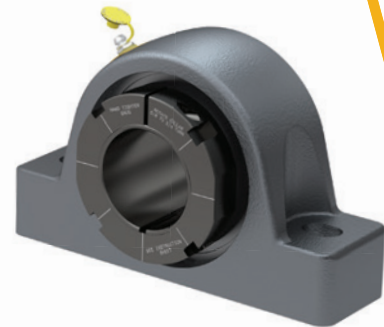
### Cable-free communication

The robot gantry's contactless energy transfer system, which eliminates the need for restrictive cables, also extends to the communication processes. In this context, an EtherCAT data light barrier transfers the interpolated posi-



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tion setpoints from the central motion controller to the four servo inverters in the moving housing box at 1 ms intervals. A motion controller calculates the complex robot motion control—and can do so for up to four robots at once. Motion control involves performing calculations to prevent collisions and coordinating the robots to achieve a productive overall system. If a machine in a production network requires double the material flow output, the gantry system gives users the option

to move a robot from another section on a flexible basis. Handling units that draw their power with cables, in contrast, are tied to their section. As a result, the associated resources become movable and systems as a whole are more flexible and productive. Entirely new machine concepts can be created based on this approach. The demands placed on communication are correspondingly high as well.

### Optical real-time communication

The automation provider opted to use the real-time Ethernet protocol EtherCAT in the gantry—once again dispensing with cables by implementing an optical connection to the mobile units. The drive data can be delivered to the robots via data light barriers. Having separate motion controllers in each robot is a thing of the past: one does the job for running the whole robotic system. With each cycle taking 1 ms, the optical system has practically no latency periods when transmitting the interpolated position setpoints to the inverters or feeding back the relevant actual values.

Communication for the functional safety technology works in the same way. For this application, a central safety controller for all robots and the machine as a whole was selected. This safety controller communicates directly with the MOVI-C automation controller via EtherCAT using the EtherCAT FSoE (Fail Safe over EtherCAT) protocol. This setup enables both controllers to share data with ease, simplifies programming considerably, and offers excellent conditions for diagnostics and debugging thanks to its high information density.

### Solutions in a nutshell

The seamless integration of the FSoE safety master and the EtherCAT data light barrier are integrated into a comprehensive automation solution including motors, electronics and visualization. Clearly, working with a skilled automation provider can streamline the development process and the newest drive technology innovations and trends can be considered. In this context, standardized interfaces play just as important a role as prepared software modules or application-specific function modules.

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# REO AG

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The Solingen-based company REO AG continues to expand its range of e-motor components and peripheral components. The company is therefore continuing its consistent path towards the electrification of new and existing mobility concepts, whilst also remaining true to its traditions spanning almost 100 years.

REO has been developing and producing electrical components since 1925 and, in doing so, has acquired a high level of technical expertise over the decades. Nowadays, the company sells special braking resistors, chokes, filters and transformers for use in e-motors in vehicles, marine and aviation applications, all with highly scalable performance ratings.

REO focuses in particular on the specific areas of application for its products, generating market-defining impetus with its innovative production processes, efficient workflows and continuous further development. As a



result, REO AG has already been able to utilize its own expertise in a variety of international research and development projects and make a significant contribution to the success of new products.

REO is very much convinced of the future of the e-motor: “Electric motors

are extremely efficient when compared to conventional motor types like the combustion engine”, explains Sven Reimann, management board member and head of development. He goes on: “At the same time, e-motors benefit from energy recovery during braking, low noise level, simple design and do

## SMT

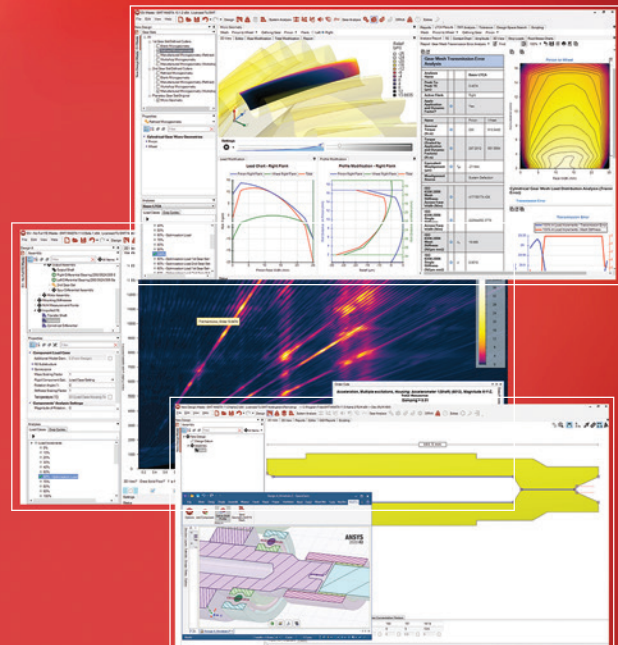
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not cause any local emissions. With REO's components, we are able to make our contribution to improving e-motors and making them more efficient. This is why we are convinced the e-motor will be an integral part of the future of mobility."

Additional benefits include a longer life cycle, safe operation requiring virtually no maintenance at all and reduced costs—provided the components used are high quality. In order to be able to ensure and maintain this consistent level of quality and thereby pursue new developments, extensive quality testing along with the application of sophisticated analytical methods have always been at the heart of our product development and improvement methods. Compliance with the various standards in force, as evidenced by certificates issued by accredited laboratories, underscore this requirement for high quality.

Thanks to this new "electrification" strategy, REO AG has pooled its strengths to produce inductive, resistive and electronic components. An enormous level of vertical production throughout the entire production system in REO's German plants combined with our independence from global suppliers help to safeguard our production and deliveries.

[www.emobility.reo.de](http://www.emobility.reo.de)

## ABB

### INTRODUCES NEW COLLABORATIVE ROBOT PORTFOLIO

ABB is expanding its collaborative robot (cobot) portfolio with the new GoFa and SWIFTI cobot families, offering higher payloads and speeds, to complement YuMi and Single Arm YuMi in ABB's cobot line-up. These stronger, faster and more capable cobots will accelerate the company's expansion in high-growth segments including electronics, health-care, consumer goods, logistics and food and beverage, among others, meeting the growing demand for automation across multiple industries.

GoFa and SWIFTI are intuitively designed so customers need not rely on in-house programming specialists. This will unlock industries that have low levels of automation, with customers able to operate their cobot within minutes of installation, straight out of the box, with no specialized training.

"Our new cobot portfolio is the most diverse on the market, offering the potential to transform workplaces and help our customers achieve new levels of operational performance and growth," said Sami Atiya, president of ABB's Robotics & Discrete Automation Business Area. "They are easy to use and configure and backed by our global network of on-call, on-line service experts to ensure that businesses of all sizes and new sectors of the economy, far beyond manufacturing, can embrace robots for the first time."

ABB's cobot portfolio expansion is engineered to help existing and new robot users accelerate automation amid four



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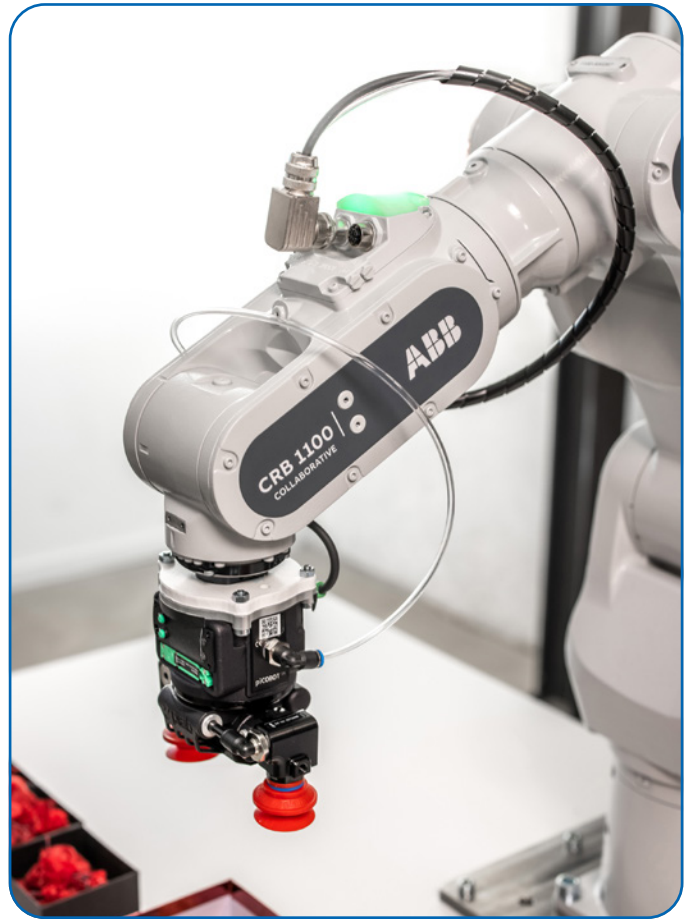


key megatrends including individualized consumers, labor shortages, digitalization and uncertainty that are transforming business and driving automation into new sectors of the economy. The expansion follows the Business Area's focus on high-growth segments through portfolio innovation, helping to drive profitable growth.

GoFa and SWIFTI are engineered to help businesses automate processes to assist workers with tasks including material handling, machine tending, component assembly and packaging in manufacturing, medical laboratories, logistics hubs and warehouses, workshops, and small production facilities.

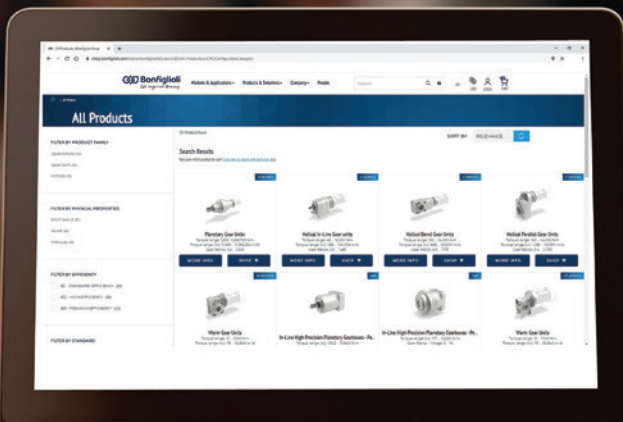
"With this expansion, we are making cobots easier to use and deploy, with real-time support to help speed their adoption in businesses that may have not considered their use previously," Atiya said. "Our experience is that the best performing operations harness people's skills, alongside the potential of new technologies."

Users comfortable with operating a tablet or smartphone will be able to program and re-program the new cobots with ease, using ABB's fast set-up tools. Customers will also benefit from ABB's global industry and application expertise, which has been developed from installing more than 500,000 robot solutions since 1974 and supported by ABB's network



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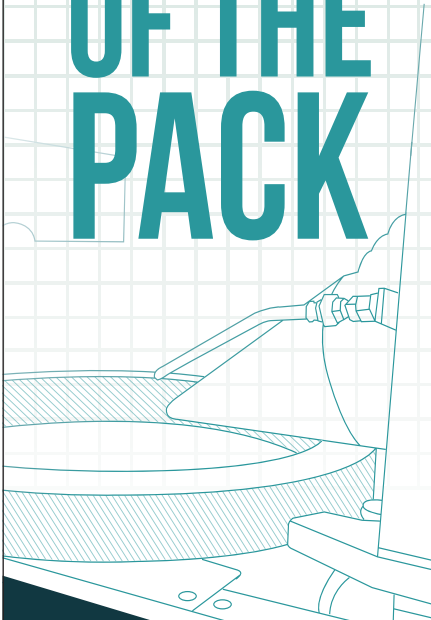


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The new GoFa and SWIFTI cobot families build on the success of ABB's YuMi family, which has been helping businesses safely automate key tasks since YuMi, the world's first truly collaborative robot, was launched in 2015. Today, ABB's YuMi cobots are working alongside people in factories, workshops and laboratories all over the world, performing tasks from screwdriving and assembling electronics and electrical components, to making valves and USB sticks, and testing COVID samples in laboratories.

Every ABB cobot installation includes a start-up package that provides ABB Ability™ condition monitoring & diagnostics as well as a support hotline free for the first six months to access ABB's expert technical assistance, which is offering support across all industry segments.

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## Dunkermotoren

OFFERS ETHERCAT WITH  
DISTRIBUTED CLOCKS

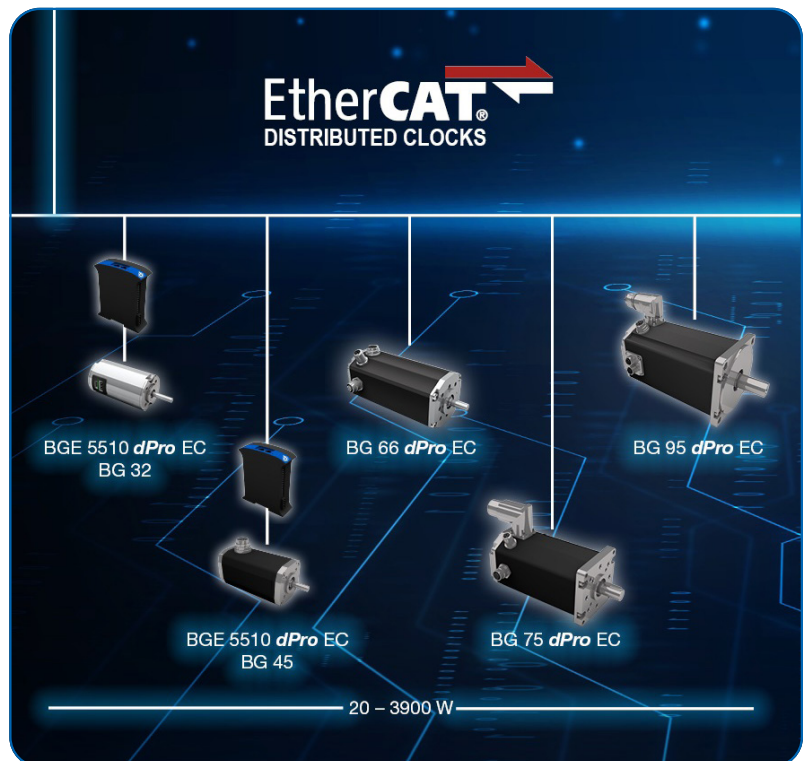
The complete BLDC motor series dPro from Dunkermotoren is now also available with EtherCAT interface.

The dPro versions are available with integrated servo controller (BG 66 dPro EC to BG 95 dPro EC) or as external version (BGE 5510 dPro EC). In contrast to the previous EtherCAT product portfolio, a special highlight is Distributed Clocks and the associated possibility of real-time synchronization.

A large number of brushless motors of the BG series in the power range from 10 W to 1100 W are controlled via the industrial Ethernet interface (CoE protocol). Easy integration of the units into the Beckhoff TwinCAT environment is guaranteed with the help of a simply explained "Let's Connect" manual and the appropriate parameter files (ESI).

Early next year, the EtherCAT drive units will be equipped with another "must have" feature. With the safety function "Safe Torque Off", the motors will be found in the future in numerous autonomous vehicles (AGV or AGV) or in traditional mechanical engineering.

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## Bosch Rexroth

OFFERS LONGER LUBRICATION INTERVALS ON BALL SCREW RAIL SYSTEMS AND ASSEMBLIES

The ball rail systems BSHP and ball screw assemblies BASA from Bosch Rexroth now achieve lubrication intervals that are up to four times longer. In more and more applications, they can even be used maintenance-free over the entire service life of a component. As a result, low-maintenance or maintenance-free linear motion technology minimizes operating costs and also protects the environment because less lubricant is required.

The results of the most recent tests show that the lubrication intervals for Rexroth's ball rail systems BSHP are twice as long as they were before. The runner blocks can cover up to 20,000 km before the first relubrication, the same distance as from Germany to New Zealand.

Bosch Rexroth's latest generation of ball screw assemblies BASA achieves up to 200 million revolutions with the basic factory lubrication. In this case, the intervals are as much as four times higher. The balls on the screw cover a distance of around 12,800 km—the same distance as from Germany to Hawaii.

The fact that the time span until relubrication is now longer for both product groups is due not only to the constant improvements to production processes, but also to Bosch Rexroth's

innovative design. Thanks to their patented entry zone, the BSHP runner blocks achieve optimum precision, friction forces and friction force fluctuations. The ball screw assemblies BASA are designed to achieve particularly high load ratings. Both groups of components offer extraordinary robustness, precision and performance.

As a result, Bosch Rexroth has put in place ideal conditions for reducing operating costs and protecting the environment. After all, longer lubrication intervals reduce the use of resources. If they double, the quantity of lubricant required is halved. If they are four times as long, only a quarter is needed.

For applications which require relubrication, there are various lubrication options to ensure optimum accessibility to the linear guides in the machine. The ball runner blocks BSHP for example are accessible from eight locations.

Bosch Rexroth's linear motion technology is efficient when it comes to engineering too: using the online configurator, a component designed with the Linear Motion Designer program can be configured ready for installation and ordered from the e-shop in a matter of minutes. CAD data is generated and provided automatically.

[www.boschrexroth-us.com/linear-motion](http://www.boschrexroth-us.com/linear-motion)

**EXTENDED LUBRICATION INTERVAL**

1 Interval  
~ 12.800 km  
(Germany - Hawaii)

1 Interval  
~ 20.000 km  
(Germany - New Zealand)

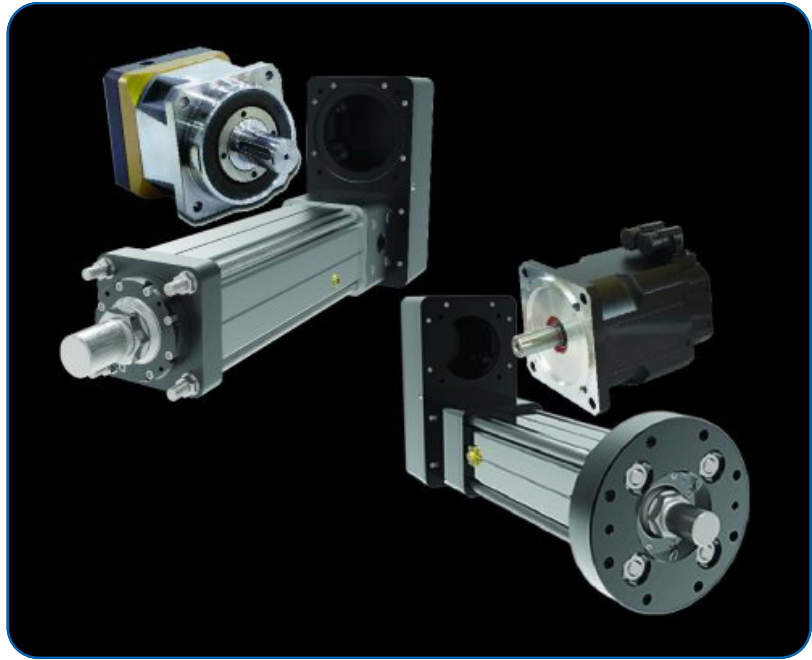
# Curtiss-Wright

## LAUNCHES MOTOR SUPPORT PROGRAM FOR EXLAR UNIVERSAL ACTUATORS

Curtiss-Wright's Actuation Division recently announced the release of its new ASSIGN motor program for Exlar FTX and FTP Series actuators. These high-force/duty cycle, electric, rod-style actuators now provide the ability to support the mounting of almost any motor.

The Exlar FTX Series actuators offer continuous load force ratings to 178 kN (40,000 lbf), speeds to 1,500 mm/sec (59 in/sec), and stroke lengths from 150 mm (6 inches) to 900 mm (36 inches). The Exlar FTP Series actuators offer continuous load force ratings to 356 kN (80,000 lbf) and speeds to 401 mm/sec (15.8 in/sec), and stroke lengths from 150 mm (6 inches) to 900 mm (36 inches). The versatility of these actuators makes them suitable for a wide range of factory automation applications.

The new ASSIGN (Any Servo,



Stepper, Integrated, Geared, or NEMA) configuration capability simplifies selection of a wide range of motors, allowing customers to choose in-line or parallel mount configurations that accommodate a larger variety of motor dimensions.

The program substantially increases the number of motor/actuator combinations available when using Exlar FTX and FTP Series actuators, giving customers the ability to use the best motor for their application.

[www.cw-actuation.com](http://www.cw-actuation.com)

spiral bevel gearboxes



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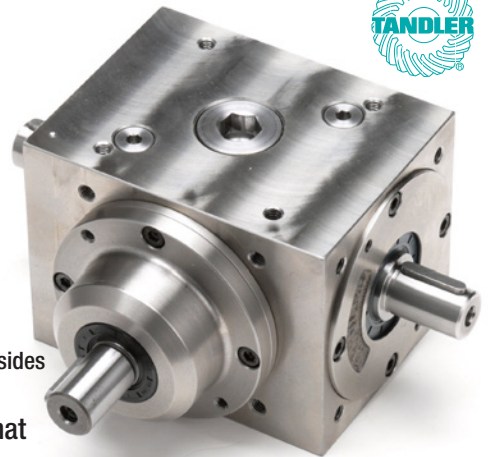


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# Michell Bearings

SUCCESSFULLY COMPLETES THRUST AND GUIDE BEARINGS TEST FOR NUCLEAR STATION

Michell Bearings has successfully completed station blackout (SBO) tests on a thrust and guide bearing used within the reactor coolant pump at a new build nuclear power plant.

In what is thought to be one of the world's first successful bearing run downs, the test demonstrated the bearing's ability to survive a station blackout condition without the use of an externally powered high pressure oil injection system. Failure of the on-site power generators concurrent with the loss of off-site power ultimately results in a station blackout condition as there is no on-site electricity available to power the high pressure oil injection system. In order to meet testing requirements, the bearing must be able to run down to a stop, under full load, and restart without any subsequent intervention. As part of the contract to supply six thrust and guide bearings, a custom made test rig was constructed at the Michell Bearings site in order to satisfy the test conditions. The test rig was designed to closely replicate real world bearing operating conditions such as the possibility of a station blackout, where the bearings

are required to shut down safely without the aid of electrical power to drive the reactor coolant pumps. Paul Bruce, Engineering Director at Michell Bearings, said: "We were delighted to be able to provide a solution to satisfy such challenging conditions. This is testament to the operation of our bearings, along with our high levels of research and development. "Damage to the working surfaces of the tilting thrust pads is not permitted. The combination of full thrust load and very slow rotational speeds over a sustained period results in the bearing operating under very low oil film thicknesses. Consequently, special design considerations are required to survive such a condition." The bearings were designed, manufactured and tested at the Michell Bearings manufacturing site based in Newcastle upon Tyne, UK. This latest success comes after Michell Bearings developed and successfully station blackout tested a set of thrust internals with a leading European reactor coolant pump manufacturer in 2018.

[www.michellbearings.com](http://www.michellbearings.com)



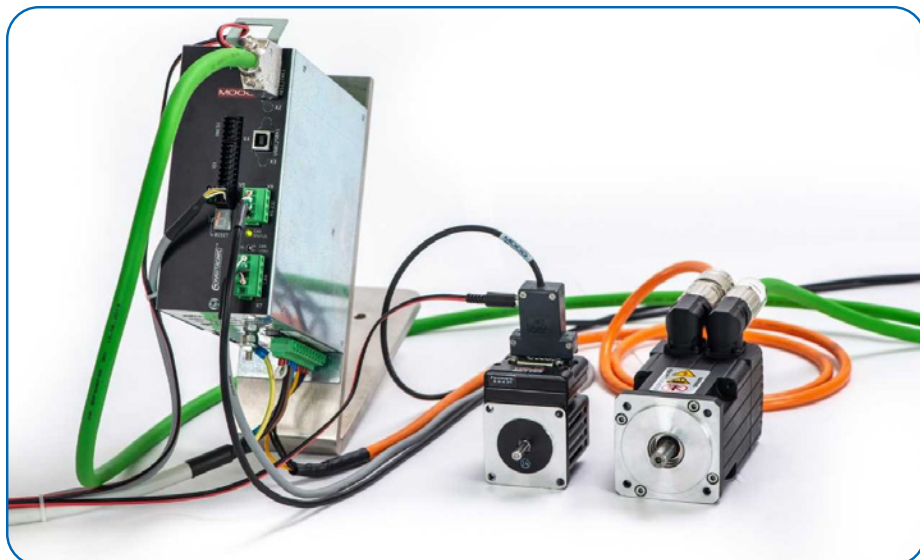
# Moog Animatics

## INTRODUCES THE DS2020 DRIVE WITH COMBITRONIC SYSTEM

Moog Animatics announces the release of the DS2020 digital servo drive with Combitronic capability. This single-axis drive operates a Moog CD series motor, providing high torque capabilities for large axes of motion and other demanding applications.

The DS2020 drive with Combitronic expands the standard drive's capabilities by allowing it to act as a follower device on the Combitronic network, which means the drive can be easily controlled by any SmartMotor on that network. This allows the DS2020 Combitronic drive to fit and work seamlessly in SmartMotor-based machines and applications, while supporting the familiar SMI software and AniBasic programming language to configure and program the entire system.

"The introduction of the DS2020 Combitronic system marks an evolutionary step in the SmartMotor



product lineup," says Ray Walsh, general manager at Moog Animatics. "This new product offering allows Moog to satisfy customer application needs where larger, high torque motors are required, while leveraging the advantages of SmartMotor technology."

Incorporating the Combitronic communication protocol into the DS2020 drive allows target customers to simplify their machine, making it more

compact. In addition, this enhancement helps retain the SmartMotor's traditional ease-of-use while also addressing the power needs of large axes of motion and other demanding applications.

[www.moog.com](http://www.moog.com)

# Omni Powertrain Technologies

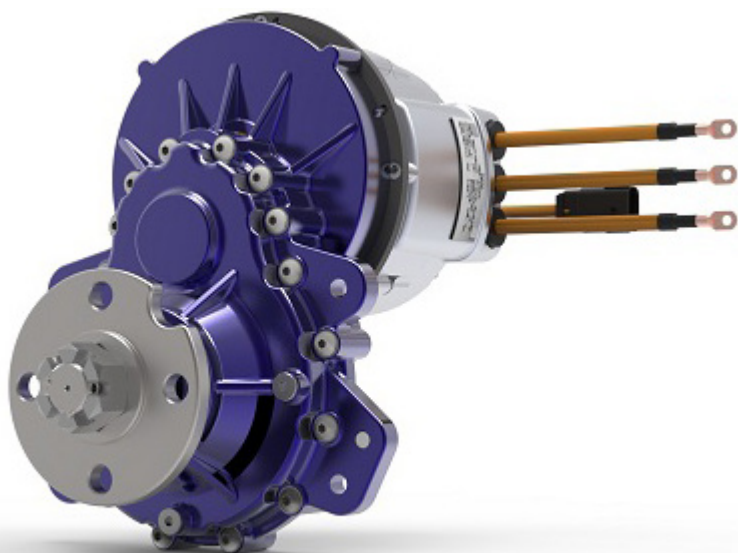
## INTRODUCES PARALLEL SHAFT DROP-BOXES FOR ELECTRIFIED VEHICLES

Omni Powertrain Technologies announces the development of a new series of parallel shaft gearboxes which address cost, performance and packaging needs for applications in off-high-

way including turf equipment, mobile elevating work platforms, material handling and general construction equipment. The new range provides continuous torque output from 200 Nm to 3,000

Nm and offers choices in reduction ratios from 15:1 to 60:1. Helical ground gears are included in the drives to offer reliable and quiet operation. These gearboxes can be combined with axial flux motors from Omni Powertrain to offer a complete drive system with a compact package form. Air or WEG cooled motors can be supplied with an IP67 rating and a continuous power output of 2.5 to 44KW. Motor and gearbox combinations can be tailored to meet the needs of OEMs.

[www.omnipowertrain.com](http://www.omnipowertrain.com)



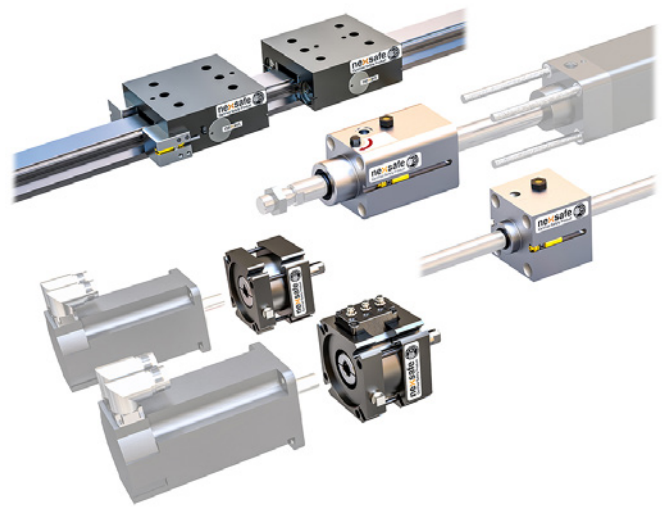
## Nexen

### INTRODUCES NEXSAFE FUNCTIONAL SAFETY CERTIFIED BRAKES

Nexen Group, Inc., announces the launch of NexSafe Certified Safety Products, providing machine builders with a verified and reliable solution to increase the safety of processes and machines. NexSafe Rail Brakes, Servomotor Brakes, and Rod Locks are the first in North America to earn the Intertek Functional Safety (FS) Mark. They are certified to comply with ISO 13849-1, Categories B through 4 and Performance Levels PLa through PLe.

“The Intertek Functional Safety mark provides customers like Nexen a way to illustrate reduced hazards and risks to operating personnel, machinery, and surrounding environments at a time when they are facing increased demands around functional safety,” said Pierrick Balaire, global business line leader at Intertek. “We’re pleased to grant Nexen with this certification, the first of its kind in North America, and look forward to continuing to work with them, and others, as they provide their industry with high-quality products, as well as peace of mind.”

“Customers look to Nexen for superior products that stay ahead of the curve. Our new NexSafe certified safety brakes give machine builders the operational and competitive advantage of safer machines, and that carries through to a



higher level of safety and productivity for their end users,” said Tim Dillon, senior vice president of global sales and marketing at Nexen Group.

With spring-engaged, air-released functionality, NexSafe products are default to lock, making them ideal for emergency stopping and holding applications. NexSafe Rail Brakes, Servomotor Brakes, and Rod Locks can be mounted to servo motors, linear devices, pneumatic cylinders, round rails, linear rods, round shafts, and linear guide systems.

[www.nexengroup.com](http://www.nexengroup.com)

## SKF

### OFFERS REGENERATING LUBRICATION OIL SYSTEM

An oil-recovery system, which SKF has used to regenerate lubricant at two of its production plants, is now available to customers as a service.

SKF RecondOil’s Double Separation Technology (DST) continually removes contamination, including nano-sized particles, from lubrication oil. This allows for a circular use of the oil, over a longer period of time.

“There is no comparable technology,” says Carl Philip Fredborg, team lead for deployment and aftersales, SKF RecondOil. “No other conventional mechanical filtering technology can remove nano-sized particles, which eventually cause oil to oxidize and degrade.”



Incorporating a DST system can help to raise machine performance by maintaining lubricant cleanliness. It can also cut the cost of oil purchase and disposal and help reduce CO2 emissions. Early stage life-cycle assessments conducted by SKF estimate that every tonne of reused oil can reduce CO2 emissions by up to 3 tonnes.

The technology has been proven at two different SKF production sites in Italy. In Airasca, SKF introduced the DST system to increase stability in the production of housed bearing units for the automotive industry. At the Cassino plant, which makes deep groove ball bearings for food processing applications, ongoing tests show the technology increases bearing performance in terms of noise and vibration, critical parameters in these applications.

The plants expect to see further improvements, and local teams will follow up any additional environmental and performance-related benefits. SKF also expects less machine wear and increased uptime at each facility.

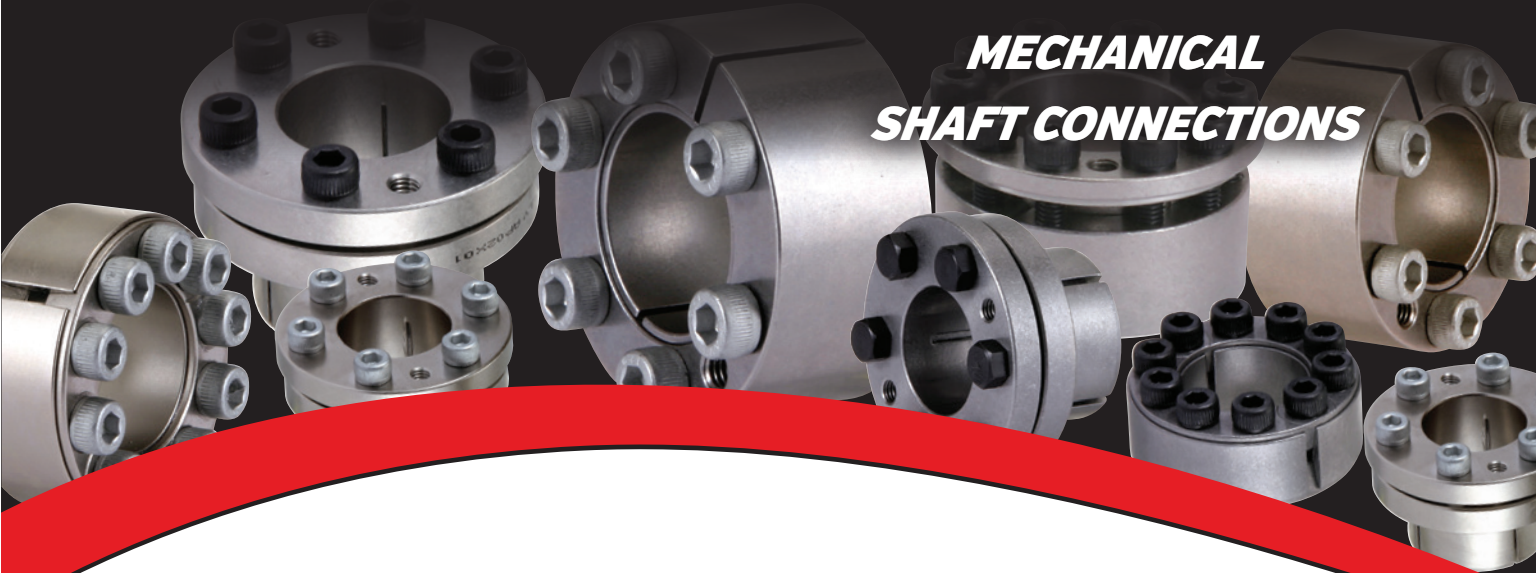
Following the successful installation at the Italian plants, DST technology will now be introduced more widely across SKF. While DST will not be sold directly to customers, SKF will offer oil regeneration as a service, under a fee- and performance-based agreement. SKF foresees that this will benefit customers by cutting oil-related costs and simplifying oil management for users. At the same time, it will lower the environmental impact and increase the performance of applications.

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# Electrification Reimagined

Matthew Jaster, Senior Editor

**It's difficult to keep up with all the electric trends, technologies and forecasts taking place across the transportation sector.** What we do know is digital transformation is leading the way. There's always new data available in areas like battery technology, energy efficiency, autonomous vehicles and hybrids. Thankfully, this editor has been sealed air-tight in his upstairs office for 8+ months now—courtesy of the pandemic—creating a unique opportunity to attend as many virtual automotive and manufacturing events as possible. The following is a cheat sheet on E-Mobility, electrification, and the push toward a digital future.

## CTI: Digital, Informative, Interactive

The next CTI Symposium USA is scheduled for October 11-14, 2021. If you have any interest on the current and future challenges facing the automotive industry, it's an event worth participating in start to finish. At last

year's Symposium, electrification and E-Mobility presentations examined everything from legislation issues to fuel cells and hybrid trends.

Patrick Lindemann, president, transmission systems and E-Mobility at Schaeffler Group USA described automotive technology like a ketchup bottle, 'sometimes it may come out a little at a time or come out on the plate all at once.'

When CTI interviewed Chairman Dr. Hamid Vahabzadeh, strategy advisor, AVL List GmbH, he was asked to explain how OEMs' product lines will need to change to meet net-zero-emissions targets, he said electrification is the name of the game and the end game seems to be the battery electric vehicle technology.

"While many companies have developed and produced a wide variety of electrified drivetrains for their hybrid electric vehicles leveraging their existing ICE based platforms, they are actively developing pure battery electric vehicles to achieve the net-zero

emission target. One of the most difficult applications to tackle is the light and medium-duty truck applications due to their payload and towing requirements, and yet, most OEMs have announced production plans for such vehicles. This shows the wide spectrum and scalability of the technology," Vahabzadeh said.

The underlying theme of the event was the systematic approach needed to create integrated solutions for the electric motor, the inverter and the gearbox. Product development is a huge challenge thanks to the variety of solutions and technologies available for E-Drives.

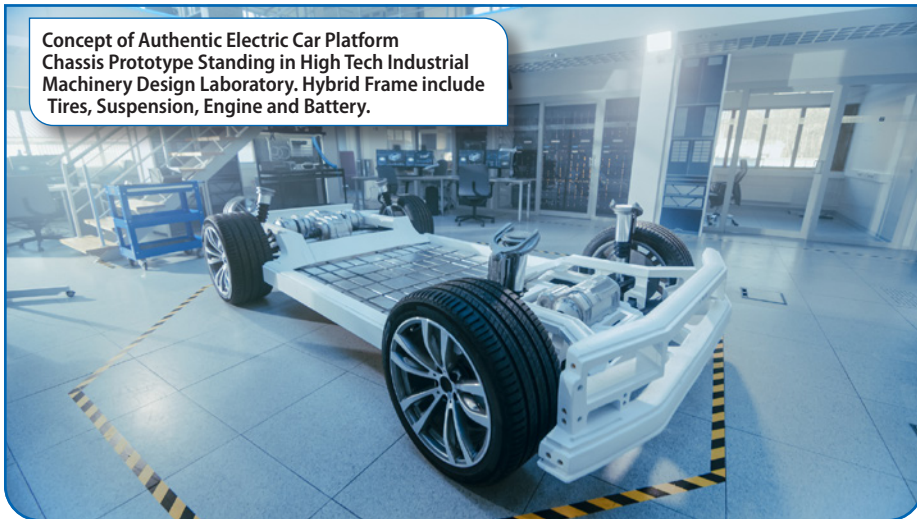
## E-Strategies from Automotive Manufacturers

While energy regulations are getting tighter and more restrictive, automakers like GM and Ford have recently announced their 'all-in' approach to e-mobility and electrification.





Concept of Authentic Electric Car Platform Chassis Prototype Standing in High Tech Industrial Machinery Design Laboratory. Hybrid Frame include Tires, Suspension, Engine and Battery.



### General Motors

During a Washington Post Virtual Conference in March, GM President Mark Reuss announced a joint development agreement with SolidEnergy Systems (SES) and gave the public some details on its next-generation Ultium battery chemistry.

“Affordability and range are two major barriers to mass EV adoption,” said Reuss. “With this next-generation Ultium chemistry, we believe we’re on the cusp of a once-in-a-generation improvement in energy density and cost. There’s even more room to improve in both categories, and we intend to innovate faster than any other company in this space.”

The expected battery energy density increase could enable higher range in a similarly sized pack or comparable range in a smaller pack. The weight and space savings from smaller battery packs could help with vehicle lightweighting or create more room for additional technology.

Part of the foundation of GM and SES’ collaboration on Li-Metal prototype batteries is GM’s extensive lithium metal battery experience. The company’s expertise in this field has resulted in 49 patents granted and 45 patents pending. SES will also bring its own lithium metal intellectual property to the collaboration.

GM announced this rapid technical progress for possible use in future

Ultium-based vehicles just one year after the reveal of the first-generation Ultium Platform. The first Ultium-based products are expected to go on sale later in 2021.

Additional announcements on GM’s zero-emissions future included:

GM revealed a modular propulsion system and highly flexible global EV platform powered by proprietary Ultium batteries.

GM committed more than \$27 billion to EV and AV product development and plans to launch 30 EVs globally by the end of 2025, with more than two-thirds available in North America. Cadillac, GMC, Chevrolet and Buick will all be represented, with EVs at all price points for work, adventure, performance and family use.

In January 2021, GM unveiled BrightDrop, a new business that aims to electrify and improve the delivery of goods and services by offering an ecosystem of electric first-to-last-mile products, software and services to help empower delivery and logistics companies to move goods more efficiently.

GM’s zero-emissions technology will extend to fuel cells, and the company announced it will supply its Hydrotec fuel cell power cubes to Navistar for use in its production model fuel cell electric vehicle—the International RHTMTM Series.

GM is investing \$2 billion to transition the Spring Hill, Tennessee plant to



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build EVs, including Cadillac LYRIQ.

GM announced that the Detroit-Hamtramck assembly plant, named Factory ZERO, will be GM's first plant that is 100 percent devoted to electric vehicles and in fall 2021, will start building the new GMC Hummer EV.

In 2019, GM announced the formation of Ultium Cells LLC, a joint venture with LG Chem to mass-produce battery cells in Ohio for future battery-electric vehicles. Construction is currently underway at the facility.

### Ford Motor Company

Ford ended 2020 strongly, improving its automotive and credit businesses in the fourth quarter while showing and shipping new vehicles designed to delight customers, expand profitability, and sustain free cash flow.

"The transformation of Ford is happening and so is our leadership of the EV revolution and development of autonomous driving," said Ford President and CEO Jim Farley. "We're now allocating a combined \$29 billion in capital and tremendous talent to these two areas, and bringing customers

high-volume, connected electric SUVs, commercial vans and pickup trucks."

Customers in the U.S. in the fourth quarter began taking delivery of the all-electric Mustang Mach-E; the Bronco Sport, ahead of the summer return of the legendary Bronco; and the 2021 F-150 pickup — all expected to be significant contributors to 2021 results.

"At Ford, our commitment to fleet customers goes beyond the mix of their fleet," said Alex Purdy, director of business operations, enterprise

connectivity, Ford Motor Company. "By supporting all makes and models, expanding the capabilities of Ford Telematics and providing complimentary management tools, we're arming fleet managers with the knowledge they need to maintain uptime and increase productivity across their fleet."

With Ford Telematics, fleet operators can now gather, view and monitor data from all their vehicles, regardless of manufacturer. With this expanded functionality, fleet managers will be able to analyze all of their fleet vehicles in one easy to use dashboard— including the ability to improve uptime, monitor performance and plan maintenance services.

Customers can leverage this capability on most non-Ford vehicles by using a plug-in device that connects to each vehicle with a wiring harness that leaves the OBD II port available for use. Additionally, this expanded functionality is provided as part of the regular subscription cost for Ford Telematics.

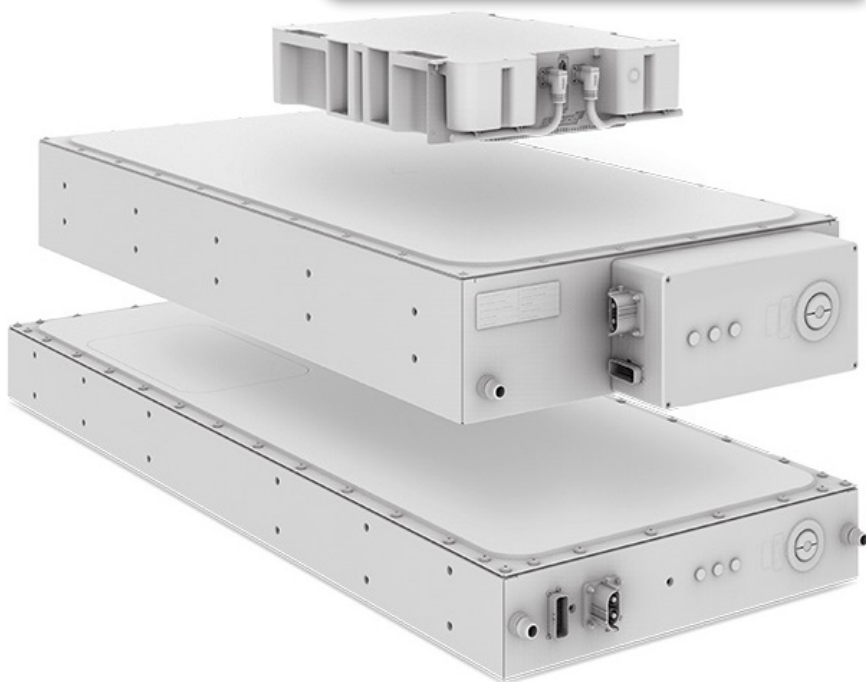
The ability to support all makes and models is just the latest step Ford has taken to expand the breadth of Ford Telematics. Fleet customers who deploy electric vehicles also have access to an electric vehicle telematics dashboard, which provides features such as electric-vehicle data, charging reports, and web-based pre-conditioning that can help optimize battery efficiency.

In addition, Ford is moving to make its services even more accessible with the launch of Ford Telematics Essentials for Ford vehicles, a complimentary

Electrification trends include battery technology, energy efficiency, autonomous vehicles, and hybrids.



Akasol AG designs and manufactures customizable battery packs for use in buses, commercial vehicles, rail vehicles and industrial vehicles, as well as in ships and boats.



level of service for commercial customers that will be available beginning in the second quarter of 2021.

Ford Telematics Essentials gives customers access to vehicle health insights such as odometer readings, diagnostic trouble code and information around oil life, engine hours and recalls. Later this year, this complimentary service will also allow fleets to digitally track and plan maintenance or repair services with local dealers.

### E-Strategies from Component Manufacturers

Meanwhile, organizations looking to develop electric technologies continue to join forces to bring new electric components to market.

LG Electronics and Magna International Inc., for example, announced a joint venture to manufacture e-motors, inverters and on-board chargers and, for certain automakers, related e-drive systems to support the growing global shift toward vehicle electrification. This enables the two companies to continue to grow their electric powertrain product offerings by leveraging existing technologies, engineering capabilities and global footprints. The market for e-motors, inverters and electric drive systems is expected to have significant growth between now and 2030.

LG has established experience in the development of electric vehicle components most notably for the Chevrolet Bolt EV and Jaguar I-PACE. LG will help accelerate Magna's time to market and scale of manufacturing for electrification components, while software and systems integration are competencies that Magna brings to this venture. This JV will allow customers to select from a portfolio of reliable components through to integration of an entire electrified powertrain.

Additionally, BorgWarner recently signed a business combination agreement with Akasol AG to position BorgWarner to significantly expand its commercial vehicle electrification capabilities.

Headquartered in Darmstadt,

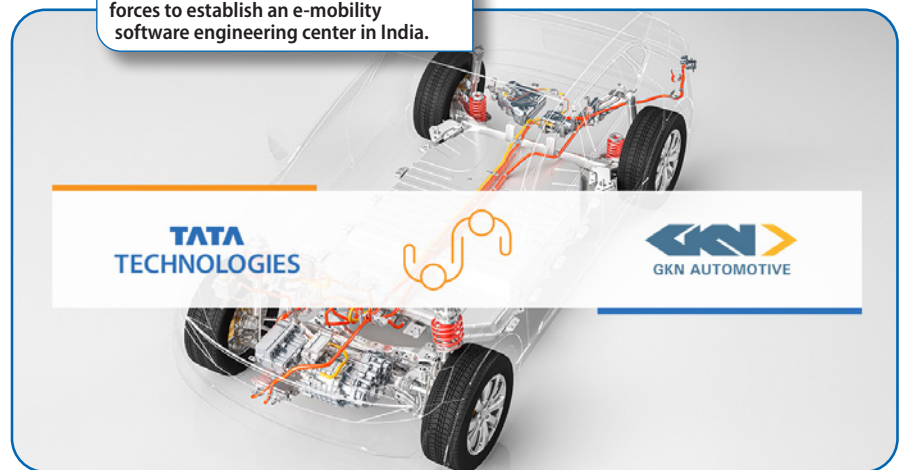
Germany, Akasol AG designs and manufactures customizable battery packs for use in buses, commercial vehicles, rail vehicles and industrial vehicles, as well as in ships and boats. This proprietary system technology is cell-agnostic, providing a low-cost, flexible solution to world-class customers. With more than 300 full-time employees and three facilities across Germany and one facility in the United States, Akasol believes it is well positioned to capitalize on the large market opportunity across Europe and North America.

"Akasol is an excellent strategic fit as BorgWarner seeks to continue to expand its electrification portfolio and capitalize on the profound industry shift towards electrification. Akasol's manufacturing footprint and estab-

would significantly strengthen its commercial vehicle and off-highway battery systems business as it continues to execute its electrification strategy. With the global, lithium-ion battery market for electric vehicles expected to grow, Akasol believes it is well positioned to meet the demand for battery systems in the global electric commercial vehicle market.

"The executive board welcomes the strategic partnership with BorgWarner, as it offers significant strategic perspectives to Akasol," said Sven Schulz, CEO and founder of Akasol. "BorgWarner shares our vision of emission-free mobility, and with joint forces, we will expand Akasol's technology and market leadership for high-performance battery systems."

GKN and Tata Technologies is joining forces to establish an e-mobility software engineering center in India.



lished, in-production customer base are complementary to BorgWarner's and would accelerate our foothold into the fast-growing commercial vehicle and off-highway battery pack market," said Frédéric Lissalde, president and CEO of BorgWarner.

"Akasol is highly-regarded as a reputable and reliable partner, and like us, they have a customer-first mentality and a culture of innovation and environmentally friendly technology leadership. We look forward to welcoming their incredibly talented team to BorgWarner."

BorgWarner believes the acquisition

GKN Automotive is strengthening its eDrive technology leadership as 13 more electrified models from 10 leading global brands enter the market, powered by its world leading systems.

The new platforms span four major global automotive manufacturers and range from premium four-wheel drive SUVs to an iconic electric city car.

The innovative technologies on these models include GKN Automotive's world class compact and efficient three in one eDrive systems. These systems bring together leading-edge advances in electric motors, transmission, traction inverters, software and controls.

This major milestone comes just one year after the announcement that GKN Automotive has over one million eAxles on the road and is the result of collaboration with the world's leading automotive manufacturers to fully integrate advanced eDrive systems into electric and hybrid cars.

"This is further evidence that our investment, innovation and expertise in world-leading eDrive technologies is paying off. Our ambitious plans for eDrive will ensure GKN Automotive plays a leading role in driving the world's electrified future," said Dirk Kesselgruber, president ePowertrain, GKN Automotive.

"Our customers are already benefitting from the efficiencies and innovations that GKN Automotive eDrive systems bring and we intend to keep innovating for even better performance," he added.

Oliver Jones, vice president business development ePowertrain summed it up best, "It's exciting to see more of our innovative eDrive technologies on the road. We're accelerating our work to bring our advanced, compact and efficient electric drive systems to market on even more vehicles." **PTE**

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# AGMA Electric Drive Committee Discusses xEV Technology

Mary Ellen Doran, Director of Emerging Technology, AGMA

The AGMA Electric Drive Committee met more than a dozen times in 2020 to discuss new technology. With each meeting the committee grew in membership and information gathered. It ended the year with almost 40 participants from major OEMs, gear manufacturers, machine tool manufacturers, and suppliers to the industry—all keenly interested in the movement to hybrid and electric vehicles.

Committee Chair, Michael Cinquemani, president and CEO of Master Power Transmission, Inc. worked with committee members to take the culmination of these discussions and create a document for the AGMA membership. The white paper that is being released by the committee in April, 2021. This document provides a gearing-centric snapshot of the current automobile and truck technology shift, with the focus on the gear. This paper is the Committee's commitment to fulfill the emerging technology goal to "Identify, investigate and inform AGMA members of Emerging Technologies that may disrupt or significantly impact the power transmission industry."

The paper is divided into three sections.

**Part One** provides the big picture information on economics, policy and regulations, and recent research projects specific to this space. It includes some history of electrification for context but then discusses what we should watch for in the future. It includes current car sales and then goes into some details on the evolution and importance of consumers in this space. There has been a fundamental shift from early adopters who took advantage of early incentives and had a "green" ideology to those that choose to drive a Tesla because of the sheer performance of the vehicle. The section then lists some of the many policies and regulations from around the globe that are driving a reduction on carbon emissions.

**Part Two** is where the committee talks gearing. There is a profound reduction in the number of gears that are produced for an internal combustion engine versus the number of gears in an electrified driveline. The committee has worked to gather information on the diversity in drivetrain designs and provide information on the nuances to technology in this space. Both automotive and truck are discussed in detail as is the quest for the silent drivetrain. And the committee has provided comment on machine tool and heat treatment for this sector. This section also works to provide some clarity to important questions specific to the gear industry—*How will gear manufacturing be impacted by the vehicle technology shifts? Will gear production be outsourced by OEMs?* and more.

**Part Three** gives examples of bleeding-edge technologies that are not yet in mainstream that could be profound disruptors if the technology bears out. It also looks at new concepts for batteries and new ideas like Transportation-as-a-Service (TaaS).

The paper hopes to provide information to the AGMA membership on gears in this space. We have worked to answer some of the more important questions that have come up in discussions about the switch to electric drivetrains. We understand that vehicle manufacturers will experience a period of flux where they will be working to make both internal combustion and multiple electric drivelines simultaneously. And one important question to which they found some clarity was—Who will make the gears? The Committee has found that while there has been outreach for gear prototypes and overflow the large, established OEMs are keeping gears in-house, for now. One comment from a committee member was, "those that do it today at volume will do it tomorrow."

One other big area of discussion is a new problem for gear manufacturers—regenerative braking. In addition to the production of more torque, regenerative braking requires performance on both flanks of the gear. This has resulted in the need for higher precision and durability on the gears. The paper discusses this issue with detail.

There will be a full list of committee members in the paper, but I would like to personally thank each one of them for their time and thoughtful participation to work together to lift the entire industry in this emerging space.

As with all four AGMA Emerging Technology Committees, Electric Drive Committee participation is open to any individual that works for a member company and to those outside the membership who can directly contribute to the collaborative discussion. I urge you to become more familiar with the emerging technology activities of AGMA. We have a new webinar series the first Wednesday of each month. Check out our website that contains a list of committee meeting dates, articles of interest, videos of the week, and more information on how you access this paper when it is ready. **PTE**

[www.agma.org/emerging-technology](http://www.agma.org/emerging-technology)

**Mary Ellen Doran** has been working at AGMA for ten years. In 2018, she moved into the new role of Director, Emerging Technology. Through this role, she developed a new area of work for the association. Now, she and the committee members are able to provide actionable information to gear manufacturers on technologies that may be of importance to their future, or may disrupt their future. The goal of the Emerging Technology Committees is to: "identify, investigate, and inform AGMA members of emerging technologies that may disrupt or significantly impact the gear manufacturing industry." Mary Ellen leads the four emerging technology committees: 3D metal printing/New materials; Electric drive technology; Robotics and automation; and Industrial IoT. Prior to her emerging tech position, she worked in the communications department developing the website, electronic newsletters, and marketing pieces for AGMA. She holds a Bachelor's of Fine Art in graphic design from The Ohio University.



# Electrification Outlook

## An E-Mobility Conversation with Jeff Hemphill, Vice President and CTO at Schaeffler Group North America

Matthew Jaster, Senior Editor

Our first conversation with Jeff Hemphill took place in February 2017. Back then, Schaeffler was focused on its “Mobility for Tomorrow” strategy. Hemphill—without the aide of a crystal ball—believed that the future of the transportation industry was going to be complicated with a diverse mixture of solutions and technologies existing side-by-side on our roads.

Electrification, E-Mobility, and digitalization still lead the way in 2021. The transportation industry continues to adopt hybrid and electrical systems to replace conventional powertrains, solve the battery challenges of tomorrow and prepare drivers from around the world for a clean energy revolution.

Meanwhile, Schaeffler continues to expand on the traditional principle that the emphasis is no longer just about the bearing or the motor or the clutch, but the entire integrated system.

“As OEMs are getting more confident in the volumes of electrified vehicles, they’re seeing the real benefits of bringing everything together to make the most optimal system,” Hemphill said. “In the past they may get power electronics from one company and a

motor from another company and a clutch from another and so on. Now, they see the benefits of complete system integration.”

### A Priority on Optimization

Schaeffler supplies technologies for all electrified drivetrains. Mass production of the electric axle transmission, a key component of electric axle systems, has been running successfully since 2017, providing optimum transmission ratios and power transfer from the electric motor to the wheels. This is a highly versatile component with a wide range of applications.

In the Audi e-tron, for example, Schaeffler electric axle transmissions, with different structural designs, are used on both axles for all-wheel drive capability. And the Porsche Taycan is fitted with a high-efficiency Schaeffler coaxial electric axle transmission to provide the required transmission ratio on the front axle. Schaeffler has also secured multiple orders for its complete “3-in-1 electric axles”, which combine the electric motor, drive unit and power electronics in a single system. These are high-performance electric axles with advanced power density.

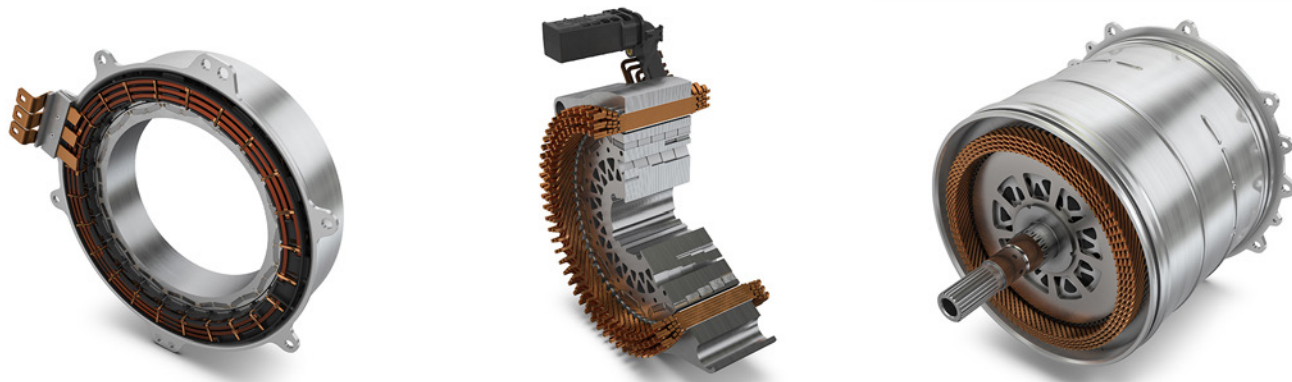
Today, Schaeffler has begun to see the start of the mass production of hybrid modules, hybrid drive units and all-electric axle transmissions. The basis of Schaeffler’s electric motor production is a modular, highly integrated technology platform. Schaeffler has announced a mass production order for electric motors featuring wave winding technology, a technology that provides high power density as well as advantages during assembly.

As reported last year, Schaeffler has received a record order for dedicated hybrid drives. From 2024, Schaeffler will deliver an entire drive unit comprising two electric motors and transmission with integrated power electronics. A system power rating of 120 kW offers sports-car like performance with low fuel consumption.

### E-Mobility Trends

While system integration tops the list of E-mobility trends, Hemphill sees many of the same trends continue today that were discussed in 2017. “Batteries are still a challenge, but they continue to get cheaper and cheaper and we’re also seeing a renewed inter-

Schaeffler electric motors for hybrid modules, hybrid transmissions and all-electric axle drives offers a wide application spectrum, from 20 to over 300 kW.



est in hydrogen fuel cells, especially for heavy-duty vehicles.”

Condition monitoring is another area that is seeing some new developments.

“OPTIME, for example, was introduced in a plant setting allowing users to monitor an entire installation from their smartphones,” Hemphill said.

Using advanced, proprietary algorithms, Schaeffler can combine data such as acceleration, demodulation, and kurtosis into actionable information for the end user utilizing a fully wireless, battery-powered vibration and temperature monitoring system.

“We’re working on similar condition monitoring technologies for autonomous vehicles. You start to think about the vehicle more like a machine on the shop floor where utilization is important,” Hemphill said. “You’re going to be using the vehicle 70-percent of the time, so you can’t afford unexpected downtime. We’re trying to use these same OPTIME principles—basically instrumented bearings to try and predict when the bearings need to be changed out of a robo-taxi, for example.”

And with the level of information making its way through electric vehicles, security becomes an additional challenge.

“It’s fine when you’re using your own data to determine when you may need to change the right wheel bearing in an E-axle, but if you’re talking telematics and you have thousands of robo-taxis all connected to the cloud you’re looking at potential cybersecurity issues,” Hemphill said.

Hemphill used the data breach at Target back in 2013 as a prime example of this. “Target’s network was hacked by someone that came in through the air conditioning system because nobody would ever suspect protecting an air conditioning system to prevent cybercrime.”

“It’s the same concept in automobiles,” Hemphill added. “You have all these different systems talking to each other and they could potentially compromise the entire system with the right data breach.”

As E-Mobility technology evolves so too will the need for stronger cybersecurity measures.

“Internally, we’ve launched our own series on cybersecurity and how to embed it in our mechatronic systems,” Hemphill added.

### The Autonomous Outlook

The proverbial ‘hype train’ on autonomous vehicles has slowed down recently, but Hemphill believes companies in this market segment are farther along than people think.

“Waymo is a perfect example,” Hemphill said. “They’re giving away hundreds of rides per week without a safety driver. In my opinion, that is a lot of autonomy out on public streets.”

In fact, Waymo published a recent report discussing the most important things an intelligent driver needs to do to understand what the road users around it are going to do next. Is that pedestrian trying to cross the street? Is that car parallel parked, or about to pull into my lane? Will that speeding vehicle stop at the stop sign? Accurately predicting the behavior of other road users is one of the hardest problems in autonomous driving. It also has significant safety implications.

In addition, Aicha Evans, CEO of the American autonomous vehicle

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company Zoox, recently told *Bloomberg* that commercial launch of its urban transport vehicle won't be coming in 2022, but it's coming "a lot sooner than people imagine."

Hemphill believes autonomous driving will be coming in the not-so-distant future in known routes and Geofencing—the act of limiting automotive autonomy to certain geographic areas.

"I don't know if the day is coming soon when you can push your key fob and the vehicle will take you from Columbus to Pittsburgh, but the technology is certainly moving in the right direction," Hemphill added.

Safety will continue to play the biggest role in the success of the autonomous vehicle. Schaeffler Paravan Technologie, for example, is the further development of Paravan's SPACE DRIVE drive-by-wire technology and the development and sale of mobility systems. SPACE DRIVE was developed by Paravan GmbH to help drivers with physical disabilities by replacing cumbersome mechanical

vehicle control systems with 100%-reliable, fully electronic systems.

Alongside electronic accelerator and brake activation, SPACE DRIVE features steer-by-wire functionality, which enables safe and reliable vehicle steering by purely electronic means, thereby eliminating the need for a steering wheel, steering column and associated mechanical linkages. Steer-by-wire is a key enabling technology for self-driving cars, for which safe and highly reliable steering is a fundamental requirement. Even in part-time autonomous passenger cars with steering wheels, the space saved by eliminating the steering column opens up completely new possibilities for vehicle and cab interior design.

"This technology has a billion kilometers of use and it was all developed based on the idea that people with physical disabilities could drive a normal vehicle," Hemphill said. "As this reliable drive-by-wire technology continues to develop, we'll be able to answer some of the challenges facing autonomous vehicles in the future."

## The Year of Zoom Meetings

What might be most fascinating about our conversation in 2021 is how a technology-driven organization like Schaeffler didn't miss a beat when faced with the many obstacles of 2020.

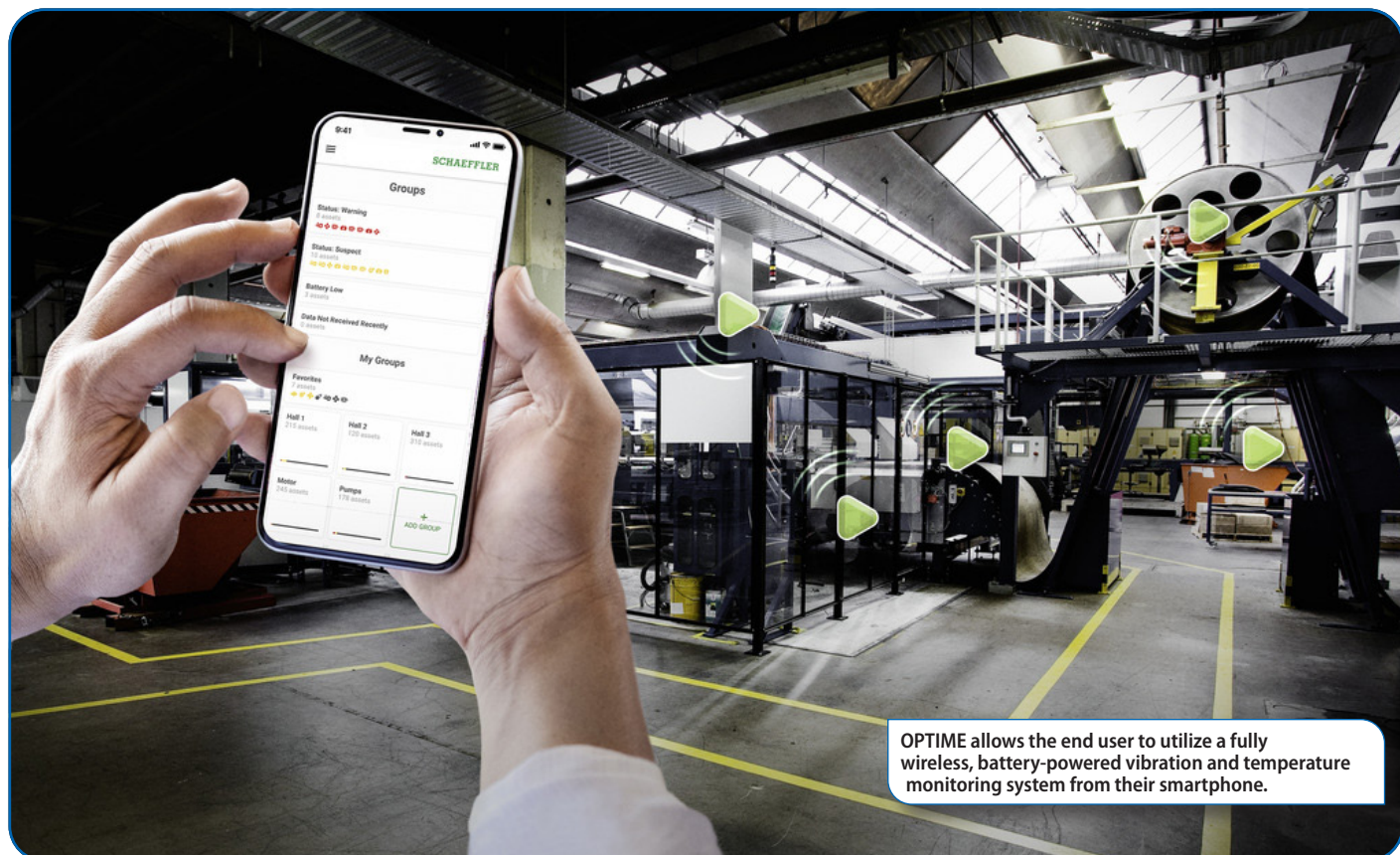
When the pandemic hit, Hemphill wasn't sure how day-to-day operations were going to play out. "I used to travel two to three days per week and now I haven't left my spare room in six months!"

He was amazed at how quickly Schaeffler's IT department was able to get the company online.

"It happened almost overnight, and we've been able to conduct everything virtually—even collaboration with our customers. It's worked out much better than we first imagined."

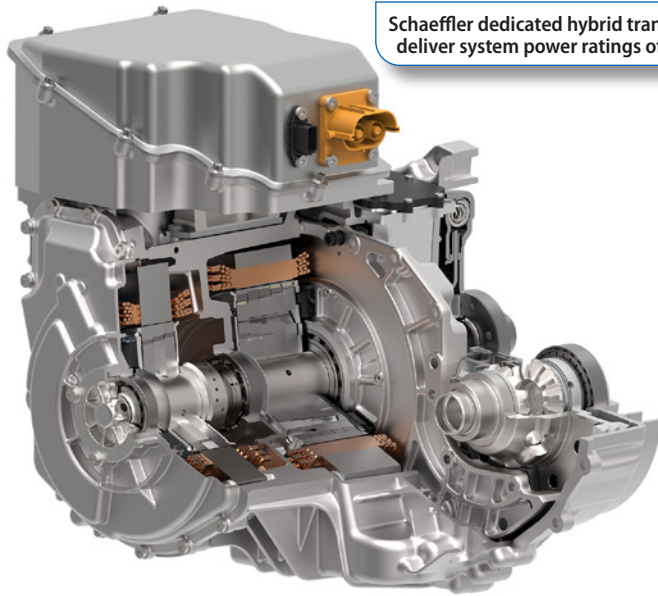
In fact, Schaeffler has begun more advanced E-Mobility and next generation transmission projects during the pandemic than before it began.

"In the long-term, the question will be how much did we rely on being in the office for the company culture, the sharing of ideas, standing around the



OPTIME allows the end user to utilize a fully wireless, battery-powered vibration and temperature monitoring system from their smartphone.





Schaeffler dedicated hybrid transmissions deliver system power ratings of 120 kW.

coffee machine, etc.? How much will we travel in the future? How much work will still be completed from home after this is all over? It will be interesting to see how the pandemic will alter corporate culture,” he added.

### Additional Roles

On top of his many roles at Schaeffler, Hemphill began his term as the new president of SAE International on January 20, 2021. He is a 23-year member of SAE International. In addition to serving on the SAE Clutch Standards Committee, he has authored and organized various SAE International technical papers, served on meeting panels, presented at SAE International conferences, and participated in and organized sponsorship of SAE International’s North American International Powertrain Conference since its inception.

“SAE has been a constant presence throughout my career,” said Hemphill. “Its mission—to advance mobility knowledge and solutions for the benefit of humanity—s of critical importance during this time of rapid innovation and industry transformation.”

In the broadest sense, Hemphill simply wants to keep the flywheel turning during his term as president. “I don’t think a lot of people realize how much SAE does for the mobility industry. Everything that is critical to innovation including standards, technical papers,

education, etc. I want to simply keep the momentum going in these areas.”

Some of his personal goals for the position include examining how intellectual property intersects with standards. “This has been an issue in the cellular market and we’re beginning to see it in the automotive industry as well.”

Hemphill would also like to be an ambassador for SAE’s OnQue Digital Standards System, an intelligent solution that revolutionizes the delivery of standards while enhancing their utility.

With the digital tool users can link and integrate industry standards to product definitions and development tools supporting model-based engineering, systems engineering, digital twin, and other applications requiring systems integration.

### Future Outlook

So, we’re back to that question about what our roads are going to look like, how are vehicles are going to operate and what the future holds for E-Mobility?

Hemphill believes we’ll see electrification continue to grow in the light vehicle fleet. While significant changes will start to take shape in the automotive industry, 70 percent or so of the vehicles on the road will still have a combustible engine even if they’re a hybrid.

Last mile delivery—the movement of

goods from a transportation hub to the final delivery destination—is an area where E-Mobility could really take off. UPS, Amazon, the U.S. Postal Service etc. can benefit from electrical fleets.

“More companies are embracing these technologies and it’s the perfect platform for electric vehicles,” Hemphill said. “The total cost of ownership (TCO) can be much less in this market segment if the operator doesn’t have to change the oil, doesn’t have to change the air filter, and the brakes only need to be changed half or one-third of the time. I think this will be the fastest growing area in E-Mobility and electrification. It just makes good commercial sense.”

Meanwhile, Hemphill will continue to meet with his team at Schaeffler, look carefully at the E-Mobility trends and forecasts and determine what course of action the company will take next.

“We’re always trying to decide what area to spend our R&D efforts,” Hemphill said. “You’d like to do a little bit of everything, but you simply can’t. It’s important, however, to have some of your research efforts focused on the future. It’s a constant portfolio balance, I’d say.” **PTE**

[www.schaeffler.us](http://www.schaeffler.us)

**Jeff Hemphill**, vice president and CTO at Schaeffler Group North America.



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# Mayr Provides Shaft Couplings for Torque Transducers in FZG Worm Gear Test Stands

Mayr Power Transmission

The Gear Research Center (FZG) at the Technical University of Munich has been conducting efficiency and wear tests on worm gears since its foundation. For reliable and accurate measurement results, the connection of the measuring shafts used is of particular importance.

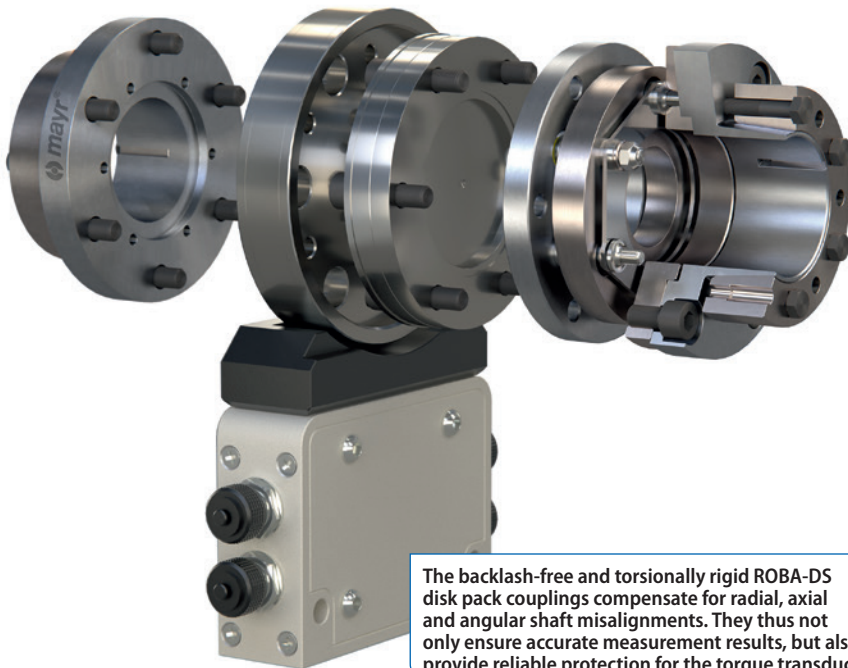
For this purpose, FZG relies on the ROBA-DS shaft misalignment compensation couplings by Mayr Power Transmission, which have been specially adapted for torque transducers. These couplings are precise, backlash-free and torsionally rigid and they compensate for any occurring misalignments.

Whether in conveyor technology, extruders, elevators, actuating drives or steering gears for vehicles—worm gears are used in a wide range of applications. They are low-noise and low-vibration in operation and enable high gear ratios in a small installation space.

“At the Gear Research Center (FZG) of the Technical University of Munich, this gearing is constantly being tested and we are continuously further developing calculation approaches for the efficiency and the load-bearing capacity,” said M.Sc. Philipp Norgauer, a member of staff at the chair of machine elements. This requires tests that are carried out on specially adapted worm gear test stands.

“In the tests, the efficiency is determined by means of performance difference measurement at the input and output of the test gear unit,” added Norgauer. “For accurate measurement results, the connection of the gear shafts and the measuring shafts used is of particular importance. The measuring shafts must be bearing-supported free of parasitic forces to achieve the required measurement accuracy.”

Compensation of shaft misalignment



The backlash-free and torsionally rigid ROBA-DS disk pack couplings compensate for radial, axial and angular shaft misalignments. They thus not only ensure accurate measurement results, but also provide reliable protection for the torque transducer.

For this reason, shaft misalignment compensation couplings by Mayr Power Transmission are used together with the torque transducer or measurement flange, as they minimize the interference parameters affecting the measurement flange. Such interference parameters or so-called parasitic forces frequently occur due to alignment errors in the drive line. This means, misalignments between the input and the output sides occur in almost all applications. The existing radial, angular and axial shaft misalignments lead to bending moments as well as radial and axial forces on the measurement flange. Usually, all misalignments occur simultaneously. Even the most precise alignment of the shaft train—even using the state-of-the-art laser alignment equipment available today—can only provide limited relief. In addition, the misalignments through existing tolerances in the size accuracy of the components used and through external influences, for example the temperature,

cannot be completely eliminated.

This is why torsionally rigid shaft misalignment compensation couplings such as the ROBA-DS 9110/9210 disk pack couplings are indispensable accessories for torque transducers. These couplings transmit the torque backlash-free and with extreme torsional rigidity, and compensate for existing radial, axial and angular shaft misalignments. They therefore not only ensure accurate measurement results, but also provide the best possible protection for the measurement flange, the mechanically weakest link in the drive line, thus ensuring a long service lifetime. In addition to their high running smoothness and low mass moment of inertia, the couplings are characterized by a high balance quality; and they are particularly robust and resistant.

**No restrictions for nominal torques**

“For all ROBA-DS disk pack couplings, the nominal torques stated in the catalog can be used without restrictions,” explained Ralf Epple, product

manager at Mayr Power Transmission. “A reduction in the nominal torque due to misalignment, overall load configuration or balancing requirements is not necessary.”

The couplings are compact and unite both high performance density and absolute backlash-free function: Design details such as the blasting of the disks and the use of specially-shaped collar bushings provide a backlash-free flow of force with excellent force flow density between the input and output. The ROBA-DS disk pack couplings transmit torques up to the nominal torque absolutely backlash-free and with a consistently high torsional rigidity. The specified shaft misalignments can be 100% utilized without affecting the transmittable torque.

#### Integration in almost any test stand and drive constellation

“The connection of the ROBA-DS couplings and the measurement

flanges to the shaft train generally takes place backlash-free via high-quality shrink disk hubs,” Eppler continued. “Various coupling designs specially tailored to the different test stand requirements and flexible combination options permit the integration of measurement flanges in almost any test stand and drive constellation.”

The standard designs of the ROBA-DS measurement flange coupling cover a speed range from 8,000 to 30,000 rpm, depending on the size. New additions to the portfolio are mass-optimized measurement flange couplings made of aluminum or titanium for high-speed applications.

“It is our ultimate goal to produce couplings that are compact and of high-performance density,” said Eppler. “The geometric basis must be right. There is no point in simply designing a large coupling in aluminum or titanium, when a compact steel version,

which is more rigid and can handle more alternating loads, may be better suited to the application.”

It’s crucial, therefore, that customers should always consider the application when selecting the coupling and the material. Here, however, it is always necessary to weigh up between the material properties, e.g. weight, rigidity or fatigue strength, and the final customer application, i.e. the actual speeds, load alterations, load cycles, bearing distances and bore diameters. And last but not least, of course, the price/performance ratio also counts. **PTE**

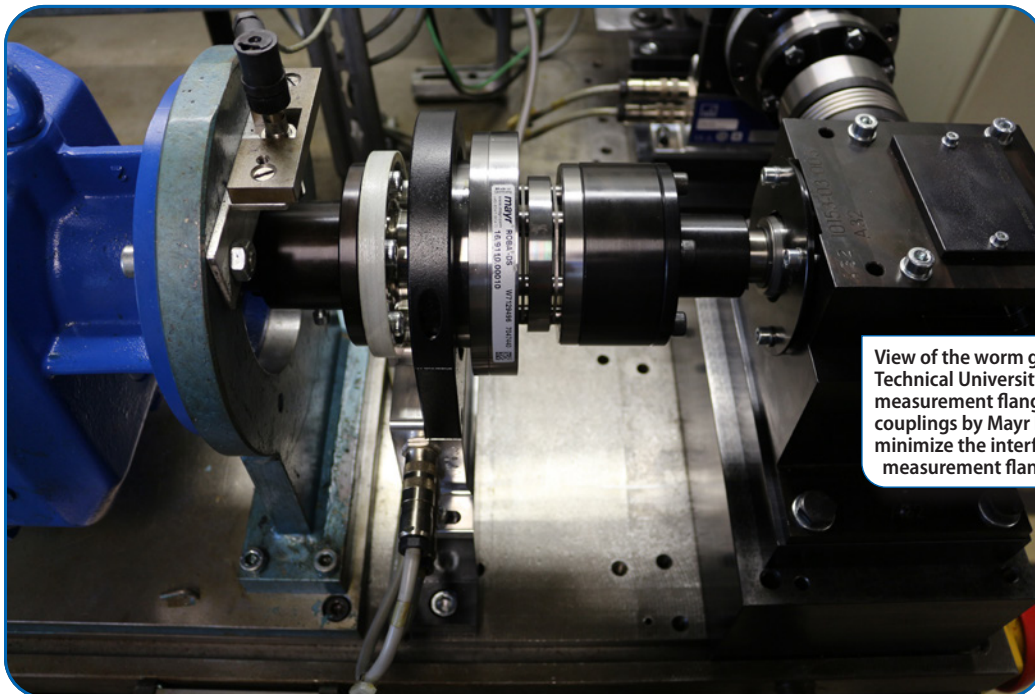
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View of the worm gear test stand of the FZG at the Technical University of Munich: Together with the measurement flange, shaft misalignment compensation couplings by Mayr Power Transmission are used. They minimize the interference parameters affecting the measurement flange.

# Problem with Disk Pack Coupling

## THE QUESTION

I have a problem with a disc flexible shaft coupling that is used in screw compressors. This coupling is cracked and damaged after a short time, and the changing rate of this coupling is very high — about every 3 months. But as I understand from the machine manual, the coupling replacement may be every 8,000 hours or 12 months. I checked the alignment by laser alignment device; it was okay, but the problem still exists. I observed a similar deflection/buckling on it after 3 months in operation. (I would be most grateful) if you could please advise me about this issue..

*EXPERT RESPONSE PROVIDED BY Robert Errichello.*

### Features of Disk Pack Couplings

Disk pack couplings are popular couplings because they offer several attractive features::

- Compact with high torque capacity
- Require no lubrication
- Disk packs can be visually inspected without disassembly
- Disk packs can be visually inspected with a strobe light while running
- Disk packs can be removed and replaced without removing hubs from shafts
- Failing disks are easily visually detected
- Offer high torsional rigidity and no backlash

However, there are limitations

- Limited misalignment capability
- Limited fatigue life due to bending stresses in the disk packs
- High misalignment shortens the fatigue life
- Little or no vibration damping

### What to do when disk pack couplings fail

The first step is to determine whether your disk pack coupling is appropriate for the application, and confirm that it has adequate load capacity. Start by asking the coupling manufacturer to send their service representative to review your application and help you determine whether you have the right coupling for the application. Disk pack couplings come in a variety of types including close-coupled or spacer-couplings, single-flexing or double-flexing, semi-floating or full-floating shaft, and hollow or solid shaft. Once it is confirmed that you have the right coupling type, the next step is to determine whether the coupling size is proper.

Service factor must be large enough

The service factor is a multiplier applied to the normal

operating torque to account for the load characteristics of the driving and driven equipment. Besides the normal operating torque, the service factor must be large enough to accommodate harsh duty such as high peak loads or frequent starts and stops. The coupling manufacturer's catalog rating for the disk pack coupling must be greater than the calculated value of the normal operating torque times the service factor.

Service factors have evolved from experience that is based on past failures (Ref.1). That is, after a coupling failed, it was determined that by multiplying the normal torque by a factor and then sizing the coupling, the coupling would not fail.

Service factors are used to account for higher torque conditions of the equipment to which the coupling is connected. In API 671, a recommended service (or experience) factor of 1.5 times normal torque is applied for special purpose couplings for refinery service (Ref. 2).

Most manufacturers of disk pack couplings recommend a service factor of 1.5 minimum. However, catalog rating procedures and recommended service factors vary widely, and it is important to follow and use the ratings and service factors recommended by the actual coupling manufacturer and not intermix them with other manufacturer's rating procedures and service factors.

### Startup torque accumulates fatigue damage

Peak torque typically occurs during startup when the driver accelerates the torsional system up to its operating speed. An induction motor is capable of an overload torque of at least three times the normal operating torque. A particularly harsh startup torque occurs with a synchronous electric motor. The startup of synchronous motor driver is usually associated with torsionally excited vibrations and low-cycle fatigue problems. The frequency of these torsional impulses is twice the line frequency at zero speed, and the frequency decreases linearly as speed increases. At

synchronous speed the frequency of the impulses becomes zero. As the speed increases during a start, the frequency of the impulses coincides, for a moment, with the lowest natural frequency of the torsional system. During the resonance, the magnitude of the torsional oscillations can develop an overload torque of six times the normal operating torque. Depending on how fast the motor can pass through the critical speed, the coupling will accumulate several cycles of fatigue damage. Unfortunately, disk pack couplings do not provide much damping to limit the dynamic oscillations associated with system resonance. Consequently, frequent starts increase the risk of fatigue failure, and it is prudent to limit the number of starts of a synchronous motor.

### Check the alignment of the coupling

The most common failure of a disk pack coupling is fatigue of the disk pack due to excessive misalignment (Ref. 1). This is usually caused by poor initial alignment of the connected machines. However, it can also be caused by operating conditions. Changes from initial alignment can occur because of bearing wear, settling of foundations, loose anchor bolts, pipe strain, and base distortion due to torque, thermal deformation, and vibrations in connected machines. Alignment checks should be made under cold startup temperature and after the connected machines are at hot operating temperatures. If there is large thermal deformation, it might be necessary to bias the cold alignment to compensate for thermal deformation. The following list describes typical issues with installed disk pack couplings that can lead to failed disk packs (Ref. 2).

Ideally the disk pack should be centered in a neutral position where it remains flat and parallel with the end flanges. However, even if the disk packs look ideal after the initial alignment, the disk packs might distort under operating conditions. Therefore, it is important to inspect the installed couplings.

### What to look for when inspecting installed couplings

1. Reddish brown color bleeding out between disk laminations at the outside diameter (OD) of the disk pack. This indicates fretting corrosion due to loose bolts or chemical attack. See Figure 1.
2. Fine line crack starting in the outer disk tangent to the washer (OD). This indicates a fatigue failure due to excessive misalignment. See Figure 1.
3. The disk pack is wavy and the dimension "N" between flange faces is smaller than indicated on the installation instructions or applicable assembly drawing as shown in Figure 2. The coupling has been installed in a compressed condition or equipment has shifted axially during operation. Check for thermal growth problems. If the application has a sleeve-bearing motor, make sure that the operating centerline of the motor rotor is properly positioned. Realign the axial position of the equipment to relieve disk pack compression during operation.
4. The disk pack is wavy and the dimension "N" between flange faces is larger than indicated on the installation instructions or applicable assembly drawing as shown in Figure 3. The coupling has been installed in an elongated condition or equipment has shifted axially during operation. Realign the axial position of the equipment so

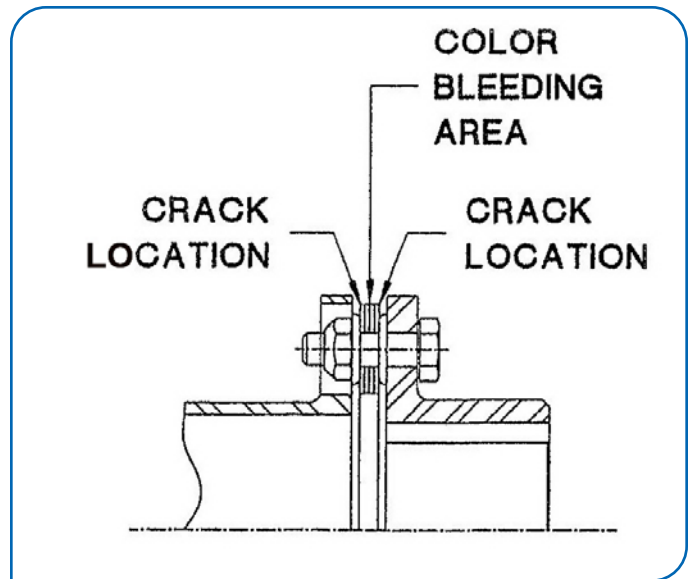


Figure 1 Fatigue failure due to excessive misalignment.

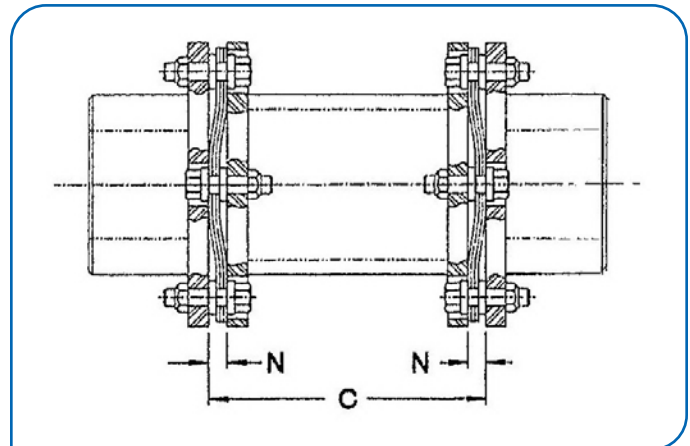


Figure 2 The disk pack is wavy and the dimension "N" between flange faces is smaller than indicated on the installation instructions or applicable assembly drawing.

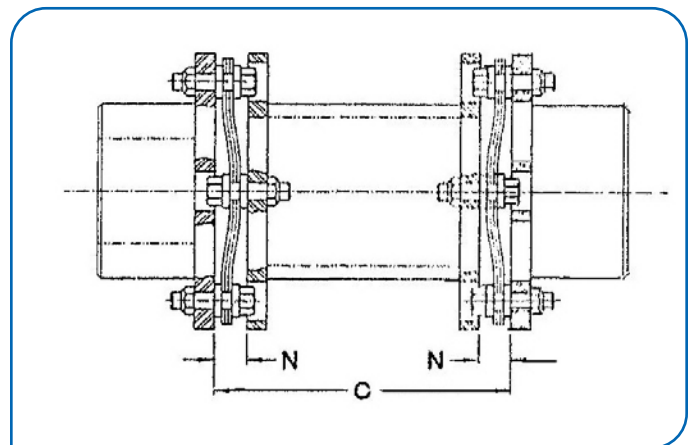
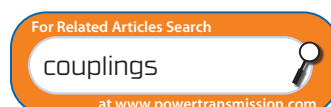


Figure 3 The disk pack is wavy and the dimension "N" between flange faces is larger than indicated on the installation instructions or applicable assembly drawing.



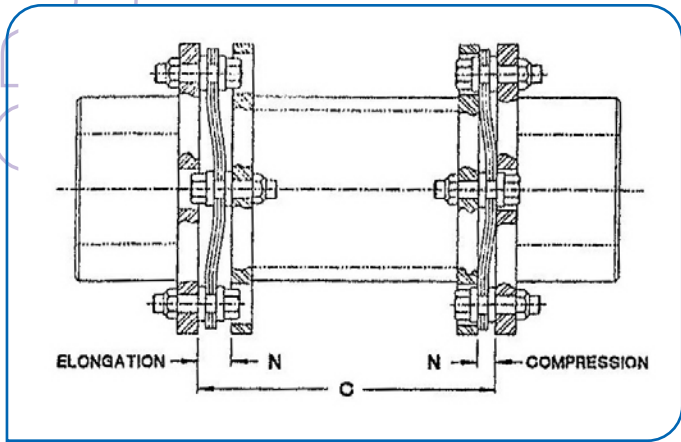


Figure 4 Wavy disk packs on both ends of the coupling. One end is compressed, and the other is elongated.

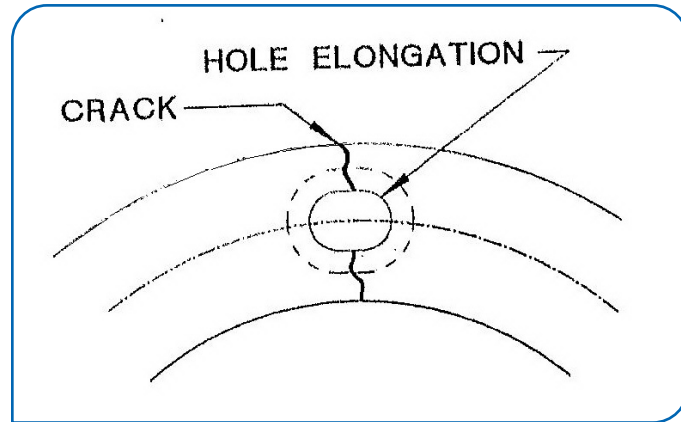


Figure 5 The disk is broken through the bolt hole.

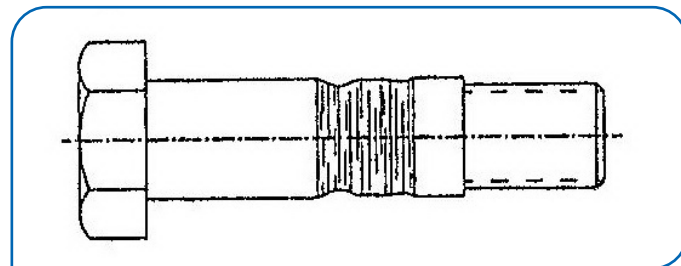


Figure 6 Do not turn the bolt during the locknut tightening process.

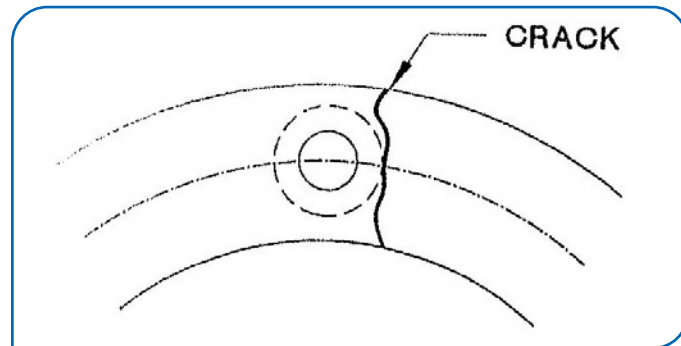


Figure 7 Excessive misalignment during operation.

that the coupling operates with a neutral flat disk pack. If the application has a sleeve-bearing motor, make sure that the operating centerline of the motor rotor is properly positioned.

5. Wavy disk packs on both ends of the coupling. One end is compressed, and the other is elongated. See Figure 4. This is called “oil canned” disk packs. The disk pack has no neutral center where it remains flat and parallel with the end flanges. Loosen all locknuts, correct the axial spacing, and tighten the locknuts. If this doesn’t resolve the problem, the disk packs might have been permanently deformed. Replace the disk packs and reassemble the coupling.

### Inspect failed couplings

It helps to show the coupling manufacturer’s service representative failed disk packs. Service representatives know the failure modes for disk packs, and specimens of failed disk packs might help in diagnosing the root cause of failure. By understanding the root causes of failures, remedies can be applied, and failures can be prevented in the future.

The following list describes the failure modes that typically occur in disk pack couplings, the root causes of failure, and the remedies (Ref. 2).

### What to look for when inspecting failed couplings

1. The disk is broken through the bolt hole as shown in Figure 5. This indicates loose coupling bolts. Replace the disk pack and tighten locknuts to the specified torque.
2. Disks are embedded in the bolt body. This is usually the result of a loose bolt or severe torque overloads. This can also appear when turning the bolt during installation. Replace the bolt and tighten the locknut to the specified torque. Do not turn the bolt during the locknut tightening process. See Figure 6.
3. Disk is broken adjacent to washer face. Cracks usually start in the outermost disk and progress through the disk pack. This indicates excessive misalignment during operation. See Figure 7. Replace both disk packs and realign the equipment. Make a hot check of alignment to ensure it is within the coupling specification.
4. Disk is broken adjacent to washer face with fretting corrosion in the area of the crack. This indicates excessive misalignment during operation. See Figure 8. Replace both disk packs and realign the equipment. Make a hot check of alignment to ensure it is within the coupling specification.
5. The disk pack has a bulge between the bolts, or is bowed toward one flange in alternate chordal positions as shown in Figure 9, bolts are bent, or bolts are damaged as shown in Figure 6. This condition is a result of a large torque overload induced into the system above the peak overload capacity of the coupling. The remaining disk pack chordal sections will be very straight and tight. If the bulge appears in only one chordal section, there might be a loose bolt on one side of the distortion. Loosen all locknuts and unseat the bolts. The bulge should release and flatten out. If so, retighten the locknuts. If the distortion does not disappear, replace both disk packs and retighten the locknuts. If there is a synchronous motor driver, measure the startup torque at the motor shaft with strain gages to determine if torsional resonance causes overload torque that exceeds the peak torque capacity of the coupling. Check the coupling selection and apply the proper size and type of coupling for the characteristics of the application.

## Remedy for failed disk pack coupling

If the answer is yes for the entire following list of questions, and no adverse operating conditions have been discovered, it indicates that a greater service factor is required for your application, which means a larger disk pack coupling is required. Alternatively, the coupling might need to be changed to a different style with larger load capacity such as a flexible gear coupling.

1. Has the manufacturer's service representative confirmed that the coupling is the correct type for the application?
2. Has the service factor been calculated?
3. Has the peak torque been measured?
4. Has the cold and hot alignment been measured?
5. Has the installed couplings been inspected for proper disk pack deformation?
6. Has the failed coupling been inspected for root cause of failure? **PTE**

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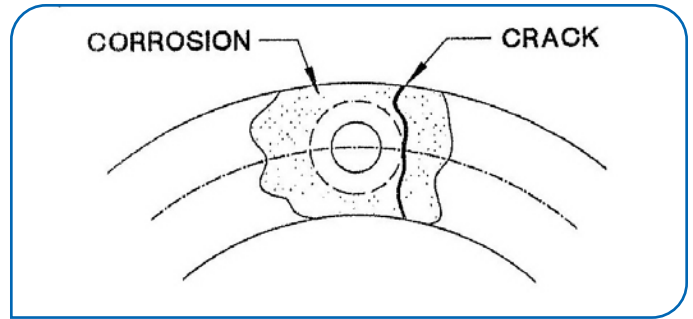


Figure 8 Disk is broken adjacent to washer face with fretting corrosion in the area of the crack. This indicates excessive misalignment during operation.

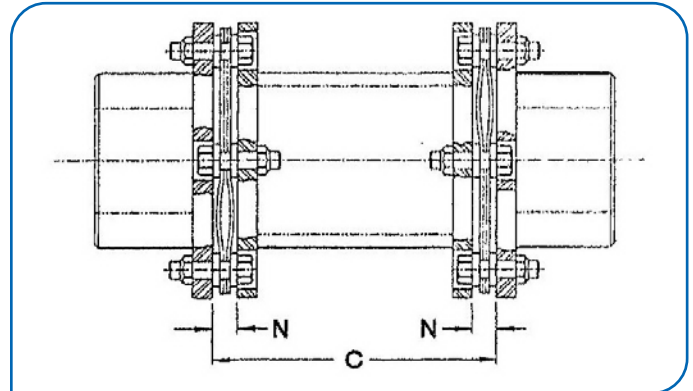


Figure 9 The disk pack has a bulge between the bolts, or is bowed toward one flange in alternate chord positions.

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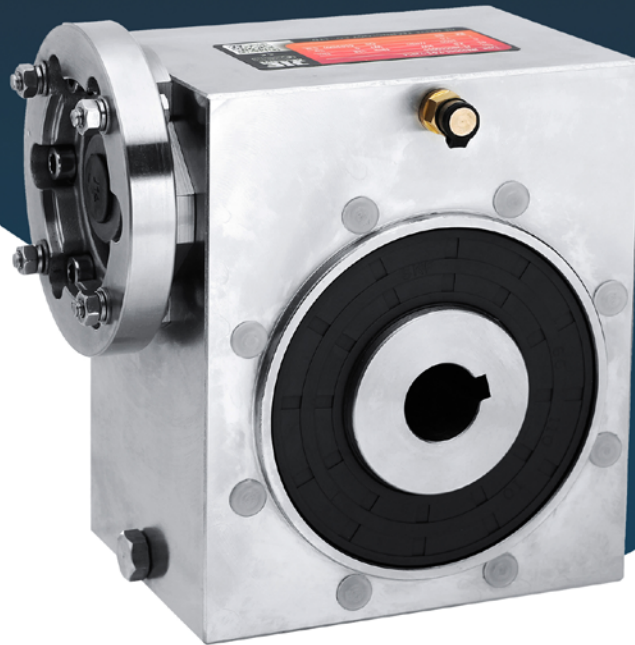
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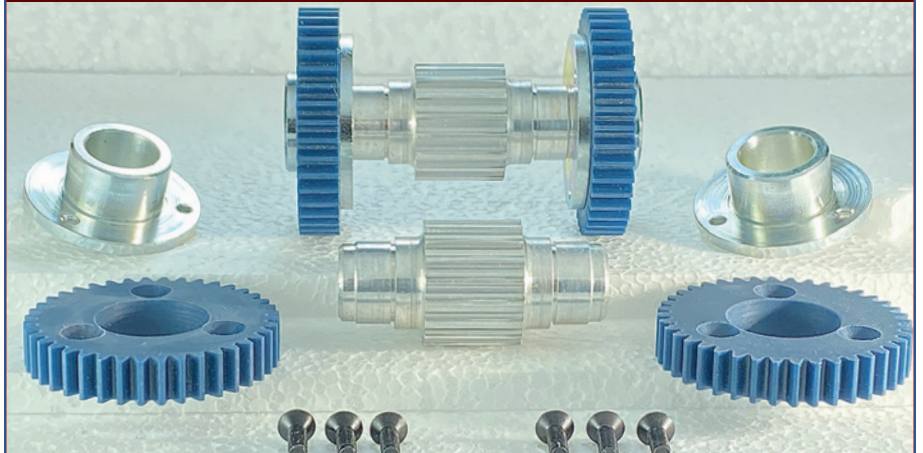
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# An Overview of Fretting Wear

Sandeep V Thube

## Introduction

Fretting is considered as a type of wear that occurs in the presence of a small movement between machine components (Refs. 1–2). The small movement could be observed in parts that are not intended to move, and also parts where limited movement is allowed by design. Bolted joints, hollow-bore-shaft mating area, keyways, turbine blade roots, bearing races, shrink fitted and press fitted parts are examples of where unintended movement occurs. And flexible coupling, splines, cams, leaf springs are components that are allowed to have limited internal movement.

Fretting can be elaborated with one of the above examples—hollow-bore and solid-shaft arrangement. Two independent machineries can be connected with this arrangement, in order to transmit power and rotational

motion. Fretting is commonly observed at contact surface due to mating parts' unintended relative movements in radial and axial directions. Reasons for those movements could be traced back to the design, manufacturing tolerance and/or installation of the components. The red-color-stained area with some debris (and/or fine red powder) is an evidence of a fretting condition. As a consequence of this condition, the mating surfaces lose their geometric tolerance and create misalignment between components. Often, it becomes impossible to separate the solid shaft from the hollow bore at the time of maintenance, or replacement.

This article dives into the reasons of this failure, its consequences and mitigation methods. The article also discusses about the life prediction of components. First, we will

have to understand the fretting failure mechanism.

## Failure Mechanism

Technically speaking, the fretting wear can occur when a pair of structural elements are in contact under normal load, while cyclic stress and relative movement are forced along the contact surface.

The localized 'relative movement, which is small and oscillatory, between two ferrous materials is defined as 'slip amplitude'. The slip amplitude is a peak-to-peak amplitude of the relative motion, and it could be as small as 0.25 microns (Ref. 3). In this mechanism, pressure and sliding initialize material adhesion. It is also described as 'micro-welding' in the literature. That leads to the material transfer from one surface to the mating one (Fig. 2).

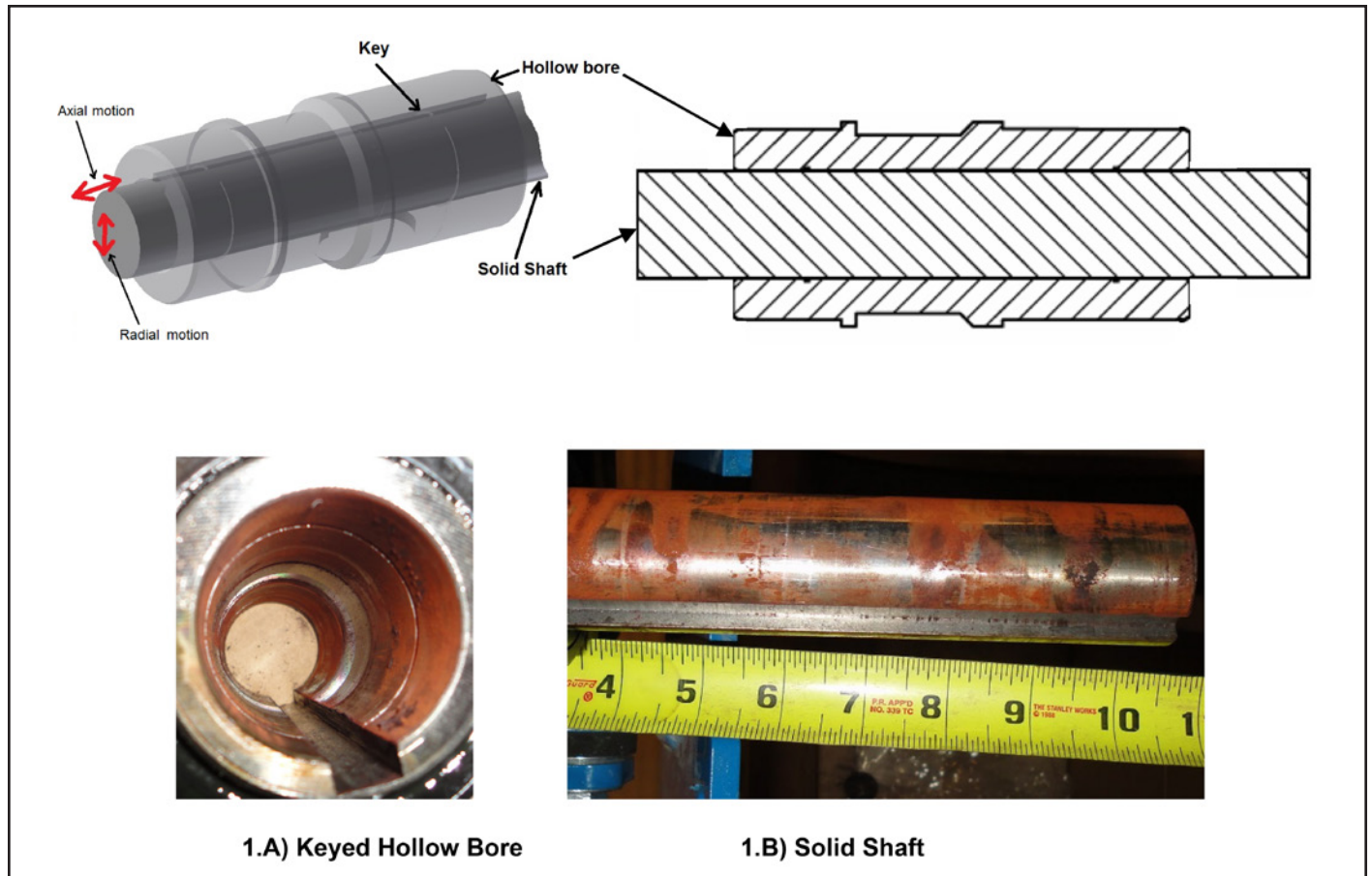


Figure 1 Fretting condition example—staining is an evidence of fretting occurrence.

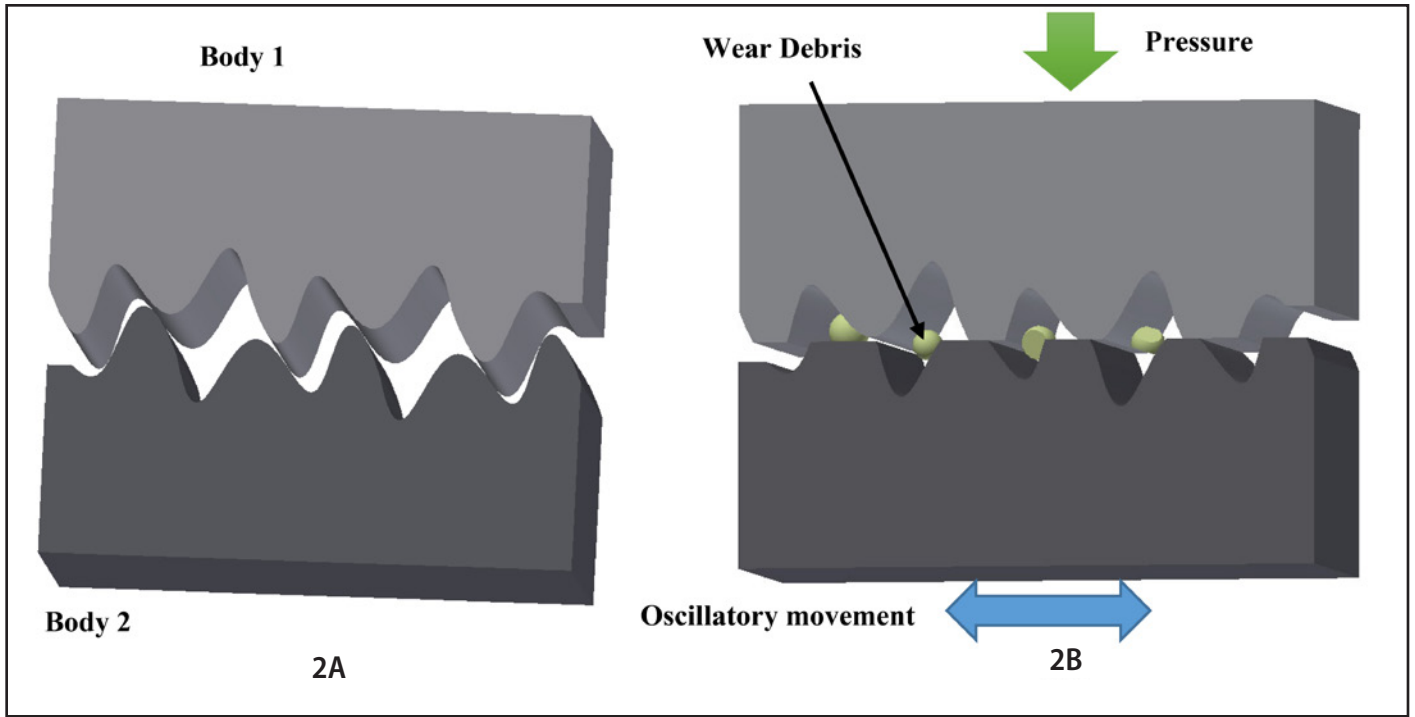


Figure 2 Microscopic surface asperities of two bodies before making contact (2.A); pressure and movement brake asperities to form wear debris (2.B).

Later, the transferred material oxidizes, and its dislodging forms red oxide powder ( $Fe_2O_3$ ), called hematite (Fig. 3). The powder is formed in presence of oxygen, at room temperature; this powder does not carry magnetic property. Generated particles of the powder are extremely hard, and act as an abrasive.

Generation of the powder leads to more clearance between the mating surfaces, and consequentially more intense relative movement. Again, closing the loop, it would increase the rate of powder generation.

There are more than fifty parameters that influence the fretting fatigue process. Type of materials of the mating surfaces, their shapes, surface roughness, hardness, pressure in the contact zone, slip amplitude, frequency are some of them.

### Influencing Factors

Contact pressure and displacement amplitude are generally considered the most important contributors in deciding the extent of fretting (Ref. 4). An increase in the magnitude of one or both of them correspondingly increases the surface damage. It is also proposed that the contact geometry greatly influence the extent of the wear (Ref. 5).

Surface hardness greatly influences the wear fatigue life of components. It

has been documented that the contact surfaces with different hardness show less wear volume than the surfaces with the same hardness (Refs. 6-7). When surfaces hardness differs, in general, wear debris from the harder surface is retained on the softer surface, protecting it from wearing out.

Further, explaining another influencing factor- temperature, one study shows that the local hot spots at contact surfaces of AISI 52100 steel drive

microstructural changes in materials (Ref. 8). These hot spots could reach above  $1000^\circ\text{C}$  temperature, altering mechanical properties of the material.

Surface roughness impacts the coefficient of friction in the beginning of the surface interaction, influencing the fretting mechanism (Ref. 9). During the wear process, the surface degradation changes the initial roughness. Depending on the material type, it has been reported that the initial roughness



Figure 3 Fine oxide powder as a result of fretting.

acts in favor of or against the fretting wear.

The oxide wear debris also plays a role in fretting wear. Depending on the ‘adhesion-dominant’ or ‘abrasion-dominant’ fretting mechanism, the wear debris helps to accelerate or reduce the wear damage (Ref. 10). In the referred study, it was experimentally shown that the presence of the debris in bronze-on-steel contact added more wear damage, while in steel-on-steel contact, alleviated it.

### Prediction

Stresses are concentrated at edges of the contact, initiating crack at those locations. The concentration of stress can be calculated using numerical method — finite element analysis (FEA) (Refs. 11–12). Using critical distance theory, stress distribution under fretting condition can be calculated, and hence the fatigue life.

Laboratory testing is capable of varying many influencing factors like slip amplitude, frequency, and contact pressure (Ref. 13).

### Fretting Mitigation

Even though the occurrence and timing of the fretting phenomenon is not quite predictable, once occurred, it is still possible to address it and avoid its further acceleration. Extra attention should be paid to constrain unwanted movements of components. The relative movement of the mating shafts highlighted in Figure 1 can be minimized by clamping shafts axially. Per Author’s experience, the clamping rings

added on the both ends of the shaft, as shown in Figure 4, help to align of the shaft help to align the components with each other, and arrest axial as well as radial relative (unwanted) motions.

As mentioned before, fretting cracks are usually observed at high stress concentrations areas like shaft shoulders, steps, component edges etc. The stress concentration could be addressed in the design phase of the assembly or component. For instance, providing undercuts at contact ends of the hollow bore and solid shaft arrangement would help to alleviate the stress (Ref. 3). Applying lubrication between contact surfaces is one way of mitigating fretting. However, the lubricant use should not increase the slip due to reduction in coefficient of friction. If a thin oil is used, it needs to be replenished; it may be less than ideal. Solid lubricant like molybdenum disulphide or zinc oxide are preferable to be utilized; however, for high fretting cycles, they may not be effective.

Surface treatment is considered to increase surface hardness in order to improve fatigue strength. Other options, viz. Surface coating (chromium coating), use of PTFE material are also available to delay the effect of fretting wear (Refs. 14–15).

### Summary

Understanding of fretting wear is evolving, as are the solutions to counter it. This article briefly touches different aspects of this wear problem, including its mechanism, different influencing factors, and mitigation techniques. **PTE**

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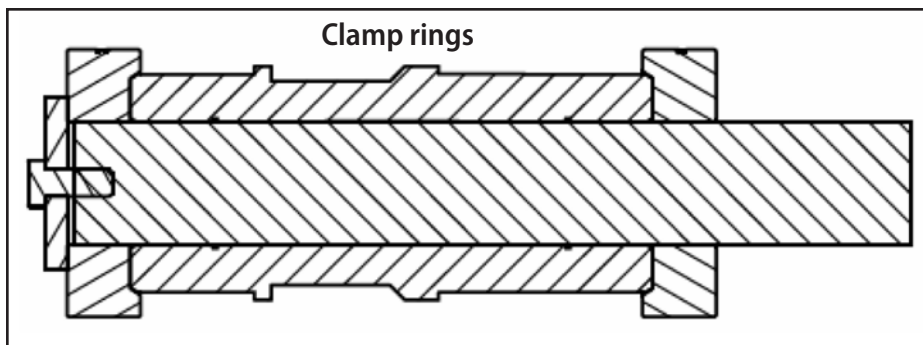



Figure 4 Constraining unwanted movements on fretted shafts to reduce further wear.

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# How Reliable is a Reliability Calculation?

Hanspeter Dinner

## Objective of the Study

Bearing failures are a major concern in wind turbine main gearboxes. The risk of bearing failure  $F(t)$  is calculated from the bearing life  $L$ . If this is done for all bearings in a gearbox, then, the bearing subsystem reliability for the required life  $R(H_{req})=1-F(H_{req})$  may be calculated. Methods used for such calculations for wind gearboxes are well established and have been widely used in other fields, (Refs. 5–11).

A calculated failure risk will not necessarily reflect the failure rate experienced in the field. The reason for this is, e.g., that only a few failure modes are open to a reliability calculation. Here, another, sometimes overlooked reason, is addressed: The calculated reliability will change with any small variation of input parameters or calculation method.

## Reliability as a Design Requirement for Wind Turbine Gearboxes

ISO 81400-4, (Ref. 1), states “...The required design life shall be specified for each of the major subsystems of the gearbox including gears, bearings, housings, shafts and seals...” In this statement, attention is directed to the underlying reliability of the material data or load capacity numbers associated with the life calculation of components. For the bearing rating, design

rules (Refs. 1–3) usually stipulate a bearing failure probability of 10%. If in a gearbox each bearing reaches the required life  $H_{req}$  (e.g. 175,200 h=20 y, using  $L_{nmrh}$  along (Ref. 4)) at a probability of failure of  $F=10\%$ , the reliability of the bearing subsystem is less than 90%. The reliability of the bearing subsystem is the product of all bearing reliabilities.

**Single bearing reliability calculation.** In B20 revision of AGMA 6006, (Ref. 2)), bearing reliability  $R(t)$  as a function of time  $t$  is calculated with a three parameter Weibull distribution:

$$R(t) = e^{-\left(\frac{t-\gamma}{\eta}\right)^\beta} \text{ where } \eta = \sqrt[\beta]{\frac{L-\gamma}{-\ln(R_0)}}$$

$L$  = Modified reference rating  $L_{nmrh}$ ,

$\gamma$  = Location parameter =  $C\gamma * L$ ;

$C\gamma = 0.05$

$\beta$  = Shape parameter = 1.500

$\eta$  = Scale parameter

$R_0$  = Reference reliability, reliability used to calculate  $L_{nmrh}$ ,  $R_0 = 90\%$

## Bearing Subsystem Life and Reliability

**Base line model and reference conditions.** The bearing subsystem of a 3MW class main gearbox is investigated. The rotor shaft is supported by two bear-

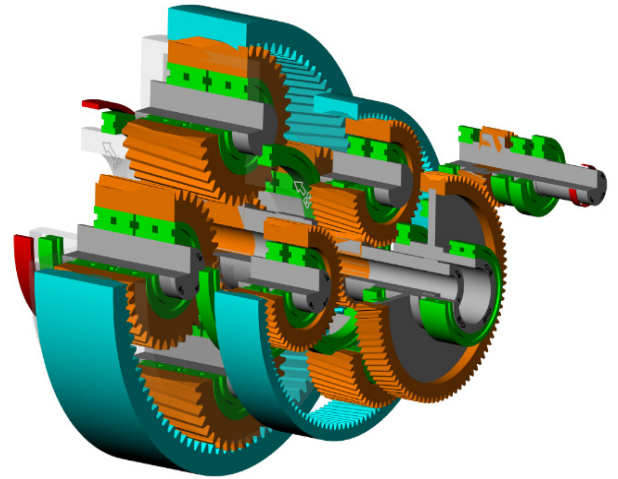


Figure 1 KISSsoft model used for calculation. Planetary carrier not shown; housing not shown.

ings; planet carrier bearing life is assumed as “infinite.”

Different effects are considered in the calculations. From a reference condition listed below, small changes are introduced to study how they affect the reliability of the bearing subsystem.

**Results, reference calculation.** With settings per DNV GL guideline (Ref. 3) and above, calculations are done using KISSsoft software (Ref. 1), giving:

For all 32 bearings, the reliability function  $R(t)$  is plotted (see figure 2 in grey). Bearing subsystem reliability (blue) is calculated therefrom. The intersection of subsystem life  $H_{req}$  at 175,200 hours (vertical, red) and the time dependent subsystem reliability (blue) results in a subsystem reliability value of about 0.59 (blue, dashed, horizontal line).

Table 1 Reference conditions for the calculation of the bearing life

Property	Reference value	Affects
Clearance, position in tolerance field	Mean value in tolerance field	Operating clearance, load distribution in bearing
Inner and outer race temperature	Temperature differences per Table 4, ISO 81400-4, [1]	Operating clearance, load distribution in bearing
Load application position	Load in center of gear face width	Load distribution, planet bearings
Planet load distribution (Ky)	Ky= 1.10 for LSS, Ky= 1.05 for ISS	Load on planet bearings LSS, ISS
Nominal torque	100% nominal load	Load level on bearings
Lubricant temperature	65°C	Lubricant viscosity, aISO factor
Lubricant contamination	- / 17 / 14, beta25= 75	Life rating
Bearing clearance variation, planet bearings	All bearings have same bearing clearance	Load distribution among planet bearings,
Pressure angle, gears	Operating pressure angle awt is used	Bearing forces



## Variation of Calculation Settings

**Parameters varied.** Thirteen experiments are set up. Only one parameter is changed compared to the reference calculation.

**Resulting reliability curves.** For each experiment, for all bearings, life and reliability curve are calculated. Bearing subsystem reliability and failure probability curve is plotted in (Figure 3). The resulting reliability values for the required life  $H_{req}$  are determined as intersection of the reliability curves with the vertical line at  $x = H_{req}$ . Experiment 1 and 12 gave highest reliability, highlighted (green). Experiment 8 gave second highest reliability (cyan). Experiment 2, 6 and 7 gave second-lowest reliability, (pink). Experiment 11 gave lowest reliability (grey, solid line).

Calculated reliability values  $R(H_{req})$  range from 38% to 70%. If we accept that experiment 11 is extreme and omit it, we still find a range of 19%-points.

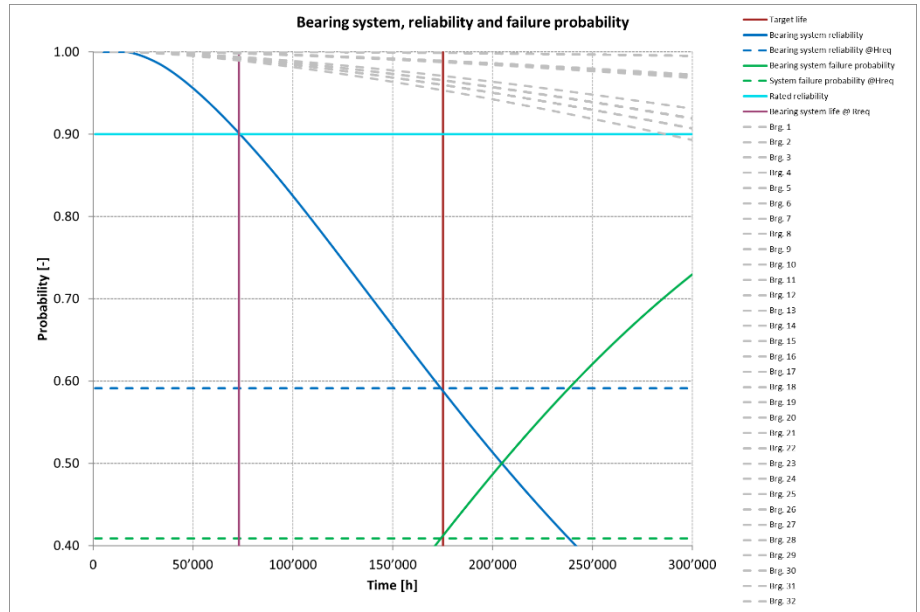


Figure 2 Bearings reliability (grey), subsystems reliability (blue), required subsystems life  $H_{req}$  (vertical, red), rated reliability (horizontal, cyan), subsystem reliability at required life (horizontal, dashed blue), subsystem life at rated reliability (vertical, pink).

Table 2 Calculated bearing life, reference values. For carrier bearings, a very high life is assumed

Stage	Position	Shaft	L10mrh in hours
LSS	RS-RS	Planet, same for all planets	314'820
LSS	RS-GS	Planet, same for all planets	9'889'777
LSS	GS-RS	Planet, same for all planets	10'504'562
LSS	GS-GS	Planet, same for all planets	345'866
LSS, ISS	RS, GS	Carrier	9'999'999
ISS	RS	Planet, same for all planets	646'878
ISS	GS	Planet, same for all planets	675'973
HSS	RS	Driving	344'247
HSS	GS-RS	Driving	9'999'999
HSS	GS-GS	Driving	622'918
HSS	RS	Driven	286'648
HSS	GS-RS	Driven	677'429
HSS	GS-GS	Driven	382'756

Table 3 Set up of the 14 experiments

Experiment	Parameter varied	Variation	Comments
1	Clearance, within tolerance field	Lower position	
2	Clearance, with in tolerance field	Upper position	
3	Inner, outer race temperature	Temperature difference between races reduced by 5K	Operating clearance but not oil viscosity
4	Inner, outer race temperature	Temperature difference between races increased by 5K	Operating clearance but not oil viscosity
5	Load position on gear face width	Offset 1 cm	
6	Load position on gear face width	Offset 2 cm	
7	Planet load distribution (Ky)	Ky values increased by 0.05	
8	Planet load distribution (Ky)	Ky values decreased by 0.05	
9	Nominal torque on gearbox input	Load decreased by 2.5 %	To consider e.g. site-specific loads
10	Nominal torque on gearbox input	Load increased by 2.5 %	To consider e.g. site-specific loads
11	Lubricant contamination	One class worse, - / 19 / 16, beta25 = 7	Reference class - / 17 / 14, beta25 = 75
11a	Lubricant contamination	One class better, - / 15 / 12, beta12 = 200	Reference class - / 17 / 14, beta25 = 75
12	Pressure angle, gears	Nominal instead of operating pressure angle	
13	Bearing clearance variation in planet bearings	Outer bearing rows in LSS planets, clearance reduced by 10 µm, inner have a clearance increased by 10 µm	To simulate that bearings are not perfectly matched

### Conclusion

**Governing effects.** The reliability of the bearing subsystem is governed by the outer bearing rows in the LSS planet bearings and the output shaft bearings. We find that the biggest influence is from the lubricant cleanliness level. This is easy to understand as the lubricant cleanliness level itself affects the rated life of the LSS planet bearings the most, since those have the lowest lubricant film thickness and therefore a low aISO factor.

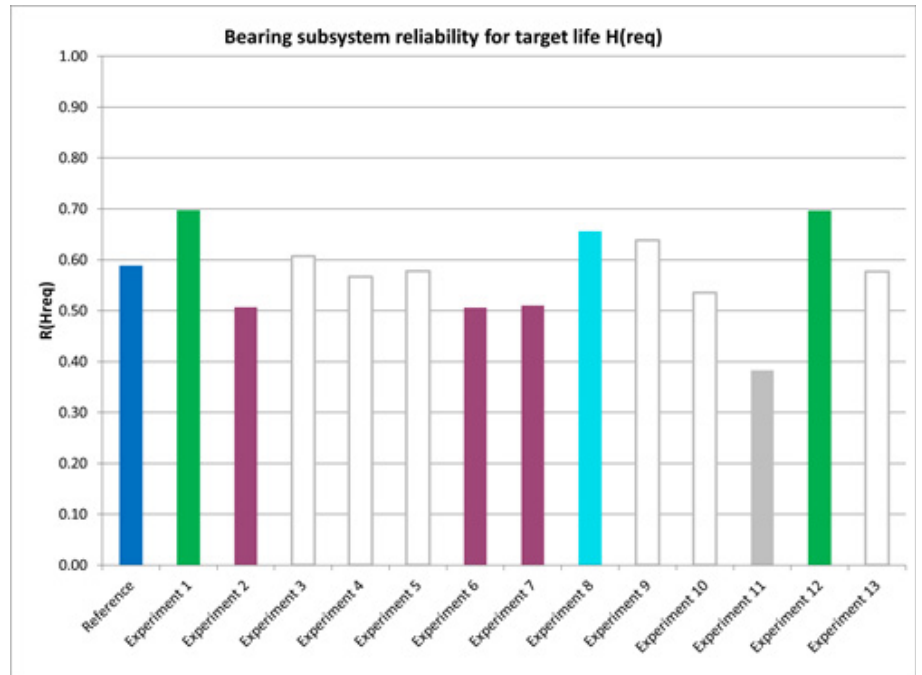
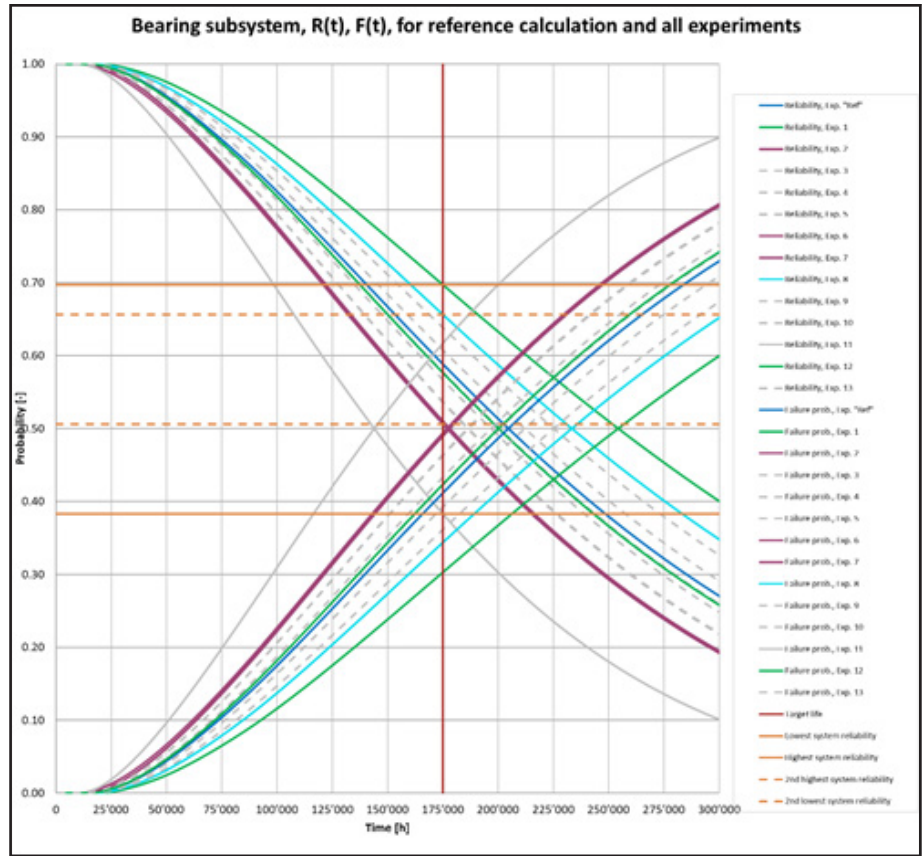
On the HSS bearings, a major influence is the pre-tension of paired TRBs and the influence of the bearing raceway temperature.

**How reliable is the reliability calculation?** We find that a calculated bearing subsystem reliability of a typical wind turbine gearbox has a typical error of ±10%-points.

If we are interested in comparing the total cost of ownership for several competing designs, based on bearing subsystem reliability numbers, this error of +/-10% is disappointing. The obvious solution is that all calculations must be done strictly with identical assumptions, calculation methods and tools. **PTE**

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**Figure 3** Bearing subsystem reliability for different experiments (blue: reference calculation, green: highest result, pink: second lowest result, grey: lowest result, cyan: second highest results, white: other results). Upper image: reliability curves. Lower image: reliability levels at Hreq.

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# Power Transmission Engineering

**Hanspeter Dinner** studied mechanical engineering at the Swiss Federal Institute of Technology, Zürich, Switzerland and the National University of Singapore. He first worked as FEM engineer with a Swiss consultancy and as lead stress engineer with a roller coaster developer. He joined KISSsoft AG as software support and project engineer. In 2008, he started the consultancy company EES KISSsoft GmbH, representing the KISSsoft company in China, Japan, Korea, Taiwan and India. He has conducted about a hundred FEM, gear, bearings and transmission projects serving the wind, tractor, industrial gearbox and fine pitch gear industry. Since August 2019, Dinner has been working in the function of Director Global Sales in the KISSsoft company.



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# Motion

## ANNOUNCES SEVEN MANAGEMENT PROMOTIONS

Motion has announced seven recent promotions to key field management positions.

**Logan Carden** was named Nashville division vice president and will be responsible for overseeing the sales growth initiatives of 20 branches located in parts of Indiana, Tennessee, Kentucky, Mississippi and Alabama. He will report to Chris Pacer, vice president group executive – central. Carden joined Motion in 2007, as a member of the corporate accounts support team. He continued to expand his roles within the company, ultimately earning a corporate account manager role in 2013 before his move to the field sales and branch operations side in 2019 with a promotion to branch manager of Motion's Evansville, Indiana, location. Carden was quickly promoted to sales manager of the Evansville and Owensboro (Kentucky) locations in March 2020. He graduated with a bachelor of arts degree from Huntingdon College in 2006, and later earned his MBA from the University of North Alabama. Originally from Birmingham, Carden is currently based in Indiana after making the move with his 2019 promotion.



**Bill Carroll** was promoted to vice president of the new Philadelphia division (Pennsylvania, New Jersey, and West Virginia), which was strategically established to serve and further the significant growth in the east group's territory. He will be responsible for overseeing 13 branches' sales and guiding their market growth, and will report to Phil Donnelly, vice president group executive — east. Carroll most recently managed the Philadelphia branch, and in his career has held a variety of managerial, sales, and support positions in the company and in its industry. He started in 1989 with Eastern Bearing of New Jersey, which Motion acquired in 1999. During his Motion tenure, Carroll has managed at four different branch operations in New Jersey and Pennsylvania. He has also worked in Motion's corporate accounts organization in a compliance manager role. Originally from Pennsylvania, Carroll is based near Philadelphia.



**Tami DeWeese** will assume leadership of the Pacific Northwest division as its vice president. In her new role, DeWeese will oversee the sales growth, strategy and operations of 19 branch and shop locations. She will report to Jeremy Barton, vice president group executive — west. A native of Washington state, DeWeese started with Motion in 2014 as a branch manager for Motion's Portland (Oregon) branch, and in 2016 took on the added responsibility of the Longview, Washington, branch. Prior to joining Motion, she was the president of a process pump company for 13 years.



**Dan Pike** was promoted to St. Louis division vice president and will be responsible for the sales growth and strategic management of 17 branch operations throughout Missouri and Arkansas. He will report to Austin Amos, senior vice president group executive — midwest. Pike began his career with Motion in 1991 as a corporate trainee, and his tenure has included various positions within the company including account representative, fluid power specialist, branch manager, corporate account manager, and most recently as area vice president corporate accounts for the midwest group. He is a native Floridian and a graduate of the University of Florida with a degree in marketing.



**Dave Purvis** was named midwest group area vice president, replacing Dan Pike in that role. Purvis will be responsible for leading the midwest group corporate accounts team, which involves managing existing corporate account relationships and driving new growth opportunities. He will also be responsible for providing corporate account partners with Motion's full offering of services and solutions to reduce these partners' total cost of ownership. He will report to Austin Amos, senior vice president group executive — midwest. Purvis started his career with Motion in 1991 at the Mattoon, Illinois, branch and has held various positions within the company, including warehouse manager, operations manager and account manager. In 2011, he was promoted to corporate account manager. Prior to joining Motion, Purvis attended Eastern Illinois University. Originally from Illinois, he is currently based in Decatur.



**Steve Kammeyer** was named area vice president for corporate accounts, west group. In his new position, he will directly engage with field personnel and leadership in creating and developing internal and external sales-driven initiatives, with a focus on corporate account customers. Kammeyer will report to and work closely with Jeremy Barton (vice president group executive - west) in the execution of these efforts. Beginning his career with Motion in 1986, Kammeyer has held various roles within the branch structure including warehousing, customer service, outside sales, and branch manager before being promoted to corporate sales manager in 2012. An Arizona native, he is based in Phoenix.



**Lisa Solomon** was promoted to area vice president for corporate accounts, central group, and will lead this group's corporate accounts team. She will be responsible for enhancing existing national account relationships and driving new opportunities for growth throughout the various industry segments within the geographic area. She will report to Chris Pacer, vice president group executive - central. Solomon began her Motion journey in 2015 as a business development manager in corporate accounts and was quickly promoted in 2016 to corporate accounts manager. Originally from Michigan, Solomon graduated from Central Michigan University with a bachelor of liberal arts in broadcasting, communications and marketing.



"We are immensely proud of what these individuals have accomplished to date and are confident that their experience, acumen and drive will help to take their divisions and the company to a new level," said Kevin Storer, executive vice president branch operations - North America and president of Motion Mexico. "Each of these promotions is well-deserved and we are looking forward to seeing the impact of their leadership, as part of Motion's bright future."

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# Watson-Marlow Fluid Technology Group

CELEBRATES HOSE PUMP MILESTONE

Watson-Marlow Fluid Technology Group (WMFTG) has passed a notable business milestone by selling the 150,000th Bredel peristaltic hose pump to a mining industry customer in Mexico. The past decade has seen a huge increase in the uptake of Bredel hose pumps in sectors such as mining and construction, where they meet strict environmental regulations in very tough working conditions.



It has been over half a century since Bredel developed the peristaltic hose pump for industrial use. Today, these high-performance units transfer and dose a whole host of aggressive, viscous and abrasive fluids and solids in sectors that include brewing, water treatment, construction, chemical and mining. A particularly fast-growing application at present is chemical transfer duties in the production of lithium-ion batteries. The single biggest order to date for Bredel hose pumps was 174 APEX units to a lithium-ion battery materials manufacturer in China.

The sale of the 150,000th pump to a customer in Mexico was part of a consignment shipped from the Bredel manufacturing plant in Delden, Netherlands, that constituted 16 pumps across eight different models. The combined flow of these pumps is circa 1,560 l/min.

Bredel pumps continue to evolve, with many notable achievements arriving in the past 10 years. A good example is the APEX range, which was introduced in 2012 and expanded in 2015. APEX pumps are designed to offer a highly competitive price/performance ratio. The range offers flow rates up to 6,200 l/h and discharge pressure to 8 bar, while the wider Bredel hose pump range includes units that provide flow up to 108,000 l/h and pressure to 16 bar.

With regard to the operating principle, Bredel pumps have no seals, valves, diaphragms, stators, glands or other costly hardware to replace, ensuring they can be easily maintained in-situ without relocation to a workshop. Only the hose requires occasional replacement, which is a simple task.

Hose technology from Bredel has also taken a number of notable steps forward in recent years. A case in point is the Bredel NR Endurance, which made its market debut in 2018. This advanced hose provides up to 50 percent longer life in abrasive pumping applications, as exemplified recently by a customer in the chemical industry.

The chemical plant pumps PCC (precipitated calcium carbonate) slurry up to 1000 cPs viscosity. Using an optimized

set-up, the standard rubber hose from Bredel lasted for 4,468,800 occlusions, which is equivalent to 110 days or 2,660 hours. However, by switching to the Bredel NR Endurance, operating life extended to 7,056,000 occlusions, approximately 175 days or 4,200 hours (a 57 percent gain). This success contributed to ROI on its new Bredel hose pumps within 12 months.

[www.wmftg.com](http://www.wmftg.com)

## VELO3D

APPOINTS JON PORTER TO LEAD EXPANSION OF COMMERCIAL OPERATIONS THROUGHOUT EUROPE

As California-based metal additive manufacturing (AM) leader VELO3D continues on its accelerated growth path, the company has announced the appointment of **Jon Porter** to head its commercial operations in Europe. Based in the U.K., Porter will oversee VELO3D's ongoing expansion efforts into this key strategic region.



Porter comes to VELO3D from Renishaw, where he worked in the business development team of the AM division. While there he was also directly involved with the international organizations (SAE, ASTM and BSI) that are developing new standards for the industrial 3D-printing sector.

Porter's earliest introduction to AM came in the 1990s working for renowned engineer-entrepreneur James Dyson. As the company grew from successful startup to leading floorcare and appliance business, Porter became involved in its early investment in AM technology. "I saw the potential for AM as a 'bridge to manufacturing' that allows for significant time compression and de-risking of both product development and the toolmaking cycle," he says. "Throughout my experience with several other companies as AM has evolved since then, the value of 3D printing as a powerful end-product manufacturing process has become increasingly clear."

VELO3D founder and CEO Benny Buller views Porter's appointment as an opportunity to better support existing customers throughout Europe while educating others about the growth-making potential of VELO3D's AM technology. "With Jon at the helm of our European base of operations, manufacturers in the region now have similar-time-zone access to someone who knows AM inside and out—and who has also experienced, first-hand, how adopting this technology can make all the difference in a company's ability to innovate and compete," he says.

Jon Porter holds a degree in engineering product design from South Bank University in London.

[www.VELO3D.com](http://www.VELO3D.com)

# Gilman Precision

## WELCOMES SEDONA COX TO BUSINESS DEVELOPMENT TEAM

Gilman Precision, a manufacturer of customized linear and rotary motion systems, is excited to announce the addition of **Sedona Cox** to their team as a business development specialist.

She will be building relationships within the Central region for Gilman Precision, including Ontario, Michigan, Indiana, Kentucky, Tennessee, and Alabama. Based in Michigan, Ms. Cox will be able to quickly address customer needs utilizing a variety of communication methods.

She has extensive consultative sales experience, working with industries as varied as life sciences, water purification, transportation, and medical devices. Ms. Cox enjoys working closely with customers, partnering with them to put together the exact solution for their particular need. Ms. Cox commented, "I am very excited to be part of the Gilman Precision team. I look forward to building quality relationships within the Central territory, while continuing to provide our customers with high caliber products and service to match."

Doug Biggs, vice president sales and marketing, commented, "We are extremely excited to have Sedona join our business development team. It is rare to have the opportunity to hire someone of the caliber of Sedona, and we believe she will help both Gilman and our customers grow their respective businesses."



[Gilmanprecision.com](http://Gilmanprecision.com)

# APMI International

## NAMES 2021 FELLOW

APMI International's most prestigious award recognizes APMI members for their significant contributions to the goals, purpose, and mission of the organization as well as for a high level of expertise in the technology, practice, or business of the industry. The 2021 Fellow Award recipient will receive elevation to Fellow status at

PowderMet2021, during the Opening General Session on Monday, June 21, in Orlando. The 2021 recipient is **Cynthia Freeby**, regional sales manager, Ametek Specialty Metal Products.

During her 40 plus year PM industry career, Cindy has been dedicated to the advancement of the PM industry. She co-chaired the annual MPIF PM/87 technical conference and served on



many boards and committees. She is the only person to have chaired three APMI chapters, Philadelphia, Dayton, and Michigan, after holding numerous officer positions within each Chapter. She received the MPIF Distinguished Service to PM Award in 2005, as well as the ASTM Distinguished Service Award in 2019 for her work in developing PM standards.

Established in 1998, the Fellow Award recognizes APMI members for their significant contributions to the society and high level of expertise in the technology of powder metallurgy, practice, or business of the PM industry. Fellows are elected through their professional, technical, and scientific achievements; continuing professional growth and development; mentoring/outreach; and contributions to APMI International committees.

[www.apiinternational.org](http://www.apiinternational.org)

# Bonfiglioli

## ACQUIRES SAMPINGRANAGGI

Bonfiglioli S.p.A. has acquired Sampingranaggi.

The acquisition includes the assets of the Italian and Chinese Sampingranaggi companies (Bentivoglio -BO, Funo di Argelato-BO and Shanghai-China), their respective warehouses, the Sampingranaggi brand, patents, designs and products for robotics, as well as all their staff.



With this acquisition, Bonfiglioli S.p.A. will be able to increase its production verticalization both in Italy and China, accessing the robotics market also through the development of other extremely precise and efficient products.

The Chairwoman Sonia Bonfiglioli commented: "I like to think that, if Sampingranaggi had not already been there in the post-war period, today Bonfiglioli would not exist. Because it all began there, in 1948, when a young technical graduate started out on a valuable journey of work and experience that, three years later, led him to set up his first business.

"For Bonfiglioli, SAMP represents a great opportunity," underlined Fausto Carboni, CEO of the Group, "in many aspects. From an industrial point of view, it offers us the possibility to integrate some strategic component productions, including bevel gears, while in terms of business development it allows us to enter the robotic gearbox market, where there is ample room for growth in future, both in Italy and in China through their local company, which that is part of the acquisition."

[www.bonfiglioli.com](http://www.bonfiglioli.com)

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# Where We're Going, We Don't Need Roads!

Matthew Jaster, Senior Editor

**Why not flying cars?** We talk on video screens. We disappear into virtual 3D worlds thanks to Virtual Reality (VR). We have robots working in restaurants. Flying cars are pretty much the last thing from *The Jetsons* cartoon missing in 2021.

They might be coming sooner than you think.

I've spoken with several power transmission component suppliers 'off the record' regarding their work in this area in the next 5-10 years. Certifications in Europe are taking place as I write this. It's quite feasible that a 45-minute commute to the airport via the highway could be a 10-minute cruise above suburbia in the coming years.

Here's a sample of some of the vehicles getting closer and closer to commercial viability in Europe:

## PAL-V Liberty

The Personal Air and Land Vehicle (PAL-V) company was founded in the Netherlands in 2008.

After being the first flying car to get road permission for Europe, PAL-V is now also the first to complete the full certification basis with the European Union Aviation Safety Agency (EASA). Based on PAL-V's 10 years of test results, EASA specialist teams finalized the requirements for the PAL-V Liberty.



Photo courtesy of PAL-V

"Getting a flying car to the market is hard. It takes at least 10 years," said Robert Dingemans, PAL-V's CEO: "Although we are experienced entrepreneurs, we learned that in aviation everything is exponentially stricter. Next to the aircraft, all aspects of the organization, including suppliers and maintenance parties must be certified."



Photo courtesy of AeroMobil

In 2009, PAL-V agreed with EASA to use the certification specifications for small rotorcraft, CS-27, as a starting point for the development of the certification basis. PAL-V worked together with EASA to amend the complete list of over 1,500 criteria to make it applicable.

"Safety is key in developing the Liberty," said Mike Stekelenburg, CTO. "We are privileged to work with top experts of EASA. Their high safety standards also allow the Liberty to be used professionally. From the start, we built the Liberty to comply with existing regulations. This strategy provides the fastest route to market."

[www.pal-v.com](http://www.pal-v.com)

## AeroMobil

The AeroMobil Company from Slovakia is the developer of a new ultra-high-end vehicle equally at home on the road or in the sky. The company recently announced details of the completed phase of its AeroMobil flight testing. When commercially introduced in 2023, The AeroMobil will have undergone over a decade of design and development, including flight testing of three functional prototypes and over 300,000 hours of engineering on the latest version.

The flight test program, which began in September 2020, is part of the EASA CS23 requirements governing all critical aspects of flight. The company started the overall EASA certification process for The AeroMobil during 2019. Through the flight test program, the AeroMobil has successfully met several key EASA CS23 requirements governing airworthiness, including the flight performance in terms of top and stall speeds as well as the impressive ability to take off within 1,300 feet and achieve a rate of climb of over 1,200 feet per minute. **PTE**

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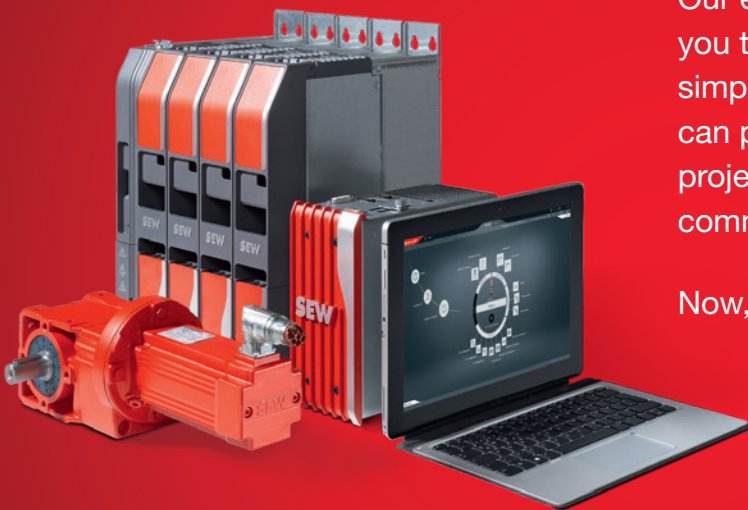


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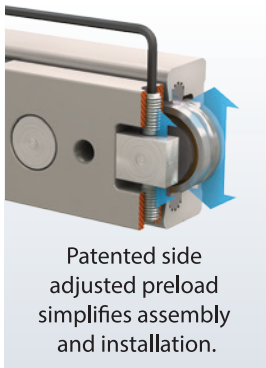
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