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MARCH 2024

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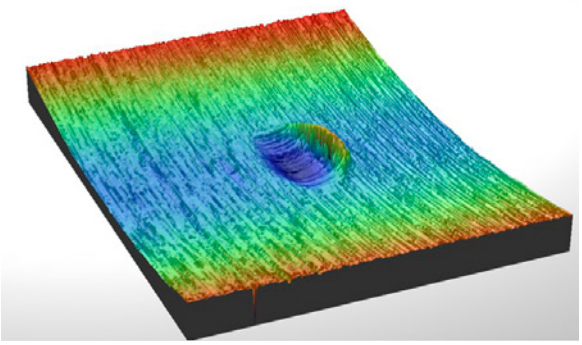
FEATURE ARTICLES

TECHNICAL ARTICLES



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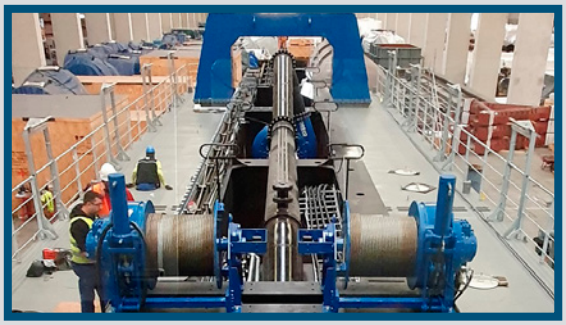
PTE VIDEOS

Bosch Rexroth Hägglunds Drives Used for Cutter-Suction Dredgers



Exceptional power and low inertia were key features for Dutch winch manufacturer Marotechniek when they set out to equip a large cutter-suction dredger for use in gold mining. A successful partnership with Hägglunds (Bosch Rexroth) secures a long service life for Marotechniek's customers.

powertransmission.com/media/videos/play/253

PTE REVOLUTIONS

Technology Convergence

CES 2024 boasted 4,300+ exhibitors, including a record 1,400+ startups from around the globe. The event continued to showcase the innovative trends shaping our future. "The resurgence of CES proves that face-to-face conversations and meetings are a necessity for the technology industry," said Gary Shapiro, president and CEO, Consumer Technology Association (CTA).

powertransmission.com/blogs/l-revolutions/post/9643-technology-convergence

Interact Analysis Examines Low Voltage AC Drive Market

The low voltage (LV) AC drive market saw unit shipments surpass 20 million in 2023 as the market continues to expand, new data from Interact Analysis shows. According to the market intelligence specialist, the pace of growth slowed last year and is expected to continue to do so in 2024, with steady growth returning to the global drives market in 2025.

powertransmission.com/blogs/l-revolutions/post/9663-interact-analysis-examines-low-voltage-ac-drive-market

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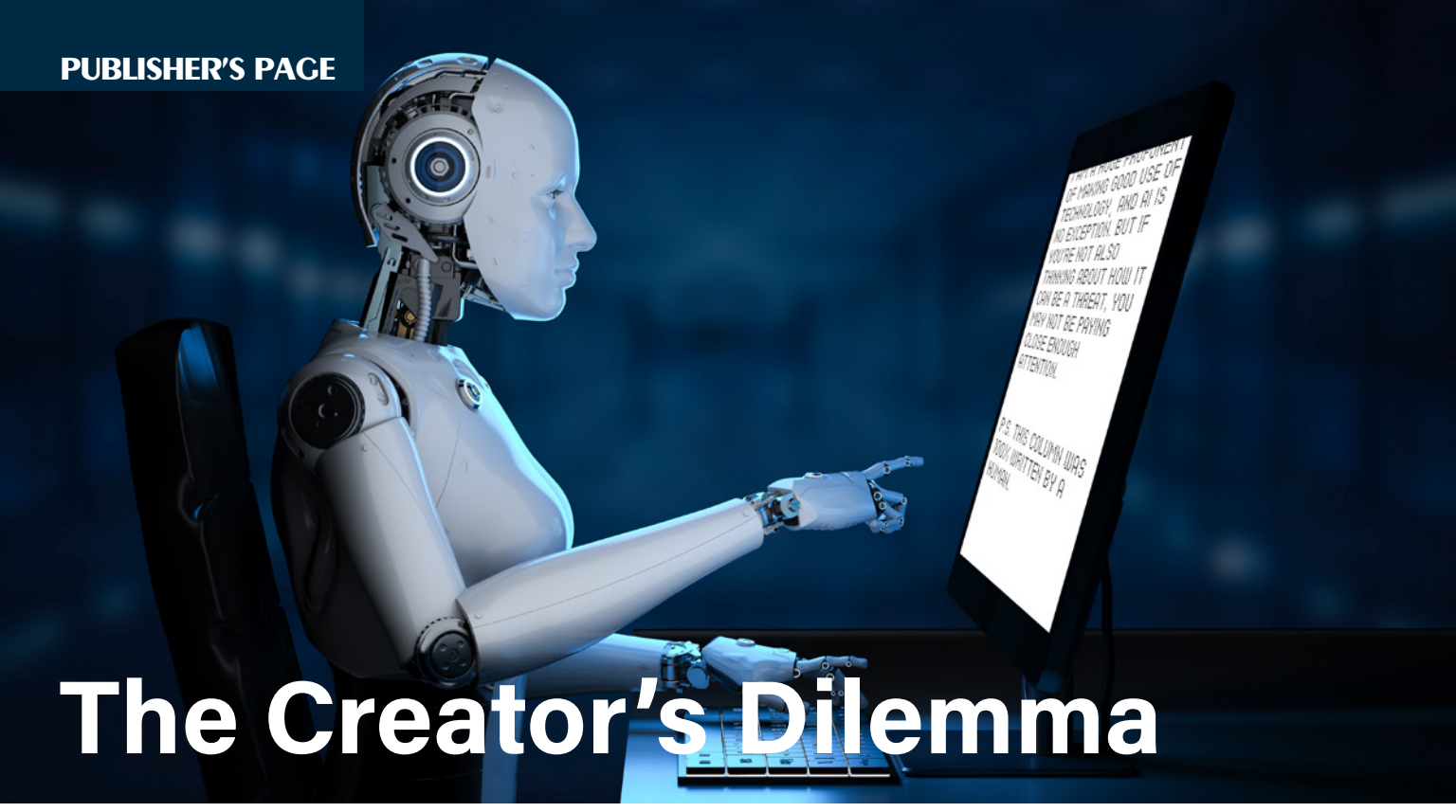


The Creator's Dilemma

AI is everywhere.

It's impacting every phase of life, and every business. Take this issue of *Power Transmission Engineering*, for example. We have articles about AI in hydraulic systems, automation systems and maintenance (p.15); smart farming and mobile robotics (p. 18); plus mentions of AI sprinkled throughout the rest of the issue.

So far, AI is being positioned as the next great tool that can help us all do our jobs better. I believe that's true. We now have AI tools that can help us write e-mails, compose business letters and do many other aspects of our jobs. All those articles I mentioned above also demonstrate great examples of how AI is being used in industry today.

Have any of you tried design engineering tools like Leo (*www.getleo.ai*)? According to their website, "Leo is trained on millions of CAD files and design inputs and is capable of transforming mechanical language into 3D mechanical models adhering to the latest industry standards and best practices. Leo will not replace engineers. Engineers using Leo will replace engineers not using Leo."

That caveat at the end is supposed to make you feel less threatened, so that you trust and use the tool.

For now, you probably can and should use AI, if not via this tool then some other.

But AI is improving and growing at a frightening rate. As someone who is a professional creator, I find this deeply disturbing. I spend most of my waking hours as a writer, editor, publisher and web developer. Almost everything I do is creating new things. Those of you who are engineers can probably relate.

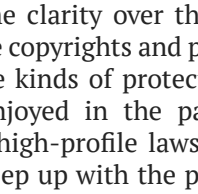
So far, in most endeavors, AI can't replace humans. But that doesn't mean it won't always be so. Already, AI-generated artwork has been auctioned at Christie's. Thousands (or more—who knows?) of AI-generated novels are available on Amazon. Mostly, we can still tell the difference. But we used to say the same thing about deepfakes. The technology has advanced, and it will continue to do so, not just gradually, but exponentially.

The implications, of course, are enormous. When AI is used in the process of creation, who owns the creation? Is it the user who guided the AI? The AI itself? The owners of the original source material upon which the AI was trained? If an AI can be trained on CAD drawings, why not patents?

There are a number of very large ongoing lawsuits that may give us some clarity over the next year. But don't expect things like copyrights and patents to offer you, the creator, the same kinds of protections against infringements you've enjoyed in the past. Regardless of the results of those high-profile lawsuits, nobody's lawyers will be able to keep up with the pace of creation that AI can sustain.

I am a huge proponent of making good use of technology—and AI is no exception. But if you're not also thinking about how it can be a threat, you may not be paying close enough attention.

P.S. This column was 100% written by a human.



Randy Stott
Publisher & Editor-in-Chief

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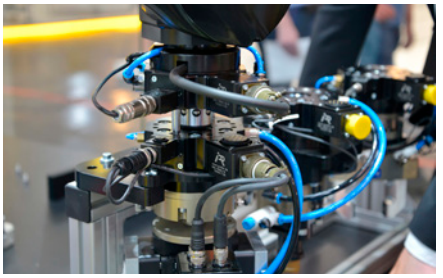
FAULHABER
Motor Assists with Robotic Tool Changer



In industry and logistics, robots generally handle monotonous tasks that they can repeat almost endlessly with steady precision. A new type of tool changer now turns the specialist for large series into a flexible all-rounder, with which even small series and individual pieces can be produced economically. The TKX changer series from the IPR specialists features a motor from Faulhaber in the electric drive of the automatic changer.

The range of tasks that is being carried out by robots has become limitless. It includes gripping, holding as well as manipulations such as clamping and screwing through to foaming and welding. And when it comes to standardized mass production, specialized robots can be used, which perform the same tasks day and night. But many processes require flexibility, such as when it comes to batch size 1. This is also important to save on investment costs. The greater the range of tasks that a robot can carry out, the better.

Mounted to the end of the robot arm, the TKX tool changer is able to remove a variety of different tools from a rack. For example, it enables the robot to first grip and position a workpiece, then to process it with tools, and finally to check and document the quality with a contour sensor or a camera. For this, the adapter needs suitable feedthroughs for the corresponding tool functions. The TKX series offers all conceivable options here, plus several lateral screw-on surfaces for additional modules. But the main task of the tool changer is to securely lock the tool when it is picked up, and to release the lock again quickly and consistently when it is set down after use.

Pneumatic or Electric?

Traditionally, many industrial applications use pneumatic power transmission for this process. Compressed air technology has proven itself over decades, and it is well suited, not least for handling very heavy objects. But a pneumatic system requires compressors, lines, and its own control system with numerous mechanical components—a considerable investment in new systems. In industries with increased demands on cleanliness and hygiene, such as microelectronics or food, pneumatics are out of the question in many places because of the unavoidable emission of compressed air. And pneumatics are an absolute no-go in clean rooms.

IPR—Intelligent Peripherals for Robots in Eppingen has seen a significant trend towards the use of electric drives instead of pneumatic ones.

"In addition to the hygienic safety, electric motors are much more flexible in use. Unlike compressed air connections, power sockets are available almost anywhere. In newly built industrial plants, pneumatic systems are generally no longer installed. For cobots and smaller robots as well as for decentralized locations, the electric version is almost always the better solution," said Roman Batz, development engineer at IPR.

The fact that the electric drive is a real alternative to pneumatics today also has something to do with motor technology, explains Batz: "Great strides have been made in recent years. For our applications, we basically need a lot of power with very small dimensions. Faulhaber offers motors that can easily hold their own compared to pneumatic drives."

Open, Close, Hold

Holding up is also meant quite literally here: The currently most powerful electric model in the TKX series, the TKE 300, is suitable for handling objects weighing up to 300 kilograms. In metal processing, heavy loads such as cast blocks or large forged parts, are handled by robots. The pulling force of their overall mass then acts upon the locking ring in the TKX changer. The torque supplied by the motor in standby mode would be enough for safe holding. But to ensure particularly reliable fixation, IPR also installed self-retaining kinematics, which were developed in-house.

A brushless motor from the Faulhaber BXT family provides the driving force for opening, closing, and holding. With its external rotor technology, it achieves a high ratio of torque to weight and volume. This power density is one of the prerequisites for the unique selling point of the new product family from IPR, which Batz describes as follows: "The TKX series are the first tool changers on the market that are available on the same platform with both pneumatic and electric drives—we also have a manual version in the product range. This means that the entire range of accessories can be used with all drive types without retooling. And switching to electric operation is also quite easy. This opens up new possibilities for robotic automation."

Reliable and Easy to Combine

The TKE changers will be available in seven sizes for handling workpieces from 3 to 300 kilograms. The electric variant of the product family thus covers a wide range of applications, from lightweight robots to stationary applications. The dimensions of the BXT motors used are adapted to the application.

"The range of sizes and the large selection of suitable gears for the optimum reduction in each case was an important criterion for us," Batz. "Robots should be able to achieve seven-digit cycle numbers without maintenance. So only a brushless motor with the highest possible

processing quality can be used. It should be easy to control and manage without additional control—the integrated speed controller takes care of that. Finally, the components have to be able to withstand temperatures of up to +80°C."

IPR Procures All Micromotors from Faulhaber

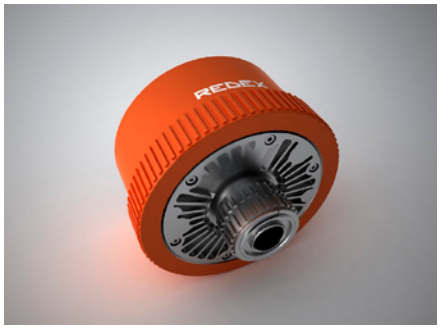
"We started working together many years ago, long before my time," says Batz. In addition to the unique quality of the products, other aspects play an important role for him.

"It starts with the very simple design of motor-gear combinations on the Faulhaber website. It takes just a few clicks to get a comprehensive overview. The technical details are very well documented, and when it comes to precisely calculating the finer points—efficiency, power consumption, temperature development over time, etc.—I always get the support I need."

faulhaber.com

REDEX

Differential Gearboxes Ensure Lay Consistency for Wire Bunching Equipment



When it comes to twisting and bunching wire and cable, consistency is key. For example, the amount of insulation required for residential wiring depends on the wire's lay—the distance between its twists, which is also known as the pitch. Without tight control during the wire bunching process, lay variations occur. As a result, the wire will require more insulation than necessary, raising its cost. A differential gearbox can drive rotating components in a single-twist buncher to provide a more uniform lay, using less power at a lower cost than a two-motor approach.

The SR differential has a unique compound epicyclic gearing design that incorporates two sun gears within the casing along with two gears for each planet axis. Redex's patented assembly process ensures equal load sharing between the planet gears: As planet gear assemblies are added, the torque capacity of the differential increases. The SR unit is designed and constructed to allow power to circulate through the differential so that one element is braking, and the other element is driving. That means the differential input motor only needs to provide driving power for braking. Furthermore, there is a large ratio between the drive motor and the driven reel. Therefore, a large change in motor speed affects a small change in reel speed, which makes the speed

control and, in turn, the lay very accurate during winding.

The SR differential gearbox is also a more attractive option than a two-motor approach, which otherwise requires a designer to size and implement two large motors—one for braking power and another large motor for the driving power. Instead, the differential approach provides greater power efficiency and space use for the single-twist buncher plus greater control of the lay. The result: lower wire-insulation costs and a better bottom line for your bunching operation.

redexusa.com

IGUS

Smart Fixed Flange Bearings Unlock Predictive Maintenance

Igus has developed intelligent two- and four-hole fixed flange bearings with wireless sensing capabilities for wear detection, enabling condition monitoring and preventing costly machine breakdowns.

Constructed from self-lubricating, high-performance plastic, the bearings feature an integrated abrasion sensor, thin circuit board and cableless battery supply. Wear interrupts the board's conductor paths, causing the electronics lose the signal. The sensor then transmits a long-range network signal to an Igus i.Cee switch cabinet module for analysis, including the percentage of abrasion. Over time, the sensor wears away layer by layer—parallel to the bearing's running surface—and will continue to transmit signals on the bearing's condition. Users can see the remaining service life and maintenance requirements via a web-based dashboard, which they can access from a PC, tablet or smartphone.

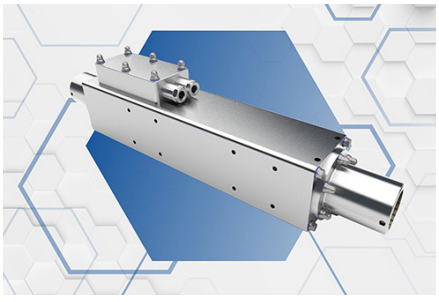
Previously, worn fixed flange bearings would have been easy to overlook, leading to expensive system failure. "This scenario is no longer science fiction," says Thomas Preissner, head of business unit, igubal Spherical Bearings, at Igus. "As part of our smart plastics range, we are gradually equipping plain bearings made of high-performance plastics with networked sensors. Our two- and four-hole fixed flanged bearings from the igubal series now also enable condition monitoring and predictive maintenance to prevent unforeseen damage."

igus.com

DUNKERMOTOREN
Launches Linear Motor Series

With the SL 38 product family, Dunkermotoren, an AMETEK brand, has launched a high-performance linear motor series. As an all-stainless-steel version, the ServoLine 38 STL is built with the highest material quality and environmental resistance.

It does not matter if this motor is used under the strictest hygienic requirements in the food sector, in industrial production, or in the harsh environment of agricultural technology—the SL 38 STL is the perfect partner in terms of power and speed. With peak forces of 3,700 N and accelerations of over 200 m/s^2, it can raise the system´s throughput to a new level, and with maximum precision.



Thanks to the sophisticated drive design with smooth surfaces, special screw connections, and stronger seals, the stainless-steel housing enables IP protection up to IP69K and thus guarantees exceptional resistance against environmental impacts. This ensures simple and thorough high-pressure cleaning as well as high corrosion resistance despite frequent contact with disinfectants and detergents.

High forces, precision, and IP classes make the SL 38 STL an all-rounder for packaging, filling and handling systems in the industrial, agricultural and food sectors.

dunkermotoren.com/en/contact-us

MIKI PULLEY
Steel ASK Couplings Offer Advantages for Centrifugal Pumps

Corrosive chemicals such as chlorine, acids, alkalis and solvents require special pumps to handle their corrosive properties. Centrifugal pumps are most often used and offer advantages during the production process particularly when operating with Stainless Steel ASK Couplings from Miki Pulley.

These couplings feature a unique "sliced" body structure making them an effective low-cost corrosion resistant solution that can accommodate many types of misalignment commonly found in chemical transfer pumps.

One piece ASK Coupling design is the ideal method for compensating all types of system misalignment in a shaft-to-shaft connection. The sliced design handles high rotation speeds in high temperature ranges experienced in chemical processing systems.

The ASK Coupling offers exceptional torsional stiffness and strength. This proven Miki Pulley coupling design assures accurate shaft rotation with precise control. The Stainless Steel ASK coupling dampens conductive heat transfer from motor to output shaft. Also important, the coupling provides limited shaft misalignment to alleviate premature system bearing wear.

The coupling's aerodynamic profile decreases noise while optimizing performance at high speeds. Simple yet reliable, ASK couplings are easily configurable to accommodate a wide range of DBSE (distance between shaft ends). Bores can be arranged with clamp, split-collar, or keyed styles for specific application requirements.

ASK Couplings are a cost-effective choice for chemical chlorine applications and small conveying systems used in the food service industry.

miki-pulley.com

MITSUBISHI
Electric Launches Selection Tool

The Factory Automation (FA) Integrated Selection Tool allows customers to plan and configure their Mitsubishi Electric machines, resulting in a downloadable Bill of Materials (BOM).

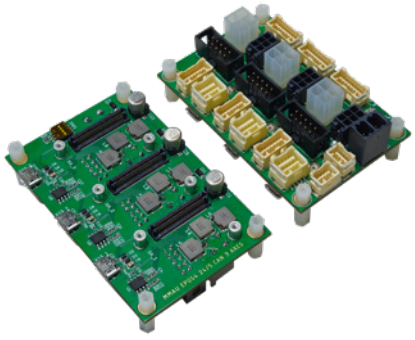
Mitsubishi Electric Automation, Inc. is proud to launch its FA Integrated Selection tool as a configuration resource for its customers. As opposed to digging through catalogs and manuals to select components that meet system requirements, the tool is designed to do this for customers in a user-friendly way.

The FA Selection too allows users to configure their system by device or network type and includes Mitsubishi Electric PLCs, VFDs, Remote I/O, HMIs, Servos, and cables. Customers can configure 1 axis or 1000 and visualize the configuration with a system configuration diagram. Once configured, the tool will output a list of selected product model names, quantity, and item descriptions and can be exported into Excel. The BOM can be used to expedite the quoting process for sales engineers, application engineers, inside sales associates, and other members of your organization.

"As a former application engineer, I can attest that some of the more challenging and repetitive work when configuring a BOM is selecting accessories. The FA Integrated Selection Tool simplifies this process by filtering results to only display compatible items and helps users discover potentially missing items before an order is placed, reducing time and mistakes for users of all levels of experience," said Dan Zachacki, product manager servo and motion at Mitsubishi Electric Automation.

mitsubishielectric.com

MAXON
Introduces 3-Axes Motion Control Motherboard



The release of the maxon EPOS4 Micro 24/5 CAN positioning controller has realized the option of significantly minimizing the "real estate" traditionally occupied by motor controllers.

The Micro is capable of motion control of brushed DC motors with encoders, and brushless DC motors with hall sensors and encoders. With a 5 A continuous current output, this miniature controller allows precise control of motors up to 120 W continuously (360 W intermittently).

Given its miniature size, measuring 32 x 22 x 7 mm, it was not designed to offer connectors for a plug-and-play facility (unlike the "EPOS4 Compact"). Integration of the Micro into a drive system requires integration through motherboard electronics design, which can be costly and time-consuming. if an application-specific PCB is not already being developed.

To eliminate this cost, and to give designers an easy development path, the maxon Australia engineering team developed the EPOS4 Micro 24/5 CAN 3-Axes Motherboard as an easy-to-integrate solution to multiaxis motion control. In this case, a single 3-Axes Motherboard offers the ability to control up to 3 x DC/BLDC motors. Achieving multiaxis motion control has never been more accessible.

As the EPOS4 Micro controllers are CANopen slaves, they require a CANopen master to send data and commands. With the 3-Axes Motherboard, connection to a CANopen master and the rest of the CAN bus is made easy with two CAN connectors. Adhering to the CiA 402 protocol, the EPOS4 Micro controllers are standardized Motion Control Slaves, ensuring compatibility with motion libraries from various PLC manufacturers.

Recognizing the often-intricate nature of drive elements within complex systems, the 3-Axes Motherboard provides extensive connectivity options. The motherboard caters to 4 x digital inputs, 2 x analog inputs, and 1 x analogue output for each EPOS4 Micro. With the flexibility to connect an SSI absolute encoder for each axis, the available options will have you covered for most applications.

Each axis can be configured individually over a USB connection. The *EPOS Studio* software offers regulation tuning, parameter configuration, and object dictionary visualization tools to assist in the integration process.

The 3-Axes Motherboard has been optimized for size, measuring 84 x 54 x 27.3 mm, without a trade-off in functionality. This small size means the motherboard is still viable if you are only driving one or two motors, and the units can be daisy-chained for any multiple DC motors required for the application.

For those seeking tailored solutions, the maxon Australia engineering team stands ready to offer a spectrum of services, including motherboard design and custom modifications, software programming and configuration, and comprehensive system design.

maxongroup.us

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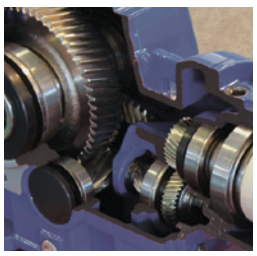

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HEAVY-DUTY, TACKY RED, PETROLEUM OIL-BASED EXTREME PRESSURE (EP) GEAR OILS

- Heavy-duty, tacky, red, extreme pressure (EP) petroleum-based gear oils.
- These tacky, adhesive, extreme pressure oils cling tenaciously to gear teeth.
- Formulated for heavy equipment and heavy service industrial applications.
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2024 Trends in Fluid Power

AI, smart manufacturing, electric vehicles, and product specification highlights industrial shift

Matthew Jaster, Senior Editor

Anticipation vs. reaction is the name of the game in fluid power, hydraulics, and pneumatics. The organizations embracing mechatronics, digital toolsets, AI and the electrification movement will be in a much better position moving forward. Here are a few of the trends/technologies to consider relating to fluid power and motion control today:

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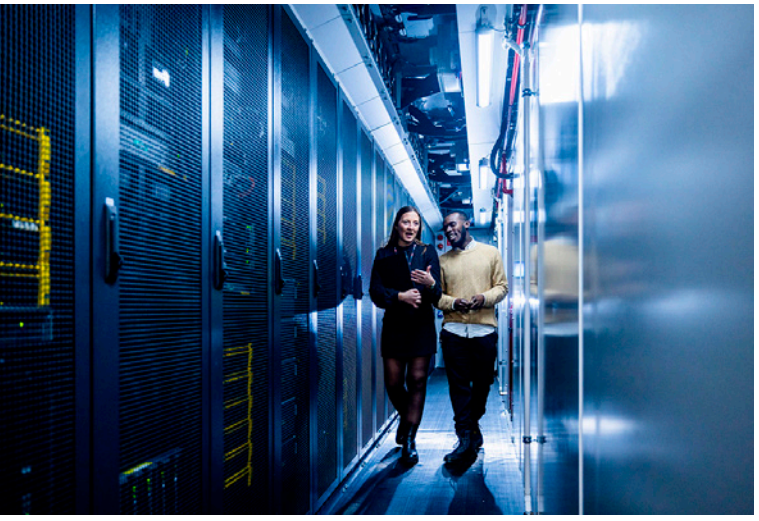


Danfoss and Google recently announced a partnership to make use of the latest advances in artificial intelligence (AI) and promote energy efficient solutions in data centers.

1. Strategic Partnerships

Strategic partnerships between Danfoss/Google, Sony/Honda, and Formlabs/AWS hint at the changing face of manufacturing. It's no coincidence that tech companies are collaborating with manufacturers to optimize work processes to enhance productivity.

Danfoss and Google recently announced a partnership to make use of the latest advances in artificial intelligence (AI) and promote energy efficient solutions in data centers.

Under the partnership, Danfoss will use Google Cloud's generative AI capabilities to optimize the customer experience, streamline internal work processes and improve productivity across the organization. This can be done, for example, by using gen AI to collect and surface information, automate knowledge, generate product descriptions, and create solutions with chatbots in e-commerce.

"This is a great example of a partnership utilizing each other's strengths and using technology to optimize the customer experience, increase productivity and reach sustainability goals. Danfoss is a leader in energy efficiency, and these solutions help support Google's 2030 goal of running our data centers on carbon-free energy 24/7. We're happy to deliver AI innovation through Google Cloud, enabling businesses like Danfoss to operate in new and smarter ways," said J.P. Clausen, vice president of data center innovation at Google.

Danfoss is working with Google to implement sustainable cooling systems for data centers and to design systems that reuse the excess heat produced by data centers. Danfoss Turbocor compressors (*danfoss.com/en/products/dcs/compressors/turbocor/*) provide highly reliable, highly efficient solutions when expertly applied by OEM partners and are being installed by Google to improve the energy efficiency and decarbonize heating and cooling systems in data centers.

Meanwhile, Danfoss' heat reuse modules will make it possible for Google to capture and reuse heat produced by data centers, providing a renewable energy source to supply heating on-site and to neighboring commercial and residential buildings, communities, and industries that need heat for their processes. Going forward, Danfoss' expertise in decarbonization solutions will be used to an even greater extent to advance data center sustainability in Europe, North America, and beyond.

"At Danfoss, we want to revolutionize how we build and decarbonize data centers together with our customers. When we partner up across industries, like we have done with Google, we accelerate this development towards building better and more sustainable data centers - using technologies available today," said Jürgen Fischer, president, Danfoss Climate Solutions.

`danfoss.com`

2. Value-Added Part Sourcing

For OEMs of agriculture, construction, mining, oil/gas, off-road, forestry, and heavy-duty trucking equipment, there can be thousands of parts to integrate into a single vehicle. These parts include the hydraulic components that provide the force or power for lifting, pushing, digging, dumping, and braking. Because of their complex machining needs, OEMs rely on preferred suppliers of hydraulic parts and assemblies to design and manufacture these critical components, which must be high quality, cost-effective, and delivered on time to remain competitive.

The existing process typically requires working with multiple vendors based on their specialization and the value-added services they provide from coatings to assemblies. Establishing these trusted relationships and orchestrating parts needs across multiple vendors takes time, consuming considerable organization resources and adding costs to OEM production.

The OEM's expanding demand for supplier support has resulted in manufacturers positioning themselves to be one-stop parts shops, offering a menu of complementary parts spanning different materials such as metal and plastic. A consolidated offering can help streamline parts sourcing for OEMs and provide better support to them as their product needs evolve.

The OEM's expanding demand for supplier support has resulted in manufacturers positioning themselves to be one-stop parts shops, offering a menu of complementary parts spanning different materials such as metal and plastic. Courtesy Premier Hydraulics.

Premier Hydraulics produces standard hydraulic fittings, valves, manifolds, hose connectors, and flanges in large quantities. In addition, the company specializes in custom-engineered products, meaning it can create assemblies or sub-assemblies with combined components.

"OEMs today want quality parts at a competitive price that are delivered on time. Beyond that, many also want value-added services like expert engineering, design support, and the ability to provide custom parts such as manifolds, flanges, valves, and fittings in various materials. Depending on how it is designed, the custom component can become a part of a kit, sub-assembly, or assembly of complete product," said Dinitrise Hicks, sales manager, Premier Hydraulics, Farrell, PA.

According to Hicks, OEMs often request custom parts, such as hydraulic fittings, that vary from SAE standards in size, thread size, pitch, or materials. Custom parts may also be necessary if OEMs require a unique part function or part combination.

According to Hicks, a common question asked by OEMs of their parts manufacturers is, "Can you make this part?" Often behind this question is an OEM's perception that the parts vendor can only work with one material or provide limited or no value-added services.

To meet OEM's need for value-added custom parts, Premier Hydraulics dramatically expanded its capabilities after the company was acquired in late 2022 by PTR Group, a leading contract manufacturer of components and subassemblies.

PTR Group has embarked on a strategic campaign to acquire companies offering complementary parts manufacturing differentiated by material and product type to broaden the breadth of their overall parts portfolio. As a result of their acquisition strategy, PTR Group now offers OEMs a wide range of parts, including metal components and subassemblies. They can also custom manufacture precision thermoplastic injection mold tooling, zinc die-cast mold tooling, and molded plastic components.

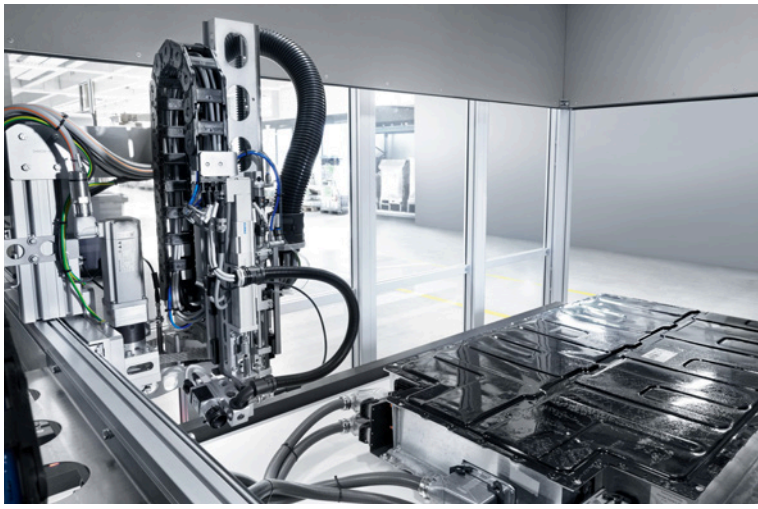
Within each of these areas, PTR Group can offer OEMs a range of complementary value-added parts and services that go beyond just manufacturing. This includes in-house part and tool design, tool build, complex assembly, and testing.

These acquisitions indicate the imperative to enhance manufacturing operations, thus maintaining competitiveness in the global fluid power, hydraulics, and pneumatics markets. (Information provided by Del Williams, technical writer, Torrance, CA.)

ptrgroup-mfg.com

3. E-Mobility and Electrification Solutions

Element—a global provider of testing, inspection, and certification services in London—is partnering with a major manufacturer to test EV battery cooling plates and their associated tubes, lines, and connectors. The manufacturer will receive reliable data that will help them to refine and rewrite internal procedures which primarily includes thermal cycling and pressure pulsation. During these tests, coolant is circulated through the plates at varying temperatures and pressures while a range of environmental extremes, including external temperatures from -30°C to over 100°C are applied simultaneously. Element will also supply the manufacturer with data regarding the performance of the plates upon startup, as technicians evaluate flow characteristics of the coolant through the plates using typical flow rates at low temperatures.



HAHN Automation Group utilizes Festo's electric and pneumatic technology to enhance the company's e-mobility solutions.

In addition to their specialized battery cooling systems, hybrid and electric vehicles share some fluid systems with traditional internal combustion engines, including hydraulics systems for brakes, transmission and steering fluid systems, and cooling systems for radiators. The components of an EV differ from those of an internal combustion vehicle; EVs also tend to be significantly heavier and have a different weight distribution. This can affect the functionality of other fluid systems in the vehicle, such as hydraulic steering and brake systems, requiring that those systems be redesigned. For many vehicles, especially novel vehicles, full vehicle lab testing is required to understand how systems affect one another, and how this might impact handling, safety, and longevity.

Additionally, electric vehicle manufacturers depend on the safe and flawless functioning of batteries. HAHN Automation Group has therefore developed a battery tester that carries out a complete test of the mobile energy storage units fully automatically. This innovation includes a 3-axis gantry for optical and leak tests, consisting of electric drives from Festo,

The HAHN Battery EOLT is a complete solution for testing battery packs. All relevant test scenarios for 90 percent of all battery packs available on the market can be implemented on the end-of-line test system because the system can be easily scaled to many sizes. HAHN Automation Group offers everything from a single source: from power electronics and test equipment to test software and automation.

"Thanks to its vast expertise in testing technology, the company helps define the best test strategies to optimize cycle times and ensure the targeted product quality," said Christian Bubat, global business development manager at HAHN Automation Group. The company worked with the

HAHN Automation Group has developed a battery tester that carries out a complete test of the mobile energy storage units fully automatically.

Production Engineering of E-Mobility Components (PEM) chair at RWTH Aachen University on the development.

How exactly does the testing work? The axis gantry moves and positions two sensors along all edges of the battery pack to detect any leaks from the battery housing and cooling unit. The camera checks that all plates and stickers are fitted correctly and that the battery pack is processed properly and detects any mechanical damage. A battery management system test checks the communication and evaluates the sensors.

"As in many previous automation projects, it has been proven that Festo is the right, globally reliable partner in electric and pneumatic automation technology," added HAHN's Head of Development, Martin Sulzbacher.

Thanks to the long-standing partnership, they have been familiar with Festo's automation products for a long time and can use them in a precise and specific way. With online product finders, intelligent engineering software and engineering tools, HAHN Automation Group designers can find the right products for the development of new machines and systems reliably, quickly and without time-consuming calculations.

hahnautomation.com

4. Scalable IIoT Solutions

Festo and Siemens announced their latest partnership at last year's Hannover Messe. Festo joined Siemens Industrial Edge Ecosystem where customers can purchase numerous apps from different providers. The integrated IoT solutions based on these apps offer customers greater productivity, flexibility, and sustainability.

Siemens launched the independent, cross-vendor app store for industrial customers in October 2021. This marketplace is based on the Siemens Industrial Edge platform. It uses edge computing to process data right at its source, such as on an industrial PC in machines or plants. Festo is offering data-driven AI solutions from the Festo Automation Experience (Festo AX) portfolio on the marketplace.

"This gives Festo an additional sales channel for industrial customers in the areas of mechanical engineering and production," said Oliver Niese, digital business at Festo. "Users benefit from the opportunity to purchase apps from different providers in a single place, to install them and run them at the machines on the shop floor."

Another customer benefit is the wide range of software components that can be integrated into production in a standardized way. IoT solutions can even be scaled across lines and factories, thus considerably reducing manual software maintenance.

"At Siemens, we want to add even more partners to the Industrial Edge Ecosystem, especially those in the field of automation," said Rainer Brehm, CEO of factory automation at Siemens. "A larger selection increases flexibility for our customers, who can build individual IoT solutions from Siemens and partner modules (Industrial Edge apps and devices). We create the greatest value for our customers when we work together across company boundaries."

Festo launched its Industrial Intelligence portfolio with the Festo AX Data Access connectivity solution, which feeds data from Festo components into Siemens Industrial Edge to supply analysis applications with data. Customers can build a monitoring solution based on the data and thereby improve maintenance processes, lower their energy consumption, and improve quality. Additional industrial apps from Festo are expected to be available on Siemens Industrial Edge, such as AI-based wear prediction for pneumatic drives.

Festo AX Industrial apps like AX Data Access are building blocks that can be combined with other applications from Festo, Siemens, and third parties to form larger solutions. They enable production employees to independently build digital solutions for optimizing productivity. The partnership allows Festo and Siemens to support their customers on the path to becoming more sustainable, more flexible, and highly efficient.

festo.com

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Festo AX provides a blueprint to increase productivity, reduce energy costs, prevent quality losses, optimize the factory floor, and create new business models. Photo courtesy of Festo.

Mobile Harvesting

Smarter, productive farming solutions in agriculture applications

Matthew Jaster, Senior Editor

While the factory has received a modern makeover in recent years, it's no surprise various industrial segments are taking advantage of digital tools to promote efficiency, sustainability, and productivity. The farming and agriculture community has embraced automation, robotics, IIoT, drones and autonomous vehicles to address global food demands and production limitations.

Continental Explores Various Agriculture Technologies

Continental Engineering Services (CES) has designed and developed an environmentally friendly weed control system. The prototype is based on optical sensor technology and supported by automotive-grade software and AI. The system provides a highly efficient and precise organic method of agricultural weed control by accurately detecting weeds and eradicating them with boiling water instead of herbicides. The concept demonstrates Continental's expertise in agriculture and the company's ability to adapt to specific industrial needs.

Continental is also working on a mobile robotic system for greenhouses. This initiative uses a versatile modular design, centered around a self-propelled robotic platform that can accommodate various implements to autonomously perform tasks such as UVC treatment, targeted harvesting, and monitoring, around the clock.

Continental recently launched user-friendly technologies like *ContiConnect Lite*, the entry to digital tire monitoring. Thanks to a Bluetooth enabled sensor inside the tire, the system gives farmers easy

The mobile robotic system for greenhouses can accommodate various devices.

A Bluetooth enabled sensor inside Continental's tires gives farmers easy access to essential tire data directly on their mobile devices.

access to essential tire data directly on their mobile devices. No additional hardware is needed. This allows efficient operations, reduced emissions, and significant cost savings by helping farmers set the right tire pressure before starting work in the field.

Additionally Continental technologies include the VF TractorMaster Hybrid tire that underscores the performance of the new generation of Continental agricultural tires with its fuel-efficient and soil-friendly tire technology. NightViu LED Working Lights improve visibility even during night harvests with high light-efficiency, and the ProViu 360 surround-view camera system increases safety for machine operators as well as their direct surroundings.

The agricultural sector has experienced continuous growth in recent decades and is an important strategic segment for the Continental Group. Christian Kötz, member of the executive board for the group sector tires reported on the company's agricultural strategy at Agritechnica 2023 in Hannover, Germany.

"Since our re-entry into the agricultural tire business in 2017, we have experienced continued growth. Leading OEMs rely on our products for their original equipment," said Kötz. "With a portfolio that now includes around 110 items in nine different product lines for agricultural machinery, we are serving the market with tailor-made advanced tire technology for optimized total cost of ownership."

ContiTech has successfully completed eight acquisitions in agriculture technology in recent years. They have also extended the agricultural footprint within the organization at seven Continental locations across the world. We aim to expand this growth even further."

`continental.com`

Fully Autonomous Tractor

John Deere showcased a 40,000-pound autonomous tractor at CES 2024 (Las Vegas) featuring new camera and GPS technology that will address labor shortages and global food demand in the agriculture market.

This high-tech vehicle is designed to revolutionize precision farming. Attendees could control the tractor miles away using their iPhones for start/stop, speed control and turning capabilities. The company has its sights on autonomous crop harvests by 2030.

The autonomous tractor serves a specific purpose: feeding the world. The global population is expected to grow from about 8 billion to nearly 10 billion people by 2050, increasing the global food demand by 50 percent. Furthermore, farmers must feed this growing population with less available land and skilled labor, and work through the variables inherent in farming like changing weather conditions and climate, variations in soil quality and the presence of weeds and pests. All of these factors impact a farmer's ability to farm during the most critical times of the year.

The autonomous tractor has six pairs of stereo cameras, which enables 360-degree obstacle detection and the calculation of distance. Images captured by the cameras are passed through a deep neural network that classifies each pixel in approximately 100 milliseconds and determines if the machine continues to move or stops, depending on if an obstacle is detected. The autonomous tractor is also continuously checking its position relative to a geofence, ensuring it is operating where it is supposed to, and is within less than an inch of accuracy.

To use the autonomous tractor, farmers only need to transport the machine to a field and configure it for autonomous operation. Using *John Deere Operations Center Mobile*, they can swipe from left to right to start the machine. While the machine is working the farmer can leave the field to focus on other tasks, while monitoring the machine's status from their mobile device.

John Deere Operations Center Mobile provides access to live video, images, data and metrics, and allows a farmer to adjust speed, depth and more. In the event of any job quality anomalies or machine health issues, farmers will be notified remotely and can adjust to optimize the performance of the machine.

`deere.com`

The John Deere autonomous tractor can be transported to a field and configured for autonomous operation.

With its Coaxial Twin Rotor design and impressive payload capacity, the DJI Agras T40 drone can handle multiple tasks, from mapping and surveying to spraying and spreading.

Advanced Farming Drone Technology

Leveraging aerial imagery, multispectral data collection, and crop spraying for precision agriculture, Volatus Drones empower farmers and the agricultural community to optimize their practices for a more environmentally sustainable future. Using cutting-edge drone technology, agriculturists can quickly and efficiently collect visual and multispectral data over hundreds—and even thousands—of acres per day, providing them with critical information to identify crop issues at an early stage, monitor crop growth, optimize nutrient utilization, and make informed decisions that lead to successful and profitable crop yields.

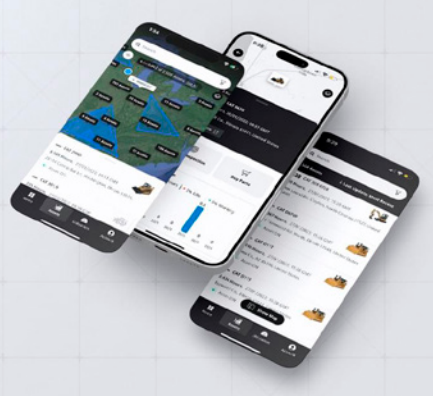
With its Coaxial Twin Rotor design and impressive payload capacity, the DJI Agras T40 drone can handle multiple tasks, from mapping and surveying to spraying and spreading. The drone offers Active Phased Array Radar + Binocular Vision providing a 360-degree obstacle sensing and intelligent terrain technology. It can combine multiple functions in one drone including mapping, spraying, and spreading. The DJI Agras T40 was designed to withstand harsh environments. Rugged, flexible, and recyclable, the Marlyn Cobalt three-part EPP foam body has been engineered to operate in the most challenging conditions with increased surveying speed, accuracy, and control. With a cruise speed of 65 km/h and a flight time of up to 50 minutes, the wingtip-mounted propellers and large tailfin give the Marlyn Cobalt stability in survey/airplane mode while constantly correcting altitude to get the sharpest aerial images in the toughest of winds.

`enterprise.volatusdrones.com`

Telematics and Preventative Maintenance

A good way to ensure that machines experience no unexpected downtime is by using telematics data to perform preventative maintenance. By using tools like the *Cat Inspect* app or *VisionLink* software, you can schedule maintenance around project deadlines and send reports and alerts to the appropriate parties without delay so that maintenance isn't missed.

Telematics devices also provide valuable insight into operational efficiency. To make sure that operators are using the equipment appropriately, telematics allows workers to receive alerts when they are doing things like coasting in neutral, not wearing seatbelts, or pushing the machine into engine overspeed. Identifying where and when these behaviors occur can be turned into a training opportunity for machine operators. This data can also be used to set a benchmark for performance.



A good way to ensure that machines experience no unexpected downtime is by using telematics data to perform preventative maintenance.

By using fleet management software, organizations can both reduce paperwork and create more thorough, searchable record keeping. With the *Cat Inspect* app, users can perform machine inspections and send them to the appropriate people without lots of manual paperwork to fill out. This allows for any action items to be addressed immediately, which increases safety and machine efficiency and solves issues in a timely fashion.

It's not just large operations that benefit from fleet telematics systems either: smaller operators can still adopt these solutions and will find that the preventative maintenance aspect is especially useful for productivity improvement. For those with one to five machines, telematics can make preventative maintenance more predictable. And as smaller operators begin to grow and can't be physically present at the job site, they can take full advantage of this data to see when machines stop, start and idle.

What if you have a mixed fleet? You can install Cat telematics devices on competitive equipment to capture data and perform maintenance. What data you can gather, however, will really depend on the age and size of each machine.

A telematics program can be an excellent way to gain more insight into your machines by increasing productivity and utilization and improving safety and performance.

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Powering the Future of Transportation

The interplay between mining and EV infrastructure

Aaron Fagan, Senior Editor

As the world transitions towards sustainable energy solutions, the demand for electric vehicles (EVs) is rapidly growing. This shift not only highlights the importance of reducing carbon emissions but also underscores the critical role of mining in supporting the infrastructure needed for this green revolution. From lithium-ion batteries to rare earth metals, mining plays a pivotal role in powering the future of transportation. The intricate relationship between mining and EV infrastructure highlights challenges, opportunities, and the path forward.

The advancement of EV infrastructure heavily relies on the innovation and production capabilities of motion and control industries. Electric propulsion systems, motor controllers, energy storage solutions, and power distribution networks constitute the backbone of electric mobility. These components not only enable the efficient operation of EVs but also contribute to reducing carbon emissions and enhancing overall vehicle performance.

The Role Mining Plays

EVs rely heavily on advanced battery technology, predominantly lithium-ion batteries, to store and deliver power efficiently. These batteries require key components such as lithium, cobalt, nickel, and graphite, all of which are mined from various parts of the world. For instance, lithium is extracted from mineral-rich brine pools or hard rock deposits, while cobalt and nickel are often mined alongside copper or extracted from nickel laterite deposits. Graphite, another essential component, is primarily sourced from graphite-rich ore deposits.

Like the mining sector's contribution to EV battery production, the motion and control industry relies on a range of critical materials. High-performance magnets, advanced semiconductor materials, lightweight alloys, and precision-engineered components are just a few examples of the essential elements driving innovation in electric propulsion systems. Ensuring a sustainable supply chain for these materials is paramount to supporting the continued growth of electric mobility.

The Brine Mine

Brine mines play a crucial role in the extraction of lithium. These mines typically consist of vast underground reservoirs or salt flats containing lithium-rich brine solutions. Extracting lithium that way involves pumping the brine to the surface and then evaporating the water, leaving behind lithium carbonate or lithium hydroxide. Brine mining operations are often located in regions with specific geological characteristics, such as arid climates and salt flats, where lithium concentrations are naturally high.

While brine extraction offers certain advantages, such as lower production costs compared to hard rock mining, it also poses environmental challenges, particularly concerning water usage and the management of brine disposal. Sustainable practices, such as water recycling and minimizing ecological impacts, are essential for mitigating these concerns and ensuring the long-term viability of brine mining operations.

As the demand for lithium continues to surge with the growth of EVs and renewable energy storage, the development of responsible brine mining practices becomes increasingly vital in meeting global supply needs while minimizing environmental footprint.

Challenges in the Mining Supply Chain

While the demand for these critical minerals is surging, the mining industry faces several challenges in meeting this demand sustainably. Environmental concerns, social impacts, and geopolitical tensions surrounding resource-rich regions pose significant hurdles. The concentration of these minerals in a handful of countries raises concerns about supply-chain security and potential disruptions.

In addition to powering EVs, the electrification of mining equipment is gaining traction as another critical aspect of reducing carbon emissions in the mining industry.

Electrified mining equipment, such as haul trucks, loaders, and drilling rigs, offer significant environmental benefits over traditional diesel-powered machinery. By utilizing electric power sources, these machines produce fewer greenhouse gas emissions and reduce reliance on fossil fuels, aligning with the broader goals of sustainability and reducing the carbon footprint of mining operations.

However, transitioning to electrified mining equipment presents its own set of challenges, including infrastructure requirements for charging stations and battery technology capable of withstanding the demanding conditions of mining environments. Nevertheless, investments in electrification technologies for mining equipment hold promise for not only mitigating the environmental impact of mining but also improving operational efficiency and worker safety in the long run.

Environmental Impact and Sustainability

The extraction and processing of minerals for EV batteries can have adverse environmental consequences if not managed properly. However, advancements in sustainable mining practices, such as responsible sourcing initiatives and technological innovations, offer avenues to mitigate these impacts. Efforts to recycle and reuse battery materials are gaining traction, reducing the reliance on virgin resources, and minimizing environmental footprint.

While EVs are often hailed as environmentally friendly alternatives to traditional gasoline-powered cars, critics point out that large-scale mining operations are energy-intensive and that the nature of mineral extraction and processing may offset some of the environmental benefits gained from using EVs.

While recycling of battery materials is often touted as a solution to mitigate the environmental impact of EV batteries, some point out challenges and trade-offs associated with recycling processes. They argue that current recycling technologies are not sufficiently efficient or cost-effective, resulting in low recycling rates and environmental pollution from discarded batteries.

The energy and resource inputs required for recycling may offset some of the environmental benefits gained from using recycled materials, raising questions about the overall sustainability of the recycling process.

Geopolitical Considerations

The geopolitics of resource distribution adds another layer of complexity to the EV supply chain. Certain countries possess significant reserves of critical minerals, giving them considerable leverage in the global market. This dynamic has led to concerns about supply security and the potential for trade disputes or geopolitical tensions. Diversifying sources of these minerals and promoting international cooperation are crucial strategies to mitigate geopolitical risks and ensure a stable supply of materials for EV production.

Investment in Infrastructure

Building a robust infrastructure to support the widespread adoption of EVs is essential for realizing a sustainable transportation future. This includes not only the development of charging networks but also the expansion and modernization of mining operations and processing facilities. Governments, industry players, and investors need to collaborate to fund and incentivize infrastructure projects that promote responsible mining practices, enhance supply chain resilience, and accelerate the transition to electric mobility.

Critics of EVs and the associated infrastructure raise concerns about the finite nature of the minerals required for battery production. They argue that the rapid growth in demand for lithium, cobalt, nickel, and other critical minerals could lead to supply shortages and price volatility, ultimately hindering the widespread adoption of EVs. As reserves of these minerals are concentrated in a few countries, there are fears of geopolitical tensions and trade disputes over access to these resources.

Technological Innovation and Research

Advancements in mining technologies and materials science are instrumental in overcoming challenges associated with EV battery production. From exploration and extraction techniques to battery chemistry and recycling processes, ongoing research and innovation are driving improvements across the entire supply chain. Breakthroughs in energy-storage technologies, such as solid-state batteries or alternative materials, hold the potential to reduce dependence on traditional battery components and further enhance sustainability.

Some skeptics question the long-term viability of lithium-ion batteries as the primary energy storage solution for EVs. They argue that current battery technology has limitations in terms of energy density, charging speed, and lifespan, which could restrict the widespread adoption of EVs. Critics advocate for exploring alternative energy storage technologies, such as hydrogen fuel cells or advanced capacitors, which they believe may offer superior performance and sustainability compared to lithium-ion batteries.

Conclusion

The convergence of mining, motion power, and EV industries underscores the multifaceted nature of the transition toward sustainable transportation. By recognizing the interconnectedness of these sectors and fostering collaboration, we can drive positive change and usher in a future where mobility is not only efficient and accessible but also environmentally responsible.

The electrification of transportation represents a paradigm shift towards a cleaner, more sustainable future. However, realizing this vision requires a holistic approach that considers the entire supply chain, from mining to end-of-life recycling. By prioritizing responsible mining practices, investing in infrastructure, fostering innovation, and engaging stakeholders, we can build a resilient EV ecosystem that benefits both the environment and society. As we navigate the challenges and opportunities ahead, collaboration and commitment to sustainability will be key in powering the future of transportation.

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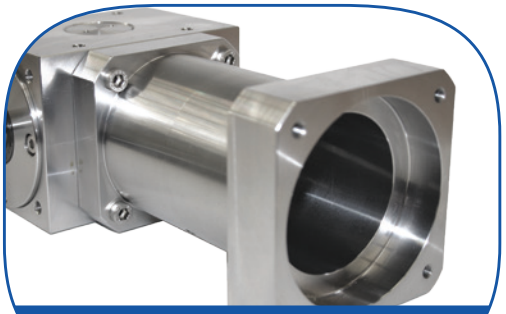

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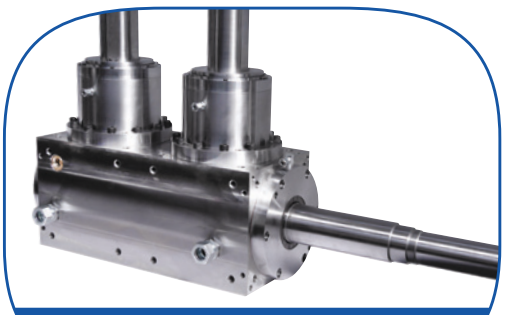

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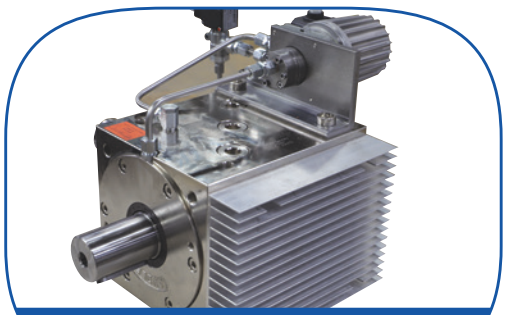

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Introducing the Bearing Show 2024

Uniting innovation with end-user needs

Aaron Fagan, Senior Editor

Mark your calendars for March 19–21, 2024, as the Bearing Show—colocated with Lubricant Expo—descends upon Huntington Place in Detroit. As North America's premier exhibition and conference dedicated to bearings, this free-to-attend event promises to be a groundbreaking convergence of industry leaders, technological advancements, and invaluable networking.

Designed to bridge the evolving demands of bearings end-users with cutting-edge technologies, the Bearing Show serves as a vital nexus for OEM development, maintenance professionals, and R&D engineers alike. From machine manufacturers to industrial plants, global distributors, and beyond, attendees will find themselves immersed in a community offering innovation and connection.

At the heart of the Bearing Show lies a commitment to aligning end-user needs with the latest advancements throughout the supply chain. Featuring exhibitors representing the entire ecosystem, from finished bearings to condition monitoring, tools & equipment, components, materials, testing, and machinery, participants will explore the full spectrum of bearing production and application.

Whether you're a component supplier, equipment manufacturer, or a comprehensive bearing solution provider, the Bearing Show offers an opportunity to expand your business. Through connections and meetings across the breadth of the bearing ecosystem and customer base, attendees will unlock new avenues for growth and collaboration.

March 19

9:30–10:45 am
Leadership Panel: Future Proofing the Lubricants Sector

11:15 am–12:30 pm
Enabling Technologies for Reducing Scope 1 Emissions in Heavy Duty and Off-Road Applications

11:15 am–12:30 pm
Bearing Systems and Designs

2:00–3:15 pm
Evaluating Resource Availability Within the Lubricant Supply Chain

2:00–3:15 pm
Managing Oil Degradation and Bearing Wear Through Lubrication Best Practices

3:30–4:30 pm
The Carbon Puzzle: Getting a Grip on Data, Processes, and Measurements to Achieve Scope 2-3 Carbon Reductions

March 20

9:30–10:45 am
Developing the Supply Chain for Re-Refined Base Oils

9:30–10:45 am
Ensuring Uptime and Reliability by Implementing a Quality Lubrication Program

11:15 am–12:30 pm
Driving Demand for Re-Refined Base Oils: Balancing Performance, Economic, and Environmental Trade-Offs

11:15 am–12:30 pm
Showcasing Advances in Preventive Maintenance & Condition Monitoring

2:00–3:15
Investigating Performance Capabilities and Compatibility of Biobased Technologies

THE BEARING SHOW NORTH AMERICA

2:00–3:15 pm
Food fight! Overcoming The Challenges of Food-Grade Lubrication Environments

3:30–3:55 pm
Evaluation of Environmentally Acceptable Lubricants for Army Corps of Engineer Operated Dams and Navigation Structures

3:30–4:30 pm
Examining Performance Requirements of Next-Generation Metal Working Fluids

4:00–4:30 pm
Unravelling Renewable Feedstocks, Biodegradability, and Environmental Compatibility of Lubricants, Greases, and Fluids

March 21

9:25–10:40 am
Examining Hardware Design Trends Within EVs and Implications for Lubricant Requirements

9:30–9:55 am
Understanding Lubrication Requirements of Advanced Robotics

10:00–10:25 am
Microporous Polymeric Lubricants: The Environmentally Friendly Way to Lubricate Bearings and Chains

10:30–10:55 am
Energy Efficiency of HVI HF Hydraulic Oil

11:15 am–12:30 pm
Improving Range and Energy Efficiency of EVs Through Advances in Lubricant Technology

11:30–11:55 am
Ghost Particles—Particle Counting Methods and their Impact on ISO Cleanliness Codes

12:00–12:25 pm
Alkylated Naphthalene—Synergetic Booster for High-Performance Formulations

12:30–12:55 pm
Unlocking Profit Through Strategic Lubrication Management: A Deep Dive into Calculating Value; Total Profit Added

2:00–3:00 pm
Testing Advancements and Developments for EV Lubricant Evaluations

Technologies on Display Include

- Ball Bearings
- Lubrication
- Roller Bearings
- Bearing Components
- Maintenance
- Seals
- Caging
- Measurement Devices
- Sensors
- Condition Monitoring
- Mounted Bearings
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Beyond Bearings: Unleashing the Potential of Ball Splines in Robotic Designs

The often-overlooked benefits of integrating high-speed, multiaxis motion on a single shaft

Pablo Olachea and Ian Miller

When motion system designers need complex, high-speed, multiaxis motion, they might first think of elaborate, prepackaged robot arms. Or, if they need only a few axes, they might configure a separate profile or round rail for each axis. But hiding between those options is simple and proven ball spline technology. This multiaxis motion solution has existed for years and is still highly relevant to today's complex motion schemes. Ball splines use a unique architecture integrating rotary and linear motion on a single shaft. This gives them more flexibility to implement complex motion schemes in tighter spaces, providing a two-for-one deal in motion control (Figure 1).

Figure 1—Ball splines, which enable rotary and linear motion on a single shaft, deliver high reliability and life expectancy under varying operating conditions. All figures courtesy of Thomson Industries, Inc.

Integrating Rotary and Linear Motion

Ball splines allow both linear and rotational motion. This is accomplished with a common shaft performing two independent motions (Figure 2). The shaft includes axial ground grooves called "splines" along its length. This also includes a ball spline nut that rides along the axial ground grooves, locking rotational movement or radial moment loads.

To drive the axial rotation, the ball spline nut is turned. This nut houses a series of balls allowing free motion along the axis (i.e., the nut can slide along the shaft with minimal friction). When rotated, these balls apply a perpendicular force to the shaft via the spline cut grooves, turning it.

To drive linear motion, the spline shaft is moved forward or backward using a linear actuator, like a piston. Since the ball bearings roll within the grooves (instead of gliding), a lower coefficient of friction and wear creates a smooth, precise linear movement and higher velocities.

Because of the anchoring/support, this arrangement also resists torsional loading (i.e., the shaft resists rotation unless driven by the motor). If a torsional load is applied externally to the shaft as it is extending/retracting/stationary, the spline nut supports it, resisting that load.

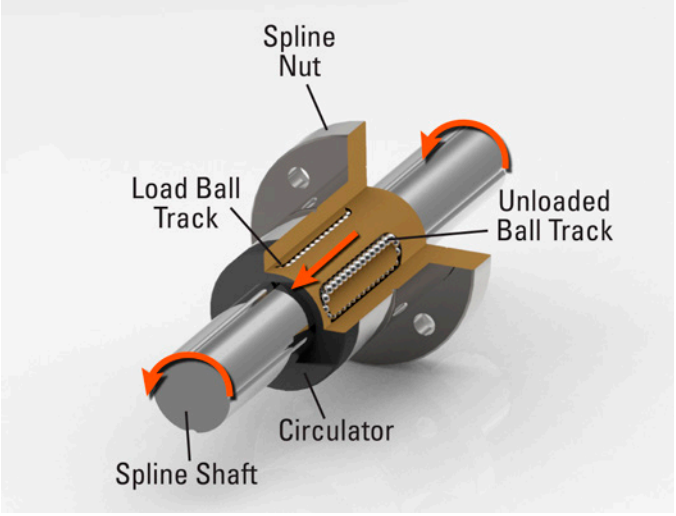

Figure 2—Enabling linear and rotary motion on a single shaft, ball splines deliver many benefits to robotic designs, including increased compactness, load capacity, speed, and accuracy.

Benefits

Better Space Utilization

Compressing multiple axes into one makes ball splines more space-efficient than traditional bearing solutions. This entails fewer components and moving parts, plus a larger load capability within that space than comparable linear bearings offer.

Higher Load Capacity

Wide, precision-ground grooves increase load-carrying capabilities and improve rigidity and stiffness for handling up to twice as much moment load as traditional bearing assemblies. Ball splines also distribute more load along the shaft's length. This lets them carry higher loads than conventional bearings, which may be more subject to localized stress concentrations. Ball splines are also better with off-center loads, common in tool change and pick-and-place applications.

Negligible Friction

The ball guidance system provides nearly friction-free motion through precise contact with tangential points of rolling balls guided by spline shaft grooves and the race within the nut.

Higher Speeds

Ball splines need only small forces to displace the spline nut axially while transmitting torque and minimizing friction. This contributes to about 20 percent increased speed over a traditional ball screw and smoother operation. Ball splines can handle speeds up to 2 m/s.

High Precision and Accuracy

Ball splines offer high precision and accuracy in positioning, making them ideal for applications requiring exact control. Zero backlash ensures no rotational play or lost motion when changing directions. Ball splines maintain this precision and low friction even under heavy loads.

Easy Installation and Maintenance

Installation is easy, typically requiring a rough bore and mounting holes drilled and tapped to secure the flanged nut, or a rough bore and keyway for a round nut. The simple design makes ball splines easier to troubleshoot and service. The maintenance team can pull the spline from the shaft, lubricate it and put it back in, while profile rail and ball screws require higher upkeep.

High Durability

Ball splines have a longer service life than some traditional bearings due to increased ball-bearing point contacts, which reduces stress and increases load capacity. The less stress on the balls, the heavier the load they can handle while resisting wear and providing consistent performance.

Ball splines often feature seals and protective covers that shield the ball bearings from contaminants like dust and debris, further extending life. The ball spline architecture has a safe load capacity from every angle, unlike a radial bearing, where the balls must be carefully positioned to balance the load.

Cost Savings

Upfront savings are substantial for two axes of motion, and savings multiply with higher volumes. Ball splines are significantly less expensive than packaged, multiaxis systems. Having fewer components and moving parts makes them more economical than profile rail assemblies. They deliver better moment load resistance for the price and require less surface preparation for installation. Ball splines' cost is like round rail assemblies, but within

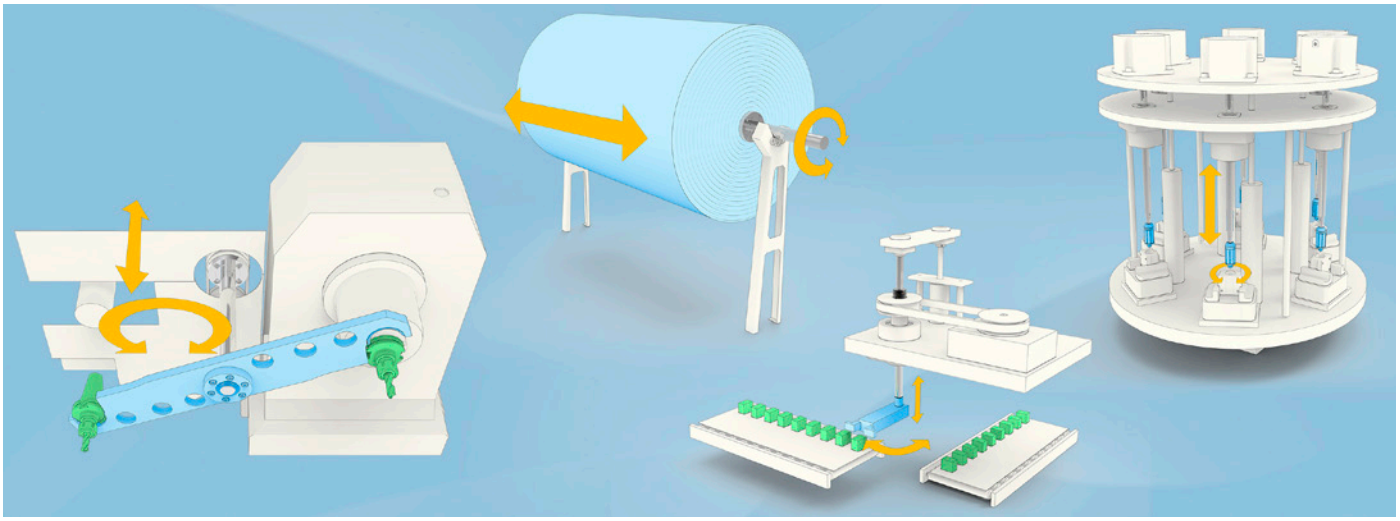

Figure 3—The benefits of ball splines make them ideal for various applications, including (from left to right) CNC machining, paper mill drums, pick and place, and machine automation.

a smaller footprint and fewer axes. Long term, fewer components need maintenance, saving time and money.

Applications

Motion designers integrating linear and rotary motion should evaluate ball spline technology to see if configuring them on the same shaft is beneficial. Here are some application examples in factory automation, transportation, and healthcare/research that have taken advantage of ball spline functionality:

Factory Automation

- Repeatable pick-and-place assembly, such as high-speed semiconductor object positioning in which an arm picks an item from the assembly stage, rotates and places it on another.
- CNC tool positioning in machining and milling operations.
- Packaging equipment for precise control of filling and capping mechanisms.

Transportation

- Aircraft controls, such as flap deployment and throttle adjustment.
- Military vehicles to facilitate rotation, gun elevation and vehicle steering.

Healthcare and Research

- Robots to assist in surgical procedures.
- Medical imaging devices to facilitate the precise motion of CT scanners, or other high-precision image acquisition devices.
- Laboratory analysis, such as microscope stage and sample positioning.

Some vendors offer online guidance to help machine designers optimize ball splines for their applications. For example, one ball spline selection tool offers visual aids that give users the best configuration in minutes.

Finding Their Place

Ball splines are perfect for machine designers needing motion on multiple axes. Compared to packaged, multi-axis systems, ball splines require less space and can be deployed at higher speeds, with lower friction; greater precision; longer, more predictable life; and easier maintenance. They can also be less expensive.

While a ball spline might replace packaged robotic arms, their space efficiency and zero backlash make them usable as components of those assemblies, possibly extending a vertical stroke or assisting with heavier radial and axial loads.

As business operations become more complex, and digitalization, AI and mobility advances bring more axes of motion into automation strategies, the ball spline's unique performance and versatility may finally receive the respect it deserves.

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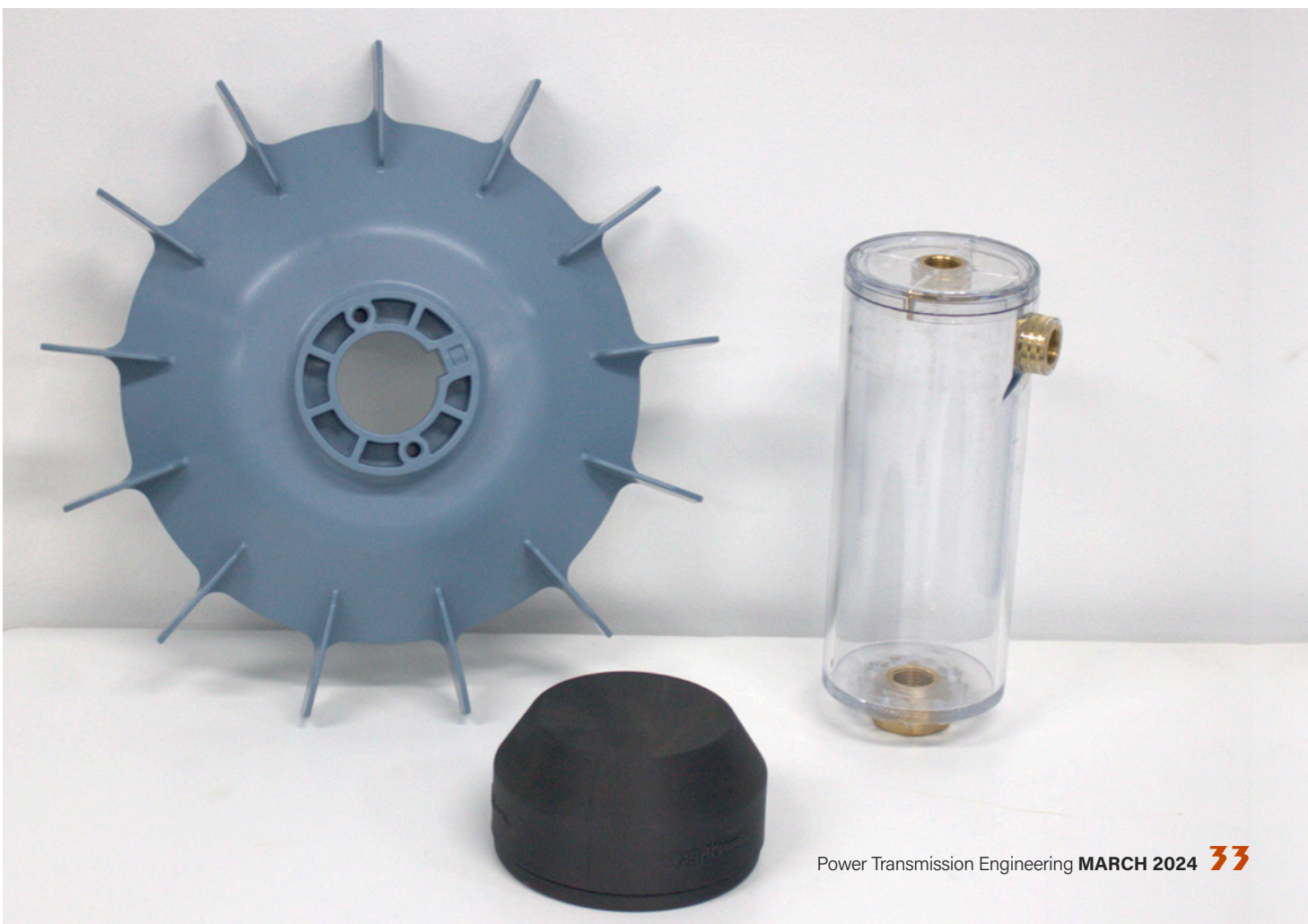
Designing Plastic Components for Power Transmission Engineers

Justin Frohock, R&D Engineer, Sumitomo Machinery Corporation of America

Steel, iron, and aluminum are the dominant materials in the mechanical power transmission industry for good reason: high power density requires the high strength and stiffness of metallic materials. Plastics, however, offer valuable features that should be utilized for good gearbox design. Their low density, low cost, and corrosion resistance properties are ideal for low-stress applications such as fans and covers; transparent plastics are ideal for oil expansion tanks to aid operators in visualizing oil level and appearance from varying distances; high-strength plastics can be used as couplings between metallic components to eliminate fretting wear. Despite their value, plastics are still used infrequently enough in the gear industry that engineers often mistakenly design plastic components as if they were metallic.

Designing plastic components has never been easier. Guides to the basic concepts of plastic design, such as wall thickness, draft, ribbing, etc. are readily

Figure 1—Sumitomo Cyclo Cooling Fan (left). Sumitomo Safety Cover (center). Sumitomo Oil Fill Cup (right).



available, and fully automated design analysis of a component can be generated at many rapid manufacturing websites. While these resources allow anyone to design a manufacturable plastic component easily, they typically don't guide how a plastic component might interact within an assembly or environment.

Plastic materials have unique interactions that should be considered before design finalization. As noted herein, some common pitfalls should be avoided and mitigated during the first iteration of a plastic prototype design to maximize success.

Thermal Expansion

Thermal expansion is a common consideration with metallic components when designing press fits, setting bearings, etc. But consider that plastic materials typically have a thermal expansion rate 5 to 10 times higher than steel: this can cause some issues. When plastic components operate on a shaft or within a bore, resultant fits should be calculated. Furthermore, plastic thermal expansion rates are often high enough that dimensional change due to temperature should be included in tolerance analyses or "stack-ups" to ensure the intended final fit. For example, depending on the specific grade of plastic, a 50 mm long component made of Nylon 66 will expand up to 0.25 mm when undergoing a 50°C temperature rise. Thermal expansion could be contributing to the tolerance stack-up just as much as the tolerance itself! When analyzing thermal expansion, it's vital to ensure data accuracy: use the actual data sheets for the chosen material or standardized sources like CAMPUS (*campusplastics.com*), as material properties of plastics can vary wildly even within the same polymer family (Ref. 1).

Water Absorption

Plastic components are injection molded, 3D-printed, or otherwise manufactured with the raw material completely dry. After the component is released from the mold, it begins absorbing moisture from the ambient air, until it achieves equilibrium with the environment. This is the state at which plastic components are physically measured, and mechanical properties such as strength and hardness are reported. However, if a component's operating environment has higher moisture content, e.g., it's submerged in water or an environment with heavy splashing, the plastic will absorb more water. This additional water content impacts the component's mechanical properties and causes it to swell physically. Most plastics only change slightly due to this phenomenon, but many families of Nylon (PA) are affected significantly, in some cases growing as much as 1 percent. Referencing the previous Nylon example, the 50 mm long Nylon 66 component could grow 0.5 mm from moisture content alone. This can cause similar issues to thermal expansion and needs to be accounted for by choosing the right material in applications that may experience high moisture content (Ref. 2).

Stress Relaxation

Plastic components undergo a phenomenon known as stress relaxation (not to be confused with creep). When a plastic component is subjected to constant strain, the internal stress in the plastic will reduce over time. This has several effects, but the most common application of stress relaxation is in the bolted joint. Bolts generally stay tight because opposing inter-

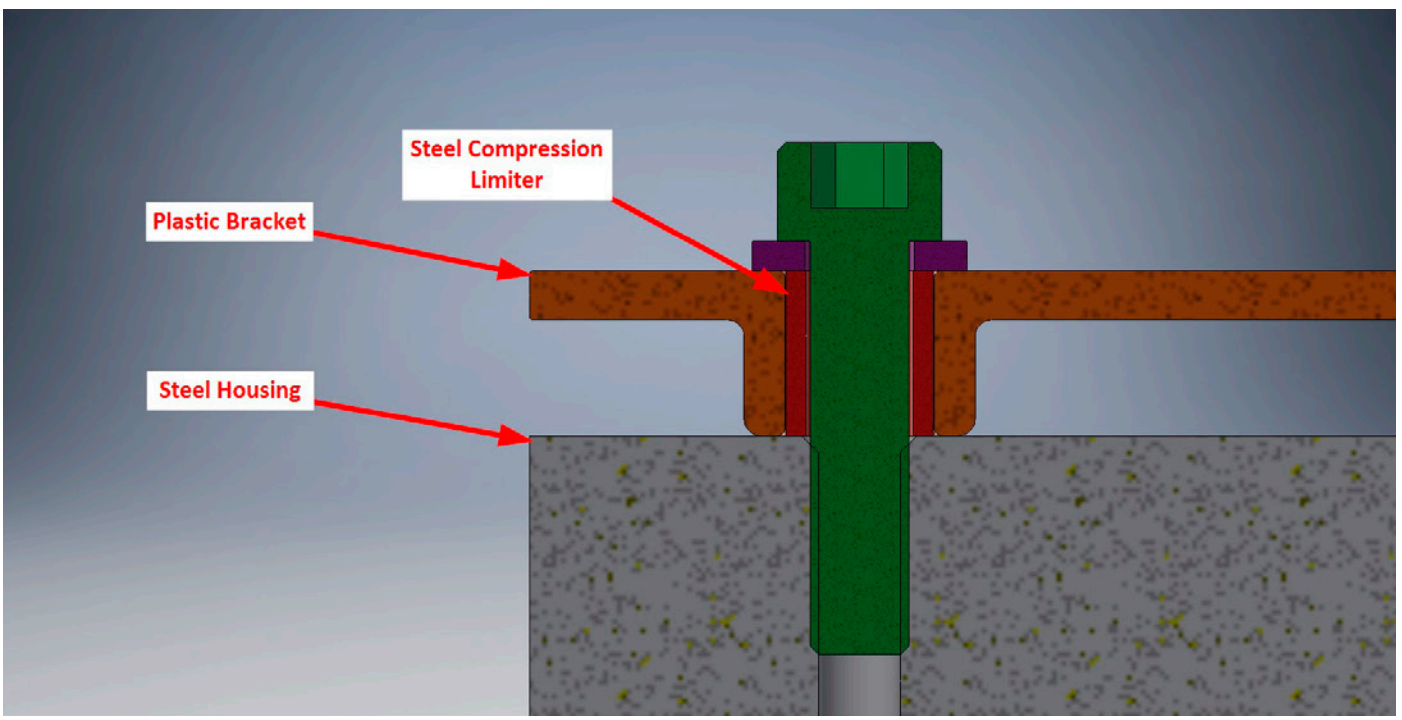


Figure 2—Example of compression limiter use.

nal stresses within the bolt and the bolted members cause resultant forces on the threads, which then stay in place due to frictional forces. However, since plastics undergo stress relaxation, a traditional bolted joint with plastic members will lose its axial stress over time, and thus lose friction in the threads, allowing the bolt to loosen. Fastening a plastic component generally requires the use of compression limiters or thread-forming screws. Compression limiters are metal tubes inserted into the component to act as the bolted member for standard fasteners (see Figure 2). Thread-forming screws for plastic are specially designed to retain their clamping force despite stress relaxation (Ref. 3).

Knit and Meld Lines

Plastic components are injection molded by forcing molten plastic to flow through a mold under high pressure. Since the plastic is in a liquid state, the long polymer molecules intermix as they flow, and remain entangled when they solidify. This creates much of the component's material strength since molecules share loads over many intertwined neighbors. In a plastic component with a hollow feature such as a hole, molten plastic must flow around the hole, splitting into two fronts that meet on the opposite side. When the two fronts combine into a single flow front, the meeting point is called a "meld line;" when the flow fronts coincide at the end of the mold, the meeting point is called a "knit line" (see Figure 3). At knit and meld lines there is significantly less intermixing of molecules, and thus the strength at the knit line may be much lower than the rest of the material. This is especially pronounced using brittle materials or materials including glass fiber reinforcement, where the strength at a knit or meld line can be less than half that of the general material. Thus, when designing hollow components, one should be especially aware of how the mold will fill, to ensure that knit lines don't form in critical areas (Ref. 4).

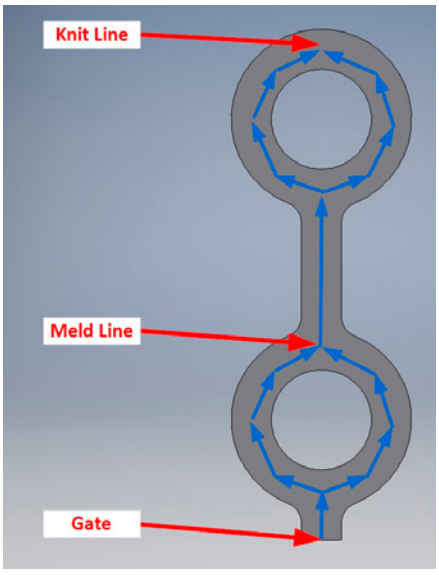


Figure 3—Meld and knit line examples.

Conclusion

Plastic components are used in the power transmission industry, but they certainly aren't incorporated as often as they could be. Plastics offer low cost, low weight, and feature benefits that can't be attained with metals. When designing a supporting feature, consider utilizing a plastic design, keeping in mind the unique design parameters that plastics demand. Use an online plastic design guideline or tool such as those available from Xometry (*xometry.com*) or ProtoLabs (*protolabs.com*) to ensure that a component is manufacturable and keep the above concepts in mind when ensuring the component is compatible with its assembly and environment.

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Justin Frohock is working as a Research & Development Engineer at Sumitomo Machinery Corp. of America in Chesapeake, VA. He has a B.S. degree in Mechanical Engineering from Old Dominion University. He has 11 years of experience designing, developing, and testing geartrains in multiple industries, and holds two U.S. patents.

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Spindle Bearings—Potential Damaging Mechanisms and Mitigation

Exploring contact conditions in both steel-steel and hybrid ceramic bearings

Guillermo E. Morales-Espejel, Liang Guo, Feliciano Greco, and Marc Gelardini

Introduction

Application conditions of super-precision spindle bearings can be represented in a simple way by a diagram involving bearing speed and bearing load. Bearing speed is represented by the quantity nd_m where n is the bearing rotational speed in rpm and d_m represents the bearing mean diameter in mm. In this schematic diagram (Figure 1) different application conditions can be distinguished. Bearing load is better represented by the maximum Hertzian contact pressure (P_h) in the inner ring of the heaviest loaded rolling element. In this diagram several application areas (platforms) can be found: (i) performance, (ii) extreme and (iii) ultrafast.

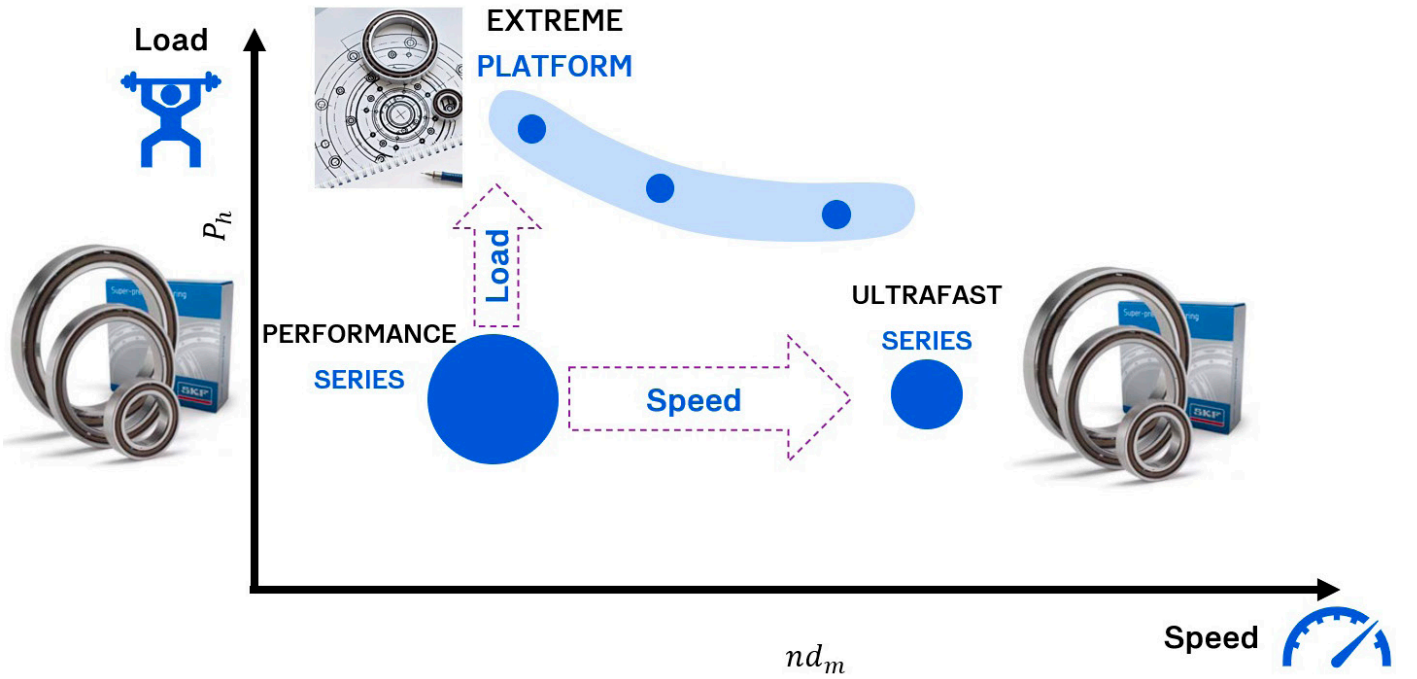


Figure 1—Schematics of the different SKF super-precision bearing platforms for spindle applications showing their relative position respect to load and speed.

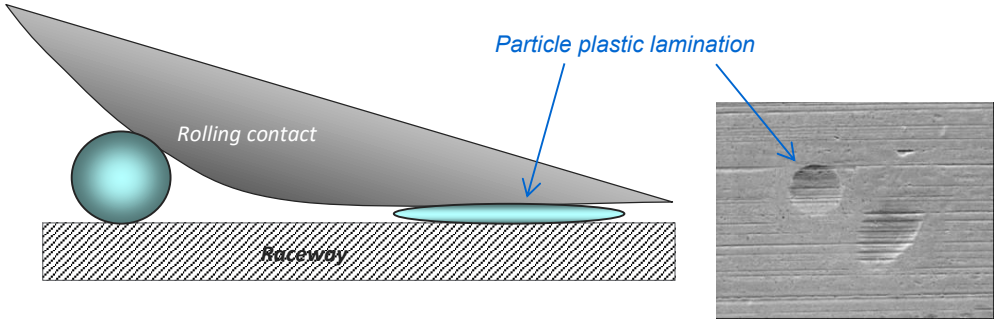
Bearings in this schematic might have different damaging mechanisms according to their relative position respect to load and speed axes. It is important to understand these mechanisms to properly select a bearing. In the present article the main damaging mechanisms covering all regions of Figure 1 will be explained, besides some potential solutions or mitigation actions will be mentioned.

Performance Series

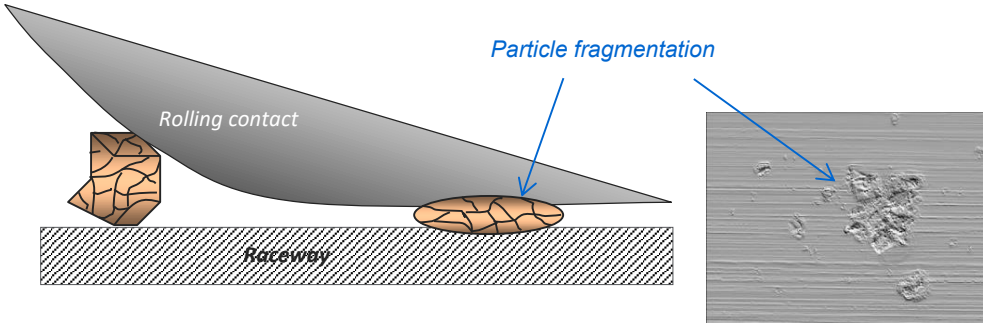
The operation zone here is the classical one for "standard" super-precision bearings, steel-steel and hybrid ceramic. Typical damaging mechanisms here are indentations and surface distress. Looking in detail of each one of them follows.

Solid Particle Indentations

For a solid particle to be damaging in a bearing contact, it must be entrapped and it must be big enough to create an indentation. The hardness of the particle also plays a role, hard-brittle particles will chatter and will create very tiny but sharp indentations, softer particles (metals and fibers) will create indentations with rise material around (shoulders), see Figure 2. However, fiber particles in general will produce very shallow indents (basically negligible). The process of indentation has to do with the material of the particle and the material of the raceway, the harder the particle the smaller but the sharper and deeper the indentation becomes. The harder the raceway the shallower the indent that will be created. There are many works in literature that show indentation mechanisms from particles. However, entrapment and indentation together have been studied in the past by SKF. In Ref. 1 a simple entrapment model is derived for assumed spherical particles, but it can be generalized to any geometry because the relevant geometrical aspect is the local radius of curvature of the particle. With this model the plot of Figure 3 has been obtained, where the maximum diameter of the particle that can be entrapped is given as a function of the rolling bearing diameter and the coefficient of friction between the rolling bearings walls (raceway) and the particle.



(a) Ductile particle (metallic)



(b) Tough particle (mineral oxide)

Figure 2—Schematics of entrapment and indentation process of ductile (a) and brittle (b) particles in rolling bearings.

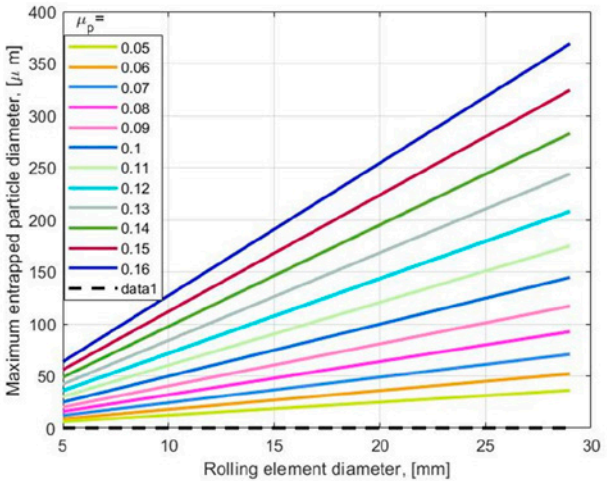


Figure 3—Maximum entrapment particle diameter for different rolling element diameters and different particle-bearing friction coefficients.

It is reported in Ref. 1 that laboratory experiments were carried out where friction coefficients of $\mu_p = 0.1$ were measured. However, in Ref. 2 it is reported that a bigger range is seen in field applications ($0.1 \leq \mu_p \leq 0.15$).

Ref. 1 also describes an indentation model, based on the geometry of the deformed particle. The indentation can be characterized by a simple indentation profile as described in Figure 4.

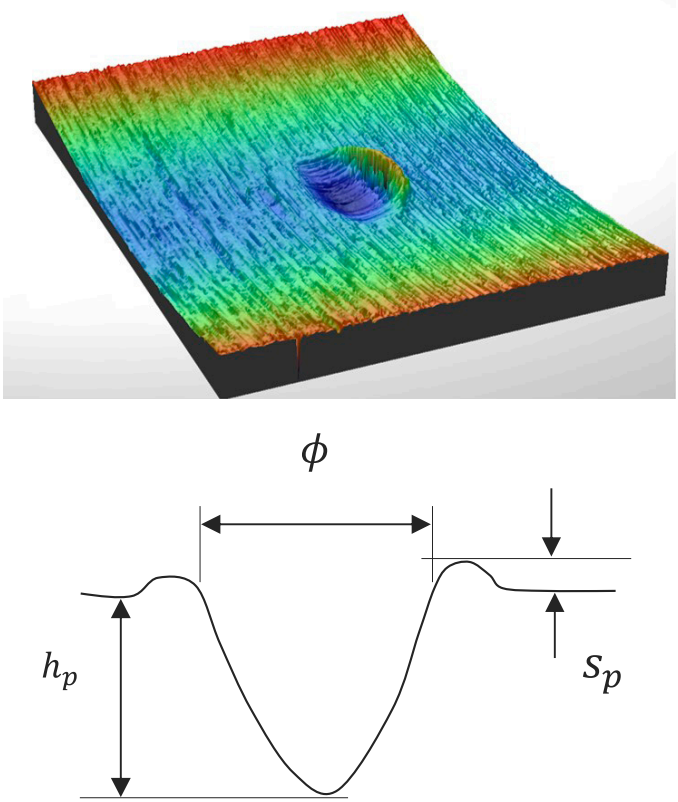


Figure 4—Schematics of the simplified geometry of an indentation profile.

Ref. 3 proposes a model that separates surface from subsurface survival, based on the SKF Generalized Bearing Life Model (GBLM) approach (Ref. 4) to estimate the damage induced by the indentations in bearings. This damage (represented by a damage integral) is a function of the contact pressure, the lubrication quality (κ) in the bearing and the three geometrical aspects of the indentation described in Figure 4. A more general approach for damage calculation due to solid particle contamination in bearings is given in the ISO 281 standard (Ref. 5), with the estimation of the variable η_c also denoted as e_c in this standard. Finally, Ref. 2 includes a diagnosis methodology based on bearing inspection to estimate the cleanliness level in the application for ISO 281 utilization.

Embedment of Particles

In conditions of speeds and loads typical of this series, particle contamination can be critical, due to the high sliding in the contacts. Increasing rotational speed in a bearing (even under fixed sliding-rolling ratio and spinning) will directly increase the sliding speed in a nearly linear way, with potentially some fluctuations in the real contact angle (in the case of ball bearings). Therefore, this increase in sliding speed can enhance the entrapment and embedment of particles on the raceway which will locally (due to sliding) increase heat generation from friction. Especially in the case of non-metallic material (oxides, ceramics, etc), therefore in steel-steel bearings the particles might isolate local heat transfer and send it back to the contacting opposite surface, generating local smearing marks and eventually seizure damage due to lubricant film thickness collapse. The process is illustrated in Figure 5. Oil-air applications may blow away external particles making the particle entrapment more difficult. However, greased bearings do not have the means to do this and will more easily entrap these particles. Rings with higher hardness can better cope with embedment, this is the case for series with harder steel than "standard" for example, in the performance and ultra-fast series.

Surface Distress

Surface distress has been discussed in (Ref. 6). This is a damage mechanism which involves the competition of surface fatigue and mild wear, and it is due to poor lubrication conditions in the bearing, either from low viscosity lubricants or starvation (lack of available lubricant close to the contact). The asperities in thin lubricant film conditions will induce high pressures at the asperity tips and microcycles of fatigue and this will induce tiny cracks generation (see Figure 6). Mild wear is the kind of wear (either abrasive due to tiny particles or chemical) that will remove only the asperity tips (it does not change the profile of the contacting surfaces). This "polishing" effect of asperity tips can reduce the pressures and reduce the stress, it can also remove fatigued mate-

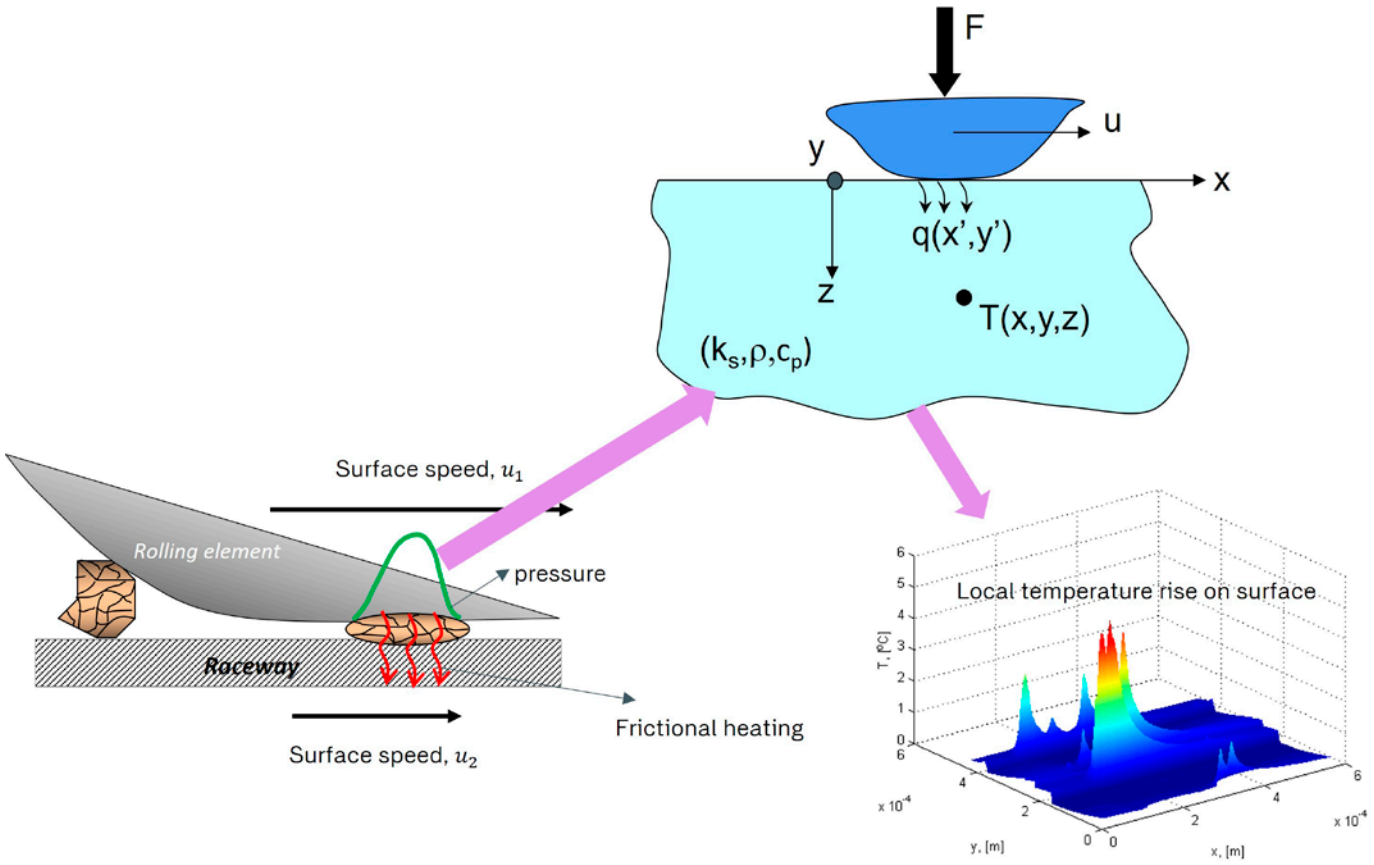


Figure 5—Schematics of potential local smearing damage mechanism due to nonmetallic entrapped particles in steel-steel bearings with high sliding conditions. In the figure (as an example) the particle is embedded on the upper surface (rolling element). However, in reality for steel-steel bearings particles can also be embedded in the raceway.

rial which will reduce the possibility of crack openings. Thus, for spindle applications surface distress can be induced mainly from starvation effects due to high speeds (kinematic starvation). In relation to this, Ref. 7 shows test results of steel-steel and hybrid ceramic bearings at different combinations of load and speed to try to assess the so-called transition diagrams in rolling bearings, with standard lubrication (spindle) conditions, which also covers grease, and standard bearing steel (ASTM 52100). Figure 7 shows the results, where clearly hybrid bearings better deal with harsher conditions. Hybrid bearings are also better off when it comes to poor lubrication (Ref. 8). It must be noticed that the transition diagram sets the boundary between the fatigue and the seizure (or adhesive wear) damaging modes (Ref. 9).

In high-speed applications, the difficulty is always the estimation of the real kinematic starvation conditions, Ref. 7 includes a calculation model, but even there the link between the availability of oil in the raceway and the specific lubrication system used is not easy to make. Often some testing is needed to establish this link. In general, simple quality lubrication estimations ("kappa") include a certain degree of starvation but it is difficult to link it to a particular lubrication system or grease, thus this parameter could be overestimated. As shown in Ref. 7 the "real" effective kappa, if not sufficient lubricant is provided, might decrease with increasing speed in high-speed conditions rather than to increase as classical calculations would indicate. This behavior is illustrated in Figure 8.

Naturally, when speed or load is increased in this category of "performance series" bearings the risk to cross the damage mode limit from surface distress to seizure increases. Seizure damage manifests itself first as an enhancement of surface distress since the surface material can start losing hardness due to reheating, then discoloration can appear, see Figure 9, eventually the damage can be catastrophic.

Notice that for this series the load is usually low (P_h≈1.3 GPa), lower that the fatigue limit for bearings (1.5 GPa), thus subsurface fatigue is not expected.

Extreme Platform

Surface Distress and Seizure

For this platform, load and speed are high, the combination can reach the limits of $P_h \approx 3.0$ GPa with $nd_m \approx 3\text{x}10^6$, tests with different steels for the rings and with hybrid ceramic bearings have been carried out successfully to show that even in conditions close to the above limit the bearings survive (Refs. 10, 11), see Figure 10.

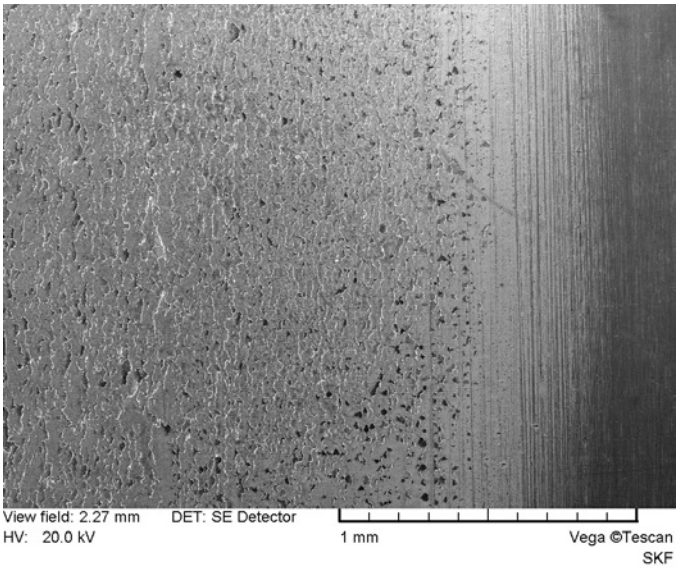


Figure 6—Microphotograph of advanced surface distress on a bearing raceway.

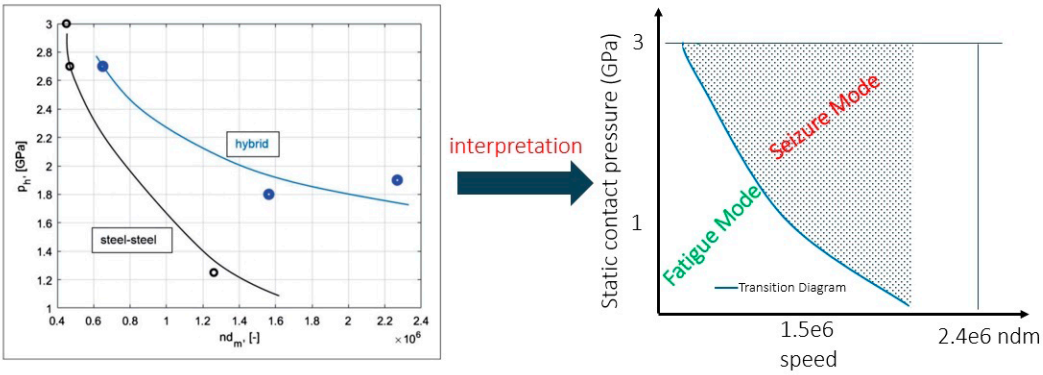


Figure 7—Transition diagrams from tested bearings for steel-steel and hybrid ceramic rolling bearings under standard (spindle) lubrication conditions and rings made of ASTM 52100 steel, inspired from Ref. 7. On the right-hand side plot the interpretation of the two potential damaging mechanisms.

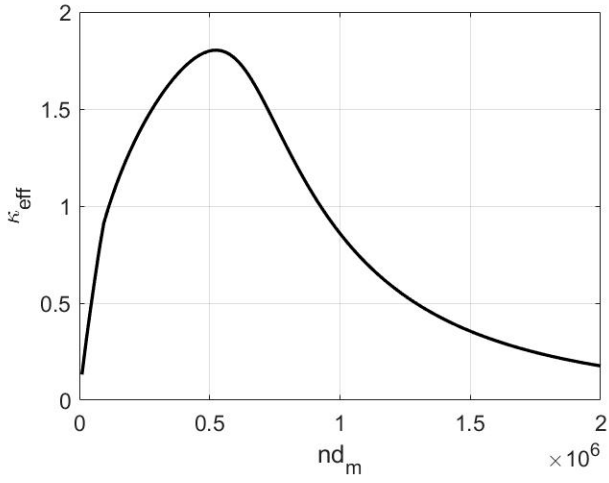


Figure 8—Illustration of a calculated effective kappa in a high-speed bearing, inspired from Ref. 7, as affected by severe kinematic starvation.

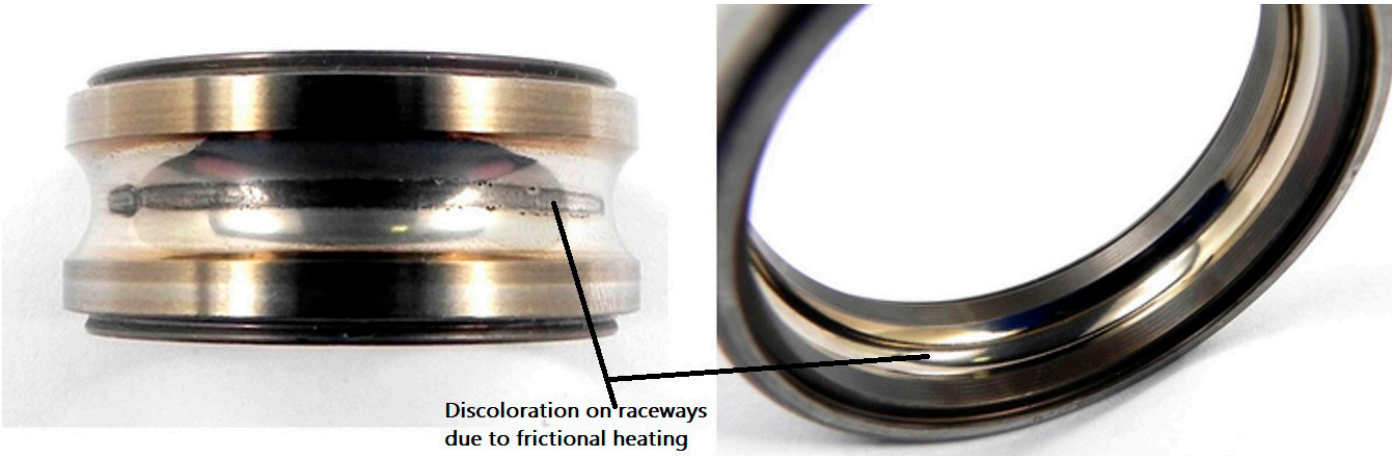


Figure 9—Damaged raceways due to frictional heating showing the first signs of seizure.

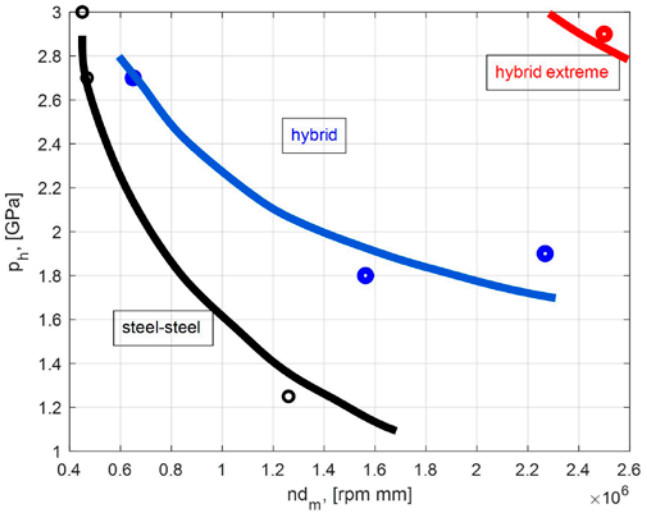


Figure 10—Transition diagram comparison between the "performance series", denoted as steel-steel and hybrid versus the "extreme platform," here denoted as hybrid extreme, inspired from Ref. 11.

In these conditions, certainly the most stressed part of the bearing remains to be the surface due to frictional heating. However, since likely the loads are higher than the fatigue limit of bearings steels (~1.5 GPa maximum Hertz pressure), the subsurface might also accumulate some fatigue, but certainly the life remains dominated by the surface of the raceways.

Embedment of Particles

In these extreme conditions, the use of hybrid bearings is compulsory therefore, the embedment process of particles in the steel rings can still happen. However, the local overheating process described in Figure 5 might not produce extra damage since the opposite surface is a ceramic material, more resistant to heat.

Ultrafast Series

For the performance of this series the load is relatively low ($P_h \leq 1.3$ GPa) but the speed can be very high ($nd_m \geq 3\text{x}10^6$), therefore the major damaging mechanism is structural strength in the cages, potentially high pressures on the outer ring which could drive the damaging mechanisms to a situation similar to the Extreme Platform, where indentation and seizure could be an issue (despite the fact that the hardness of this steel is higher) together with poor lubrication due to kinematic starvation. But again, here surface dominating damage modes will prevail.

Mitigation Measures

Some mitigation measures have to do with the way the bearings are designed, for example, for "Ultrafast Series" and "Extreme Platform" a strong cage is required, as well as ring of special (or harder) steels that have a relatively high softening temperature to reduce seizure risks, all this combined with ceramic (silicon nitride) rolling elements. In these tough conditions a good lubrication balance of air (pressure) and lubricant is very important. In the area of "Performance Series", where surface distress is dominant, availability of lubricant (without excess) is also critical. Many of these bearings are grease lubricated where the grease selection is critical. In some cases hybrid (ceramic) bearings could also be required here, since they are more resilient in poor lubrication situations and seizure.

Bearing Life Estimation

Traditionally engineers use ISO 281 (Ref. 5) or equivalent for life calculation in bearings. This methodology can be useful in many applications, especially where subsurface fatigue is dominant. Which is not the case in any of the spindle applications discussed above. For this, SKF has developed a bearing life model that can separate the surface survival from the subsurface, modelling explicitly the surface in the life calculation, this model is known as the SKF generalized bearing life model or GBLM (Ref. 4). The basic concept of GBLM is given by Equation 1, being e the Weibull slope.

$$L_{10GMS} = \left[\frac{1}{L_{10sub}} + \frac{1}{L_{10surf}}\right]^{-1/e} \text{ (stress-based)} \quad (1)$$

This compared with the traditional method equivalent to ISO 281, given by Equation 2

$$L_{10m} = a_{SKF}\left(\frac{C}{P}\right)^{p} \text{ (load-based)} \quad (2)$$

Application Example

Considering the super precision bearing (SuPB) 7008 CE in hybrid and steel-steel executions, Table 1 describes operating conditions typical of the different zones of Figure 1. Notice that since in high speeds, the actual lubrication condition in the bearings is uncertain (due to kinematic starvation), then for a fair comparison the lubrication quality parameter has been fixed to $\kappa = 1$ in all cases.

Condition	Execution	Performance Series	Extreme Platform	Ultrafast Series
Contact pressure [GPa]	steel-steel	1.1	2.53	1.1
	hybrid	1.3	3	1.3
Speed, nd_m [rpm mm]		1.3×10^6	3.0×10^6	4.0×10^6
Lubrication, κ [-]		1	1	1
Contamination, η_{ci} [-]		0.8	0.8	0.8

Table 1—Operating conditions for the example (SuPB 7008 CE).

With the data of Table 1 and the application of Equations 1 and 2 the calculated bearing lives are summarized in Table 2. Notice that in the L_{10GMS} life calculations (which are calculated from a stress-based model) the corresponding SKF bearing solution has been considered (design features, especial material, etc.), while for the calculations of L_{10m} (obtained from a load-based model) these features cannot be totally considered. In an ISO 281 calculation only standard "super-precision bearings" steel-steel is included and only geometry aspects are included in the evaluation of the dynamic load rating C.

Calculated Life [Mrevs]	Execution	Performance Series	Extreme Platform	Ultrafast Series
L_{10GMS}	steel-steel	NA	NA	NA
	hybrid	$9.44\times10^{6(*)}$	182	$2.14\times10^{5(*)}$
L_{10m}	steel-steel	1.28×10^6	34.7	5.13×10^5
	hybrid	1.28×10^6	34.7	5.13×10^5
(*) Model in development, results can change				

Table 2—Life results from calculations, using Equations 1 and 2.

Notice that the steel-steel bearings of Table 1 can only be calculated with Equation 2 for the time being. As explained above, also notice that Equation 2 does not make any difference for hybrid bearings or any other special features in the bearing (i.e., different steels).

Some bearing manufacturers seem to increase their C value (dynamic load rating) to boost calculated bearing life even after knowing that this parameter has an influence only on the subsurface. This can only be justified if proper endurance tests are carried proving the overall increase in subsurface bearing life. To force equating the lives of Equations 1 and 2, the C value of Equation 2 would need to be multiplied by a factor f, thus:

Equation 3	Execution	Performance Series	Extreme Platform	Ultrafast Series
f	steel-steel	NA	NA	NA
	hybrid	1.94	1.74	0.747

Table 3—Calculated f factors for the cases of Table 2.

$$f = \left(\frac{L_{10GMS}}{a_{SKF}}\right)^{1/p}\frac{P}{C} \quad (3)$$

Table 3 shows a summary of the calculated f values from Equation 3 for the cases of Table 2. The results of Table 3 show how unfit Equation 2 is to reflect the behavior of Equation 1, where the separated effects of surface and subsurface are considered. For the "Performance Series" and the "Extreme Platform" an increase in the C value of $f > 1.7$ would be required to match the predictions of Equation 2. However, for the "Ultrafast Series" Equation 2 is already unsafe and then it requires a reduction of the C value of nearly 20 percent. But more important, only a fixed multiplication factor of C non-linked to the bearing subsurface performanceis completely seems artificial and nonphysical and should be avoided.

Conclusions

Potential damage mechanisms of spindle bearings are described, depending on the operational zone of the bearing within the speed-load map. Some mitigation measures have also been pointed out. Besides, the standard life calculation method is revisited and compared with the more advanced GBLM method, which includes the separation of the surface survival. From here the following conclusions can be drawn:

1. The classical subsurface fatigue damage mode is unlikely in spindle applications operating in almost any zone. In general, surface dominating damaging modes will prevail.
2. For the "Extreme Platform" and "Ultrafast Series," it is likely that the seizure (adhesive wear) damaging mode will be more relevant. However, in some cases the "Ultrafast Series" could also suffer from some surface distress due to the effects of kinematic starvation.

3. For the "Performance Series," surface distress is more likely. However, improved material in this series will also benefit the subsurface.
4. Particle contamination in all cases will be damaging and should be minimized.
5. It is concluded that only a simple multiplication factor to the Dynamic Load rating (C) of the bearing is somehow artificial and nonphysical, due to several reasons: (1) damage in general is not related to the bearing subsurface, (2) a constant increase in in predicted life in all operating conditions does not reflect the competition between surface and subsurface damaging mechanisms, as reflected in the GBLM model and the reality.
6. Overall increase of C values can only be justified if proper endurance tests are carried out, showing the overall increase in bearing life, triggered by a material performance improvement in the subsurface.

PTE

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SKF has been awarded a Platinum Medal by EcoVadis, one of the most trusted providers of sustainability ratings for use in supply chains. This prestigious recognition places SKF in the top one percent among the more than 100,000 companies assessed worldwide for its commitment to sustainable business practices.

The EcoVadis assessment evaluates 21 sustainability criteria across four key themes: Environment, Labour and Human Rights, Ethics and Sustainable Procurement. The rating identified several strengths across SKF's business, including policies, reporting, best in class GHG (Greenhouse gas) management system and strong decarbonization ambition with approved science-based targets.

Magnus Rosén, head of sustainability at SKF, says: "We are proud to have been awarded the EcoVadis Platinum Medal for the fourth year running. This rating reflects not only the ambitious goals we have set for ourselves and the value chain but also how sustainability sits at the heart of SKF, embedded in our purpose, our strategy and in our strive to bring positive impact across the organization worldwide."

EcoVadis' business sustainability ratings are based on international sustainability standards, such as the Ten Principles of the UN Global Compact, the International Labor Organization (ILO) conventions, the Global Reporting Initiative (GRI) standards and the ISO 26000 standard. The ratings provide an evidenced-based analysis on performance and an actionable roadmap for continuous improvement.

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HANNOVER MESSE

Enhances Cooperation with German Robotics Association

The topic of robotics is an integral part of Hannover Messe. Robots of all sizes and shapes—from industrial robots and cobots right through to autonomous mobile robots—can be found throughout the exhibition grounds of the world's leading trade fair for industry.

A special highlight this year is the Application Park in Hall 5, which has a strong partner at its side in the form of the German Robotics Association (DRV). Among other things, the DRV has made it a mission to promote and foster the use of robotics in Germany. Given the shortage of skilled workers, there is undoubtedly potential in this direction, with Germany ranking fifth behind China, Japan, Korea and the USA in global comparison.

"With the robotics experts from DRV, we have partners at our side with whom we will further build on the topic of robotics, in conjunction with that of automation, at Hannover Messe. There is no better place in the world to showcase the diverse examples of robotic applications," says Hubertus von Monschaw, global director Hannover Messe at Deutsche Messe AG.

The DRV will be the exclusive partner of the Application Park for the coming year. There, young robotics companies and start-ups will present the diverse spectrum of possible applications for robots, as well as the interaction between humans, machines and artificial intelligence. Visitors can get a first-hand look at robotics-based automation and try it out for themselves. A highlight is the driverless transport systems, impressively demonstrating that drivers can be dispensed with in many areas of activity in the future.

"This exhibition platform offers visitors to Hannover Messe a unique opportunity to engage with new technologies and learn how robotics, AI and automation can help solve the enormous challenges facing industry," enthuses Helmut Schmid, CEO of the DRV.

The 13th Robotics Congress took place February 6–7, 2024, at the Technology Academy in Hannover. In plenary sessions or in workshops, participants had the opportunity to gain insight into the latest developments and trends in the field of robotics. The DRV is playing an active role as development partner behind the program.

hannovermesse.de

WIELAND

Acquires Concast Metal Products Co. and Randall Bearings Inc.

Wieland has acquired Concast Metal Products Co. and Randall Bearings Inc., strengthening the presence of Wieland Group in premium copper and copper alloy market segments in North America.

With more than 130 years of history and a strong reputation for excellent customer service and manufacturing capabilities, Concast provides a broad product and service portfolio to its customer base. The company's high performance casting operations are located in Mars, PA, and Birmingham, OH.

Randall Bearings, with locations in Lima, OH, and Coldwater, OH, offers high-end machined bronze and brass parts, catering to industries such as agriculture, construction, fluid power, oil and gas, heavy equipment, defense, and transportation.

"With the acquisition of Concast and Randall Bearings, we further expand Wieland's manufacturing and service capabilities in North America. We are very much looking forward to welcoming an experienced workforce and strong leadership team to the Wieland Group," said Dr. Erwin Mayr, CEO of the Wieland Group.

wieland.com

March 2–9

IEEE Aerospace Conference 2024

The International IEEE Aerospace Conference, with AIAA and PHM Society as technical cosponsors, is organized to promote interdisciplinary understanding of aerospace systems, their underlying science and technology, and their applications to government and commercial endeavors. The annual, weeklong conference (Big Sky, Montana) is set in a stimulating and thought-provoking environment. The 2024 conference will be the 45th in the series. Plenary sessions feature internationally prominent researchers working on frontiers of science and engineering that may significantly impact the world we live in. Registrants are briefed on cutting edge technologies emerging from and intersecting with their disciplines. Each year, a large number of presentations are given by professionals distinguished in their fields and by high-ranking members of the government and military.

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March 11–14

MODEX 2024

MODEX 2024 (Atlanta, GA) offers the latest information on supply chain equipment and technology. The event features more than 150+ free education sessions. Meet more than 900 exhibitors from over 140 countries to discuss how their cost-cutting equipment and technology can futureproof your supply chain. Topics include warehouse equipment, inventory management, material handling, emerging technologies, packaging, sustainability and more. Motor and drives exhibitors include ABM Drives, Cone Drive by Timken, Framo Morat, JIE USA Inc., Maxon US, Misumi, Nord Drivesystems, THK America and more.

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March 19–21

Bearing Show/ Lubricant Expo North America

The Bearing Show is North Americas (Detroit, MI) newest exhibition and conference, connecting the evolving needs of bearings end-users with the latest technologies serving, OEM development, maintenance professionals and R&D engineers. Meet visitors from OEM's, machine manufacturers, industrial plants, global distributors, and more. Matching the needs of end-users with the innovation and opportunities occurring throughout the supply-chain is essential. The Bearing Show features exhibitors from the entire ecosystem, including finished bearings, condition monitoring, tools & equipment, components, materials, testing, and machinery used in the processes of bearing production and application.

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April 22–26

Hannover Messe 2024

From drive and fluid technology to digital platforms and IT security to industrial internet and robotics, Hannover Messe (Hannover, Germany) reflects the manufacturing industry's broad scope and provides important economic and social impulses every year. Additional 2024 topics include 5G technology, additive manufacturing, automation, sensors, e-mobility, material handling and more. An industry in the process of change needs to keep moving – and being moved. New requirements call for innovative developments toward drive solutions that are increasingly intelligent, flexible, and efficient. Components networked down to the smallest actuator enable ever more powerful, perfectly orchestrated workflows.

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May 6–9

Cleanpower 2024

Cleanpower 2024 (Minneapolis, MN.) grows businesses by gathering key decision makers and stakeholders across the wind, solar, storage, hydrogen, and transmission industries for discussion, deal making, networking and a whole lot of fun. The trade show not only brings together the different technologies that make up the renewables mix; onshore wind, offshore wind, solar, storage, and transmission but also the different segments within the industries; manufacturers, construction firms, owner operators, utilities, financial firms, corporate buyers and more. Cleanpower will feature the latest products, services and technologies coming to the renewable energy industry.

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Sweet Little Lies

Building A Replicate of the Original Lie Detector Machine

Matthew Jaster, Senior Editor

Artists Bruce Rosenbaum and Ben Cowden earned film credits recently for prop design on the PBS documentary *The Lie Detector: A Truly Unbelievable Story*. This ambitious historical account of real-life inventors, marketers, law enforcement professionals, and snake oil salesmen traces the interconnected lives of John Larson, William Marston and Leonarde Keeler in their independent efforts to detect lies and expose liars.

Rosenbaum said documentary filmmakers are always challenged by visual collateral and material that supports their projects. This is especially true when dealing with historical topics where film and photographic evidence may be hard to find or nonexistent.

For the invention of the polygraph, the producers asked Rosenbaum and Cowden to combine their skills to recreate the original lie detector machine.

"We only had photos of the original Larson Lie Detecting machine—no surviving machine exists—so there was nothing physical to work from when we started to assemble our components for modification and fabrication. Our goal was to use as many authentic period objects as possible to make it feel like the original machine," Rosenbaum said.

Components including a historic gauge, battery, leather blood pressure cuff and 1920s medical apparatus (pictured) were used to mimic the original lie detector equipment that would record vital signs from the suspect as they answered the interrogator's questions.

"We did not feel that we had to make perfect reproductions for the documentary—just have the look and feel to give the sense of how it functioned in the situation. For one of the machines, we used a more recent existing model of the polygraph and 'aged' it back by doing a vinyl wrap on the machine and replacing some elements with older, period pieces," Rosenbaum added.

Law enforcement eventually lost confidence in the equipment as a means of obtaining criminal evidence. However, Marston, a marketer with a higher degree of showmanship, found a customer base with Hollywood film executives who sought ways to gauge and assess audience reactions.

In the 1940s and '50s the nation's war on crime and racketeering sparked a renewed interest from law enforcement. Keeler coined the term "polygraph," which became popularized in true crime stories. Keeler's "box-shaped" lie detector machine also became a hit with banks and American corporations for identifying white collar crime and fraud committed by employees.

Rosenbaum not only provided the props but portrayed one of the three inventors in a nonspeaking role in the film.

"I was a bit nervous getting in front of the camera and making our (prop) machines move and appear that they were actually working on the test subjects," said Rosenbaum. "Rob Rapley, the director, and all of the film crew, made the set feel like we were a well-oiled machine and it came off perfectly—no lie!"

Rosenbaum said polygraph machines are still not allowed as courtroom evidence because it is unproven that heart, pulse, and perspiration, etc. correspond with truth or lying.

"Humans are so complex. I'm not sure any type of sensor will ever be definitive science in detecting truth or lies. In fact—with some practice—people can outwit lie detecting machines," Rosenbaum said. "However, with companies like NeuroLink experimenting with embedding microchips in human brains the more likely lie detecting machine in the future will be reading someone's mind."

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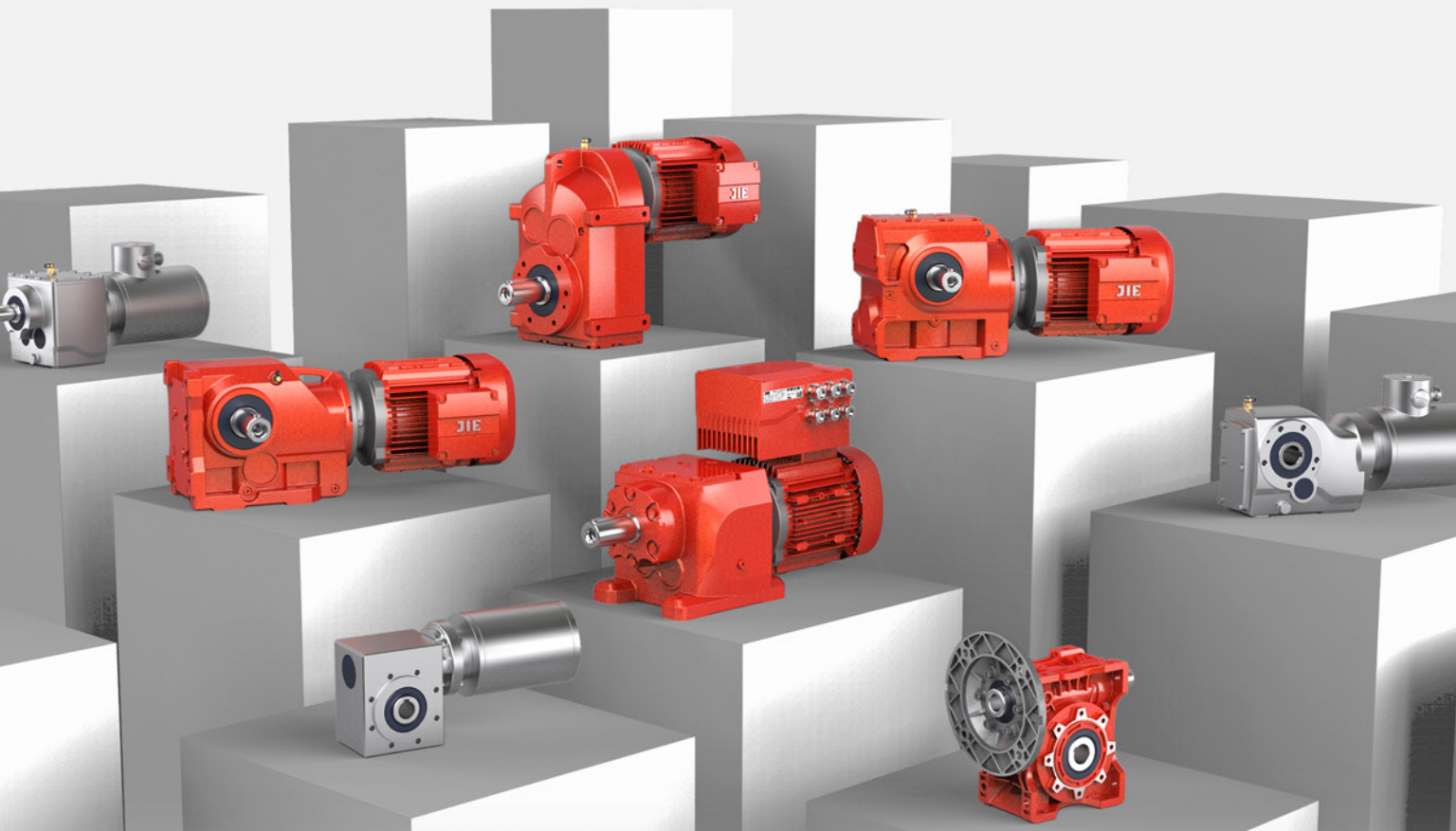

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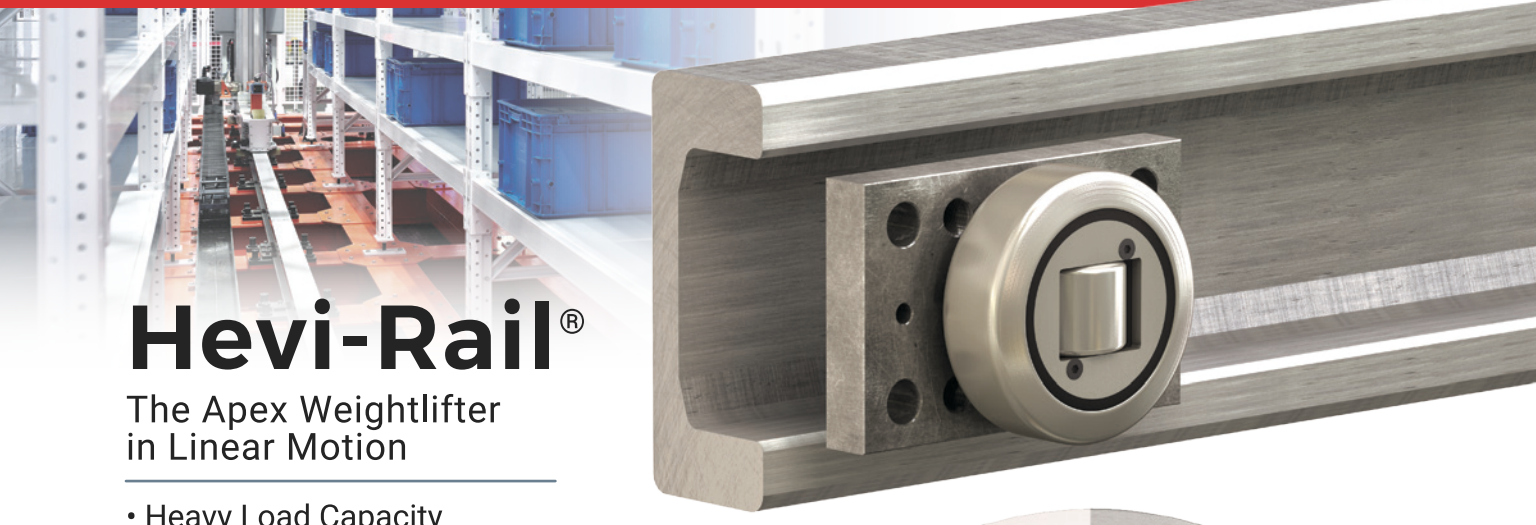

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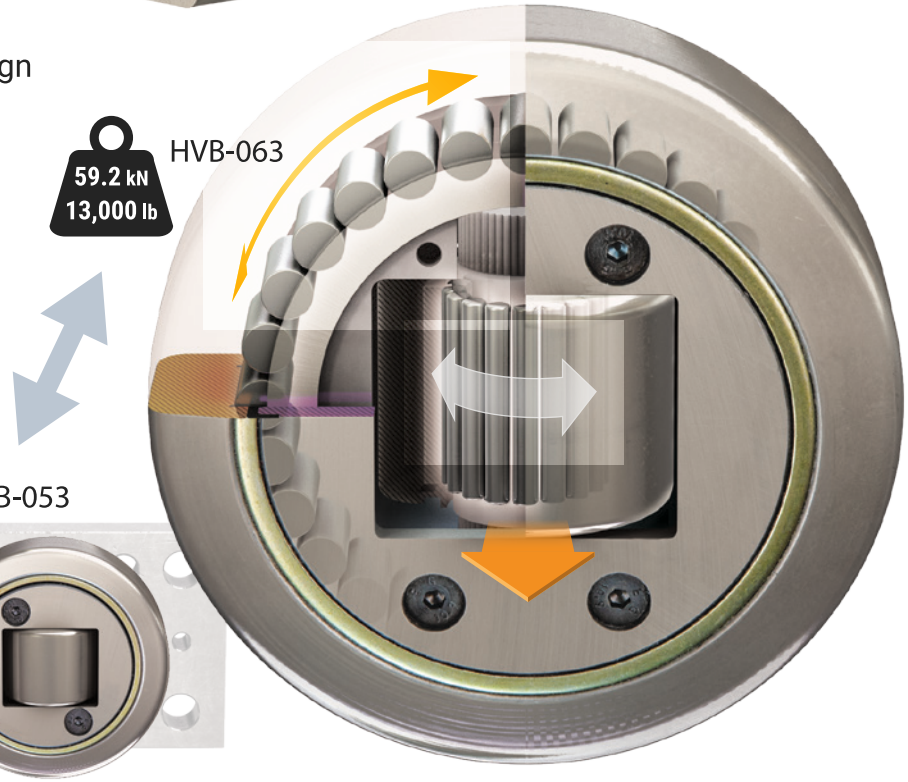

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