PTE

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MARCH
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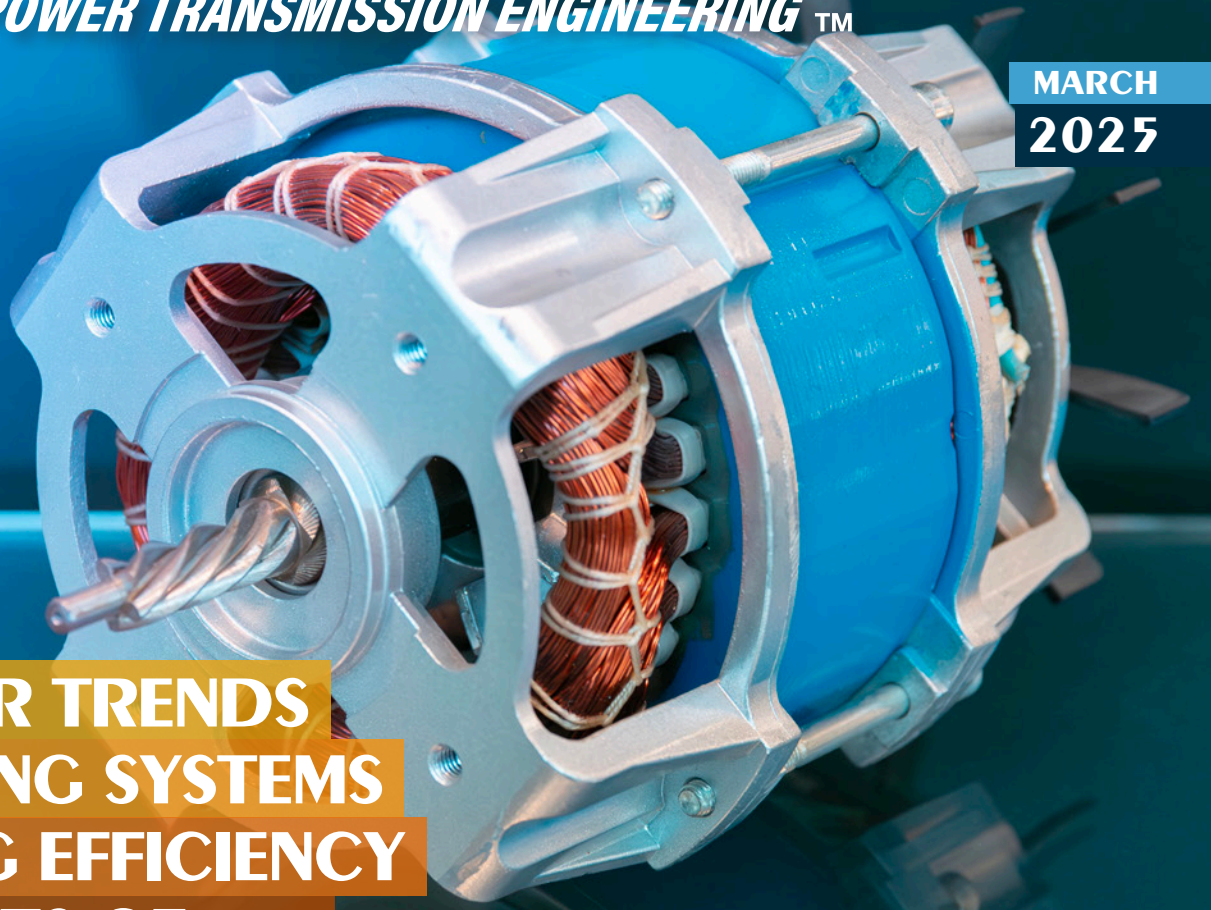

MOTOR TRENDS
BRAKING SYSTEMS
MINING EFFICIENCY
BENEFITS OF INCHING DRIVES

TECHNICAL

Mitigation of Gear Whine Noise in Agricultural Tractor Application

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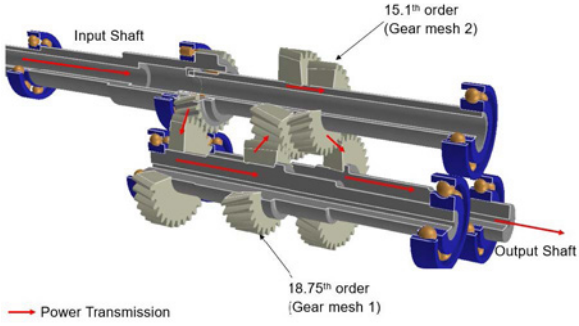

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Study examines load dependent noise characteristics encountered during field operations.

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VOL. 19, NO. 2

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PTE REVOLUTIONS

COLLABORATE 2025: A ROBOTICS AND AUTOMATION EVOLUTION

500+ manufacturing professionals from across North America, automation specialists, educators, and industry thought leaders from MIT, Siemens, and the Association for Advancing Automation (A3) came together recently for Universal Robot's Collaborate 2025 event in Novi, MI.

powertransmission.com/blogs/l-revolutions/post/10190-handson-automation

THE BEARING SHOW 2025

This year, The Bearing Show will look at the latest developments in OEM bearing requirements, particularly regarding future fuels and electrified drivetrains. On day one, companies including, Nexteer Automotive, FEV and HF Sinclair, Ford and GM will be presenting on evaluations of bearings within high-speed drivetrains and modern bearing challenges in automotive motion control.

powertransmission.com/articles/10184-the-bearing-show-2025

79TH STLE ANNUAL MEETING & EXHIBITION

Join your peers and the tribology community for the 79th STLE Annual Meeting & Exhibition, May 18–22, 2025, at the Hyatt Regency in Atlanta. Each year STLE's conference showcases some 500 technical presentations, application-based case studies, best practice reports and discussion panels on technical and market trends. The exhibition and popular Commercial Marketing Forum spotlight the latest products and services of interest to lubrication professionals that come from around the world, representing a full range of the industry's most prestigious corporate, government and academic institutions.

powertransmission.com/articles/10191-79th-stle-annual-meeting-and-exhibition

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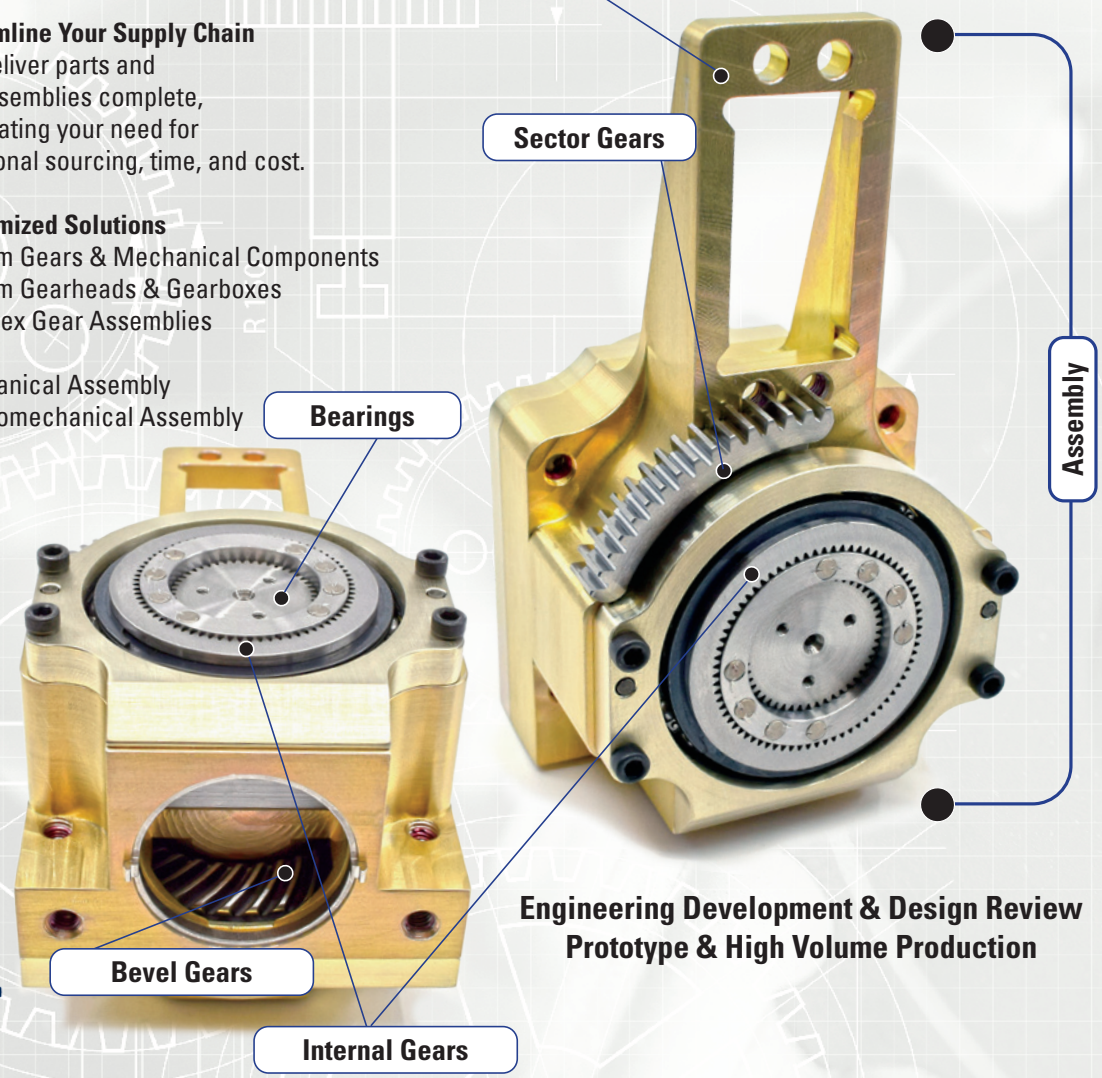

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A New Phase in Motor Technology

If you haven't been paying attention lately, you might think that electric motors are an old, stodgy technology. After all, most of the real inventions occurred way back in the nineteenth century, with contributions from historical geniuses like Faraday and Tesla. We've been using DC motors and AC induction motors since the late 19th century. In many cases the basic design has remained unchanged.

But the world of electric motors is changing drastically, driven by global goals of energy efficiency and electrification, coupled with a continued desire to reduce reliance on rare earth metals and other limited-supply commodities. Throw in an explosion in the field of robotics and the proliferation of drones, and you have a recipe for continued, impressive innovation.

"In the past two years more truly innovative new technology development has occurred than in the previous two decades," says John Morehead in his column on electric motor trends (p. 34). Morehead is a longtime veteran of the motor industry, having served in executive and senior management roles with Bodine Electric, Bison Gear & Engineering, Dunkermotoren and Crouzet Motors. Today he runs a strategic consulting business, and he's also our newest *PTE* contributor. You can look forward to reading more of his wisdom in the coming issues.

And he's definitely not alone in this observation. We've seen it first-hand at a number of recent trade shows, including IMTS, Pack Expo, CES and MINExpo. Senior Editor Matt Jaster's article on aerospace motor trends (p.16) gives some of the highlights, including unique approaches to motor design for vertical takeoff and landing (VTOL) aircraft.

We'll definitely be paying attention to the motors space over the coming years.

This issue also includes an emphasis on mining applications, with an article from Regal Rexnord on mining safety and large industrial braking systems (p. 20), a detailed look at CMD Gears' inching drives for grinding mills (p. 26), and a piece on slewing drives and other components from Liebherr (p. 28).

We are always on the lookout for innovations in the power transmission industry. Please let us know if you know of any new technologies, interesting applications or changing trends in the way gears, bearings, motors, gear drives and other power transmission components are being used. Please reach out to me at *stott@agma.org* with any feedback or insight regarding our coverage.

PTE

Randy Stott
Publisher & Editor-in-Chief

partner

In the intralogistics and material handling industries, efficiency and uptime are key. Businesses require a partner who can help them increase accuracy and ramp up production to meet consumer demands.

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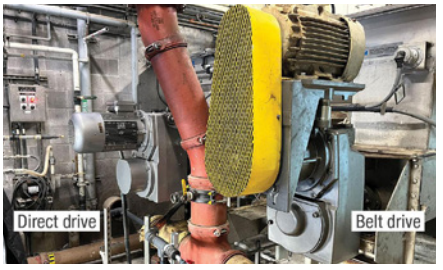
Direct Drive Systems Outperform Belt Drives in Efficiency, Safety and Cost-Effectiveness



Two common types of drive solutions available on the market are direct drive solutions and belt drive solutions. With direct drives, the gearmotor is directly connected to the load being driven and does not require additional connection components. Belt drives, in comparison, are offset from the driven load and require belts and pulleys to connect the two. They also often include a motor mount, sheaves, machine guard, and a torque arm, making them a more complicated set up than the gearbox, NEMA adapter, and motor combination of direct drives. The compact direct drives also provide higher efficiency, reliability, and safety features compared to traditional drive packages.

Gearmotors from Nord Drivesystems are offered as parallel shaft and right-angle mounted direct drives for versatile installation according to application and space constraints. The gear units are manufactured with robust, one-piece Unicase housings with all bearings and seal seats contained within the housing for additional protection and reliability. Bearing life is extended in this design thanks to the lack of radial loads on the motor shaft and the gearbox input shaft. Nord electric motors combine easily with their modular gear units and provide high-efficiency, high output torques, and an ample output speed range across multiple frame sizes.

Variable frequency drives extend these capabilities, providing precise speed control of the drive, reducing the number of system variants, and decreasing the quantities of spare parts backstock.

Direct drive systems offer improved safety over belt drives as interaction with equipment is minimized and the enclosed solution reduces the chance of injury. Belt drive systems require additional protection measures and resources for safeguarding users from their moving parts. Belts also require adjusting or replacing multiple times per year which can be dangerous if not handled properly by skilled personnel.

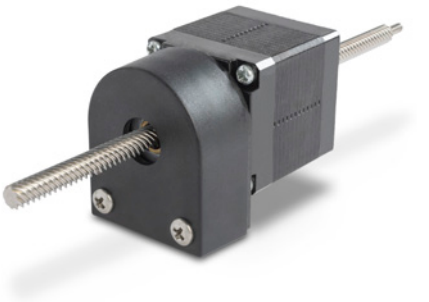
Maintenance for Nord direct drives systems is significantly quicker, easier, and more cost effective than belt drives due to fewer wear parts and modularity. If the motor needs replacing, the old motor can simply be uninstalled, and the new one attached and connected to power. Motor replacement on belt drives, however, requires the whole system be unassembled before the new motor can be attached and the belt adjusted. Direct drive systems prove themselves to be more efficient than belt drives due to reduced mechanical friction and no belt tension reduction. Since they do not have belts, they also do not require downtime to re-tension the belt, achieving greater system availability. In intralogistics systems that consume a lot of energy such as conveyor operations, energy efficient direct drives with premium efficient IE5+ synchronous motors significantly reduce energy costs and system variants thanks to their constant torque even at partial load and low speed ranges.

nord.com

THOMSON INDUSTRIES

Upgrades SMLA Online Selector Tool

Thomson Industries, Inc. has announced a significant upgrade to its stepper motor linear actuator (SMLA) online selector tool, adding the ability to include encoders in the design process. The new option streamlines the design and purchasing process for engineers and machine builders, making it even easier for them to weigh their options for incorporating position data into their designs.



The Thomson selector tool automates the process of selecting the right SMLA for machine design needs. With a few intuitive steps, engineers can define motor frame size, screw and nut configurations, and now, thanks to this upgrade, they can also specify the exact encoder required for their application. Users can specify encoder cycles per revolution (CPR), non-index or index feedback control, or single-ended or differential output without leaving the online specification session. As users make their selections, the tool automatically updates the product specifications and provides real-time visualization, reflecting changes in the actuator's dimensions and design.

"This upgrade gives our customers the flexibility to choose the right motor and seamlessly integrate the entire assembly, including encoders, all in one interface. By automating what was previously a manual and time-consuming process, we have made it faster and more intuitive," said Lindsey Brimage, senior product manager for screws at Thomson. "Now, with real-time updates and CAD model downloads, our customers can get exactly what they need, more efficiently than ever."

thomsonlinear.com/en/products/motorized-lead-screws-products

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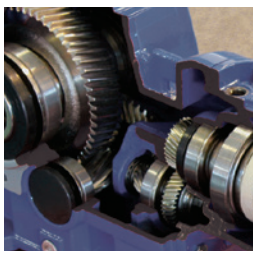

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KLING GEAR OILS
HEAVY-DUTY, TACKY RED, PETROLEUM OIL-BASED EXTREME PRESSURE (EP) GEAR OILS

- Heavy-duty, tacky, red, extreme pressure (EP) petroleum-based gear oils.
- These tacky, adhesive, extreme pressure oils cling tenaciously to gear teeth.
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KOLLMORGEN

Expands Functional Safety Support with SafeMotion Monitor Upgrade

Kollmorgen has updated its *SafeMotion Monitor (SMM)* firmware: *SMM2.0*. This upgrade allows OEMs to leverage *SMM* functional safety features with more encoder and motor types to support a wider range of applications such as material forming, multiaxis measurement equipment, food processing and food packaging.

Originally standard for the 2G Motion System, *SMM2.0* will now be compatible with all motors that feature any HIPERFACE-DSL rotary-safe feedback system. This includes the AKM2G and AKMA motor lines, which now feature a wider range of feedback system options. *SMM2.0* also enables a second instance of Safe Operating Stop (SOS) for greater design flexibility.

As a result of updated regulations related to functional safety enacted by the EU, customers across the globe, in a wide range of industries, are seeking upgrades to meet these new standards. *SMM2.0* makes compliance easier, with a comprehensive set of 16 safety features, including SafePosition, SafeStop and SafeSpeed.

"As the demand for functional safety increases, we want to make it easier for our customers to build this capability into their machine designs," said Christopher Cooper, product management senior director. "We're excited to announce that *SMM2.0* provides easy, drive-resident functional safety for a wider range of motors, for even more demanding applications."

`kollmorgen.com/en-us/solutions/industry/safety`

ABB

Launches AppStudio Software Tool

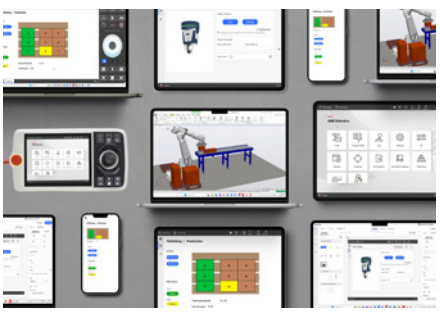

ABB has launched *AppStudio*, an intuitive no-code software tool designed to empower users of all experience levels to quickly and easily create customized robotic user interfaces. With intuitive functionality and features including a collaborative cloud-based library enabling users to share application templates, *AppStudio* will reduce setup times by up to 80 percent.

"A growing shortage of skilled labor requires the further simplification of

automation and programming, especially among small and medium size enterprises (SMEs) where complexity is seen as a major barrier to implementing robotic automation," said Marc Segura, president ABB Robotics Division. "Designed for novices and experts alike, *AppStudio* is an exciting addition to ABB's current software offering. By making it easier to create robot interfaces, it will save users significant time on setup and allow for fast and seamless robot integration across diverse applications."

Compatible with all ABB robots on the OmniCore controller platform, *AppStudio* offers unprecedented flexibility and ease for creating customized robotic user interfaces. After installing the software, users can repurpose a previously used setup or select from a cloud-based library of templates, models, modules, and examples enabling them to select options in twenty languages. Alternatively, customized interfaces can be created to fit any device and application, including the OmniCore FlexPendant, tablets, and mobile phones.

go.abb/robotics

REDEX

Delivers Precise Positioning for Machine Tools

Redex is pleased to announce its patented Dualdrive and Twindrive preloading technologies now give CNC machine designers several ways to build a zero-backlash system.

These approaches leverage Redex modular SRP, DRP, KRP and KRPX Series rack and pinion reducers whose output pinions are preloaded against the rack to eliminate backlash—a longstanding challenge with designs that require long axis travels and require positioning over the entire length of travel to less than 0.001 inch.

Here's how DualDRIVE and TwinDRIVE preloading technologies work to create a zero-backlash system:

Redex Patented DualDRIVE. These systems achieve a mechanical preload by torsionally winding one pinion against the other when both pinions are in contact with the same rack. DualDRIVE needs just one motor, and no special controllers are required.

TwinDRIVE. Twin Drive technology electrically brakes one pinion against the other—driving—pinion when both pinions are in contact with the same rack. These systems incorporate two motors and gearboxes for use with CNC control.

Redex SRP, DRP, KRP and KRPX Series rack and pinion reducers, together with Dualdrive or Twindrive technology, let machine designers

create zero-backlash preloaded systems that achieve precise positioning and improved stiffness in CNC applications. These reducers feature optimized radial and torsional stiffness, very high linear accuracy, compact sizes and precision geometry for meshing with the rack. They can be implemented in the following ways:

DualDRIVE
Two Right Angle SRP planetary reducers (SRP DualDRIVE Kit)
Two Right Angle KRP planetary reducers (KRP DualDRIVE Kit)
One Right Angle DRP including two planetary reducers in one housing (DualDRIVE)

TwinDRIVE
Two SRP planetary reducers (SRP TwinDRIVE Kit)
Two KRP planetary reducers which is called (KRP TwinDRIVE Kit)
One DRP including two planetary reducers in one housing (TwinDRIVE)

redexusa.com

VOITH
Presents Efficient Transmission Technology

Numerous bus operators worldwide are already enjoying the benefits of Voith's DIWA NXT automatic transmission system—especially for intercity and regional bus services. With its first mild hybrid transmission from the DIWA product family, the technology group is closing the gap between diesel-only vehicles and those with alternative drive concepts.

For operators of scheduled services in predominantly rural areas, the DIWA NXT offers the perfect opportunity to quickly and easily make their fleets much more environmentally friendly. In many regions, the infrastructure for operating sustainable drive solutions is still being developed in what is a costly and protracted process. More powerful electricity grids or the essential facilities for charging electric vehicles are just two of the tasks that need to be mastered enroute to more sustainable mobility.

The DIWA NXT automatic transmission enables fuel consumption to be substantially reduced even over long distances and at high speeds. Depending on the type of terrain covered, the mild hybrid ensures fuel savings of up to 16 percent thanks to its central CRU. The integrated secondary retarder allows most of the braking operations to be wear-free, which also substantially reduces the load on the service brake. These two factors not only enable more economic operation of the vehicles but also help reduce harmful air pollutants and

particulates, ensuring compliance with statutory regulations.

The efficient drive technology with a second overdrive also provides a high level of ride comfort even over long distances and at high speeds, making the journey much more pleasant for passengers and drivers alike.

Another advantage of the DIWA NXT comes into play in hilly terrain, because even in buses with a heavy gross vehicle weight, steep inclines are no obstacle thanks to the Voith drive concept. For example, buses weighing around 19 tons can easily manage inclines of 12 percent in second gear, making them much more efficient than buses with conventional drive systems.

In combination, these qualities mean that vehicles with DIWA NXT offer especially high flexibility of use and demonstrate their high efficiency in both intercity and urban traffic.

voith.com

FAULHABER

Expands Portfolio with High-Performance DC Motors

Designed for even greater flexibility and a wide range of applications: The new 1218 SXR and 1228 SXR DC motors. These models expand Faulhaber's proven DC motor portfolio and set new standards in performance and versatility for miniature drive systems.

The new SXR motors offer standard higher performance and a broader range of configuration options to meet the demands of modern drive solutions. They provide flexible voltage variants from 3V to 18V as well as different bearing configurations. Additionally, the motors can be customized—from front and rear shaft modifications to options for vacuum and temperature environments. The optimized rotor balancing ensures longevity and smooth operation.

At the core of the new SXR family is the innovative hexagonal coil with a high copper filling factor and straight wiring. This technology delivers significantly enhanced performance and efficiency compared to traditional pin coils. Additionally, a new magnet

grade improves magnetic induction amplitude and temperature stability.

Compatible and Flexible for Various Applications

All components in the SXR series are RoHS compliant, and the electrical connections offer flexible configuration options. The main markets for this product line include high-tech industries that rely on quality, reliability, and an outstanding power-to-volume ratio. These include sectors such as prosthetics, surgical tools, metrology, semiconductor processing, and automation solutions.

The new SXR models are compatible with a wide range of Faulhaber products, such as the new Faulhaber planetary gearheads 14GPT. They provide various solutions: diameter-compliant, high performing and compact at competitive prices—ideal for applications requiring the highest levels of precision and reliability.

faulhaber.com

IGUS
Offers a Safe, PTFE-Free Version of Its Versatile Telescopic Rail System

A safer choice for customers, this rail system extends up to 2 meters (m) and is suitable for many applications, including vehicles, furniture and medical technology. PTFE is part of a group of chemicals known as PFAS, which could be facing stricter regulations or bans in the future. Despite incorporating a new, PTFE-free plain bearing, the drylin NT-60-4 telescopic rail does not compromise performance. Igus experts have tested the robustness of the material at its in-house test laboratory. Rails carried a centric load of 200 Newtons (N) in a vertical installation, and the system remained functional after 25,000 opening/closing cycles.

"Our material experts have succeeded in manufacturing the sliding elements from a new type of high-performance plastic called iglide JGPF, which does not use polytetrafluoroethylene," says Michael Hornung, product manager, drylin linear and drive technology at igus.

"The sliding elements made of iglide JGPF impress the NT-60-4 with a smooth and dry operation without additional lubricants. The telescopic rails can be pulled out much more reliably, with less maintenance, and more hygienically than classic telescopic extensions with ball bearings. They are now also available without PTFE," says Hornung.

Consisting of three interlocking aluminum profiles, the drylin NT-60 rail system has a width of 60 millimeters (mm) and height of 24 mm. Full-extension and partial-extension versions are available. Rail profiles are available in silver or black anodized, and igus offers flat variants (NTKA-60), as well as versions with high end caps (NTKB-60) for edge protection. Installation sizes NT-35 and NT-27 are also available in a PTFE free version.

"We attach great importance to successively expanding the drylin linear technology portfolio to include these robust, PTFE-free variants," says Hornung. "In addition to the telescopic rail series, the PTFE-free product range also includes drylin W solid plastic carriages, flat and pre-loaded prism carriages from the drylin N family, and carriages from the drylin T series, which can also be retrofitted with PTFE-free sliding elements in existing systems."

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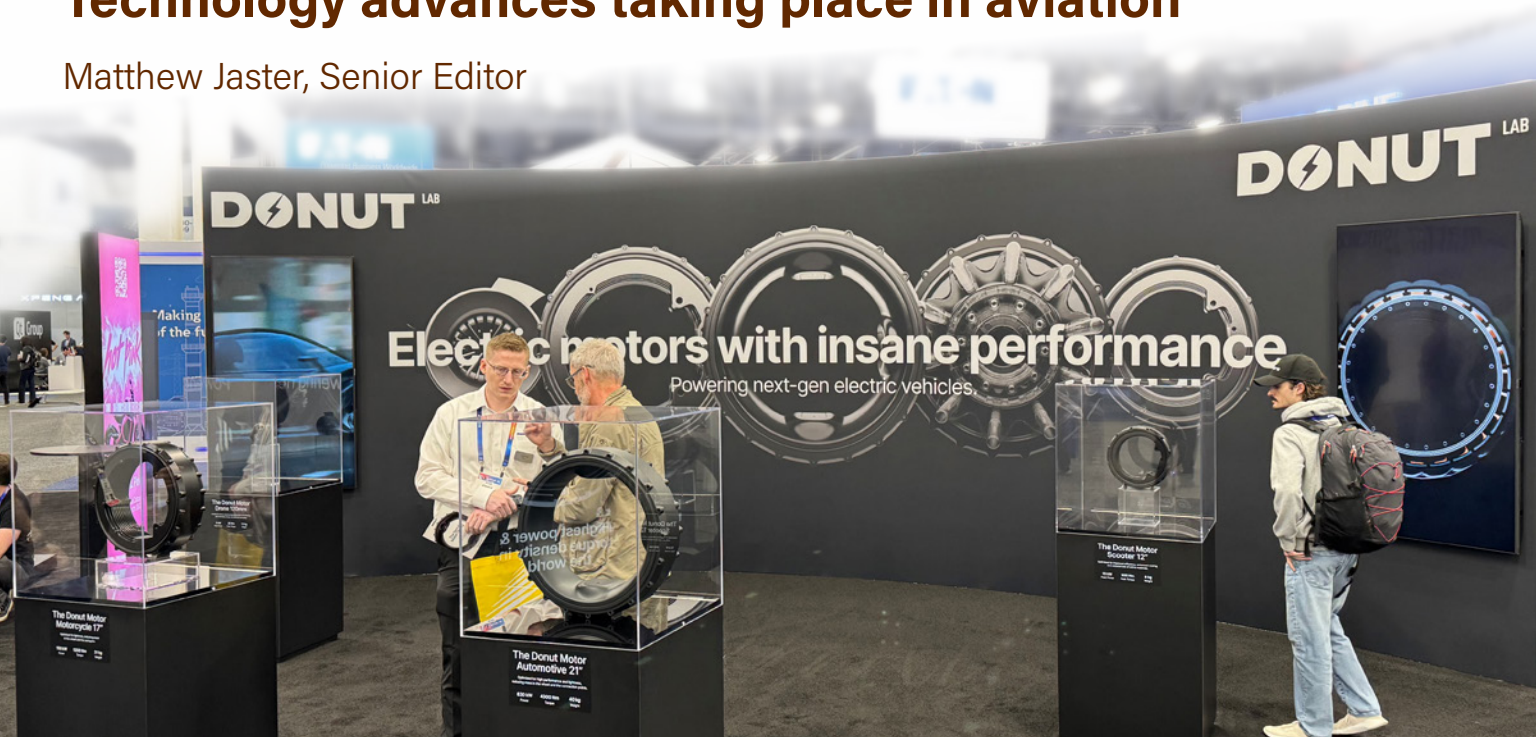
Aerospace Motor Market Trends

Technology advances taking place in aviation

Matthew Jaster, Senior Editor



Donut Lab presented its innovative platform of motor technologies at CES 2025 in Las Vegas.

The trade show circuit has offered a wealth of e-mobility and motor technologies recently. From IMTS and Pack Expo to MINExpo and CES 2025, there are plenty of disruptors in the motor segment for power transmission components. One area—in particular—is the aerospace industry where vertical takeoff and landing (VTOL) rotorcrafts continue to redefine aerial transport, variable frequency drives (VFDs) support aircraft performance, stepper motors provide passenger comfort and software enables engineers to optimize electric motor design.

Donut Lab Adds Innovation to VTOL Technologies

HyperQ Aerospace is reshaping the landscape of VTOL rotorcraft with their innovative RotorHawk—a remotely piloted heavy-lift craft designed for high-speed and complex missions. By harnessing Donut Platform's motors and modular architecture, HyperQ unlocks new capabilities in range, payload, and flexibility.

The Donut Platform enables HyperQ to create long-range, heavy-lift drones with exceptional payload capacity, maintaining peak efficiency without sacrificing agility. This advanced propulsion and modularity provides the torque, power, and precision needed for diverse missions, from confined urban logistics to challenging off-grid operations.

This technology was on display recently at CES 2025 where Donut Lab's engineering team discussed how this electric motor technology could redefine aerial transport.

In addition, the motor family can deliver high-precision control required for robotic motion capabilities ensuring robotic systems operate seamlessly, executing tasks with required accuracy and fluidity.

Powered by "The Brain," the Donut Platform brings computing capabilities tailored specifically for AI-driven robotics. This next-generation control unit allows robots to process and adapt in real-time, enabling smarter automation, dynamic responses, and advanced functionalities.

The Donut Motor provides exceptional power and torque in a compact design, allowing for more efficient and agile robotic systems. The unique design minimizes mechanical complexity, reducing wear while maximizing responsiveness and performance.

donutlab.com

Portescap Provides Stepper Motors for Environmental Control Systems

Stepper motors play an integral role in ensuring the comfort of airplane passengers. Achieving precise, repeatable control of the crucial electronic expansion valves within an aircraft's Environmental Control System (ECS), these

Portescap stepper motors provide custom design properties suitable for environmental control systems within aircrafts.

motors must also ensure high durability. With customization for design integration also a common requirement, this makes motor specification a crucial stage in the development of an aircraft's ECS.

Within an aircraft cabin, an ECS is essential, both for safety, as well as the comfort of passengers and air crew. This technology regulates the pressure and temperature within the cabin, and integral to the system are the valves that control airflow. Particularly for the management of air conditioning and refrigeration, the electronic expansion valve (EEV) is key. With the role of precisely controlling refrigerant flow, these valves enable efficient temperature regulation onboard.

An electric motor actuates the electronic expansion valve via signals received from the ECS controller, which monitors cabin temperature. The motor drives precise valve regulation to control refrigerant flow into an evaporator. While the evaporator is fed by air from outside the aircraft, which is heated by compression or through bleed air from the engine, the blend of refrigerant balances air temperature within the cabin.

The advantage of an electric motor and controls is variable modulation, and it's this flexibility that is crucial to fine-tune refrigerant flow and optimizes passenger and crew comfort. The motor must be able to achieve the required level of precision, and stepper motors are the typical choice. This motor design opens or closes the expansion valve in small, controlled steps; these increments are measured in fractions of a degree, dependent on the resolution of the motor, and this adjustment achieves precision in valve control.

Crucially, the stepper motor also ensures repeatable control. Since it moves in discrete steps, with each step corresponding to a fixed angular movement, this enforces its precision. Enhancing control repeatability, a stepper motor also provides the higher torque required for the relatively low speed operation of the valve. This means that the stepper motor can generate sufficient holding torque to maintain its position without losing steps when under pressure of the refrigerant.

Although an aircraft's ECS should include redundancy, protecting against motor failure is vital to minimize the cost and time of maintenance. The design of the stepper motor is inherently durable as it doesn't rely on mechanical brushes to achieve commutation, and neither does it need a feedback device or a complex closed-loop controller. This simplicity also helps secure a lower cost in procurement. However, when selecting a stepper motor, it's essential to ensure it can withstand temperature extremes, including temperatures up to 130°C faced by the evaporator, as well as the low temperatures of the refrigerant.

Low weight and size are also important to improve an aircraft's fuel efficiency and cargo-carrying capability. Stepper motors achieve high torque density for their low-speed operation requirements, and as they don't require complex external electronics or feedback, this advantage reduces the total weight and size of the package.

As part of motor specification, customization might be required, particularly to enhance design integration. Features such as customized mounting plates and output pinions might be necessary, as well as modifications to the motor itself. Partnering with a micro motor manufacturer like Portescap that provides customizable, off the shelf designs, as well as fully tailored motion solutions, is beneficial. This approach not only minimizes the time and cost of internal development, but the experience in motor customization helps to ensure performance and reliability is maintained.

portescap.com

ABB Optimizes Motors, Generators and Drives

ABB has modernized a variable speed drive (VSD) for NASA to extend, by at least 10 years, the life of the wind tunnel at its National Transonic Facility (NTF) at Langley Research Center in Hampton, VA. The tunnel is used to optimize aircraft performance and fuel consumption by mimicking flight conditions at high altitudes and close to the speed of sound. It has been used to test the Boeing 777, the Space Shuttle and its Booster Rocket.

In 2021, NASA's engineers identified a need to upgrade the tunnel's medium voltage (MV) drive, due to the aging of the drive's components. ABB supplied the drive in 1997 as the most powerful of its kind in the world: the 101-megawatt (MW) drive can test models in air or nitrogen flowing at transonic speeds and at ambient or cryogenic temperatures. As a result, the NTF can simulate a wider range of flying conditions than any other wind tunnel, enabling engineers to gain unique insight and hone aircraft designs.

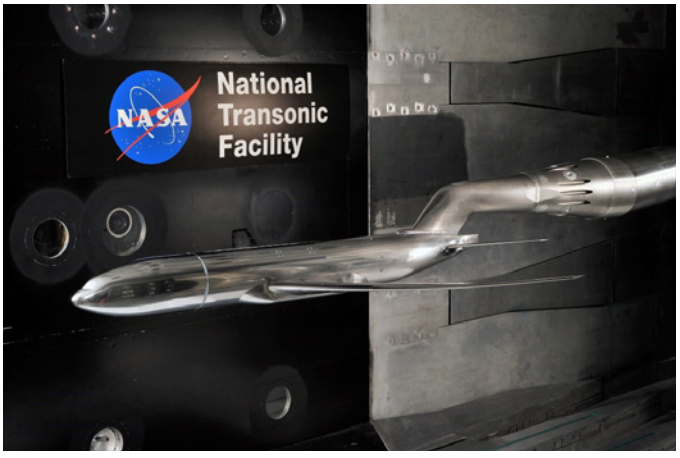


ABB recently modernized a VSD for a NASA Research Center.

After ABB's service specialists evaluated the performance and mechanical connections of the existing drive, the next step was to develop a solution based on modern high-efficiency power electronic components to match the original drive's maximum power, while achieving high availability and reliability. This resulted in the modernization of the drive, replacing key components inside the existing footprint with the latest ABB state-of-the-art technology. The scope included upgrading the small part of the drive (control unit), which minimized the duration and disruption of the project and demonstrated circularity by minimizing waste and logistics as much as possible.

"NASA relied on ABB's domain expertise, technology and services to ensure its National Transonic Facility (NTF) provides high reliability and uptime to maximize availability for its testing programs—and optimize the life-cycle value of its assets," said Oswald Deuchar, head of modernization services, ABB Motion. "Extending the life of the wind tunnel by at least 10 years supports NASA's operational goals while upgrading the drive's key components demonstrates efficiency and circular approach."

NASA ordered the upgrade project as the first activity under an ABB Motion OneCare service agreement that also covers spare parts and maintenance. This type of agreement provides flexibility for operators like NASA to bundle together the services they want so that they can optimize the life cycle of their motors, generators and drives.

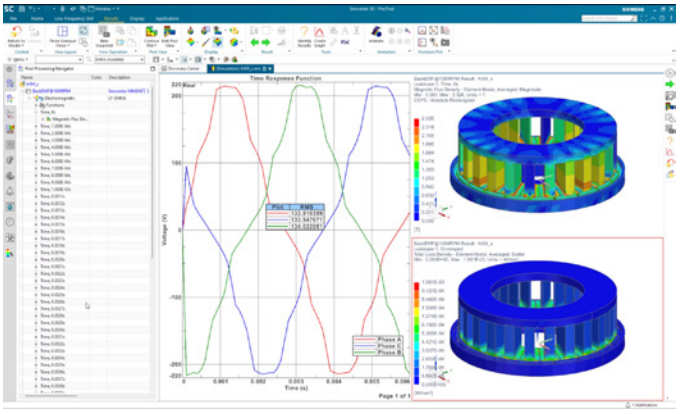
abb.com

Siemens Software Highlights Motor and Gear Optimization

Software advancements in Siemens* Simcenter *provides motor and gear system support from a design perspective.

Siemens Digital Industries Software recently updated its *Simcenter* portfolio, delivering advancements in aerostructure analysis, electric motor design, gear optimization, and smart virtual sensing. These enhancements are designed to streamline workflows, accelerate certification, and provide deeper insights into system performance.

"These updates empower engineers to meet the evolving challenges of electrification and advanced air mobility," said Jean-Claude Ercolanelli, senior vice president, simulation and test solutions, Siemens Digital Industries Software. "We're delivering tools that drive innovation, improve efficiency and support a more sustainable and connected future."



Simcenter ***enables design and simulation of axial flux motors in a single workflow.***

Simcenter enables faster design and simulation of compact, high-power-density motors with axial flux motor simulation. Engineers can quickly create lightweight designs using Siemens' *Simcenter E-Machine Design* software, then transition seamlessly to 3D simulations in Siemens' *Simcenter* 3D software for comprehensive electromagnetic, thermal and mechanical performance assessments.

In turn, the latest software update introduces gear design optimization where engineers can utilize lightweight gear blank parameterization and an optimization framework to improve gearbox noise, vibration and harshness (NVH) performance. These tools help reduce late-stage design changes and streamline the development cycle.

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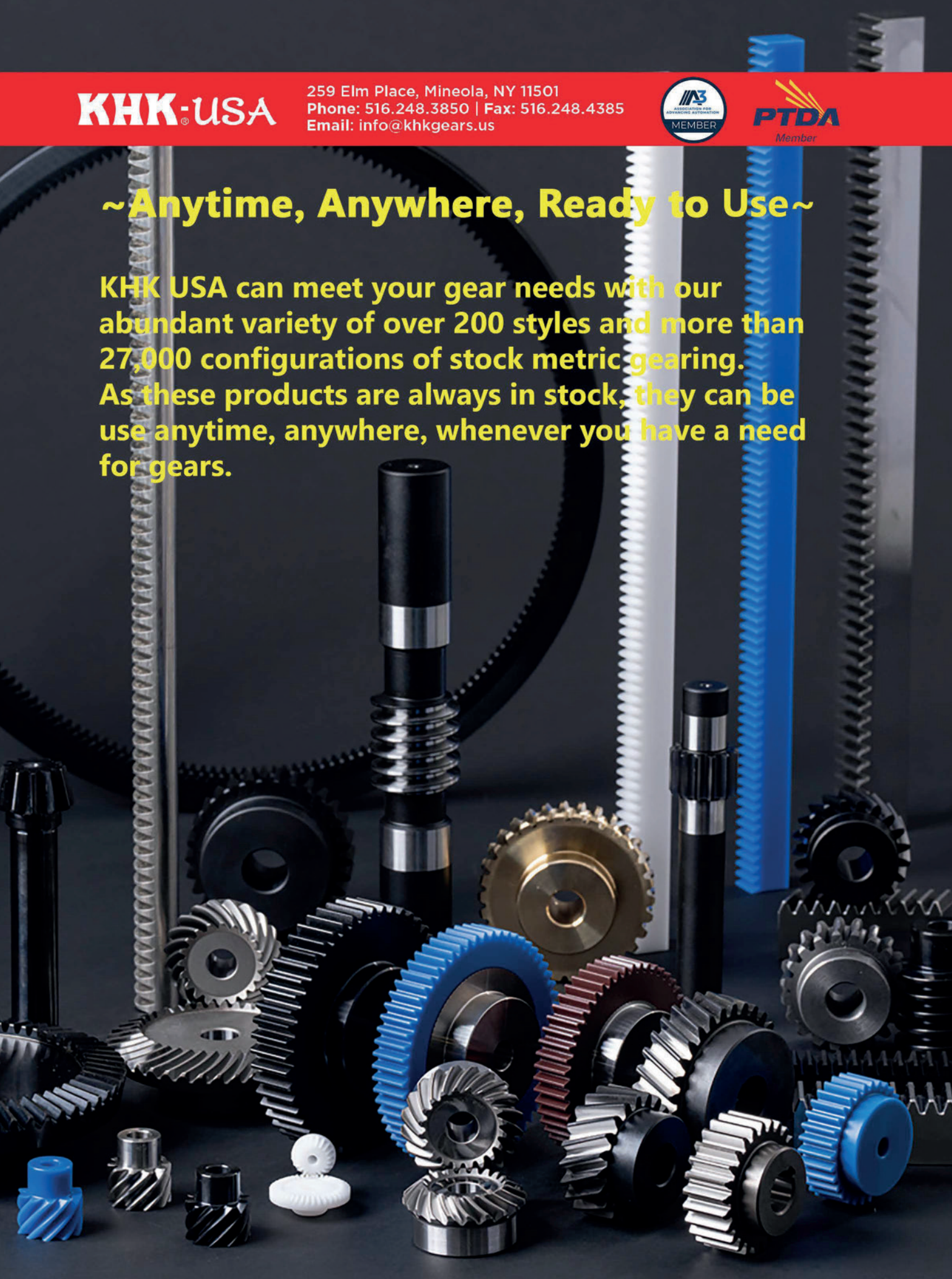

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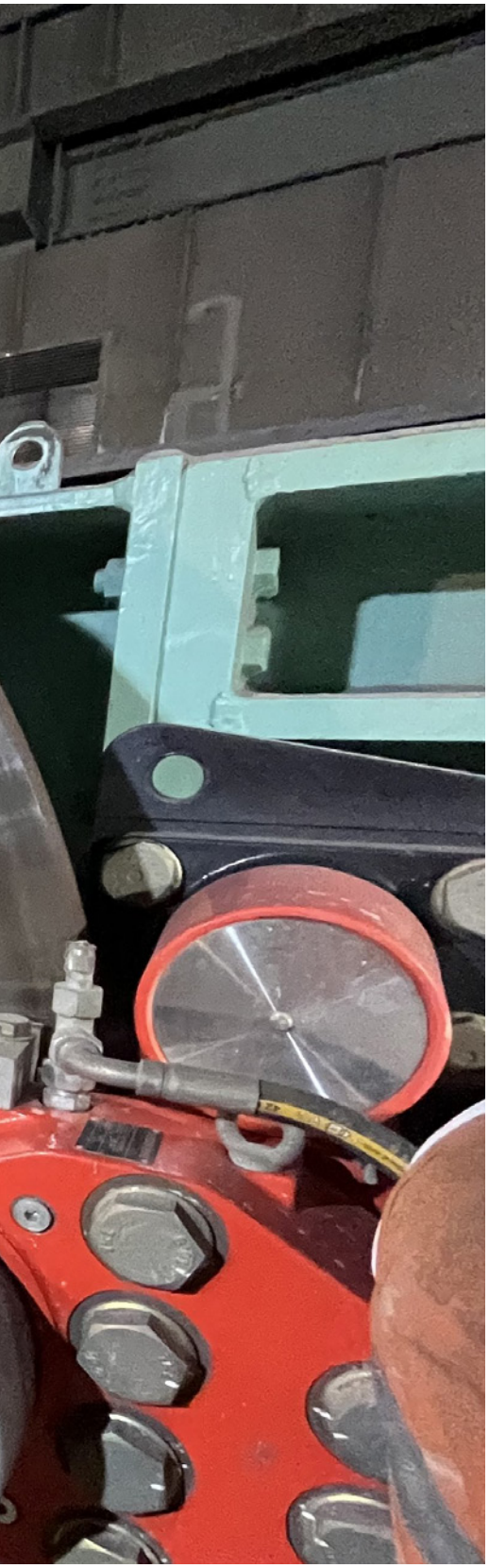
The Importance of Safety in the Mining Industry

Regal Rexnord examines operational efficiency of braking systems

Robin Schmidt, Sales Manager Mining–North America and South America, Regal Rexnord

Innovative braking solutions incorporate features like hydraulic releases and soft braking, significantly reducing wear and tear while ensuring precise control.



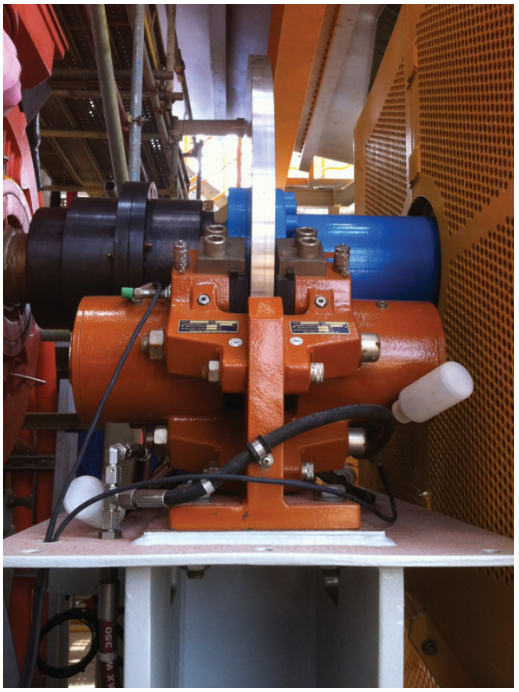
The rugged, high-stakes environment of the mining industry requires safety to be non-optional. Every piece of equipment, every process, and every decision must come together to ensure the livelihood of the workforce is preserved and operational excellence is achieved.

From conveyor systems to hoists and grinding mills, these critical components play a large part in providing essential raw materials to the global economy. One crucial element that plays a vital role in all these sectors, however, is the braking systems of these heavy applications.

The Critical Role of Brakes in Mine Safety

Brakes are a fundamental component in various mining applications, playing a crucial role in ensuring the safety of operations. Some key examples of how brakes are properly utilized within the industry include:

1. **Conveyors:** Conveyor systems are used to transport materials over long distances within a mine. Brakes are essential for controlling the speed of conveyor belts, preventing overloading and mechanical failures that could lead to accidents. Effective braking systems ensure that conveyors can be stopped quickly in emergencies, reducing the risk of injury to workers.
2. **Hoists:** Hoists are used to lift and lower materials and personnel in mines. Reliable braking systems are critical for hoists to prevent uncontrolled descent, which could result in severe accidents. Advanced braking technologies, such as fail-safe braking systems, ensure that hoists can stop safely even in the event of a power failure.
3. **Grinding Mills:** Grinding mills are used to crush and grind ore into smaller particles. Brakes are vital for controlling the rotational speed of the mills, ensuring safe operation. In case of an emergency, brakes can quickly stop the mills, preventing potential hazards such as mechanical failures.



Braking requires accurate speed modulation and contingencies for power loss, speed signal errors, or mechanical failures. All photos courtesy of Regal Rexnord.

The Future of Mining Safety

Deloitte released the report "Technological Advancements Elevating Health and Safety in Mining Operations" to address AI and IoT opportunities to help enhance health and safety practices—and, in some cases, even remove employees from working in hazardous conditions.

AI-driven predictive maintenance constitutes a pivotal facet of mining safety, leveraging data from equipment sensors and historical maintenance records to preemptively detect machinery health deterioration. Current maintenance practices vary by mining company, from planned maintenance to "as needed" maintenance when problems arise. Unplanned maintenance may increase the risk of incidents due to the higher potential lack of planning and confirmation that critical controls are in place. Predictive maintenance utilizing AI can predict specialized maintenance needs for each piece of equipment using an array of data from historical maintenance records, mine operations data, equipment telemetry and computer readings, and overall trends for a given piece of equipment. This predictive maintenance reduces unplanned downtime and unplanned failures that often result in increased injury rates.

Robotics for hazardous operations

The mining industry has long been an early adopter of robotics, particularly in underground environments where the application can increase workers' ease of travel underground and potentially remove them from harmful environments. Technological advancements in robotics and the application of both IoT sensors and artificial intelligence processing is effectively changing what's possible with robotics.

One useful application of robotics is exploration or mapping of subterranean spaces that may have been considered a confined space or have other known hazards that prevent human interaction. Confined spaces, for example, present several challenges; sending robots into confined spaces, which may contain poor air quality, flooding, collapsing areas, poor visibility, and chemical/gas exposure, for exploration or mapping purposes could be very effective.

Additionally, robots could be used for first response in rescue operations for which part of the risk is unknown hazards or conditions. Robots can assess structural conditions, mapping hazards, and delivering critical supplies including medical and oxygen. Rescue robots can be used rapidly after an incident, while response operations are planned, and can be equipped to perform rescue or triage operations and save lives with basic medical supplies and oxygen, thermal cameras, and environmental sensors.

Underground Drones

Drones have emerged as powerful instruments for mining with a variety of applications, many of which can improve health and safety outcomes. In underground environments, drones can be used to map areas that are difficult or impossible for humans to access. In recent years, the reliability and efficiency of drones has dramatically increased with IoT and will further accelerate with AI applications. IoT sensor applications on drones have allowed for real-time data and improved obstacle avoidance, real-time flight path adjustment, and various other critical improvements to enable smart and connected environments not possible a few years ago. One example is emergency response drones (ERDs). A drone can provide first responders with critical information to assess hazards and risks in a very timely way. In underground environments at Newmont, response drones are equipped with thermal imaging to aid recovery times. Other sensors such as methane or other gases identify hazards in real time and share them with rescue teams. Newmont's emergency response specialist noted of ERDs, "They provided critical and practical operational information to our responders to ensure they can perform their activities without having to place themselves in harm's way." Providing real-time data to rescue teams, drones enable informed decision-making and significantly augment the safety of search and rescue operations.

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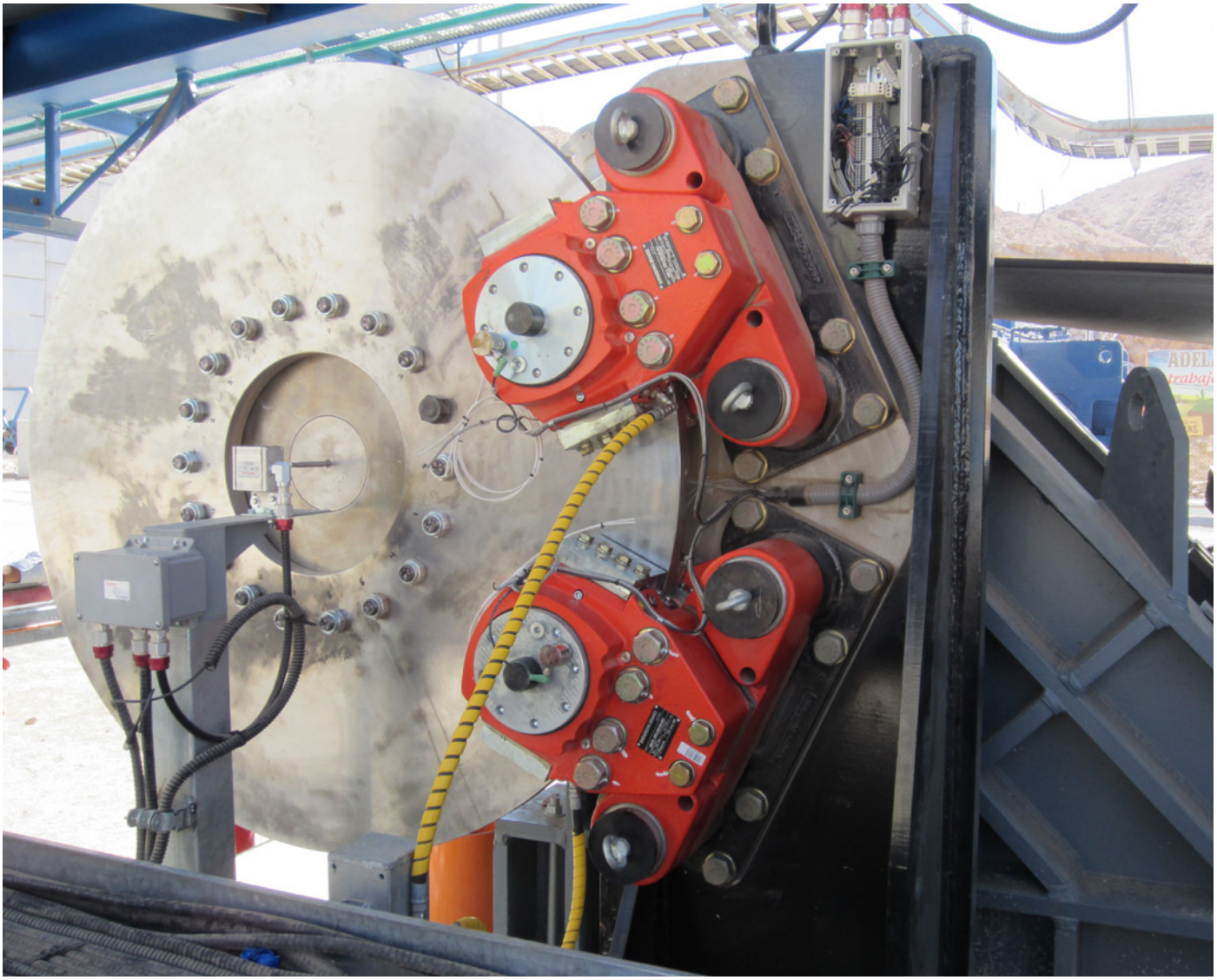
Application Considerations and Technological Advancements

There are many factors reviewed when designing and selecting a braking system—the torque applied when braking, location and orientation of the equipment, and operating conditions to name a few. However, braking is not as simple and on or off; often it requires accurate speed modulation and contingencies for power loss, speed signal errors, or mechanical failures.

Innovations in smart braking technologies have aided significantly in managing increased demands, detecting and monitoring equipment wear and status, and responding to changes in system resource availability.

A good example of these safety features being considered can be seen in Regal Rexnord's emphasis in advanced braking solutions



Safety improvements on components can protect the workforce from operational hazards.

from one of its brands, Svendborg Brakes. Innovative braking solutions incorporate features like hydraulic releases and soft braking, significantly reducing wear and tear while ensuring precise control. Having these systems installed and in mind ensure proactive steps are being taken to significantly reduce the chance of injury on the work site.

SOBO (SOft Braking Option) iQ's deployment by Svendborg Brakes has continued to show immense improvements towards the safety of conveyor systems. Integrating advanced braking algorithms with state-of-the-art hydraulic technology is a great step towards ensuring the safety of those on the jobsite.

Designed to mitigate uncontrolled loads and prevent catastrophic failures, SOBO iQ's braking protocols ensure smooth and controlled deceleration and the intelligent feedback mechanisms optimize braking force dynamically enable safe and reliable operation under various load conditions.

Pursuing Safety in a Mine

Incorporating a design partner with a focus on powertrain solutions into a new project or existing refurbishment can aid in identifying the variables needed for consideration and resources available to combat risk. This inclusion can pay dividends in both upfront design efforts and long-term risk prevention. The cost of downtime due to poor system selection can be immense, and a preventable injury or fatality would be catastrophic.

While the mining industry has made progress in improving safety standards, the journey towards a completely safe working environment is ongoing. Continuous innovation and adherence to safety protocols are imperative.

Brakes, as a critical safety component, exemplify how targeted improvements in equipment can significantly enhance the safety of mining operations, and by prioritizing safety, the mining industry can protect its most valuable asset—its workforce.

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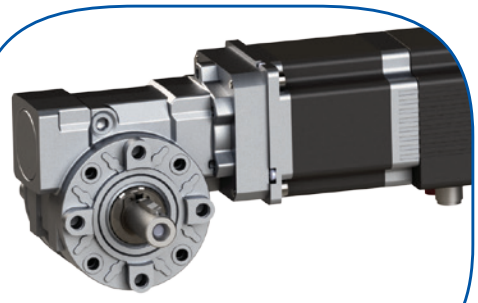

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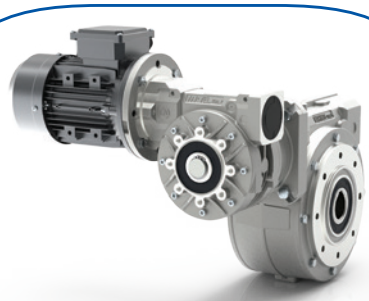

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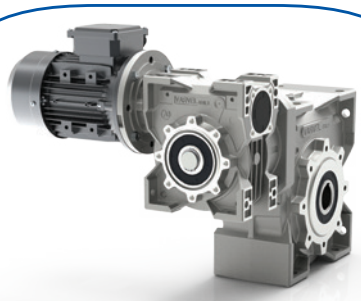

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Benefits of Inching Drives

CMD Gears enables mills to operate under challenging conditions

Matthew Jaster, Senior Editor

Hydraulic inching drives are highly adaptable and can be customized to suit mills of different sizes and configurations.

The mining industry relies heavily on efficient and reliable equipment to process large volumes of ore and mineral resources. One critical component in this ecosystem is the grinding mill, which plays a pivotal role in comminuting materials to prepare them for further processing. Grinding mills, particularly the large semi-autogenous (SAG) and ball mills, often operate under challenging conditions that demand precision, durability, and adaptability. A key technology enabling these mills to operate safely and efficiently is the hydraulic inching drive system.

"Hydraulic inching drives are auxiliary systems that provide precise, low-speed operation of large grinding mills during maintenance, inspection, and troubleshooting activities. They complement the primary mill drive systems, which are typically designed for normal operations," said Victor Manoury, sales engineer at FCMD North America, a company of Groupe CIF along with CMD Gears & Ferry Capitain.

Why Are Inching Drives Necessary?

Grinding mills in the mining industry are massive structures, with diameters that can exceed 40 feet and weights reaching hundreds of tons. Operating and maintaining these mills present unique maintenance challenges.

"Tasks such as replacing liners, repairing internal components, or inspecting the mill require precise positioning and rotation of the mill shell. For safety, inching drives allow controlled movement of the mill, minimizing the risk of accidental overspeed or uncontrolled rotation during maintenance," Manoury said. "During initial installation or post-maintenance alignment, inching drives enable precise positioning of components such as pinions and ring gears."

How Hydraulic Inching Drives Work

The hydraulic inching drive consists of several components working together to provide low-speed operation:

Hydraulic Motor: This motor converts hydraulic energy into mechanical motion, enabling the slow rotation of the mill.

Portable Hydraulic Power Unit (HPU): The portable power unit supplied pressurized hydraulic fluid to the motor, controlling its speed and torque.

Gearbox: The inching drive includes a high-reduction gearbox to achieve the necessary torque at low speeds.

Control System: An advanced control panel allows operators to regulate the speed, direction, and duration of mill rotation, either from the main cabinet of the HPU or from a remote control.

Brake System: Hydraulic inching drives incorporate robust braking systems to securely hold the mill in position when not in motion.

Engaging/Disengaging Mechanism: The system is equipped with engaging and disengaging systems, hydraulically controlled and operated, to transition from normal operation to inching mode.

Advantages of Hydraulic Inching Drives

There are several advantages to hydraulic inching drives including enhanced safety where operators have complete control over the mill's motion, minimizing risks during maintenance tasks. These hydraulic systems are also highly adaptable and can be customized to suit mills of different sizes and configurations.

A frozen charge occurs when material solidifies inside the mill, causing an imbalance that can damage the equipment if restarted without proper management. The hydraulic inching drive helps detect frozen charges by rotating the mill slowly and monitoring the resistance or torque feedback during the process.

In addition, balance positioning is crucial for ensuring that the mill is in a safe and optimal position for maintenance or during startup. Hydraulic inching drives offer precise control over the mill's rotation, allowing operators to place the mill exactly where needed.

CMD Hydraulic Inching Drives are designed and manufactured for high torque and low-speed applications, CMD's inching drives are built for the most demanding operations worldwide.

"Our versatile inching drives can be moved across your plant, offering a plug-and-play solution for maintenance. This flexibility allows cost savings by reducing the need for multiple systems or spare parts. Complete Package CMD inching drives come equipped with all necessary accessories and can be combined with CMD torque-limiting couplings and brakes typically installed with variable frequency drives," Manoury said.

Complete drive systems—including ring gear, pinion, gearboxes, and couplings—are also available. CMD offers comprehensive support from design and manufacturing to installation, commissioning, and aftersales service.

CMD delivers inching drives for heavy-duty applications. The company offers over a century of experience combined with continuous innovation and a commitment to supporting heavy-duty operations with reliable, high-performance equipment.

"Our field engineering team provides inspections, monitoring, and technical assistance as needed. Operators can control the inching drive from a safe distance, enhancing safety during hazardous operations. Intelligent systems enable precise positioning and rotation, reducing the need for manual intervention. Sensors and monitoring tools provide real-time performance feedback, enabling proactive maintenance and minimizing downtime," he added.

Applications in Mining

Hydraulic inching drives are essential in the following scenarios within the mining industry:

1. **Liner Replacement:**
   Liners in grinding mills wear over time due to constant impact and abrasion. During liner replacement, inching drives provide precise rotation, allowing workers to position the mill shell for safe removal and installation.
2. **Inspection and Cleaning:**
   Regular inspection of the mill interior is critical for early detection of wear, cracks, or other issues. Inching drives allow slow and controlled mill rotation, making it easier for maintenance teams to conduct thorough inspections.
3. **Alignment and Commissioning:**
   During the commissioning phase, inching drives help align the mill components, such as the girth gear and pinions, ensuring smooth operation of the main drive system.

Experience and Knowhow

With over 150 years of accumulated knowledge and experience, CMD has been a trusted supplier for mining, cement, and other heavy-duty industries. "As part of our commitment to continuous innovation, CMD has developed a new generation of hydraulic inching drives equipped with state-of-the-art technology. Designed to handle the increasing power demands of the mining industry, CMD's hydraulic inching drives are built for the world's largest gear driven grinding mills, up to 22 MW," Manoury said.

CMD delivers the newest and largest inching drives for heavy-duty applications. The company offers continuous innovation and a commitment to supporting heavy-duty operations with reliable, high-performance equipment. CMD Gears hydraulic inching drives meet the demands of today's industries while preparing for tomorrow's challenges.

"CMD provides customized solutions to meet specific application needs, offering complete systems from the motor to the shell including gearboxes equipped with gear/grid couplings, pinion and ring gears up to 16 m , and components designed to meet the specific needs of the customers supply of hydraulic or electromechanics inching drives ," Manoury said.

fcmdna.com

Liebherr's slewing bearing consists of 68 segments with a total diameter as large as six small cars in row. All photos courtesy of Liebherr.

Modernizing Component Technology

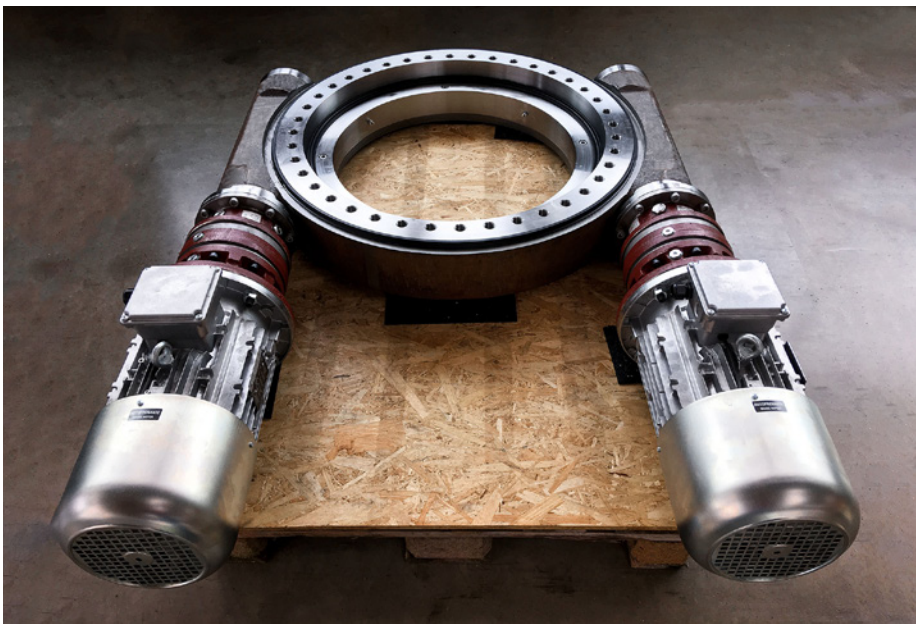
Liebherr offers innovative solutions for heavy-duty applications

Matthew Jaster, Senior Editor

Between trade shows including MINExpo and CES 2025, we've been treated to a great deal of new technology in areas like mining, agriculture, construction and heavy industrial components. Liebherr has modified its component portfolio to include digital measurement, electrification and maintenance-free technologies. Liebherr's component product segment offers advanced solutions for slewing bearings and slew drives that meet the rising demands across a variety of applications and industries. These components are future-ready and play a vital role in making operations much more efficient.

Slewing Bearings of the Future

Industries worldwide are under pressure to reduce their environmental footprint, while becoming more efficient, sustainable and safer. But how can these goals be achieved? Often, the answer lies in the hidden champions of heavy industry: slewing bearings and slew drives. These components are at the heart of machines in a wide range of applications, including excavators, cranes, tunnel boring machines, antennas, offshore cranes, bridges and wind turbines. To meet the growing demands, Liebherr focuses on continuous innovation. These advanced slewing bearings and slew drives are designed to seamlessly adapt to modern standards, making operations more efficient, safer and environmentally friendly.



This Liebherr slew drive is equipped with an electric motor.

Bearing clearance monitoring (BCM), for example, provides a digital solution for measuring wear in slewing bearings. Built-in sensors allow precise measurements of axial and radial wear without requiring technicians to perform manual checks in hard-to-reach areas. This does not only improve safety but also speeds up the monitoring process. Permanently installed sensors enable quick wear measurement via a web app, which can reduce downtime by up to 75 percent.

An upgrade to the BCM can be seamlessly integrated into the customers' system without the need for additional measuring devices or gateways, reducing system complexity and allowing users to analyze measurement data within your own systems.

These slew drives can be powered electrically, offering clear advantages: They reduce noise emissions and do not require hydraulic oil, which prevents the risk of oil leaks. Electrically driven slew drives are ideal for applications where no hydraulic systems are used. They offer a clean solution, especially in sensitive environments. The electric motors are also highly adaptable and can be combined with various gears. Thanks to intermediate flanges, motors can be easily integrated and installed in a space-saving manner. Electrically powered slew drives excel in precise positioning tasks, as their power control allows for accurate movements.

Liebherr's innovative solid lubrication, Lifinity, eliminates the need for regular relubrication. In this process, a heated polymer-oil mixture is introduced into the heated bearing. As it cools, it forms a stable layer that provides long-term lubrication for the bearing. A major advantage is the significant reduction in maintenance, as regular relubrication is no longer necessary, leading to considerable savings in operating costs and time. This increases productivity, as equipment requires less downtime for maintenance, thus extending the lifespan of machines and boosting overall operational efficiency. Lifinity also reduces the risk of corrosion, enhancing the longevity of the bearing. Conventional greases and oils can leak and pollute the environment, but with Lifinity, there's no such risk. This technology also meets strict NSF/H1 standards, making it suitable for food-related environments.

Expanded Slewing Bearing Portfolio

GustoMSC BV is a designer and engineer of mobile offshore units and equipment that focus on safe and efficient operations at sea for a more sustainable future. The company recently developed a heavy-duty crane for a new type of installation vessel. For the positioning of wind turbines on the high seas, transport ships can deliver individual parts directly to such a vessel. This allows for continuous work at sea without having to fetch new parts from the harbor. And it is in this heavy-duty crane that Liebherr's segmented slewing bearing takes over a vital task. Once in place, the bearing is the core element that turns a ship crane with a lifting capacity of 2,000 tons, responsible for the installation of offshore wind turbines. The slewing bearing, developed and manufactured by Liebherr Components in Biberach, Germany, consists of 68 segments, the total diameter of which is almost as large as six small cars placed in a row. During its service life of about 25 years, the 23 m bearing will help to erect offshore wind farms and contribute to sustainable power generation. The segmented slewing bearing was designed as light as possible to increase the load capacity of the ship.

"The crucial features thereby are the induction-hardened raceways of the segments, which offer a more efficient bearing cross-section than inlaid raceway plates, and thus add to weight reduction," explains Benjamin Schmid, head of sales maritime applications at Liebherr Components. "In this way, Liebherr supports the further development of offshore mechanical engineering, which is advancing into ever larger dimensions."

Liebherr Mining Innovation

Liebherr's mining production facility in Colmar, France, is responsible for making sure products can withstand the intense mining conditions. As group manager of the testing department, Lionel Oberhauser oversees the validation tasks that come across his desk, coordinating each task with the members of his highly skilled team.

"We can have very fast-paced days because of emergencies, or calmer days when we can carry out our planned tasks. Every day is different!" said Oberhauser.

Liebherr's mining equipment continues to deliver the latest component technology.

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Testing and validation of Liebherr's mining equipment is key to quality control.

The testing department is made up of four test engineers, a workshop manager, three measurement and adjustment specialists and, of course, Oberhauser. The team uses its extensive product knowledge to define and fine-tune the parameters of an excavator prototype to ensure that the machine functions as the designers expect and is as productive and efficient as possible. They are also responsible for checking components within subsystems, such as the cooling system, have been installed correctly. To do this fine-tuning and checking, the team conducts the relevant tests for each system and subsystem and then relays the collected information to the product development teams.

"We regularly go out to our customers' sites and to Liebherr branches around the world to monitor machines in field tests, take part in troubleshooting or acquire data from the field," Oberhauser said. "Our role puts us in contact with different players both in and out of Liebherr."

Oberhauser has been part of Liebherr Mining for nearly 14 years. He worked as a test engineer in the testing department for eight years before becoming group manager for the same team in 2019.

The nature of the role was a perfect fit for Oberhauser; it allowed him to mix the theory he'd learned throughout his mechanical engineering studies with the practical skills he gained working as a structural design engineer for a company that manufactured car-carrying trucks. Plus, the work itself—overseeing the testing, validation and fine-tuning of Liebherr's huge mining excavators—was a multidisciplinary and complex challenge that he thoroughly enjoyed when he first started and still enjoys to this day.

"Although my title has changed, my job still involves handling test engineering tasks about 40 percent of the time—which I love as this kind of job opportunity is rare," Oberhauser added. "When you work for the testing department, you must be able to talk to everyone as testing our excavators requires expertise in hydraulics, electricity, electronics, software and mechanics. Such collaboration is an important and fascinating part of my job."

Accepting the role as group manager was a big challenge for Oberhauser, but one that he continues to enjoy to this day.

"What's great about my job is the feeling of having an active role in product development and customer satisfaction. Our machines are gigantic and technological monsters and we're the ones who validate them."

Having a team that he can rely on is a huge part of why Oberhauser enjoys his work. Even during times of stress, he knows that his team will always give their best. During one particularly challenging period, Oberhauser had to work out how his four testing engineers could manage the validation of seven different machines all at the same time. This was all while members of his team needed to make multiple trips around the world, some of which took them as far away as Australia and Indonesia. This not only represented technical, strategic and test equipment management challenges but also challenges in diplomacy.

"In our work, we're facing the customer. We represent the image and quality of Liebherr Mining products both inside and outside the factory and it can be a lot of pressure," said Oberhauser. "But because the members of our group are motivated, trained and committed, we were able to navigate our way through this intense period. We know we can count on each other. It's priceless."

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PTE

Electric Motor Trends

A look at current and future motor technologies

John Morehead

Elemental Motors has developed a unique architecture that dramatically reduces the size and weight of torque motors.

It's an exciting time in the electric motor industry. In the past two years more truly innovative new technology development has occurred than in the previous two decades. We can thank the e-mobility movement for that. It's not just cars, trucks, bikes and buses, but just about everything else that moves on wheels as well as on water and in the sky.

What exactly is behind all this new motor technology development? Increased energy efficiency has been the prime mover. Not only to extend EV range with existing battery technology, but beyond e-mobility independent research commissioned by ABB found that 91 percent of 2,400 global businesses surveyed said that energy efficiency now had a critical influence on their choice of electric motors.

But there are lots of other factors driving new electric motor innovations, such as reduced weight, different form factors, increased power and torque density, rare earth magnet free, reduced copper, quieter operation, longer life, design for circular economy, etc.

The following are but a few of the new electric motor technologies introduced in the past 24 months that address those factors. One must keep in mind, though, that some may not yet be commercially available while others can be designed into OEM equipment today.

With geopolitics contributing to supply chain concerns regarding rare earth magnets, German powertrain company, ZF, has introduced its In-Rotor Inductive-Excited Synchronous Motor, a compact magnet-free design with performance equivalent to the most common motors for e-vehicles, permanent-magnet synchronous motors. What's truly innovative here is the inductive exciter inside the rotor shaft that reduces losses for the energy transmission into the rotor by 15 percent.

Founded just five years ago, U.S. company H3X Technologies produces high-density, lightweight electric motors for aviation, other industries ranging in power from 30 kilowatts to 30 megawatts. What's unique is that their motors are produced with integrated inverters, making their claim of power density up to 12 kW/kg continuous even more impressive.

The concept of in-wheel or hub motors for EVs continues to be debated, but German motor technology company DeepDrive has developed a unique dual rotor motor technology that produces a two-in-one motor for greater energy efficiency and torque density. A single stator drives both rotors simultaneously. DeepDrive has gotten early support from BMW Group with a $33.5 million investment.

Axial flux motors are a hot topic today in the e-mobility world because of not only their torque and power density benefits as well as the potential to produce high direct torque at relatively low speeds,

The HPDM-30 is a 33-kW integrated motor drive weighing 4.1 kg.

Capable of delivering up to 2.5 MW, the WM2500 motor has a power density of around 18-20 kW/kg.

thereby eliminating the need for gearing. But industrial users were left just looking until Brazilian motor manufacturer, WEG, introduced its line of W80 AXgen axial flux motors configured as NEMA frame replacements for higher energy efficiency in stationary industrial applications requiring up to 500 ft. lb. torque.

Copper can be significantly reduced with Printed Circuit Board stator technology developed by U.S. company, E-Circuit Motors. What's truly innovative is that OEMs can use ECM's software tools to design their own PCB stator motors with up to 80 percent less raw materials and greater than 90 percent efficiencies while being up to 70 percent lighter.

C-Motive Technologies in the United States is the only company developing commercially viable electrostatic motors, which use no magnets and printed circuit boards with a proprietary dielectric fluid to produce high efficiency, low speed direct drive torque without gearboxes or active cooling. A 2 hp C-Motive electrostatic motor is estimated to save up to $1,400 a year in energy costs in a typical industrial application.

Chinese EV manufacturer, GAC, through its Ruipa Power Technology Company, has recently introduced a new EV motor based on an amorphous alloy they claim is the most advanced soft magnetic material in the world. It is claimed to be very easy to magnetize and has an ordinary magnetic permeability 20–100 times that of silicon steel sheets. Supposedly 90 percent thinner than traditional silicon steel sheets, the iron loss is reduced by more than 50 percent. GAC claims the new motor technology achieves up to 98.5 percent efficiency, with a 13 kW/kg power density at 30,000 rpm.

But don't think that one company's proprietary soft magnetic composite material precludes you or others from developing high efficiency electric motors. Australian company, Kite Magnetics, is commercializing a novel nanocrystalline magnetic core material developed at Monash University for motors and generators and will be offering stator cores that reduce core losses by up to 97 percent compared to traditional electric steel cores. The Aeroperm cores offer a three percent increase in torque density over conventional materials, allowing motors to be more compact and powerful.

In terms of exciting motor technology for automation applications, U.S. company, Elemental Motors, has developed a novel transverse flux motor topology that folds 6 axial and 3 radial airgap shear areas into the same case size as a conventional motor. In robotic applications the high torque density of the motor can eliminate a single stage planetary gearbox and at roughly one-fifth the weight of similar torque capability servomotors.

The embryonic field of electric flight is bringing about some incredible performance breakthroughs for large electric motors capable of powering passenger planes. New York based Wright Electric has laid claim to developing the world's most advanced electric motor for aviation. With power density up to 16 kW/kg and producing 2.5 megawatts of shaft power, the Wright motor has the potential to enable zero-emissions one-hour flights.

While all of this new electric motor technology development can be mind-boggling to the average OEM or motor manufacturer, what is most impressive is the "trickle down" effect these developments will have on industrial and commercial motors of the future. No longer can one look at the electric motor industry as stagnant and overly conservative. By and large, creative young engineers are able to respond to the tremendous growth potential e-mobility brings by looking at electric motor technology development with a fresh perspective while having a growing toolbox to call upon.

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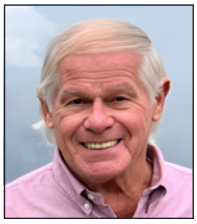

John Morehead has helped leading American, European and Asia electric motor manufacturers significantly grow their businesses for 25+ years—from UAV drone motors and ESCs to 800V EV motor systems and everything in between.

Mitigation of Gear Whine Noise in Agricultural Tractor Application

Ketan Bhate, Pravin Patil, and Prashant Bardia

In the realm of tractor gearbox applications, gear whine noise has long been a persistent challenge that significantly impacts the user experience and overall perceived performance of the vehicle. This paper delves into a comprehensive study that discusses the approach to tackling this issue through a combination of design optimizations, simulation techniques and physical validation processes.

The study begins by meticulously examining the load-dependent noise characteristics encountered during field operations, where distinct gear orders were observed prominently at given speed conditions in the noise order analysis. After conducting extensive drivetrain simulations, the research shifts its focus towards optimizing the gear tooth macro geometry, with specific emphasis on increasing the total contact ratio (helix angle and face width), while also incorporating refinements to the gear micro geometry within the confines of design and manufacturing constraints.

Moreover, the study delves into addressing gear manufacturing variations by transitioning from conventional shaving processes to tooth grinding methods, thereby effectively controlling the gear tooth profiles. To further validate the simulation model, a system-level bench test is conducted utilizing a gear contact pattern correlation approach.

Additionally, the research endeavors to develop prototype gears to facilitate physical experimentation, employing multiple parameter combinations to validate the proposed modifications. The culmination of these interventions results in a significant reduction in Operator Ear Noise Level (OENL), underscoring the efficacy of this comprehensive approach in analyzing and mitigating gear whine noise in real-world tractor applications.

This study underscores the critical importance of meticulous geometric modifications in effectively addressing and minimizing gear whine noise, ultimately contributing to an enhanced overall tractor performance and improved user experience.

Problem Statement

During the field testing of the new tractor transmission development project, gear noise was reported in a plowing application. Test data analysis was carried out to locate sources in the specific application, engine RPM range and gear engaged. Sound recordings reported by field test engineers revealed that this noise was tonal in character. The OENL was reviewed by the project team and was found to be unacceptable. A team was formed to work on the issue resolution. The objective was derived to reduce noise to an acceptable level. A multidisciplinary team was formed to address this issue which included team members from drivetrain design engineering, virtual verification, component bench testing, field testing, Noise, Vibration & Harshness (NVH) testing, prototyping, and manufacturing quality.

Literature Review

In a study by Liu et al. (Ref. 1), the impact of profile and face contact ratios on gear mesh stiffness and gear whine noise in helical gears was investigated. The research highlighted that while the total contact ratio should not be an integer, a face contact ratio close to an integer can help minimize noise. This study provided valuable insights into target contact ratios, moving away from the conventional "more is better" approach.

Munro and Houser (Ref. 2) outlined various gear noise excitations, including transmission error, mesh stiffness variations, axial shuttling, friction, and entrapment of oil or air. Post-test examinations ruled out flank friction and air entrapment as factors, and the absence of burnt oil traces eliminated oil entrapment as a parameter of interest. The study delves into the remaining factors later in this paper.

Lahoti, Patil, and Wagner (Ref. 3) emphasized the benefits of reducing transmission error and improving contact patterns to reduce gear whine noise. Their work demonstrated a strong correlation between reducing transmission error and minimizing noise, stressing the importance of analyzing these enhancements across the application load spectrum for consistent noise performance.

The work of Smith et al. (Refs. 5, 6) addressed the necessity and design considerations of tip reliefs, distinguishing between "short" and "long" tip reliefs and their respective applications.

This research integrates insights from these studies and applies them to a real-world gearbox noise issue. The paper also incorporates manufacturing trials to validate assumptions made in design and simulation, followed by testing and physical validation of the proposed solution.

Gear Drive Schematic and Nomenclature

Part of the gearing arrangement in said geartrain is shown in Figure 1.

The three gear meshes shown here carry torque through the transmission in given gear and range shift lever positions. The gear meshes of interest are Gear mesh 1 (18.75 order of input shaft) and Gear mesh 2 (15.1 order of input

First presented at the 2024 Fall Technical Meeting (FTM), October 7–9, 2024, Rosemont, IL. Printed with permission of the author(s). Statements presented in this paper are those of the author(s) and may not represent the position or opinion of the American Gear Manufacturers Association.

shaft). The red arrows mark the direction of torque flowing through this multi-axis gearing system.

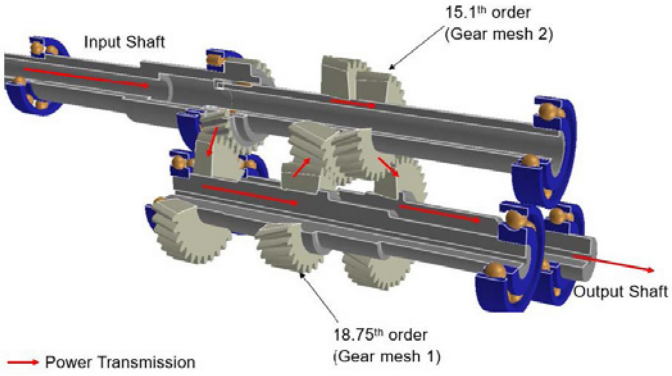

Figure 1—Gearbox schematic and power flow.

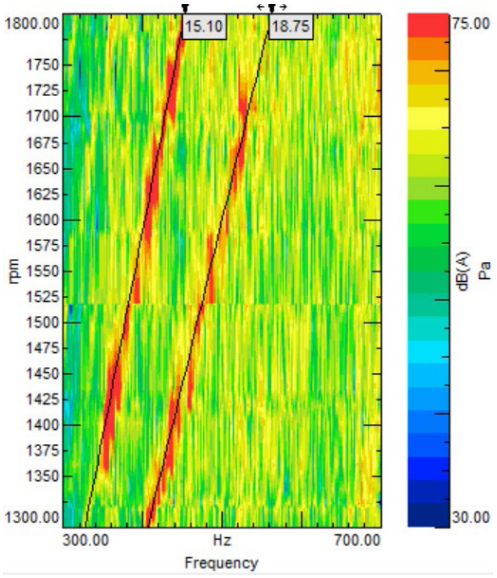

Figure 2—Baseline response.

Methodology

Noise Testing and Order Analysis for Source Identification

Noise data is recorded using a binaural headset along with engine RPM. Different sets of data acquisition were executed corresponding to constant RPMs, engine RPM sweep (from low idle to high idle engine RPM). A sampling rate of 44 kHz is considered. For test data analysis, a frequency resolution of 1 Hz with A-weighting is applied.

Based on the order analysis, high amplitude orders were identified as shown in Fig. 2. By suppressing those orders in sequence/combination and listening to the sound, dominant orders 15.1 and 18.75 are confirmed for further investigation.

The noise was specific to the combination of the speed and range lever selection. In the noisy condition, three gear meshes were transmitting torque to the spiral bevel gears connected to the rear axle through the planetary final drive. Based on the number of teeth and power flow, orders were calculated for different gear mesh combinations. It was found that the two identified orders viz 18.75 and 15.1 corresponded to one range gear mesh and one-speed gear mesh which were engaged and transmitted the torque.

Gear Geometric Parameter Considerations and Virtual Analysis

Gear Macrogeometry Improvements

To increase the profile contact ratio in each gear mesh, the modules were reduced, and tip diameters were increased marginally. To prevent contact between the tip and the root of the gear, we first performed theoretical calculations to determine the necessary root clearances. In addition to these manual calculations, we also used advanced simulation software to analyze potential tip-to-root contacts. This analysis considered factors such as increased tip diameters, misalignments, and tooth deflections. The macro geometry improvements also included, in each gear mesh, the gear face width and helix angle increase to achieve a minimum face contact ratio of 1. These design enhancements helped raise the sum of contact ratios to over 2.5 for these helical gears. A summary of these changes is provided in Table 1. These macro geometry changes were in line with the study by Liu et al. (Ref. 1) mentioned earlier.

Gear Parameter	Baseline Design (Gear mesh 1)	Baseline Design (Gear mesh 2)	New Design (Gear mesh 1)	New Design (Gear mesh 2)
Module (mm)	2.95	3.0	2.9	2.9
Pressure angle (°)	20	20	20	20
Helix angle (°)	18	16	20	24
Face width (mm)	20	18	29	23
Profile contact ratio	1.44	1.49	1.53	1.51
Face contact ratio	0.67	0.53	1.08	1.03
Sum of contact ratios	2.11	2.02	2.61	2.54
Gear mesh stiffness (N/mm)	3.2244e5	3.3362e5	4.6551e5	3.7744e5

Table 1—Gear macrogeometry parameters.

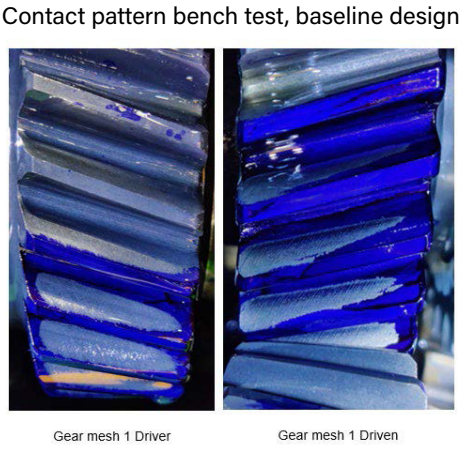

Figure 3—Baseline design physical gear contact pattern.

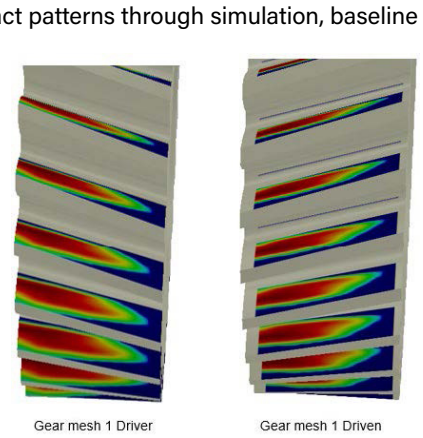

Figure 4—Baseline design simulated gear contact pattern.

To calibrate the simulation model, a gear contact pattern test was conducted on a test bench using masking compounds on the gear flank. The torque through the gear mesh was set to be the same as that in the actual application. Actual torque values in field applications were obtained by strain gauging the transmission shafts and running the tractor in field conditions. This physical test served two purposes: to calibrate the simulation model and to understand contact health issues in one of the two gear meshes. It highlighted the necessity for lead slope correction to achieve centered contact within the application load range. This insight informed the final microgeometry adjustments in the lead direction for the gear mesh of order 18.75 (Gear mesh 1).

The lead crown values were kept to a minimum to increase effective face contact ratios while ensuring no edge loading, as revealed in the contact pattern studies conducted in the simulation software.

It became evident that Gear mesh 1, with its offset contact pattern, required lead slope correction. During the development of these lead corrections, it was discovered, through software simulations, that the necessity for lead correction could be reduced by flipping the helix hand due to the change in system deflections. After evaluating the impact on the calculated bearing life, the team opted to modify the helix hand in conjunction with the previously mentioned gear design enhancements.

As indicated in the literature review (Refs. 5, 6), it is understood that when designing for full load conditions, long tip reliefs offer superior PPTE reduction compared to short tip reliefs. Parametric simulation runs also demonstrated that longer tip reliefs yielded lower PPTE results, with the PPTE outcomes showing less sensitivity to lead and profile microgeometry tolerances. Consequently, the start of tip relief angles was reduced, alongside an increase in tip relief values, to minimize the PPTE. These start-of-tip-reliefs for each of the gear meshes were close to, but slightly less than the working pitch roll angle.

The simulation results of the macro and micro gear design improvements are presented in the "Verification" section.

Manufacturing Parameter Considerations and Virtual Analysis

The selection of the manufacturing process can also be influenced by the simulation results and limitations of traditional gear tooth finishing methods. Software simulations revealed that the tolerance of the start of tip relief had a significant impact on the PPTE values. Previous gear projects involving gears of similar size indicated that even with controlled heat treatment and an additional stress-relieving cycle, shaving could only achieve start-of-tip-relief roll angle tolerances of ±1.5 degrees. Simulation data indicated that this would lead to a notable increase in PPTE values. Further attempts to address this issue are discussed in the article "Lessons Learned from Earlier Trials" later in the paper. It became evident that gear shaving was not a viable solution to reduce these gear excitations. Gears that were originally manufactured under DIN 9 grade (using shaving) were upgraded to DIN 7 grade (using grinding) by opting for hard grinding as the finishing process. It is important to note that all gears underwent heat treatment for case carburizing throughout the trials mentioned in this paper.

From the first attempts at grinding the gear flanks, a sharp edge was visible at the transition between the involute and tip relief zones of the profiles. This sharp edge was a result of high tip relief amounts along with linear tip relief grinding method causing a sudden transition from pure involute. This sharp edge could have potentially caused its own excitation when in contact under load, creating noise. To mitigate this issue, smoother transitions were deemed necessary, requiring the implementation of parabolic tip relief and transition fillet radii instead of linear tip relief tooth grinding. Simulations also demonstrated superior PPTE values with parabolic tip reliefs compared to linear tip reliefs for each gear mesh.

It is acknowledged that, regardless of the fidelity of the virtual analysis model, it remains challenging to encompass all system and assembly-level parameters and behaviors in software simulations. In response to these unknowns, it was recommended that the tooth profile grinding manufacturer produce various min/max samples within the proposed microgeometry tolerance band.

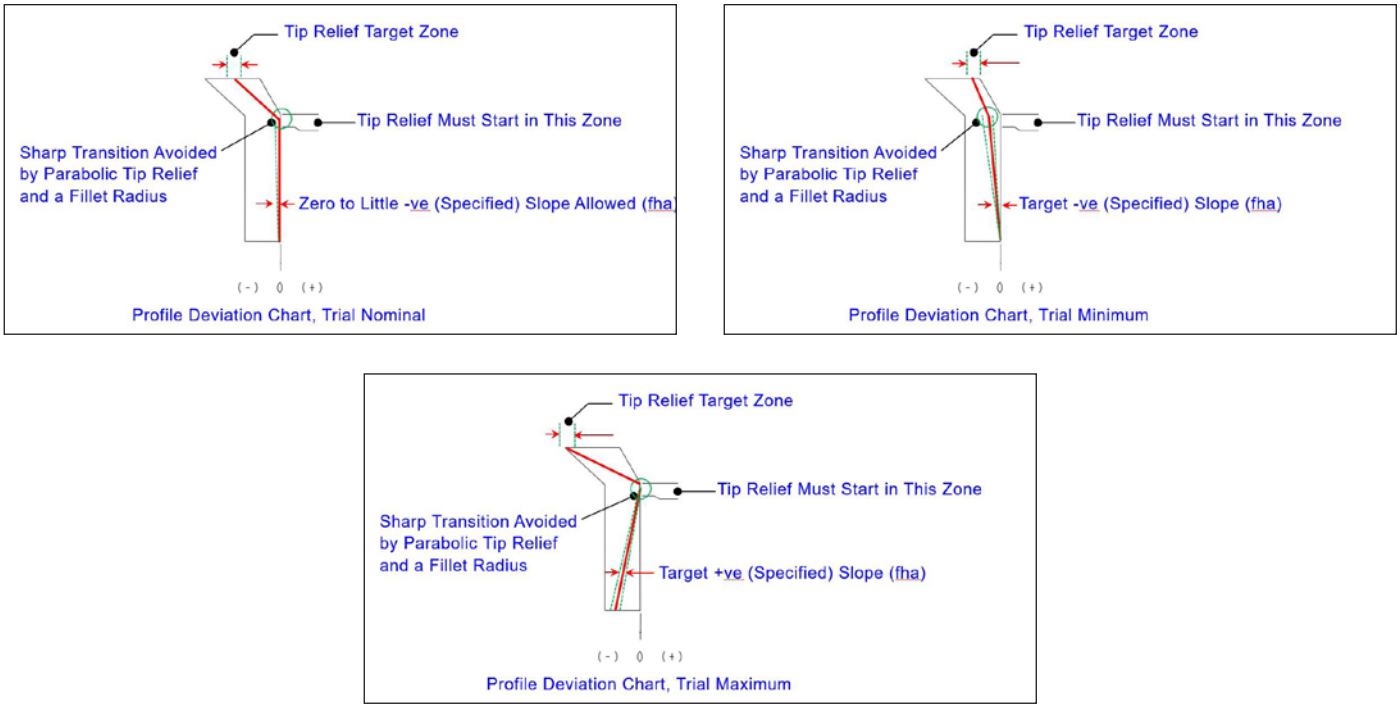

Figure 5A—Gear manufacturing profiles (Ref. 10).

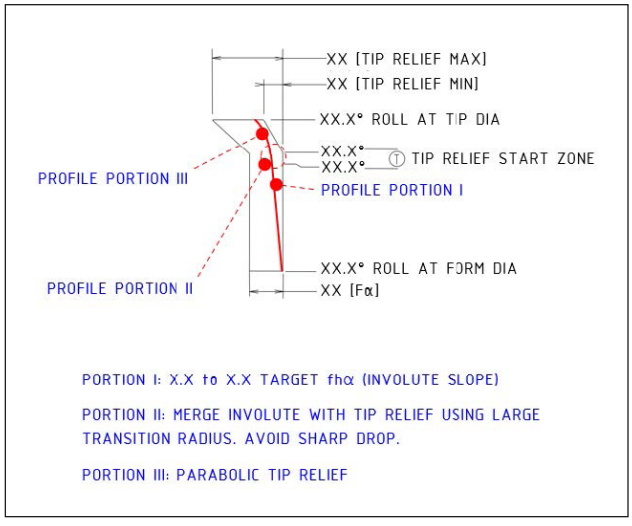

Figure 5B—Special tip relief and transition instructions.

This approach would allow for the physical observation of noise improvements resulting from different values of profile slope ($f_{h\alpha}$), tip relief, and crown.

The three profiles above (Figure 5) referred to as Nominal, Minimum, and Maximum profiles illustrate the grinding trials described earlier. Utilizing a single flank grinding machine, various possible profiles were manufactured to simulate the effects of manufacturing variations in large batch production and to identify profiles yielding improved noise results. Lead charts were prepared alongside these profiles, where "Nominal," "Min" and "Max" denoted the target, minimum, and maximum lead modifications based on the microgeometry of the proposed design. Special instructions for providing 2nd-degree parabolic tip relief and a smoother transition included specifying the intended profiles on the K chart such as Figure 5B.

Multiple samples of each design combination (nominal, minimum, and maximum) were produced for use in transmission applications during field and laboratory testing, marking a significant advancement in the solution's development and testing phase. It was discovered that intentionally introducing a limited negative slope helped enhance noise levels, leading to the incorporation of these $f_{h\alpha}$ modifications into the design.

Verification

Contact pattern validation is carried out to verify to check gears are manufactured based on desired gear profile and lead parameters. Physical contact patterns are also well aligned with the simulated gear contact pattern.

Transmission error, which is a major source for gear whine, showed significant improvement by accommodating gear macro and microgeometry improvements, listed below Figure 8.

PPTE throughout this research is depicted in the plots below. The blue markers represent PPTE at nominal design values while the black markers represent the minimum and maximum PPTE results of the tolerance study in the virtual simulation model.

With the proposed gear modification, field testing is executed to verify the response. By keeping the test methodology and instrumentation the same, noise data were recorded and analyzed. With the proposed modification, there was significant noise level reduction compared to the baseline design as shown in Figure 9. Also, jury testing was carried out for subjective evaluation to confirm the outcome, i.e., noise reduction. After confirming all

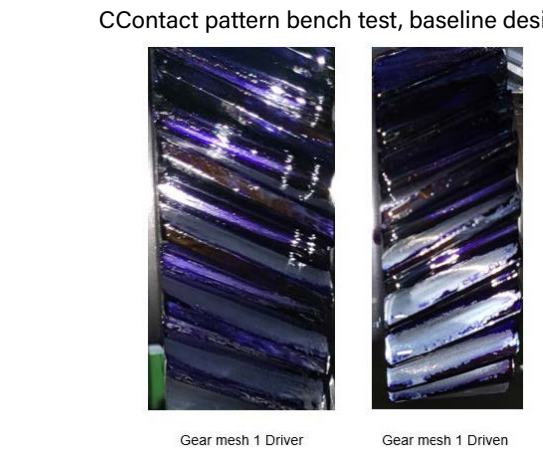

Figure 6—Baseline design physical gear contact pattern.

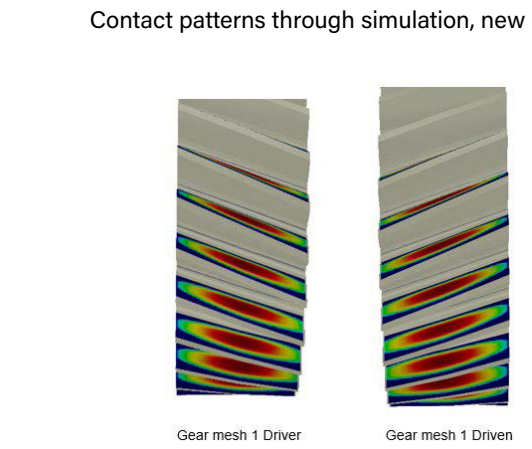

Figure 7—New gear design simulated contact pattern.

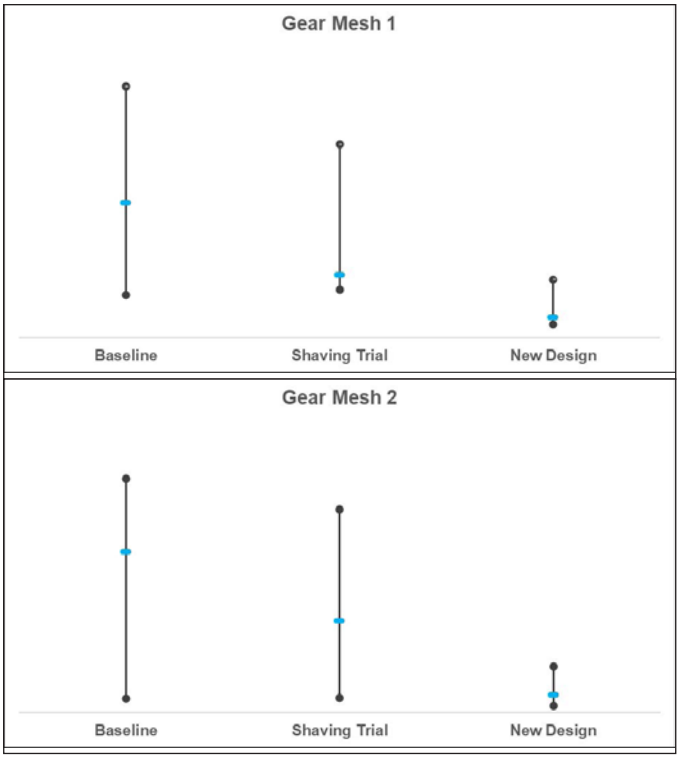

Figure 8—PPTE variation for new gear design.

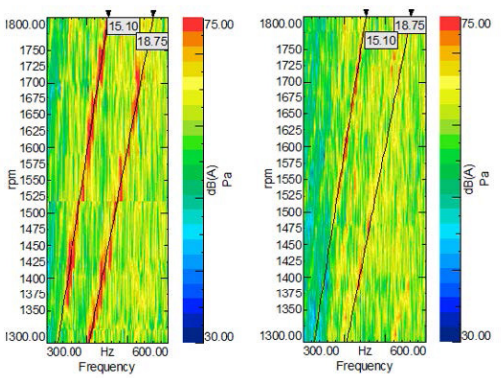

Figure 9—Baseline vs. new design response.

these trials and meeting the noise reduction targets, the recommended design modification was implemented. This resulted in enhanced customer comfort.

Lessons Learned from Earlier Trials

1. Gear runout (F_r) was a key parameter of interest during the initial trials. It is commonly understood that gear runouts can sometimes lead to abnormal noise. Low runout gears, selected from production batches by inspecting each gear for runout, were tested in the application. While there was a considerable reduction in grinding noise and background noise of the gearbox, the identified gear mesh frequencies responsible for the noise issue showed no measurable or perceptible improvements in noise levels.
2. The initial design was manufactured using shaving as its finishing operation. The first attempt to reduce noise was made by opting for shaving instead of grinding as the gear-finishing process. This trial focused on gear microgeometry optimizations, with no macro geometry enhancements, manufactured by hobbing and finished by the shaving operation. However, inspections of the manufactured gears revealed limited control over microgeometry parameters such as the start of tip relief, shape of tip relief, $f_{h\alpha}$, and lead slope. Analysis of the measured gear flank topographies in the simulation model did not show any improvement in PPTE. This lack of improvement was confirmed during field application trials, underscoring that shaving, due to its inherent process characteristics, is not suitable as a finishing operation for gear noise sensitive to microgeometrical parameters.
3. Transitioning from shaving to grinding was aimed to enhance manufacturing accuracy, achieve better control over microgeometry parameters, and attain finer surface texture/roughness. While the shift from shaving to grinding improved the gear PPTE in simulation results, an unforeseen excitation emerged from the sudden drop in the involute profile at the transition from pure involute to the tip relief surface of the gear. This abrupt profile transition resulted in a

visible edge on the ground gear flanks, leading to poor noise performance. It is crucial to study and smoothen this transition by incorporating a curved tip relief and a significant fillet radius at the start of the tip relief. This adjustment can be implemented in machine settings during single flank grinding or addressed in the design of a new dresser for the generative grinding process.

4. Gear flank surface finish was investigated separately as another parameter which could show improvement in gear noise. Upon trial minor subjective improvements were observed in noise, but there was no measurable data to support these noise improvement claims. It was concluded that for given application and design constraints, only surface finish was probably not a suitable solution to gear whine noise.

Conclusion

The literature review indicates a strong correlation between gear contact ratios and transmission error, as well as gear whine noise. The research findings are consistent with earlier work by Liu et al. (Ref. 1) which explains that a face contact ratio close to an integer is significantly associated with noise reduction.

As highlighted by Smith (Ref. 5), long tip reliefs offer greater benefits in full-load applications. Given that plowing represents a full-load scenario for the tractor under consideration, the study's outcomes align with Smith's insights.

The manufacturing trials lead to the conclusion that, for a specific gearing arrangement, negative profile slopes ($f_{H\alpha}$) exhibit superior noise characteristics compared to positive profile slopes. Intentional incorporation of such slopes in gear micro geometries can aid in reducing PPTE and potentially decreasing noise levels.

Furthermore, the study demonstrates the importance of achieving smoother transitions at the start of the tip relief, along with advocating for the adoption of parabolic tip reliefs over traditional linear tip reliefs.

Conducting contact pattern tests on a durability test bench proves instrumental in calibrating virtual simulation models effectively. It is crucial to accurately determine the torques transmitted through the transmission system, either through instrumentation or data acquisition during vehicle operation.

Acknowledgments

The authors would like to acknowledge the guidance and contribution of numerous colleagues at John Deere, without whom these efforts would not have been possible. Among these are Mr. Satish Wagh, Mr. Pravin Jadhav & Mr. Joy Fernandis from the drivetrain design group, Mr. Nilesh Patil, and Mr. Rahul Patil from the Virtual Verification group. We also would like to acknowledge the support of Mr. Pratap Jadhav & Mr. Amol Pimpale from the Physical Verification group. The authors are also very grateful for the solid support of management throughout the effort and their commitment of the necessary resources to successfully apply these technologies.

PTE

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SCHAEFFLER DIGITAL SOLUTIONS

Wins Best of Industry Award

(From left) Ute Drescher, Thomas Smolka, Daniel Kobel and Andreas Schröter
Picture: MM Maschinenmarkt.

Schaeffler Digital Solutions GmbH, a subsidiary of the Schaeffler Group based in Chemnitz, has received the Best of Industry Award 2024 in the "Best in Manufacturing: Networked Systems" category from the trade magazine MM MaschinenMarkt for its autinityDAP (Data Acquisition Platform) software. The software consolidates data from machines, controllers, and sensors in a single application to enhance the efficiency of machine parks by predicting scenarios such as unplanned downtimes. The prestigious award recognizes Schaeffler's innovative strength and commitment to achieving a fully digital factory that operates efficiently, flexibly, autonomously, and sustainably.

"The digital networking of machines and systems across the entire value stream is a core element of Schaeffler AG's digital agenda and essential for successful and consistent production digitalization," says Roberto Henkel, senior vice president operations digitalization and IT at Schaeffler and managing director of Schaeffler Digital Solutions GmbH. "The innovative autinityDAP software is a prime example of how production data can be recorded to flexible effect and used to optimize manufacturing processes. With autinityDAP, Schaeffler is setting new standards in the industry. We are very proud of this prestigious award and the recognition we have received from industry experts."

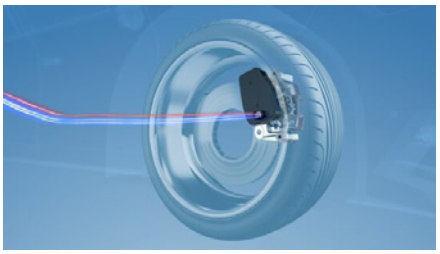
The autinityDAP software enables efficient data recording and provision for various apps and services. The open interface allows third-party systems to access the collected data, enabling flexible onward processing and integration into existing production environments. Developed in-house, the software consolidates all machine and production data on a unified platform, eliminating the need for multiple networking devices. The open, container-based software architecture enables the integration of additional apps, ensures secure data transfer, and provides extensive compatibility with various machine controllers and existing systems.

Jens Hammer, managing director of Schaeffler Digital Solutions GmbH, states: "We are delighted by the positive response we have received from our customers regarding autinityDAP. This award validates our vision of advancing digitalization within the industry. In the coming months, we will focus on optimizing autinityDAP further and developing additional functions to enhance the platform's value for our customers."

schaeffler.com

ZF

Secures Brake-by-Wire Technology for Light Vehicles



ZF has reached an agreement that includes planned volume production of brake-by-wire technology along with cutting-edge steering in a single class of vehicle.

Featuring the Electro-Mechanical Brake and by-wire technology on the rear brakes, the project will also include ZF's Integrated Brake Control and traditional front calipers, creating a "hybrid" braking system of by-wire and hydraulics that offers increased flexibility to the manufacturer. The agreement will also provide significant steering technology with ZF's Electric Recirculating Ball Steering Gear. This braking technology combined with traditional braking systems and innovative steering tools further solidifies ZF's position as the industry leader in providing complete chassis solutions to its customers while providing a major customer win.

"We are all proud to see ZF's technology leadership in the Chassis segment providing tangible value for our customers. Our goal when combining our steering, braking, dampers and actuators as well as corresponding software businesses into a single division was to create the world's most comprehensive Chassis Solutions product and system offering," said Peter Holdmann, board of management member at ZF and head of Division Chassis Solutions. "This

combined center of expertise allows us to offer comprehensive solutions that integrate advanced engineering, innovative design, and cutting-edge technology to deliver unparalleled performance and safety."

With the Electro-Mechanical Brake (EMB) as a key component of the brake-by-wire technology, ZF lays the foundation for the software-defined vehicle that will lead to new functions and features, many that emphasize safety as much as driving comfort. One such feature being explored with by-wire technology is the ability for the vehicle to autonomously brake and steer in a crash situation.

"This major business win shows that our strategy is correct and successful," Holdmann said. "With a comprehensive product portfolio consisting of hardware and software with solutions for motion control of vehicles in vertical, transverse and longitudinal dynamics, we supply customers with system know-how from a single source. This is how we actively shape the transformation to a software-defined vehicle."

zf.com

KEMCO SYSTEMS

Welcomes Sawyer as Regional Sales Manager

Nicholas (Nick) Sawyer recently joined the Kemco Systems sales team as regional sales manager. Sawyer brings an extensive background in the food and beverage industry to the team.

Sawyer specializes in assisting customers in identifying process bottlenecks and problems and implementing process treatment solutions within their respective production applications. He has a comprehensive technical background in, wastewater treatment systems, fluid handling and pump systems and has spent his career assisting industrial and municipal customers.

As a regional sales manager, Sawyer oversees and supports business development in the Northeast, including Maine, New York, Vermont, New Hampshire, Rhode Island, Connecticut, Delaware, New Jersey, Massachusetts and Maryland. Sawyer will support the needs of Kemco's customers by ensuring laundries, food processing facilities and industrial organizations are implementing the advanced technologies and services of Kemco Systems.

Nicholas (Nick) Sawyer, Regional Sales Manager

"I'm excited and grateful for the opportunity to join this incredible Kemco team, and I look forward to contributing my skills and growing together with the company," said Sawyer.

Most recently, Sawyer worked with a process equipment manufacturer, focusing on fluid handling, wastewater processing and pump solutions. During this time, he worked with design engineers, engineering firms and in-house project managers to overcome design challenges and meet customer goals.

"As we welcome Nick to our team, we are eager for him to connect with our customers and advance our reach in the food, laundry and ready-mix industries," said Matt Lewis, Kemco Systems vice president of sales and marketing.

kemcosystems.com

TIMKEN

Appoints Ryan to Board of Directors

The Timken Company recently announced the appointment of Kimberly K. (Kim) Ryan to its Board of Directors. Her election increases The Timken Company Board to 13 members.

Kimberly K. (Kim) Ryan

Ryan has served as director, president and CEO of Hillenbrand, Inc. (hillenbrand.com), a global industrial company that provides solutions for durable plastics, food and recycling and a variety of other applications, since 2021. From 2015 to 2021, she was president of the company's largest business, Coperion, a worldwide leader in compounding systems. Ryan started her career with Batesville, a former subsidiary of Hillenbrand, in 1989. She held roles of increasing responsibility within Batesville and Hill-Rom, a medical technology provider, in finance, strategy, operations, logistics, information technology and commercial division leadership prior to her current role.

"Kim's extensive experience across industrial sectors and as an executive leader will be an excellent addition to our Board," said John M. Timken, Jr., chairman of the board. "We welcome her deep expertise in global manufacturing and business operations and look forward to her valuable perspective as we work to accelerate profitable growth."

Ryan will serve as a member of the Board's Compensation and Audit committees. She holds a bachelor's degree in business administration and accounting from Iowa State University and serves

on the National Association of Manufacturers Board of Directors and as a member of the Dean's Advisory Council at Iowa State University's Ivy School of Business.

timken.com

HONEYWELL AND NXP SEMICONDUCTORS

Announce Expanded Partnership for Aviation Development

Honeywell and NXP Semiconductors N.V. announced at CES 2025 an expanded partnership that will accelerate aviation product development and chart the path for autonomous flight. This builds on the companies' existing relationship, which is focused on helping optimize how building management systems sense and securely control energy consumption, announced at CES 2024.

The groundbreaking aviation collaboration will combine Honeywell's deep aerospace expertise, the proven capabilities of Honeywell Anthem avionics and NXP's high-performance computing architecture, enabling AI-driven aerospace technology that helps improve operational efficiency for planning and managing flights. The work will also support faster transitions to new chipsets and technologies.

The companies will team to advance large-area displays for next-generation cockpits with thinner, high-resolution screens designed to improve visual clarity and system efficiency. Additionally, they will explore how to simplify and streamline migrations to newer avionic technologies, as well as extend critical aviation technologies' lifecycles, helping to deliver long-term value for aircraft manufacturers and operators.

"Our industrial domain expertise combined with NXP's best-in-class technology is a powerful accelerator for industrial leaders on the path to autonomy," said Vimal Kapur, chairman and CEO of Honeywell. "Working together, we are developing differentiated solutions and services that shape the future of automation, driving significant customer outcomes and fueling Honeywell's growth."

NXP's domain-based architecture paves the path to autonomy, featuring high-compute capabilities, integrated cybersecurity and functional safety, including technology developed for the automotive industry. It will now be adapted for aviation applications on Honeywell Anthem, the industry's first cloud-connected cockpit system. This is a continuation of co-creation between the two companies, which includes NXP applications processers embedded in Honeywell's Building Management, Fire Safety and Security products. Looking ahead, the companies are expanding this work to include AI and machine learning in building controllers.

For the aerospace industry, Honeywell will leverage a variety of NXP processors, including the i.MX 8 applications processors currently leveraged in Honeywell's Advanced Control for Buildings platform and S32N super-integration processors, providing a range of high-performance, intelligent solutions that can be adapted for the needs of various aircraft. With NXP's processors, Honeywell Anthem will deliver faster data processing for real-time AI-driven insights, enhancing safety and optimizing performance both in the air and on the ground.

"Bringing avionics closer to autonomous flight requires a unique combination of high-performance processing and AI, advanced connectivity and security, and functional safety," said Kurt Sievers, President and CEO, NXP Semiconductors. "NXP's broad portfolio and systems solutions approach makes us a natural partner for Honeywell on the journey towards creating innovative, intelligent and autonomous avionics that can sense, think and act."

One of the early adopters that will benefit from this collaboration is Vertical Aerospace, a leader in eVTOL aircraft that is currently testing its piloted VX4 prototype aircraft featuring Honeywell Anthem.

"By fulfilling the promise of advanced air mobility, electric aircraft like the VX4 represent a bold vision for the future," said Stuart Simpson, CEO of Vertical Aerospace. "Honeywell Anthem has already proven to be a highly capable platform, and we're excited to explore how its capabilities can be further enhanced by NXP's advanced computing to lessen pilot workloads while increasing situational awareness. Together, we see opportunities to make travel quicker, cleaner and safer, supporting our shared vision to transform how the world moves."

honeywell.com

(From left) Torsten Pilz, Rafael Sotomayor, Lars Reger, Vimal Kapur, Kurt Sievers, Suresh Venkatarayalu, Jim Currier and Andrew Hardy.

March 31–April 4

Hannover Messe 2025

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 2025 topics include 5G technology, additive manufacturing, automation, sensors, e-mobility, material handling and more. Traditionally, drive technology and fluid power has been represented at Hannover Messe by many companies from Germany and abroad, especially in odd-numbered years. This will also be the case in 2025 when manufacturers will present their latest applications and components for intelligent and sustainable production.

powertransmission.com/events/978-hannover-messe-2025

April 7–13

Bauma 2025

From the digital construction site to alternative drives and tomorrow's construction methods, the most important topics will be discussed, and innovative solutions will be presented during Bauma 2025 (Munich). Topics include climate neutrality, drive concepts, digital construction, sustainability, and mining challenges. In view of the high-quality standards of innovation and relevance, it is not surprising that nearly 70 percent of Bauma visitors are top decision-makers in their companies. Bauma offers attendees the ideal opportunity to establish lucrative business relationships and to profitably network with the industry.

powertransmission.com/events/903-bauma-2025

May 12–15

Automate 2025

Between intimate workshops with industry giants, keynotes, networking events, innovation competitions and live demonstrations, Automate (Detroit) offers comprehensive automation education and cutting-edge robotics, vision, AI, motion control and other technologies. Keynote sessions highlight how these technologies solve real-world challenges while theater sessions cover important topics such as how robotics and automation are transforming the economy; innovative strategies for jumpstarting an automation strategy, or how companies can cultivate talents in the workforce. This year will again feature presentations from the finalists of the Automate Startup Competition.

powertransmission.com/events/941-automate-2025

May 13–14

CTI Symposium USA 2025

CO_2 reduction is critical for automotive drivetrain. Here the battery electric drive using renewable energy is the focus. What can we do to increase efficiency and reliability, reduce cost and at the same time reduce upstream CO_2? At CTI Symposium USA 2025 (Novi, MI) the automotive industry discusses the challenges it faces and promising strategies. The latest solutions in the fields of electric drives, power electronics, battery systems, e-machines as well as the manufacturing of these components and supply chain improvements are presented. In 2025, executives and experts of OEMs, suppliers and laboratories will discuss in various panels the actual challenges the industry is facing including how to manage the e-mobility transition 2.0, the impact of politics and consumer adoption.

powertransmission.com/events/942-cti-symposium-usa-2025

May 19–22

Cleanpower 2025

Cleanpower 2025 (Phoenix) 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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The Automotive Edge

Lego and Hot Wheels celebrate the spectacle of F1 racing

Matthew Jaster, Senior Editor

While it may not be the most visually arresting spectator sport, F1 racing is certainly a behind-the-scenes testament to aerodynamics, engine technology and data analytics. Designers are always searching for ways to optimize these vehicles on race day. Many of the engineering decisions made on or near the racetrack have trickled down to other markets including automotive, aerospace and e-mobility.

Lego has decided the time has come to honor these innovations with F1 racing sets for adults and kids. The 1:8 scale model for adults features authentic livery details, a working V6 engine with moving pistons fans can explore up close when removing the engine cover, an opening wing, individual suspension, functioning steering and slick tires. The pull-back version for kids offers both an authentic look and great action-packed play.

"Play is a great way for families to bond over shared passions," says Niels Henrik Horsted, head of product at the Lego Group. "We might all have different cars we prefer, different championships or competitions we like, different racing teams we cheer on, but what unites us is our shared love of exciting racing and incredible cars!"

The Lego Technic Ferrari SF-24 F1 Car (1,361-pieces) offers intricate aerodynamic details, such as an opening DRS, Pirelli printed slick tires and a V6 engine with a spinning MGU-H. This lets builders imagine the thrill of a last-lap showdown before placing the set on display. The set features key functions such as front and back suspension and a two-speed gearbox. The Lego Williams Racing FW14B & Nigel Mansell is a 799-piece set featuring working steering, wide rear slick tires with the Goodyear logo and a detailed replica of the engine. The Lego Technic Oracle Red Bull Racing RB20 F1 Car, measuring in at over 25 in. (55 cm), is a statement for any mega fan of the team. The authentic livery, Pirelli printed tires and aerodynamic features, faithfully recreated using Lego Technic pieces.

If you'd rather showcase the technology in a smaller package, Hot Wheels will launch a new Formula 1 collection throughout 2025. Premium models come with additional details to more closely replicate F1 cars, including metal body and chassis, authentic team liveries, driver numbers and Pirelli tires.

"It's fantastic to see the Hot Wheels Formula 1 collection begin to hit the shelves around the world," said Emily Prazer, chief commercial officer at Formula 1. "We want to drive our fans' passion for racing, and these superbly and intricately designed cars will allow them to experience the drama and excitement of Formula 1 in the palm of their hands at home."

Sharing these engineering marvels with your daughters and sons may impact career decisions they make in the future. And what better way to spend an afternoon in February or March than building a Lego set or racing F1 cars across the kitchen tile?

"The spirited response from fans around the world following our Hot Wheels and Formula 1 announcement has been thrilling," said Roberto Stanichi, executive vice president of Hot Wheels and global head of vehicles and building sets. "The next phase of the partnership is all about giving fans the products and experiences that bring the worlds of Hot Wheels and F1 together in a way that has never been done before, and we're just getting started."

lego.com/en-us/categories/f1/f1-sets

creations.mattel.com/products/hot-wheels-f1-jgn95?srsltid=AfmBOorQUT9V2kgIgcHBnlx2SdTPTkFaalEzvel_i760ZYzHPlNRZ3S5

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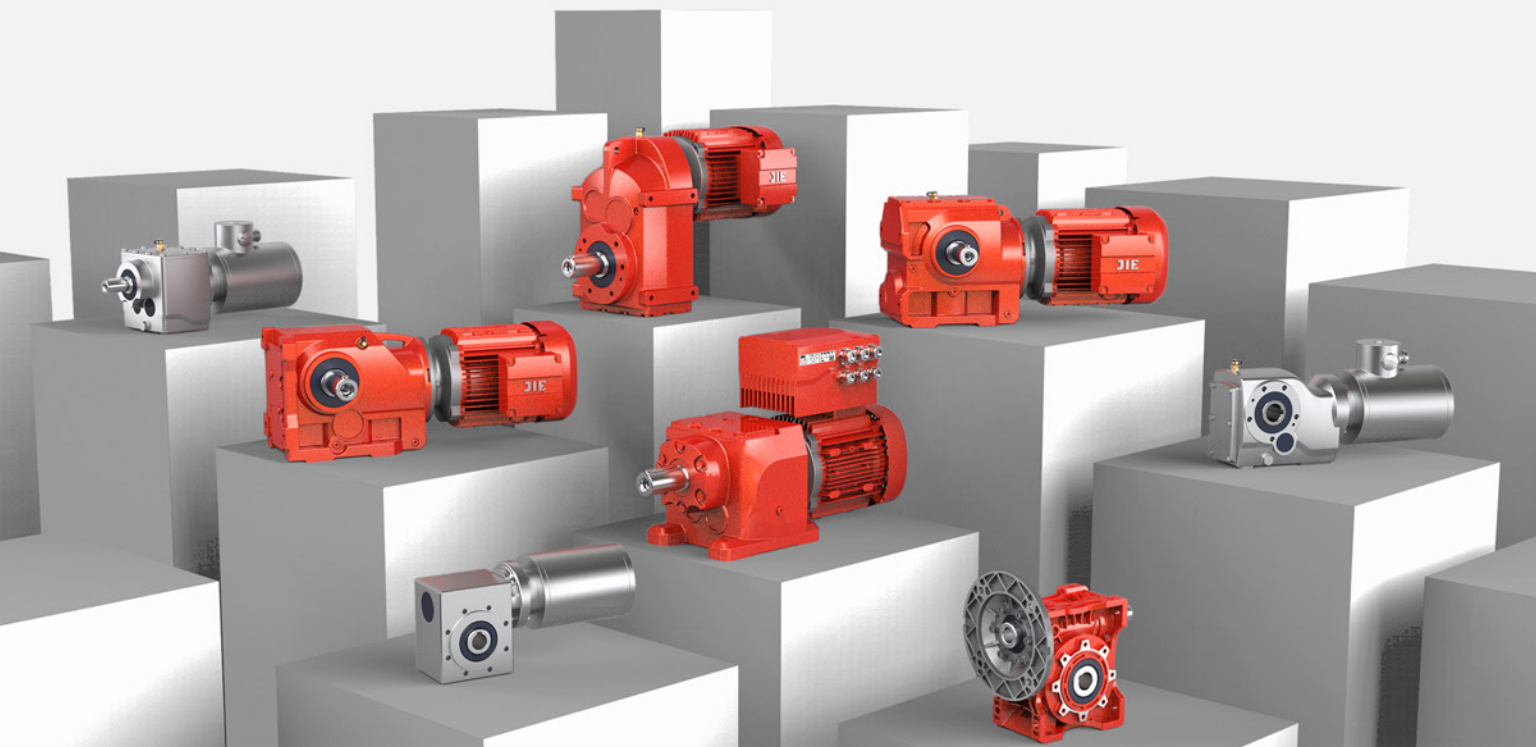

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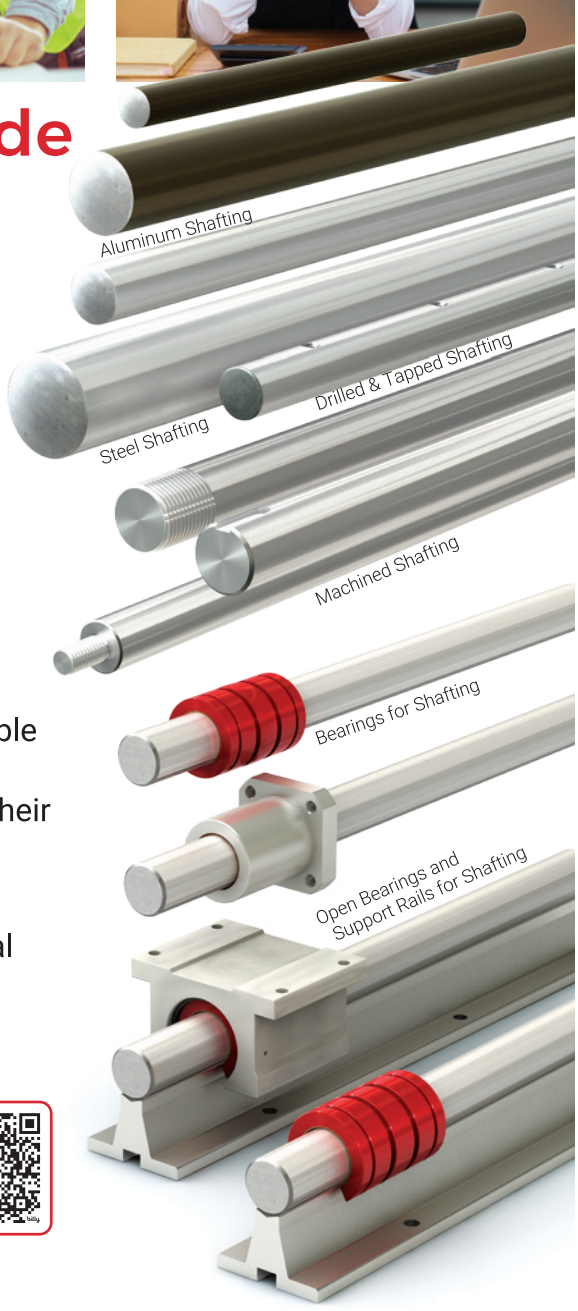

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