PTE
POWER TRANSMISSION ENGINEERING™
JUNE
2025

CTI SYMPOSIUM 2025
INDUSTRIAL GEARBOXES
GEARBOX DESIGN SOFTWARE
ELECTRIFICATION AND E-MOBILITY

TECHNICAL

Corrosion and Its Challenges for the Mechanical World
The Path of Least Resistance—Roller Bearing Damage in VFDs

powertransmission.com

AUTOMATIONDIRECT.com

Quality Sensors at Sensible Prices

wenglor the innovative family *NEW!* OPT25 Series Laser Measurement Sensors

Starting at $94.00 (OPT2512)

Wenglor OPT25 series laser measurement sensors offer best-in-class distance sensing for ranges within 1 meter. These sensors are IO-Link v1.1 compatible, employ a Class 1 red or Class 2 blue laser, use triangulation to measure distances with extreme accuracy, and can reliably detect tiny objects with a reproducibility up to 0.8µm.

- Diffuse sensing style
- Red Class 1 lasers or blue Class 2 lasers for dark and shiny object detection
- Anodized aluminum housings
- Teach-in, OLED, IO-Link, or Bluetooth configuration options (depending on model)
- 4-20 mA or dual PNP/NPN output options
- IP67 protection rating

Autonics *NEW!* Photoelectric Sensors

Starting at $35.00 (BTF30-DDTL)

Autonics BTF, BTS, and BPS series miniature photoelectric sensors feature ultra-compact slim or narrow housings that are easy to install in tight spaces. These miniature sensors offer sensing distances up to 3m with highly visible red LED or infrared light sources for reliable detection. The lineup includes:

- BTF ultra-thin series with housings only 3.7mm thick (4.6mm including lens)
- BTS ultra-slim series with housings only 7.2mm wide
- BPS compact series low-profile, flat housings only 7.5mm thick (8.1mm including lens)

ProSense *NEW!* FLG Series Light Grids

Starting at $308.00 (FLG-A46-0280)

Cost-effective ProSense FLG series detecting light grids feature a simple setup with no programming required. They are perfect for material handling, counting, and warehousing applications.

- 0.1 to 10m operating distance
- 220 to 1580mm detection heights
- 20 or 40mm resolution
- Discrete NPN or PNP output
- Rugged aluminum housings
- IP67 protection rating

ProSense *NEW!* Linear Potentiometers

Starting at $490.00 (LSR-33P-0030-A5-C1)

ProSense linear potentiometers deliver reliable, high-performance position measurements for industrial automation applications. A selection of fixed, rodless, spring-loaded, and pivoting-slide models ensure maximum adaptability.

- 10 to 1250mm stroke lengths
- Durable stainless steel rods
- Anodized aluminum housings
- DIN 43650 or pigtail electrical connections
- IP40, IP54, or IP65 protection rating

Also Available

Encoders

Proximity Sensors

Process Sensors

Research, price, buy at:

www.automationdirect.com/sensors

Order Today, Ships Fast!

TOP RATED BY CUSTOMERS

AUTOMATIONDIRECT.com
1-800-633-0405
the #1 value in automation

PTE™

JUNE 2025

FEATURE ARTICLES

TECHNICAL ARTICLES

STAY CONNECTED

Connect with us on LinkedIn
linkedin.com/groups/Power-Transmission-Engineering-PTE-2950055

Subscribe Online
powertransmission.com/subscribe

Vol. 19, No. 4. POWER TRANSMISSION ENGINEERING (ISSN 2331-2483) is published monthly except in January, May, July and November by The American Gear Manufacturers Association, 1001 N. Fairfax Street, Suite 500, Alexandria, VA 22314, (847) 437-6604.

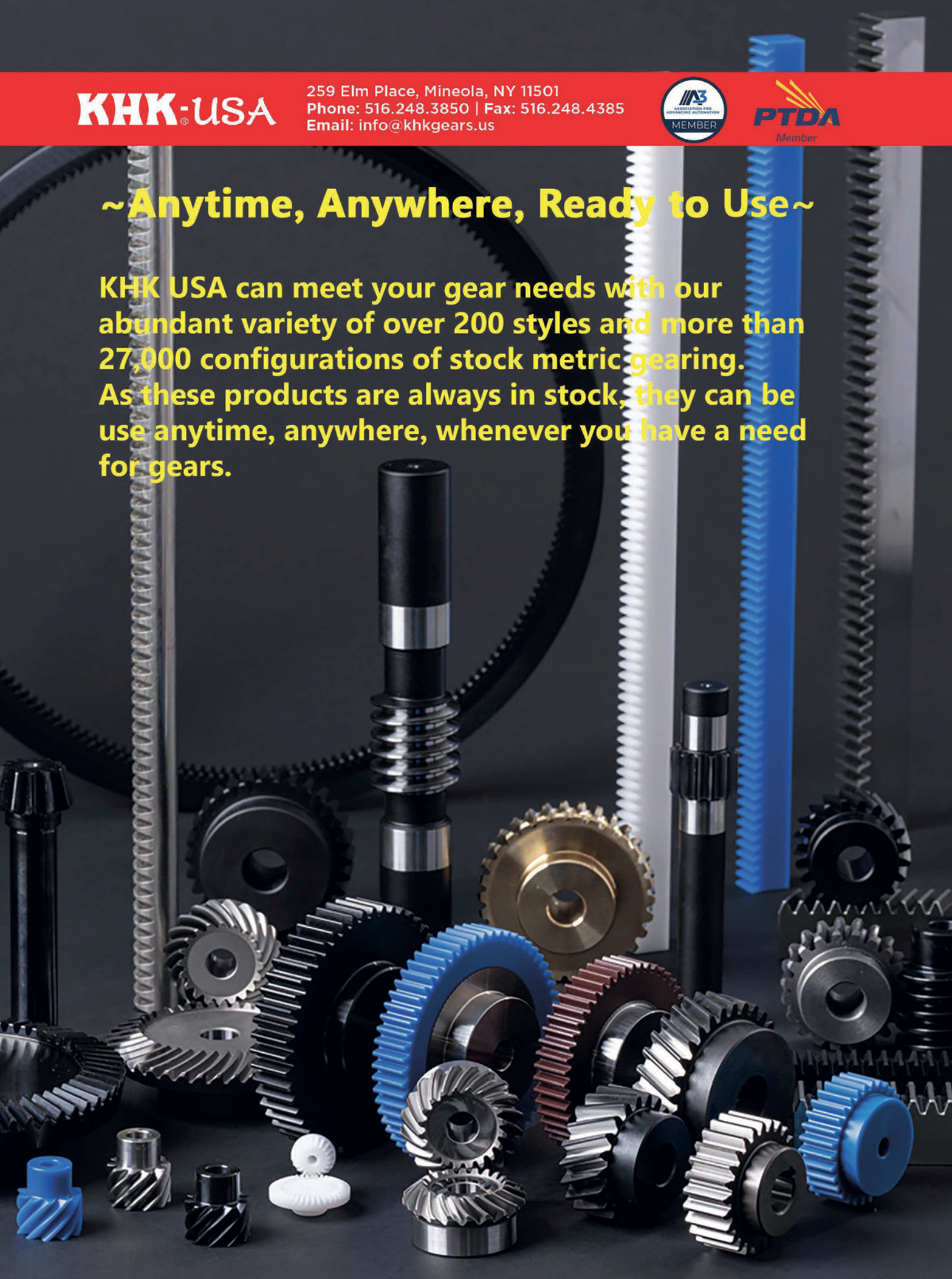
Periodicals Postage Paid at Elk Grove Village IL and at additional mailing offices.

PTE™
VOL. 19, NO. 4

KHK-USA
259 Elm Place, Mineola, NY 11501
Phone: 516.248.3850 | Fax: 516.248.4385
Email: info@khkgears.us

~Anytime, Anywhere, Ready to Use~

KHK USA can meet your gear needs with our abundant variety of over 200 styles and more than 27,000 configurations of stock metric gearing. As these products are always in stock, they can be use anytime, anywhere, whenever you have a need for gears.



PTE EXTRAS

Trelleborg Shares Insights on Sealing Needs for Industrial Robots

In this article David Kaley, Trelleborg's global segment manager for industrial automation, explains the different kinds of robots used in industrial automation, their components and the kinds of sealing elements needed to help ensure precise performance results.

powertransmission.com/trelleborg-shares-insights-on-sealing-needs-for-industrial-robots

LIFT Opens Advanced Metallic Production and Processing (AMPP) Center in Detroit

LIFT, the Department of Defense-supported national advanced materials manufacturing innovation institute, has officially opened its state-of-the-art Advanced Metallic Production and Processing (AMPP) Center in Detroit's historic Corktown district. This facility will play a critical role in strengthening the U.S. industrial base by accelerating the design, development, and deployment of novel metallic materials, filling a key gap in the nation's defense manufacturing base.

powertransmission.com/lift-opens-advanced-metallic-production-and-processing-ampp-center-in-detroit

AGV vs AMR: Which robot is right for your business?

Automation has become a key driver of efficiency and productivity, regardless of industry. Among the most popular automation solutions are automated guided vehicles (AGVs) and autonomous mobile robots (AMRs). While both technologies automate and enhance material handling and reduce manual labor, there are key differences in their functionality, flexibility, and areas of application that set them apart.

powertransmission.com/agv-vs-amr-which-robot-is-right-for-your-business

powertransmission.com

AGMA MEDIA
1840 Jarvis Avenue
Elk Grove Village, IL 60007
Phone: (847) 437-6604
Fax: (847) 437-6618

EDITORIAL
Publisher & Editor-in-Chief
Randy Stott
stott@agma.org

Senior Editor
Matthew Jaster
jaster@agma.org

Senior Editor
Aaron Fagan
fagan@agma.org

GRAPHIC DESIGN
Design Manager
Jess Oglesby
oglesby@agma.org

ADVERTISING
Advertising Sales Manager & Associate Publisher
Dave Friedman
friedman@agma.org

Manager, Member Engagment and Sales
Katie Mulqueen
mulqueen@agma.org

Materials Coordinator
Dorothy Fiandaca
fiandaca@agma.org

CIRCULATION
Circulation Manager
Carol Tratar
tratar@agma.org

MANAGEMENT
President
Matthew Croson
croson@agma.org

FOUNDER
Michael Goldstein founded *Gear Technology* in 1984 and *Power Transmission Engineering* in 2007, and he served as Publisher and Editor-in-Chief from 1984 through 2019. Michael continues working with both magazines in a consulting role and can be reached via e-mail at *mwg42@hotmail.com.*

COMPONENTS, ENGINEERING DEVELOPMENT, AND MANUFACTURING

SDP/SI
STOCK DRIVE PRODUCTS/STERLING INSTRUMENT

Precision Gears and Superior Mechanical Components

We know what it takes! Consistent Quality, Dependability, & Experience

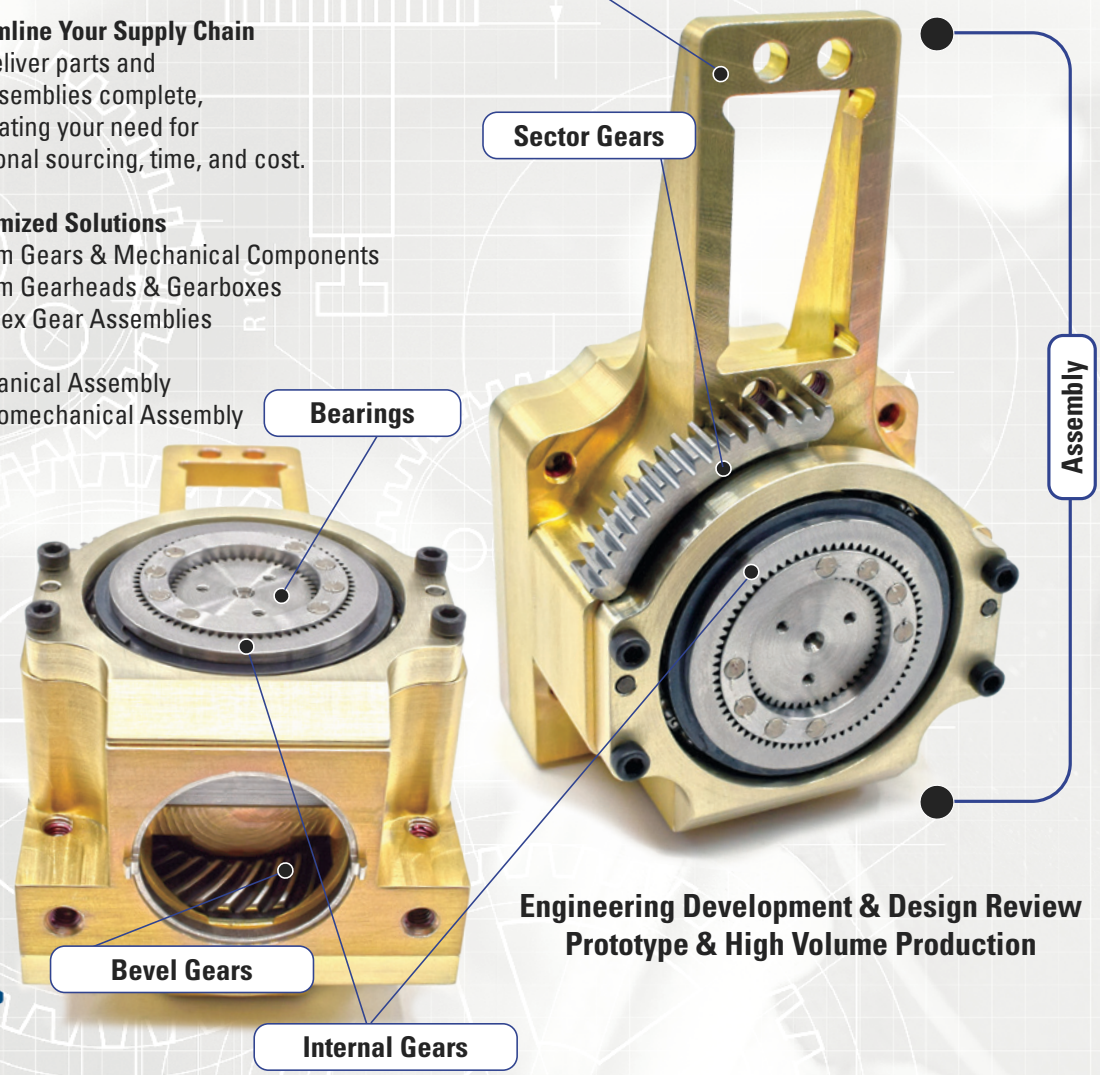
Our Certifications
ISO 9001 + AS9100
ITAR Compliant-DDTC Registered
DFARS Compliant
RoHS & R.E.A.C.H. Compliant
NIST SP 800-171 Compliant

Turning Ideas into Reality since 1950
Engineering development, design, and manufacturing expertise combined with mechanical and electromechanical component options.

Streamline Your Supply Chain
We deliver parts and subassemblies complete, eliminating your need for additional sourcing, time, and cost.

Customized Solutions
Custom Gears & Mechanical Components
Custom Gearheads & Gearboxes
Complex Gear Assemblies

Mechanical Assembly
Electromechanical Assembly



Engineering Development & Design Review
Prototype & High Volume Production

AGMA®

Designatronics INC.
Engineered Solutions for a World in Motion

SDP/SI STOCK DRIVE PRODUCTS/STERLING INSTRUMENT
QBC QUALITY BEARINGS & COMPONENTS
QTC METRIC GEARS

Web: sdp-si.com • **Email:** sdp-sisupport@sdp-si.com • **Phone:** +1 516.328.3300

Doubling Down on Motion + Power

Two things of note this issue, both having to do with "Motion + Power."

1. As you may have heard, the AGMA and ABMA have merged to form the Motion + Power Manufacturers Alliance (MPMA), bringing together the leading associations for gears and bearings. More details about the merger can be found in the Voices column (p. 8) from the former board chairs of the two associations, Michael Cinquemani and Matt Frady.

   It's important to note that the AGMA and ABMA brands are not going away. Companies will still be able to identify themselves as AGMA or ABMA members. Standards will continue to be promulgated under the AGMA and ABMA names.

   For *PTE*, this merger makes a lot of sense. We've always covered the gamut of components involved with mechanical power transmission systems. Both gears and bearings are considered "every issue" topics for us, so being attached to both organizations under the umbrella of MPMA should give us even greater access to experts and knowledge that we will continue to share with you.

2. Registration is now open for the Motion + Power Technology Expo (see ad on page 7), which takes place October 21–23 at Huntington Place in Detroit.

MPT Expo is our industry's main event. It takes place every two years, and it's your opportunity to visit suppliers across the entire power transmission supply chain. If your company makes gears, or if you buy gears, gear drives, bearings or other mechanical power transmission components, then MPT Expo will offer a wide variety of suppliers to choose from.

In addition, MPT Expo will be home to numerous educational and networking opportunities, including AGMA's Fall Technical Meeting (October 22–24).

Also, MPT Expo is held concurrently with the ASM Heat Treat show, giving you even more opportunity to explore potential suppliers and technology.

For more information about how you can be a part of this exciting Motion + Power community, I encourage you to visit our websites, come to our show, or just give us a call.

PTE

Randy Stott
Publisher & Editor-in-Chief

Registration is open!

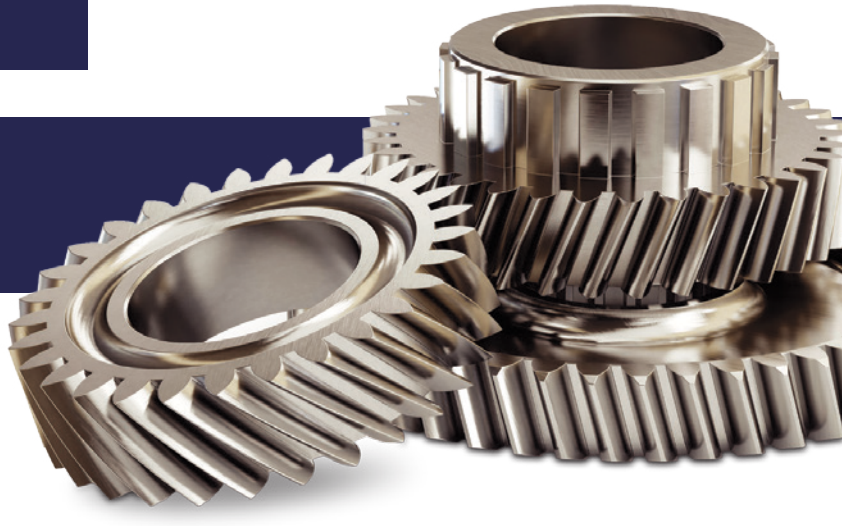
Visit MotionPowerExpo.com

INNOVATION ACCELERATED

Connect face-to-face with the full power transmission supply chain.

MOTION + POWER
TECHNOLOGY EXPO®

October 21-23, 2025
Huntington Place · Detroit, MI



American Gear Manufacturers Association®

AGMA and ABMA Unite to Form Motion + Power Manufacturers Alliance

Michael Cinquemani, AGMA Board Chair and CEO of Master Power Transmission and Matt Frady, ABMA Chair and General Manager, Dodge Industrial

On April 24, at the AGMA/ABMA Annual Meeting in Austin, the membership of each association voted unanimously to approve a merger between AGMA and ABMA, creating the Motion + Power Manufacturers Alliance (MPMA).

Back row (left to right): Matt Croson, AGMA; Steve Janke, Brelie Gear; Michelle Maddox, B&R Machine & Gear Corporation; Sara Zimmerman, Sumitomo Machinery Corporation; Jason Daubert, FLSmidth Cement USA; and Jenny Blackford, ABMA. Front row (left to right): Matt Frady, Dodge Industrial; and Michael Cinquemani, Master PT.

AGMA and ABMA will continue to keep their names in the marketplace as the 108-year-old AGMA brand and the 107-year-old ABMA brand have significant history and value to their respective memberships.

The new MPMA entity will deliver increased value through standards creation under the AGMA and ABMA brands, more robust education and workforce development programs, a strong connection of the supply chain via face-to-face events and two industry publications, and advocacy at the Federal and Executive Branch level.

The AGMA and ABMA have worked closely together on joint programming for the past 18 years, including AGMA managing ABMA since 2019. This constitutes a dynamic evolution for two of the best-in-class associations working together for the greater good of its members and industry at large.

The organizations will unite their committee structures to ensure both gearing and bearing issues and opportunities are explored, standards and programming will continue to be identified under the AGMA and ABMA names, and members will be encouraged to continue to identify as AGMA or ABMA members, as a part of MPMA.

AGMA's history is focused on standards and education, and business connections, while ABMA's value is focused on those issues as well as advocacy, brand protection and global markets, making the new Alliance an opportunity to grow value across both organizations under one umbrella. The industry is coming together as companies merge and acquire to form multi-faceted total system solutions providers, and having ABMA and AGMA come together under the MPMA makes sense to support the evolving market for the next 100 years.

The MPMA will have a united board of directors and continue to be governed by an executive committee including a chair, vice chair, treasurer, past chair and two at large seats. AGMA Member, Sara Zimmerman, Sumitomo, will serve as the chair in 2025–2026.

Combined, the MPMA will consist of more than 425 member companies representing the full spectrum of private and public companies, global and domestic business, open gear, enclosed gears and the full range of bearing solutions.

The merger represents a culmination of ABMA's and AGMA's long history of working together, including: 18 years of joint Annual Meetings and nine years of AGMA's Power Transmission Alliance. For the past five years, AGMA has managed ABMA operations.

By creating the MPMA, the two associations have a stronger voice in the standards and advocacy community, enhanced education and training positions, and added value to its publications, the MPT Expo, and the online B2B community.

To best serve the respective members, the two associations are committed to looking to the future while continuing their main pillars of membership value: Standards, Education, Emerging Technology, and Industry Information.

"The bottom line is, we are here to serve you, and we are in this together," said Matt Croson, President of AGMA, and Jenny Blackford, President of ABMA, in a joint statement. "As we move the industry forward, we will honor what got us to over 100 years of existence while we will focus on what will allow us to thrive over the next 100 years. Simply put, the associations are stronger together as this merger unites the brightest and best minds throughout the gearing and bearing community."

motionpower.org

PTE

GEAR OILS WITH THE POWER TO PROTECT

Lubriplate's complete line of premium quality gear oils has been formulated to provide unsurpassed performance in a wide range of gear reducers.

Available products include...

SYN LUBE SERIES 150 - 1000
100% SYNTHETIC PAO-BASED GEAR OILS

- High-performance, 100% synthetic, polyalphaolefin (PAO)-based gear oils.
- Compatible with petroleum-based oils and most seals for easy conversion.
- Available in ISO viscosity grades 150, 220, 320, 460, 680 and 1000.

SYN LUBE HD SERIES
HEAVY-DUTY, EXTREME PRESSURE (EP) 100% SYNTHETIC, PAO-BASED OILS

- Super heavy-duty, polyalphaolefin (PAO)-based synthetic gear lubricants.
- Formulated to meet AGMA EP (Extreme Pressure) requirements.
- For Heavy-duty, high load applications where an EP oil is required.

SPO SERIES
HIGH-PERFORMANCE, ANTI-WEAR FORTIFIED, PETROLEUM OIL-BASED, INDUSTRIAL GEAR OILS

- Petroleum oil-based anti-wear, rust & oxidation inhibited (R&O) gear oils.
- Can be used with silver alloy, copper, and copper alloy bearings.
- Premium quality, high-performance, petroleum oil-based gear oils.

SFGO ULTRA SERIES
NSF H1 REGISTERED FOOD GRADE 100% SYNTHETIC, PAO-BASED GEAR OILS

- NSF H1 registered and NSF ISO 21469 certified food machinery grade.
- 100% synthetic, PAO-based fluids for food processing and bottling plants.
- Available in ISO viscosity grades 150, 220, 320, 460, 680 and 1000.
- Fortified with Lubriplate's proprietary anti-wear additive Xtremity.

PGO & PGO-FGL SERIES
ADVANCED 100% SYNTHETIC PAG-BASED GEAR OILS

- Ultra high-performance, polyalkylene glycol (PAG)-based, gear lubricants.
- ECO-friendly - Inherently biodegradable, provides long service life, energy conserving.
- PGO-FGL Series is NSF H1 registered and NSF/ISO 21469 certified food grade.

SYNTHETIC WORM GEAR LUBRICANT

- 100% Synthetic, ISO 460 grade, polyalphaolefin (PAO)-based worm gear oil.
- Formulated especially for worm gear applications.
- Provides excellent lubricity and oxidation resistance.

APG SERIES
HEAVY-DUTY PETROLEUM OIL-BASED EXTREME PRESSURE (EP) GEAR OILS

- High-quality, petroleum-oil based, extreme pressure (EP) gear oils.
- Meets military specification MIL-PRF-2105E and MIL-L-2105D.
- Conforms to API categories GL-3, GL-4, GL-5, MT-1.

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.
- Formulated for heavy equipment and heavy service industrial applications.
- Meets military specification MIL-PRF-2105E and API classification GL-5.

"It's the Film" PREVENTS WEAR and CORROSION LUBRIPLATE SUPER-LUBRICATION

Lubriplate® LUBRICANTS

Newark, NJ 07105 / Toledo, OH 43605 / 800-733-4755
To learn more visit us at: www.lubriplate.com

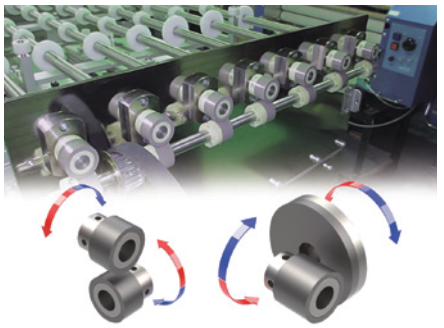
INCLUDED AT NO ADDITIONAL CHARGE

Lubriplate's ESP

Complimentary Extra Services Package

COLOR CODED LUBE CHARTS & MACHINERY TAGS
PLANT SURVEYS / TECH SUPPORT / TRAINING
LUBRICATION SOFTWARE / FOLLOW-UP OIL ANALYSIS

MIKI PULLEY
Introduces Contactless Link Magnetic Couplings



Miki Pulley Magnetic Couplings are shaft couplings that transmit torque from one shaft to another using a magnetic field instead of a physical or mechanical connection. These Magnetic Couplings are non-contact and rely on the attraction and repulsion of magnetic poles to generate rotational power. The full product range of these coupling models can withstand significant misalignments and are silent, vibration-free, and do not generate thermal conduction.

The design advantages of the Miki Pulley Magnetic Couplings include configurations that are versatile for use in various engagement angles and installations. Maximum transmittable torque is adjusted by increasing or decreasing the distance between the two hubs. Additionally, these non-contact synchronous couplings have a softer start and stop function than most standard couplings. The design allows for zero wear or dust generation. They can also be used as a torque-limiting device since there are no mechanically engaged parts.

Miki Pulley Magnetic Couplings can be used in a rotary or linear configuration and are suitable for wet or harsh environments making them ideal for industrial applications including automated mobile robots and guided vehicles, chemical mixing, food applications, material handling conveyors, medical equipment, printing and packaging and pump systems.

Miki Pulley Magnetic Couplings are available in different configurations including

Cylinder x Disk Orthogonal Type, Cylinder Parallel Type, Cylinder x Disk Orthogonal Type and Cylinder Orthogonal Type. Basic Miki Pulley Magnetic Coupling specifications are:

- Bore size range: 4–25 mm on butt shaft configurations
- Torque: Up to 15.48 Nm (11.43 ft lbs.)
- Five different models in multiple sizes available

mikipulley-us.com

BOSCH REXROTH
Expands Linear Axes Portfolio to Accommodate Heavier Payloads

In response to a growing need to transfer heavier items faster and more efficiently throughout manufacturing processes and a rapidly changing e-commerce landscape in supply chain operations, Bosch Rexroth has expanded its extensive compact modules portfolio. The new size, 280, can support items up to 250 kg, which makes it ideal for transferring battery modules, machine tools, furniture, palletizing gantries, robotic transfer units, and other larger items.

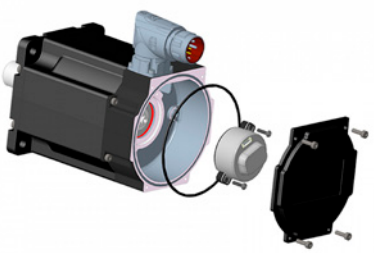
"Today's manufacturers and warehouse operators are constantly searching for solutions to help them meet diverse consumer needs, including with their heaviest items," said Sean Barunas, sales product manager, Bosch Rexroth. "These modules are engineered to meet those requirements and open new possibilities for Cartesian robot solutions."

Compared to the largest version to date—the 200—performance (more weight with the same dynamics) with the 280 increases by more than 50 percent. Payloads of up to 250 kg can be moved over a length of 5,500 mm. The high acceleration of up to 5 g and a maximum speed of 5 m/s are suited for short cycle times while maintaining high degrees of precision. As a configurable component, the modules can shorten the engineering of single axes, multi-axis, and Cartesian robots. The modules can be paired with automation packages that include a motor, drive, and controls, which speed up commissioning and make operating easier.

Additional applications for the 280 module within manufacturing and warehouse operations lie in pick-and-place processes and transporting robots or cobots from one point in the line to another. The increased load capacity allows the module to withstand more than 4x the cantilevered forces as the 200 model.

boschrexroth-us.com

KOLLMORGEN'S
Encoder Offers Multiturn Absolute Feedback



Kollmorgen has introduced the new SFD-M (Smart Feedback Device, Multiturn). It allows machine builders to achieve high-resolution multiturn feedback with absolute positioning information available at system startup.

Designed to work with AKDTM and AKD2G drives, the SFD-M absolute multiturn encoder can be

integrated into Kollmorgen housed servo motors at no additional charge compared to the SFD-3 single-turn absolute encoder, providing multiturn performance, four times greater positioning accuracy and fifty times lower EMF noise.

Comparable third-party encoders come with a premium price. With the SFD-M, customers can achieve substantial savings in machine designs that perform at the highest levels of precision, efficiency and effectiveness.

The SFD-M measures the position of the rotor shaft throughout each 360-degree rotation without requiring reference to a home position, and it registers the total number of rotations the shaft has made in either direction.

This absolute multiturn positioning capability is ideal when precise tracking of position is required over large rotational distances, such as in machine tool positioning, packaging machines, material handling, satellite tracking and many other applications.

Additionally, the SFD-M maintains absolute positioning information in real time even when the system is powered down, eliminating the need for time-consuming homing sequences upon startup.

Absolute multiturn encoders from other providers often require a battery to retain positioning information when the system is powered down or during a power failure. These external batteries require replacement and can be subject to failure. Other alternatives use mechanical gear trains, which are noisy, backlash-prone and add size to the motor.

The new Kollmorgen SFD-M eliminates these issues, instead using energy-harvesting technology to reliably maintain positioning information with no need for batteries or gear trains. Battery-free operation eliminates maintenance issues while also supporting efforts to reduce the consumption of natural resources and minimize waste.

kollmorgen.com

FAULHABER

Offers New Performance Class with new Planetary Gearhead Sizes

The new members of the Faulhaber metal planetary gearhead family are the 14GPT and 16GPT. The compact additions to the series deliver high torque with minimal volume, making them ideal for demanding applications where space is limited.

They are extremely robust, capable of withstanding frequent and sudden load changes, and operate with high efficiency. The gearheads can be combined with a wide range of motors.

The new sizes leverage the proven design principle of the GPT gearheads, which can reliably transmit extreme forces. This not only results in higher torque but also enables a particularly short overall length—perfect for applications where space is critical. Additionally, the optimized design allows for a higher speed of up to 24,000 rpm, enabling efficient use of the motor's full speed range. The increased number of gear ratios contributes to optimized thermal behavior and extends the operating range of the gearhead. Thanks to increased radial and axial load capacity, even heavier loads can be handled effortlessly.

To meet the highest standards of reliability and durability, the new GPT gearheads are made entirely of hardened stainless steel. The welded connections between components ensure a robust and long-lasting construction without the use of adhesives. This stable design ensures reliable power transmission, even under extreme loads.

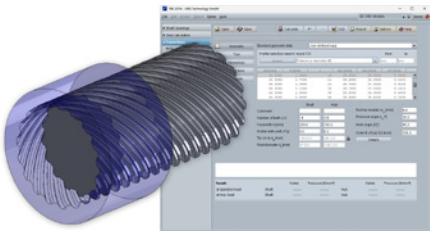
Thanks to their robust construction and high performance, the new 14GPT and 16GPT gearheads are perfectly suited for applications in robotics, laboratory automation or medical diagnostics. Whether in inspection robots, electro-optical devices or laser devices–he new planetary gearheads always deliver maximum performance in minimal space at an excellent price-performance ratio.

faulhaber.com

GWJ TECHNOLOGY

Releases New Version of TBK Software

GWJ Technology GmbH has released a new version of its *TBK* desktop calculation solution for designing, recalculating and optimizing gears, shafts, bearings, bolted joints, shaft-hub connections and other machine elements. For more than four decades, the practical *TBK* calculation software has proven its value in many industries worldwide—from precision engineering to heavy machinery. From individual machine elements with intelligent CAD integration through to complete gearbox systems, this powerful calculation tool is used in the development, design, work preparation, production and quality assurance.



The new version offers numerous improvements and, in some cases, major revisions. The input options for profile and flank modifications in the gear modules "Cylindrical Gear Pair," "Planetary Gear," "Gear Rack," "Gear Train" and "Single Cylindrical Gear" have been significantly modified to catch incorrect input and automatically calculate individual values. For example, when defining a linear tip relief with a transition radius, only the diameter for the start or end of the transition radius needs to be entered. The second value is automatically determined by the program to ensure a tangential transition. For single internal gears, a virtual mating gear can now be specified to calculate the length of the contact path and determine the length of the relief.

Other enhancements include the calculation of load spectra in the "Cylindrical Gear Pair" and "Bevel Gear" modules and the iteration of point data in the tooth form calculation. It is now possible to enter a pressure angle of up to 1 degree instead of 5 degrees for single external cylindrical gears and splines. In addition, involute splines with helix angles up to 89 degrees can be calculated and generated as 3D models. Among many other enhancements, 3D CAD plugins for the latest versions of *Solidworks*, *Autodesk Inventor*, and *Solid Edge* have been released. The ability to generate the manufacturing data table from the selected drawing view in *Solidworks* has been enhanced and integrated with *Autodesk Inventor*.

gwj.de

SEW-EURODRIVE

Introduces DR2C Motor

SEW-Eurodrive has launched the DR2C motor, an IE5 ultra-premium efficiency motor engineered for wide speed range operation and maximum long-term energy cost reductions. Designed for industries focused on minimizing total cost of ownership (TCO), the DR2C reduces energy consumption, minimizes heat losses, and enhances operational reliability—delivering a fast return on investment and sustained savings throughout its lifecycle.

The DR2C motor series utilizes Interior Permanent Magnet (IPM) technology, which integrates permanent magnets within the rotor instead of surface-mounted. This design increases torque density and achieves the highest normative efficiency class IE5, resulting in energy losses up to 50 percent lower than those of standard IE3 asynchronous motors in the same power class—achieving superior energy efficiency across the entire speed range. This leads to lower operating costs, extended service

life, and reduced environmental impact—all without compromising power or performance.

The DR2C Permanent Magnet Motor delivers maximum torque in a compact design, making it up to two frame sizes smaller than comparable IE3 asynchronous motors. This high-power density is achieved through advanced Interior Permanent Magnet (IPM) technology, ensuring exceptional efficiency and performance for heavy-load applications. Additionally, the DR2C's low inherent mass inertia minimizes energy losses during acceleration, further enhancing its dynamic response and overall efficiency.

"The DR2C IE5 motor is more than just a motor upgrade—it's a long-term, cost-saving strategy for businesses looking to cut energy expenses and improve efficiency," said Eder Matias, director of sales, drives control and automation at SEW-Eurodrive. "By reducing power losses and optimizing motor performance, the DR2C delivers a return on investment that companies will see reflected in their bottom-line year after year."

The DR2C Permanent Magnet Motor is ideal for industries where energy consumption and operational efficiency directly impact profitability including material handling and logistics, food and beverage, automotive and pumps, fans and compressors.

seweurodrive.com

SCHAEFFLER

Presents E-Motors with Outputs up to 315 kw

Today, there's no longer any doubt that electric drive systems will make inroads into construction sites in the future. Some local governments in Germany and other countries are already banning vehicles with combustion engines from susceptible urban areas. At bauma 2025, Schaeffler presented its new high-performance heavy-duty electric motors as a volume production-ready solution for electric-only and hybrid drive systems. Due to their design, they achieve especially high torques, a power-to-weight ratio (peak) of around 5–7 kW/kg, and maximum efficiencies of more than 97 percent in a speed range of 3,000–8,000 rpm. The low losses of the liquid-cooled drive motors are essential to allow long operating times between charging cycles on construction sites and ensure efficient use of energy. Minimal losses and high operational reliability were also particularly important factors for the design of the bearing and seal. Ceramic balls reduce friction and prevent damaging passage of current.

The modular motor series consists of three variants with maximum outputs of 125, 299 and 315 kW. The only difference is the length of the active parts. The individual stator laminations and the A- and B-side bearing end shields of the motors are identical in each case and therefore facilitate especially cost-efficient manufacturing. With an overall

length of 151, 206 and 261 mm and a uniform outer diameter of around 239 mm (laminated core diameter) or 280 mm (including screw connection), the motors require minimal installation space. The stator windings are designed as flat wire (continuous hairpin) windings, also known as wave windings.

Thanks to synergies from the automotive segment, the offroad sector of Schaeffler's Bearings & Industrial Solutions division offers a comprehensive range of electric drives with a continuous output of 1 to 300 kW for the construction equipment industry. Schaeffler can supply a wide range of active-part components and complete systems such as wheel-hub drives based on permanent magnet synchronous machines. All crucial manufacturing technologies also come from a single source: the stator laminations stamped "in-house," the hairpin and wave winding technology, the automatically produced coil windings, and the HV plug connector systems.

schaeffler.com

ZF

Pushes Range Extender Technology to the Next Level

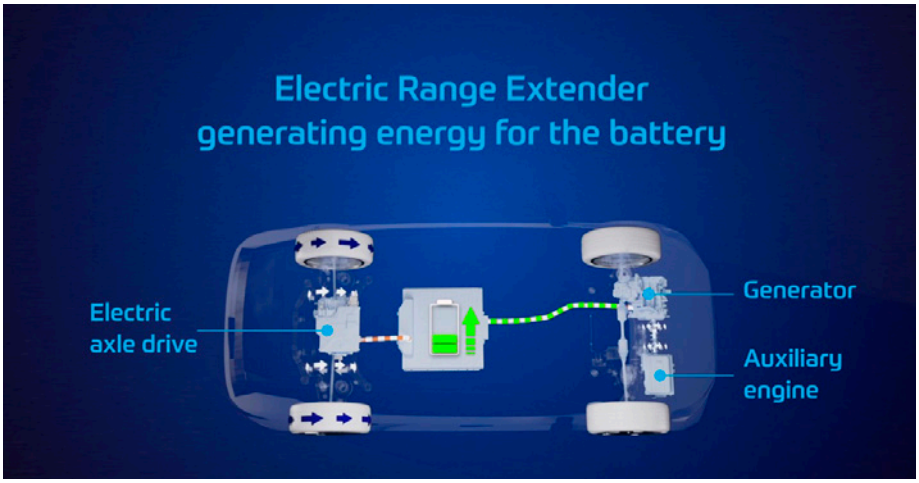
Many potential buyers of electric vehicles still feel the so-called range anxiety that accompanies all-electric driving. In these cases, range extenders can be one solution: A combustion generator that is coupled to an electric motor and thus generates energy for the vehicle battery. ZF is now introducing the new generation of this technology, which will go into volume production in 2026. Designed to meet increasing global demand, this further development is ideally suited to meet dynamic market and customer requirements as well as flexible drive concepts.

It is a scary scenario for many electric drivers: the battery's state of charge is coming to an end with no charging station in sight. "Although the all-electric range of passenger cars is around 500 km on average, range anxiety still influences a wide range of buyers when choosing their next vehicle," explains Dr. Otmar Scharrer, senior vice president R&D, Electrified Powertrain Technology. This is especially true in regions where a charging infrastructure is not yet universally available. ZF is currently developing the next generation of range extenders for these situations. "These represent a real alternative to larger—and thus more expensive—batteries or plug-in hybrids," says Dr. Scharrer.

With range extenders, a combustion engine is coupled to an electric machine that generates power for the vehicle battery as soon as its state of charge drops below a certain threshold. As you can already see from the name, this increases the range that can be driven electrically. The advantage compared to PHEVs or conventional combustion engines: The range extender machine always runs in the ideal performance range for fuel consumption, which ensures low fuel consumption and therefore also has lower CO_2 emissions.

ZF's range extender technology: A lot of experience, new developments

In recent years, ZF had already launched range extender technology in volume production. Among other things, ZF's electric machines were installed in a series of iconic London taxis. ZF is currently working on the next generation, the electric Range Extender (eRE) and the electric Range Extender plus (eRE+).



Both variants are highly integrated designs that are flexible in terms of performance, E/E architecture, 400V or 800V and semiconductor type. The eRE connects an electric motor with an integrated inverter, suitable software and planetary gearset. The eRE+ also has an intelligent clutch and a differential. As a result, it can be used either as a current generator or as an additional secondary drive, which saves manufacturers developing a separate component. Performance can be scaled in both models. The output ranges from 70–110 kW (eRE) or 70 to 150 kW (eRE+). "The new interest and the increased demand for range extenders shows that the potential of this technology is far from exhausted—in particular for model platforms that are already designed for battery-electric drivelines," says Scharrer, and adds: "Behind our solutions is the system and platform concept. This means that we are optimally equipped to be able to respond to all customer and market requirements with shorter development cycles."

What advantages range extenders offer for manufacturers and customers

Compared to parallel-hybrid drive solutions, for example with a PHEV, range extenders are compelling due to their lower additional costs, shorter development cycles, lower platform effort, and simplified supply chain management. This makes the technology particularly interesting for manufacturers who are new to the market, and may have little experience with traditional combustion engine drivelines. China is currently embarking on a proper model offensive of so-called "Range Extended Electric Vehicles" (REEV), which, thanks to

the technology, can cover distances of more than 700 kilometers. "This is where we find it convenient that there is a wide range of BEV platforms that can be supplemented by range extenders," explains Scharrer. This was another reason why the Chinese ZF locations were in charge of development.

But also, in the United States and in Europe, the interest of manufacturers is increasing. "The market for all-electric vehicles has not developed as predicted a few years ago," says Scharrer. "For this intermediate phase, range extenders can be the ideal solution." Because: With REEV, drivers can enjoy the advantages of electromobility without having to sacrifice the flexibility of PHEVs or combustion engine passenger cars. Range extenders are also worthwhile for traditional manufacturers. They allow smaller (and therefore more economical) vehicle batteries to be installed and help to comply with emission limit values for fleets.

zf.com

APPLIED MOTION PRODUCTS

STF Stepper Drives and SSDC StepSERVO Drives are now UL-Certified

The Applied Motion Products STF Stepper Drives and SSDC StepSERVO Drives are now UL Certified by Underwriters Laboratories. The drives now meet stringent safety standards with certification, reducing risks of electrical hazards, fire, or component failures. The STF Stepper Drives are DC-powered microstepping drives that control two-phase, bipolar step motors. They feature advanced current control and an anti-resonance algorithm that electronically dampens motor and system resonances, enhancing motor smoothness and usable torque across a wide speed range. Additionally, the drive incorporates electronic torque ripple smoothing and microstep emulation, significantly reducing motor noise and vibration for optimal performance.

The SSDC StepSERVO Drives are closed-loop versions of our proven, high-performance microstepping step motor drives. By integrating closed-loop servo control algorithms and pairing them with StepSERVO Motors equipped with high-resolution encoders, these drives enable StepSERVO systems that outperform traditional step motor solutions. Benefits include up to 50 percent higher peak torque, smoother and quieter operation, and reduced power consumption, delivering superior efficiency and performance.

applied-motion.com

MAXON

Showcases Latest Component Technology Including Gearheads, Motion Controllers and High Efficiency Joints

New innovative solutions from maxon include gearheads, motion controllers and high efficiency joints for robotics applications and exoskeletons. These components can be found in industrial automation, robotics and medical applications. These technologies were featured at Hannover Messe 2025 in April.

With the new backlash-free "Strain Wave" shaft gearheads of the GSW series, maxon is expanding its portfolio for high-precision drives. The GSW 55 A and GSW 62 A models offer high torque transmission in a compact design and are particularly suitable for robotics and automation applications. The backlash-free gearing ensures precise positioning—a crucial feature for dynamic and precise movements in high-end mechanical engineering and automation technology.

With the ESCON2 servo controllers, maxon offers high-performance solutions for dynamic speed control that are extremely smooth running—even for drives without high-resolution encoders. The expanded portfolio includes options ranging from the compact ESCON2 Nano 24/2 (48/144 W) to the powerful ESCON2 Compact 60/30 (1800/3600 W). The drive controllers are designed for a variety of applications and offer high efficiency as well as a wide range of interfaces for control.

In addition, maxon has the MicroMACS6 Motion Controller, a programmable unit for up to six axes. This extremely compact controller enables complex motion sequences and is particularly suitable for precise automation applications.

Another highlight is the High Efficiency Joint (HEJ), a modular system for robotics applications and exoskeletons. The integration of the motor, transmission, electronics, and sensors in a single unit significantly reduces the development effort. The system, currently available in the HEJ 70 and HEJ 90 variants, is characterized by a compact design, high dynamics, and modern impedance control with integrated torque measurement and facilitates the construction of modular robot systems.

maxongroup.com

SIEMENS

Launches Next-Generation Motion Control System for Basic Automation Applications

At this year's Automate, Siemens launched an enhanced motion

control portfolio, featuring Sinamics servo-drive systems and the new Simatic S7-1200 G2 controller, delivering performance and flexibility for basic automation applications including handling, moving, positioning and processing.

The new solution combines three key innovations: Advanced Sinamics S200 and S210 servo-drive systems, the new Simatic S7-1200 G2 controller and compatible Simotics servomotors.

"This holistic system approach represents a significant leap forward in basic automation capabilities," said Craig Nelson, product manager, motion control, Siemens Industry, Inc.

Key features and benefits include enhanced processing power with dedicated communication performance and extended memory; support for up to 31 Profinet devices with synchronized program execution; integrated motion control technology objects for simplified system configuration; advanced safety features up to SIL3/PLe and Category 4 certification; Near Field Communication (NFC) capability for wireless access to diagnostic and device data.

The new portfolio offers scalable solutions with various power options including voltage ranges from 200–400V with power ratings up to 7 kW for Sinamics S210, an ultra-fast current controller response time of 62.5 µs and flexible configuration options for single axes, coordinated axes and simple kinematics.

This cost-optimized solution includes comprehensive safety features, wireless diagnostics capabilities, and seamless integration with the Siemens TIA Portal, making it ideal for manufacturers seeking to modernize their automation systems.

usa.siemens.com/servo-drives

Hedging Your Bets on e-Mobility and Electrification

CTI Symposium offers insight into the future of the automotive industry

Matthew Jaster, Senior Editor

At CTI Symposium USA 2025, the automotive industry discussed the challenges it faces in the fields of electric drives, power electronics, battery systems, e-machines and more. This year's symposium examined topics such as EV and plug-in hybrid technology, e-motors, thermal management, automotive market analysis, passenger and commercial vehicles and the latest on powertrain solutions for work trucks.

CTI brings together experts and decision-makers from passenger car and commercial vehicles, OEMs, system and component suppliers, engineering service providers, software developers and market specialists. It provides attendees with the latest developments, innovations, information, solutions and new contacts in the automotive and electrification industries.

The extensive lecture program is designed to meet the needs of the drivetrain community. Key notes, expert discussions, deep dive sessions and the accompanying exhibition cover the full range from complete systems to components to engineering services. The content is selected by the CTI advisory board and the sessions focus on market trends, electric and hybrid drives and components, impact of legislation, infrastructure, and development tools.

"The CTI Symposium looks at the direction of the automotive industry," said Patrick Lindemann, president, e-mobility and chassis, Mechatronics Americas at Schaeffler Group and CTI Symposium chair. "Is it still full steam ahead to BEVs or is the interim solution of hybrids not so interim? What is the ultimate long-term goal? How should suppliers position themselves to bet on the right horse?"

2025 Outlook

The political landscape and technology go hand in hand and guide the consumer to their decision making. CTI sheds light on both sides.

The tariff situation, for example, is highly dynamic according to a spokesperson for a top Tier One automotive supplier. "While scenario planning is ongoing with our customers, any significant changes to the automotive supply chain will require time, effort, and investment far beyond typical political planning horizons. We expect the trends towards supply chain resiliency and reshoring, particularly for critical components, to be supported by policy. Separately, the U.S. administration is placing more emphasis on advancing autonomous driving regulations, which could unlock additional innovation and accelerate adoption after several years of limited movement."

On the electric vehicle front, Lindemann said hybrids are here to stay but the symposium gave the entire automotive industry a sneak peek as to what this market will look like in the coming years. Obviously, electrification will still be the end game, but the question remains how many decades will it take to fully get there?

"The pure BEV focus is over for now," Lindemann added.

Some surprising automotive trends include the continued strength of ICE-related technologies in the U.S. and the resilience of plug-in hybrid vehicles in China. Tesla's recent challenges are also notable.

"Redefining trade and tariffs may ultimately impact the number of OEMs, suppliers and even the vehicle mix over time (may possibly see more consolidation within auto industry)," said the Tier One spokesperson. "More broadly, there is growing regional divergence—with different technology pathways emerging between North America, Europe, and China based on policy, trade regulation infrastructure development, and consumer behavior."

Additional trends taking place in the automotive industry include rethinking supply chain strategies, the integration of AI, IIoT and digital twins to predict real-time outcomes, leveraging autonomous driving technologies, as well as a greater emphasis on mobility-as-a-service (MaaS) and Fleet-as-a-service (FaaS).

According to Tech Insights, the automotive industry is transforming in 2025, driven by advancements in electric vehicles and automation. Demand for battery electric vehicles will rise with new efficient powertrain components, while Level 2 automation becomes standard in affordable models. China will lead the deployment of advanced electrical/electronic architectures, paving the way for software-defined vehicles. Additionally, 5G chipsets will surpass 4G in automotive applications, despite semiconductor suppliers facing inventory challenges.

Where the Industry Is Going

Lindemann said the last decade showed electric vehicles are real and major hurdles are overcome. The progress of EVs in the next decade will be tremendous.

"As stated earlier, electrification will be the ultimate end game, but hybrid technology will get us there," he said.

Hybrid vehicles will get stronger here in the United States with a slower increase of BEV sales. Europe will highlight a stronger trend to BEVs, but slower than expected with some range extender technology. In Europe, current market conditions do not support the legislated pace of change, and targets are clearly at risk; adjustments in vehicle types and a stronger focus on affordability are likely to follow.

China will continue its strong push in the BEV market. China is expected to continue leading in EV adoption, supported by strong industrial policy and government-driven market incentives across a wide range of vehicle segments.

Extended-range electric vehicles are having a moment right now, as automakers reassess their BEV plans for the rest of the decade and beyond amid a slowdown in demand in some EV segments, according to *Autoweek*. EREVs are front and center as consumers want to take their electric trucks and SUVs on long road trips and make purchase decisions accordingly.

According to the Tier One spokesperson, overall, electrification will not follow a one-size-fits-all approach. Different segments, regions, and use cases will evolve uniquely, shaped by social, economic, and cultural factors. In the U.S., electric propulsion growth will likely continue to slow due to reduced regulatory support.

New Component Technology

In addition to the symposium, CTI offers comprehensive articles online and in *CTI Magazine*. Here is some recent content on component technology in these changing markets:

External Damping of Roller Bearings and its Effect on the Acoustics of an e-Mobility Gearbox

Reducing the sound emitted by the vehicle and the noise perceived by the passengers is an essential part of the development of modern e-vehicles. Bearings are crucial to the transmission of vibrations within the vehicle powertrain. This article presents a method for studying the impact of external bearing damping on acoustic properties. For this purpose, damping elements between the outer bearing ring and the gearbox housing of a gearbox used in

electric vehicles are introduced, and parameters relevant to damping are varied by means of design of experiments. First, the noise sources that occur in a gearbox for electric vehicles will be identified. The gear mesh is determined as one of the primary sources of noise. The vibrations generated by the gear mesh are transferred through the shafts, the bearings, and the gearbox housing.

cti-symposium.world/external-damping-of-roller-bearings-and-its-effect-on-the-acoustics-of-an-e-mobility-gearbox/

Dog Clutch Without Angular Backlash

Dog clutches are cost-effective but often suffer from angular backlash, causing discomfort. A novel, patented design has been developed to eliminate this issue using a purely mechanical blocking mechanism. This design, fully interchangeable with conventional mechanisms, requires no extra modifications but needs an external synchronization system. Featuring innovative gearshift dogs and blocking mechanisms, it was tested with two prototypes on test benches. The results showed the design's effectiveness, and robustness especially for hybrid and electric vehicles, addressing key shortcomings of traditional clutches.

cti-symposium.world/dog-clutch-without-angular-backlash/

Intelligent Bearing Monitoring with LubeSecure from HCP Sense

HCP Sense is an innovative start-up from Darmstadt that develops intelligent bearing monitoring systems for industrial applications. With a focus on predictive maintenance and condition monitoring, HCP Sense offers solutions to maximize operational efficiency, minimize downtime and extend the lifespan of machines.

The LubeSecure technology utilizes the fact that a bearing under full lubrication can be viewed as a capacitor in the electrotechnical sense in which the lubricating film acts as a dielectric. By measuring the electrical impedance, it is possible to differentiate between different lubrication states. This innovative approach makes it possible to react to inadequate lubrication at an early stage, before permanent metallic contact and the associated increased wear and tear occur. With that, LubeSecure technology doesn't detect damages when they occur, as comparable condition monitoring technologies, but detects the underlying reasons for damages before they can actually form.

cti-symposium.world/intelligent-bearing-monitoring-with-lubesecure-from-hcp-sense/

CTI Symposium Europe

Decarbonization and digitalization, as well as global upheavals are challenging manufacturers and suppliers alike. New technologies, new competitors and new business models are changing the market and the global economic outlook at breakneck speed. In response, governments are seeking to strike a new balance between the development of sustainable mobility and the development of their economies while also having to acknowledge broader societal trends. The European CTI Symposium will take place December 2–3, 2025, in Berlin.

cti-symposium.world/de/

PTE

ZERO EXCUSES. ZERO ROOM FOR GEAR DRIVE FAILURE.

KEEP CRITICAL EQUIPMENT RUNNING WITH PHILADELPHIA GEAR®

When communities count on uninterrupted power, Philadelphia Gear delivers the mission-critical gear drive support to keep entire cities moving.

Access end-to-end services — including OEM parts and aftermarket repair — to ensure your equipment runs reliably for decades to come.

GET STARTED TODAY AT PHILAGEAR.COM/POWER

PHILADELPHIA GEAR
POWER SYSTEMS BY TIMKEN

The Sweet Life

Improving Sugar Mill Efficiency with Fenner Industrial Motion's MAV Keyless Locking Device in Collaboration with Rossi Gearboxes

Matthew Jaster, Senior Editor

Sugarcane roller mills are essential components in the sugar industry, responsible for extracting sucrose-rich juice from sugarcane by squeezing it between two/three rolls. The efficiency and effectiveness of these mills are crucial for the overall performance of sugar production. As the industry evolves, it faces increasing pressure to improve environmental conditions, safety, operational flexibility, and reduce costs associated with maintenance and energy consumption.

The transition from traditional mechanical drives to electric mill drives has revolutionized sugar mills by offering better regulation and control, enhanced safety and significant operational cost reductions. However, to maintain such improvements, the power transmission components in these systems must also evolve to meet growing demands for performance and reliability.

"Rossi—and gearboxes in general—have different types of couplings within the operating machine. Everything depends on how the machine shaft that connects to the gearbox is designed. The best solution depends on the requirements of the machine. Every coupling has advantages and disadvantages," said Davide Balestrieri, technical department, MAV.

A Keyless Locking Solution

Fenner Industrial Motion, through its MAV product line, worked with Rossi, a leader in industrial gearboxes, to provide a keyless locking device for the sugar mill's power transmission system. Rossi's gearboxes are used globally in every stage of sugar production, from cane preparation to crystallization. The solution was the MAV Shrink Disc 3009 560 mm x 940 mm Special, which created a rigid, frictional connection between the gearbox's hollow shaft and the crusher rollers' solid shaft, eliminating the need for traditional keys/couplings or mechanical fasteners.

The shrink disc is a mechanical assembly composed of conical rings and a set of screws. They provide a rigid, backlash-free, frictional keyless connection between an outer hollow shaft (hub) and an inner shaft. This is installed directly onto the hub which is then mounted onto the shaft. They allow the transmission of torque, bending, thrust loads, etc., either alone or in combination. They are suitable for shock and reversing loads. These components provide high contact pressure between the hub and shaft, offering high load capacity in combination with ease of installation and removal.

"Rossi wants to increase the maximum torque data of several gearboxes including the EP 1500 (from 2150 kNm to 2500 kNm) to be published in their product catalogs to align with the competitors. So, they need a better performing shrink disc. The same request came for the EP1060 (from 1500 kNm to 1800 kNm), EP2120 (from 3.000 kNm to 3.800 kNm), EP3000 (from 4250 kNm to 5400 kNm), the largest models they produce. We did this easily by modifying the geometry of the shrink disc (taper, number of screws, outer diameter, etc.) In this sense, we have improved performance," Balestrieri said.

The shrink disc has provided 40+ years of proven technology for light, normal and heavy-duty applications. Fenner/MAV engineers utilize 3D CAD and calculation software, including *FEM Analysis* to provide its customer base with the necessary tools to select the proper components. MAV specializes in designing and manufacturing special items according to customer application and design requirements. The company manufactures keyless locking devices, external shrink discs, and rigid couplings for shafts ranging from 5 mm to more than 1 meter. This includes more than 40 series available in both metric and imperial bores.

The solution had to handle a significant torque of 2,500 kNm, while keeping the overall system compact and minimizing stress on the components. The MAV-designed shrink disc met these strict requirements, improving both performance and cost-efficiency in the power transmission system.

According to Fenner/MAV, the shrink disc pictured is the largest ever produced by MAV and is one of four shrink discs supplied to sugar mills.

Editor's note:
If your components or system helped solve a mechanical power transmission challenge we'd love to hear from you. Send your case studies and application articles to Matt Jaster, senior editor at *jaster@agma.org*.

Cost efficiency was gained by not changing the geometry (diameters and lengths) of the output shaft, the material and the production technology of the shaft, according to Balestrieri.

"The application of a higher performance shrink disc would have caused the shaft to suffer from excessive stress," he added.

Rossi supplies cost effective, reliable and high-performance solutions for the sugar industry, with expertise in various sugar processes and applications. These gear reducers and gearmotors offer productivity, energy efficiency and great customization capacity. Thanks to the company's engineering knowhow, they know what is required during every stage of sugar processing.

Unique Production Challenges

According to *sugar.org*, sugar cane stalks are harvested from fields in U.S. locations such as Florida, Louisiana and Texas and global countries such as India, Brazil, Australia, Thailand, Mexico and China. At the sugar mill, the sugar cane stalks are washed and cut into shreds. Huge rollers press sugar cane juice out of these shredded stalks.

Once the cane arrives at the mill it is weighed and then shredded. The shredding breaks the fibrous stalks apart, bursting the cells that contain the sweet juice. Following this, the cane is crushed through a series of rollers, separating the juice from the leftover fibrous material. The leftover material is used to fuel the mill's furnaces. Having extracted the juice, impurities need to be removed. This is done by adding lime and heating. The clear juice is then concentrated by boiling under a vacuum into a syrup.

The juice is then clarified, concentrated and crystalized. The crystals are spun in a centrifuge to remove the liquid and produce golden raw sugar (this is 96–98 percent sucrose). Raw sugar is transported to a cane sugar refinery, where it will be further purified.

The amount of molasses left on the crystals or added back to the sugar crystals determines which type of sugar is produced. Beyond the traditional white granulated sugar and light and dark brown sugars, there are lightly colored sugars, golden or tan, produced for specialty uses. As for the materials leftover from sugar processing, many of them are recycled and reused. For example, sugar cane refining results in leftover cane fiber is called bagasse. This bagasse is used to generate electricity for sugar mills and even their surrounding communities.

Global Impact

The global production of sugarcane in 2019–2020 was reduced due to limited production in India, Brazil and the United States. Unfortunately, the industry suffers the same fate as many food and beverage markets where high production costs, seasonal weather, government policies and outdated machinery and production prevent the global expansion at a greater pace. Shortages of skilled labor for harvesting and transporting sugarcane has also caused production limitations.

Customization and Modularity

Modularity can be considered the foundation of Rossi. Modular products and "modular" processes allow Rossi to engineer a solution for almost every industrial application requiring a gearmotor or gear reducer. Modularity means flexibility for the engineers behind the scenes and the ability to provide customers with a wider range of options, faster delivery and most important of all, competitiveness. The limitless configurations available allow Rossi to deliver standard or custom solutions in a cost-effective manner.

MAV and Rossi have been collaborating for over a decade, providing both standard and custom solutions across a range of industries. By combining Rossi's high-performance gearboxes with MAV's keyless locking device, the partnership has delivered a flexible and reliable solution for sugar mills, improving the efficiency and durability of power transmission systems.

"The MAV solution was to design a longer shrink disc to reduce the contact pressure on the shaft and reduce the intensity of mechanical stress, respecting the space constraints imposed by Rossi," Balestrieri said.

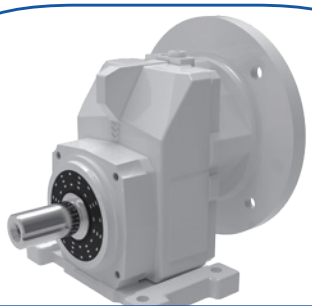
fenner.com
rossi.com

PTE

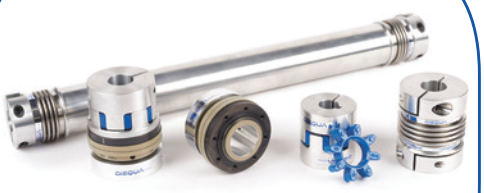
For Related Articles Search
couplings
at powertransmission.com

When off the shelf just won't do.

With our extensive range of standard components and custom machining capabilities, a custom-designed and manufactured gearbox for specific applications is something we do all the time.

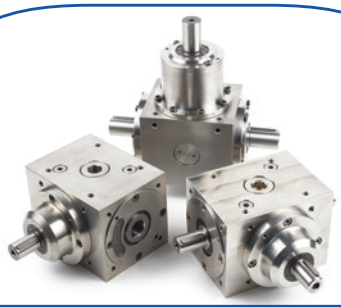


FDA Paint



Stainless Couplings

Stainless Spindles



Stainless Housings

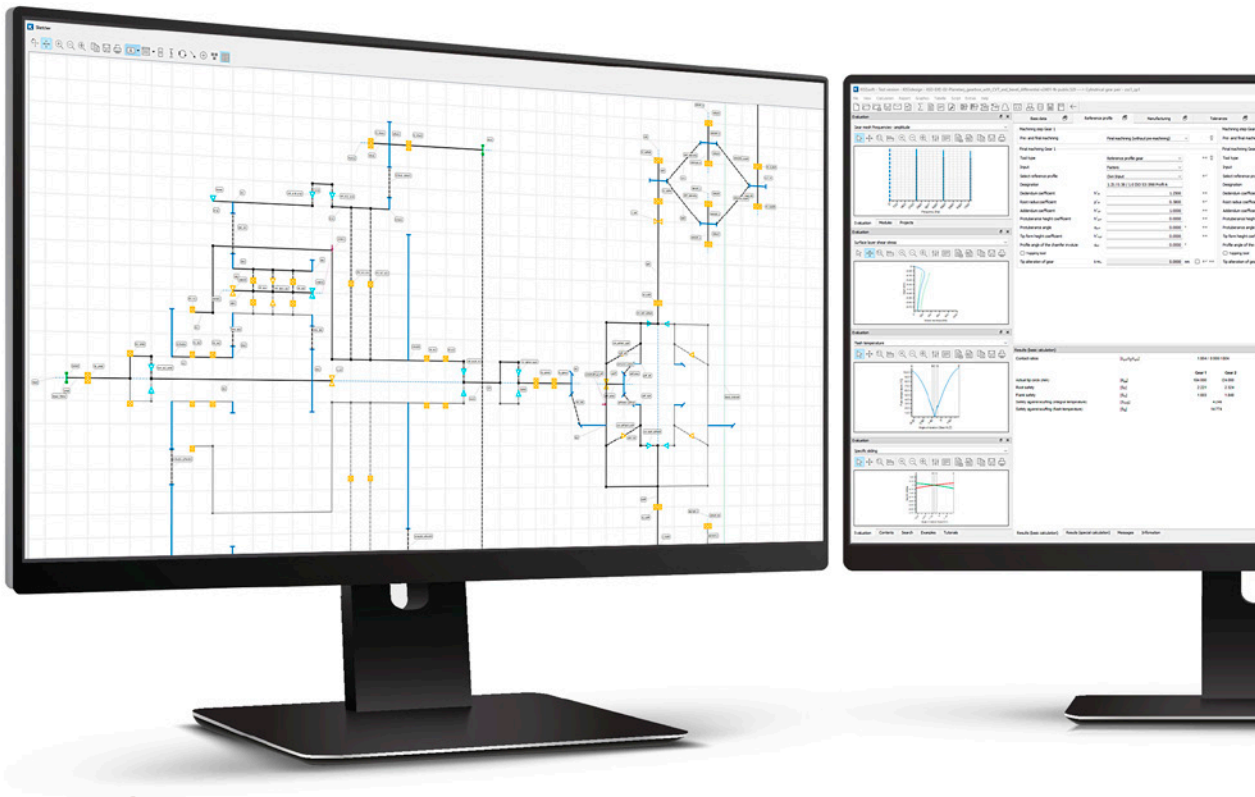
DIEQUA Corporation

180 Covington Drive
Bloomingdale, IL 60108 USA

630-980-1133

www.diequa.com

Motion Control and Power Transmission Drive Components



Powerful by Design

Accelerating gearbox development through intuitive, system-level engineering tools that adapt to any workflow

Hanspeter Dinner, Managing Director, KISSsoft AG—A Gleason Company

Speed is a key factor for success. It is as important as cost, value, uniqueness, vision, user acceptance. This holds true for processes, goods and services. And for tools, including the one presented here. A tool that is intuitive to use requires little time to learn. A versatile tool is quickly accepted by a team dealing with many projects or concepts simultaneously. A tool that adapts to the users' workflow and integrates seamlessly maintains these processes speed. Introducing the KISSsoft System Module.

Use Cases

CAE tools like the KISSsoft System Module play a crucial role in the sizing, optimization and rating of gears and other transmission components by addressing key design needs. It supports the design of new transmissions based on end user requirements, allowing for innovative solutions tailored to specific performance goals like reliability, vibration level or transmittable torque. In addition, the System Module is essential for modifying legacy systems to meet new operating conditions like the use of stronger engines, ensuring that older designs remain relevant and functional.

The System Module also supports the re-engineering of reference or competitor designs, facilitating improvements and optimizations of these. By re-creating in the KISSsoft System Module existing designs described through manufacturing drawings, it ensures accuracy and consistency across life cycle stages. One of its powerful features is the ability to manage and compare design variants that share the same topology, allowing engineers to evaluate different configurations efficiently, within a single System Module file.

For variants development, the System Module creates databases with various ratios tailored to different torque ranges, streamlining the design process for different gearbox sizes. Furthermore, it assists in visualizing and explaining concepts, preliminary designs, and proposals, making it easier to communicate and promote ideas within engineering teams, to stakeholders and potential buyers.

Finally, the System Module connects and manages available KISSsoft files, safeguarding these valuable component models used for individual analysis, ensuring data integrity and seamless integration of detail information elaborated by junior engineers in complex engineering projects managed by more senior staff. This approach keeps license costs as low as possible.

For Related Articles Search
software
at powertransmission.com

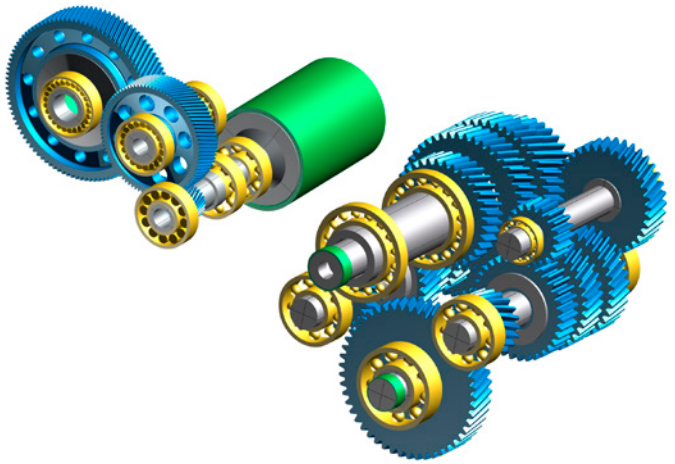
Rolling bearings

Rolling bearings			b1	b2	b3	b4	b5	b6	b8	b7
Calculation			sm_calc	sm_calc	sm_calc	sm_calc	s2_calc	s2_calc	saxle_calc	saxle_calc
Shaft			sm	sm	s1	s1	s2	s2	sc	sc
Type			Deep groove ball bearing (single row)	Deep groove ball bearing (single row)	Deep groove ball bearing (single row)	Cylindrical roller bearing (single row)	Tapered roller bearing (single row)	Tapered roller bearing (single row)	Tapered roller bearing (single row)	Tapered roller bearing (single row)
Number			SKF 6308	SKF 6308	SKF 6308	SKF NU 308 ECP	SKF 30209	SKF 30209	FAG 32011-X-XL	FAG 32011-X-XL
Geometry										
Type			Deep groove ball bearing (single row)	Deep groove ball bearing (single row)	Deep groove ball bearing (single row)	Cylindrical roller bearing (single row)	Tapered roller bearing (single row)	Tapered roller bearing (single row)	Tapered roller bearing (single row)	Tapered roller bearing (single row)
Number			SKF 6308	SKF 6308	SKF 6308	SKF NU 308 ECP	SKF 30209	SKF 30209	FAG 32011-X-XL	FAG 32011-X-XL
Inner diameter	d	mm	40.0000	40.0000	40.0000	40.0000	45.0000	45.0000	55.0000	55.0000
External diameter	D	mm	90.0000	90.0000	90.0000	90.0000	85.0000	85.0000	90.0000	90.0000
Width	B	mm	23.0000	23.0000	23.0000	23.0000	20.7500	20.7500	23.0000	23.0000
Nominal contact angle	α_0	°	0.0000	0.0000	0.0000	0.0000	14.9314	14.9314	15.1240	15.1240
Basic dynamic load rating	C	N	42300.0000	42300.0000	42300.0000	93000.0000	81600.0000	81600.0000	96000.0000	96000.0000
Basic static load rating	C_0	N	24000.0000	24000.0000	24000.0000	78000.0000	76500.0000	76500.0000	118000.0000	118000.0000
Fatigue load limit	C_u	N	1020.0000	1020.0000	1020.0000	10200.0000	8650.0000	8650.0000	19400.0000	19400.0000
Nominal clearance			ISO 5753-1:2009 C0	ISO 5753-1:2009 C0	ISO 5753-1:2009 C0	ISO 5753-1:2009 C0	Own input	Own input	Own input	Own input
Nominal diametral clearance	P_{d0}	mm	0.0130	0.0130	0.0130	0.0375	0.0000	0.0000	0.0000	0.0000
Tolerance class									DIN 620: 1988 PN Tapered roller bearing	DIN 620: 1988 PN Tapered roller bearing
Shaft tolerance		mm							k6	k6
Hub tolerance		mm							H7	H7
Inner ring temperature	T_i	°C	nan	nan	nan	nan	nan	nan	60.0000	60.0000
Outer ring temperature	T_o	°C	nan	nan	nan	nan	nan	nan	55.0000	55.0000
Rolling element temperature	T_w	°C	nan	nan	nan	nan	nan	nan	57.5000	57.5000
Offset of outer ring in X-direction	δ_x	mm	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Offset of outer ring in Y-direction	δ_y	mm	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Offset of outer ring in Z-direction	δ_z	mm	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tilting of outer ring around X-axis	δ_{rx}	°	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The KISSsoft System Module streamlines variant development by managing component models, visualizing concepts, and enabling efficient collaboration across engineering teams, supporting data integrity, cost control, and seamless integration.

Features

The System Module combines kinematic analysis, lifetime calculation, 3D graphics and system reports with a programming language. It is the tool of choice for strength and lifetime analysis of various kinds of geared systems and gearboxes. The System Module lets the user do quick and detailed parametric studies of a complete power train in very little time to compare different variants of a concept or to analyze a given design for different loads.



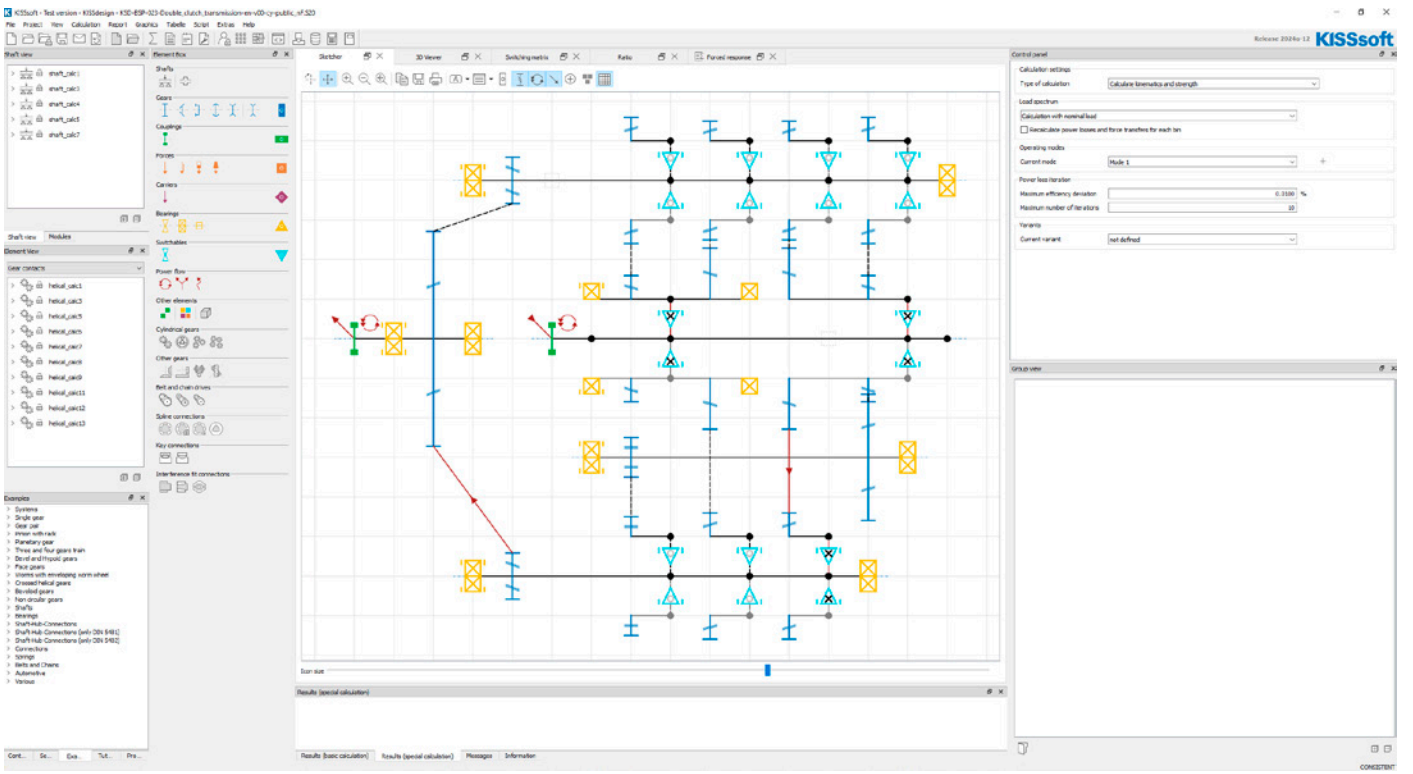
The KISSsoft System Module links all gearbox components for simultaneous strength and lifetime analysis, with 3D visualization that accelerates concept development, balances designs early and simplifies documentation in a single integrated file.

In the System Module, all parts (gears, shafts, bearings, connections) of the gearbox are linked and the strength / lifetime analysis is performed simultaneously for all elements. A three-dimensional graphical presentation of the current state of the system immediately shows the geometrical influence of every change in parameters. This approach greatly accelerates the design process and results in a much more balanced design even during the concept phase.

The machine elements calculated range from gears, shafts, bearings to shaft-hub connections. This will result in a more balanced starting design and fewer modifications will be necessary further down in the design process to reach an optimized design. Furthermore, documentation of the calculation is simplified and all calculation data for the whole gearbox is stored in a single file. The System Module uses other *KISSsoft* modules for the strength and lifetime calculations of the various components used in the system.

Basis of all component calculations is the system level kinematics calculation covering:

- Speed, torque, and power for complex systems including gears, couplings, speed and torque limiter, multiple boundary conditions
- Modeling of planetary systems like Ravigneaux, Wolfrom, Wilson, Simpson



With system-level kinematic analysis at its core, the KISSsoft System Module supports a wide range of drivetrain configurations—from planetary systems to CVTs—enabling accurate, efficient modeling of speed, torque, and power across complex transmission architectures.

- Differentials, (with bevel, face or spur gears), chain and belt transmissions
- Couplings may be activated and deactivated, slippage considered
- Allows for modelling of CVT transmissions
- System ratio and mesh ratio table in Kinematics tab
- Switching matrix for defining gear speeds
- Definition of operating modes, combining different boundary conditions with load spectra

Working Modes

With *KISSsoft*, the user may choose between three working modes:

1. **Component Level Only:** This mode involves using *KISSsoft* modules other than the System Module. It's a detailed, low-cost, and time-saving approach suitable for less complex systems where calculations for individual components are done independently from each other. This mode is ideal for projects requiring maximum speed, efficiency, and simplicity.
2. **System Level:** This mode integrates components into a holistic system, combining power flow analysis, spatial and collision-free arrangement, and top-level requirements-driven conceptual design. It is highly efficient for experienced designers with a deep understanding of all aspects of gearbox or transmission design. It is the mode of choice for most licensees globally.
3. **Collaborative Approach:** The System Module supports a team-based design process. Domain experts work on individual components using independent *KISSsoft* instances, performing detailed sizing, optimization, and analysis. Iterative design improvements are uploaded into the system model, enhancing its fidelity step-by-step.

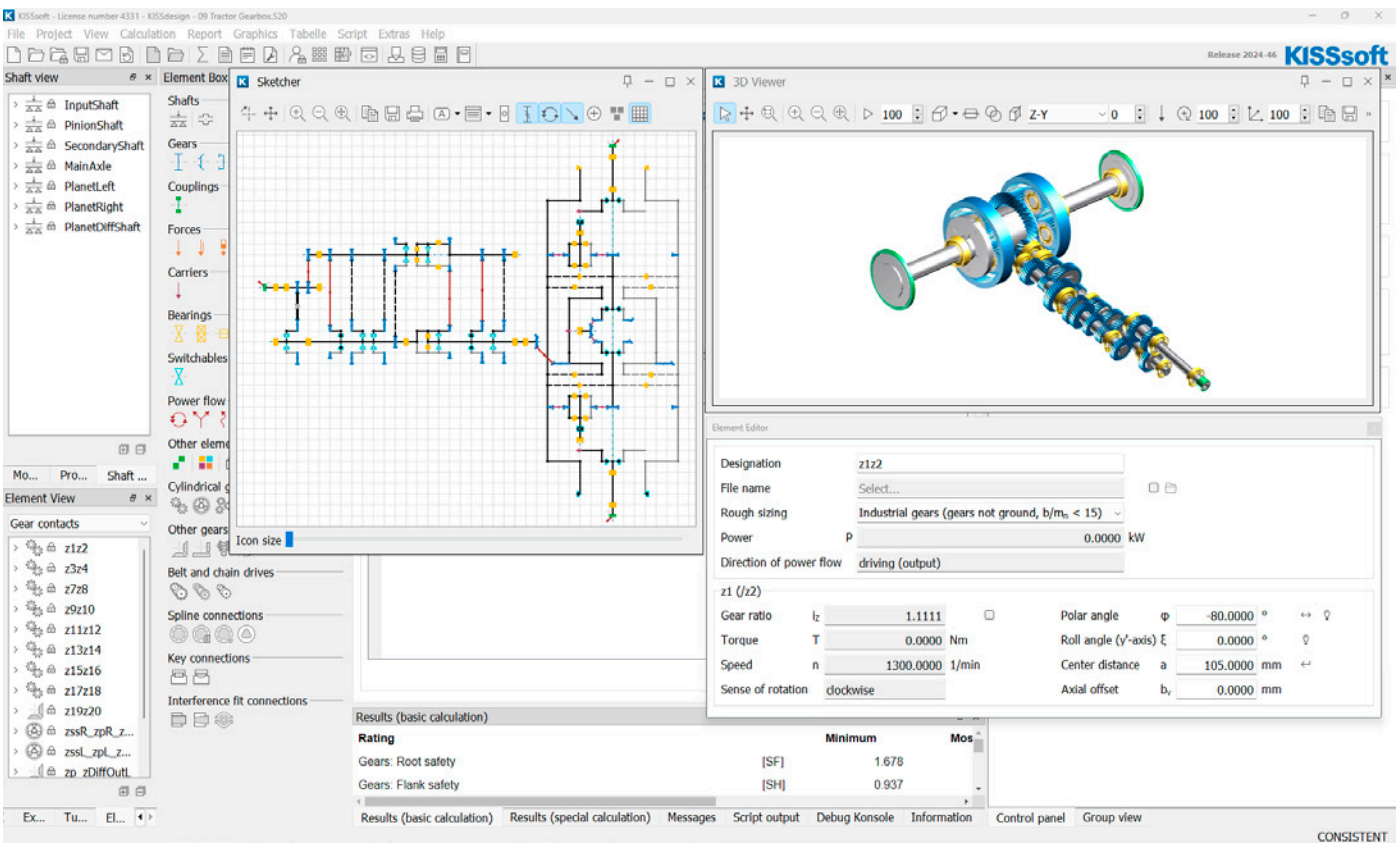
Switching between these modes is immediate, with data exchange enabled through *KISSsoft* files as well as bespoke and neutral formats (e.g., Gleason *GAMA,* Gleason *GEMS, GDE* and *REXS*).

Return on Investment

The System Module's parameter-based design approach manages the numerous parameters of gearbox and bearing design efficiently, reducing errors from manual data transfer. Experience from hundreds of projects confirms that the module accelerates project timelines and reduces errors, even for basic designs. Once engineers become proficient, they consistently rely on the System Module for its efficiency and accuracy.

kisssoft.com

PTE



The KISSsoft System Module supports three flexible working modes—Component Level, System Level, and Collaborative—enabling seamless transitions between independent, integrated, and team-based design approaches for maximum efficiency and adaptability.

Mass Production

Experience and ingenuity fuel GROB Systems work in electrification and e-Mobility

Matthew Jaster, Senior Editor

Battery module assembly. All photos courtesy of GROB Systems.

GROB has always been synonymous with the development and manufacturing of machines and production lines. Its machining centers, including the Universal line, feature unique retractable spindles and a wide range of automation capabilities. Noteworthy, is the fact these machines are built right in Bluffton, OH. My visit to the company's booth during the last IMTS in Chicago, however, uncovered an electrification and e-Mobility strategy 10+ years in the making suitable for both our *PTE* and *Gear Technology* audiences.

"We have been pioneers in designing and building the world's first highly automated, mass production assembly equipment for manufacturing hairpin stators. We essentially developed the technology from scratch more than 10 years ago and since then have delivered over 80 production lines to customers worldwide," said Thomas Neubert, chief sales officer, GROB Systems Inc., Bluffton, OH. "In addition, we are continuing our R&D, as we always push further to be the leader in advanced technologies. Next, we developed assembly systems for rotors, drive units, battery packs and modules, and most recently machines for battery cell manufacturing."

Nearly every American car builder (established and pure EV companies) use GROB equipment for some of their e-Mobility production, according to Neubert.

"Most of them engage in strategic partnerships with us, and we co-develop products that go into cars and the equipment. This not only results in shorter time to market for our customers' products, but also streamlines manufacturing processes that are cost-optimized, proven and highly reliable. Our customers highly value this synergistic approach," he said.

Challenge and Opportunities

There are two main challenges in building/developing machines for the manufacture of stators and rotors. "One is obviously the development cost for equipment, technologies and processes that have not previously existed for mass production. This is very capital intensive, and in my opinion, can only be managed by a company structured like GROB that does not pass on the development cost to customers," Neubert said.

The second challenge, and this is probably a tougher one, is this technology is constantly evolving. Neubert said this is both challenging and exciting. Changes in materials, new ideas and formats are only a few of the things that make developing standardized equipment difficult. This is especially true for battery products, where everything, down to cell chemistry, is in a constant flux to improve.

"For example, this means that a station concept that worked for one project will not be applicable in another. But most of the time, changes are even more frequent, which makes designing stations/ equipment a huge challenge. The station design must be constantly updated according to product changes, yet the original, strict deadlines need to be adhered to. This is an incredible challenge that is only overcome through very close communication and collaboration between GROB and our customers.

Additionally, every customer is looking for a way to differentiate themselves from their competitors, so there is a whole range of different products. Luckily however, most of the core processes are similar.

Electrification Realized

Neubert strongly believes e-Mobility is the future and a more sustainable way of transportation. Therefore, GROB Systems not only builds the equipment for such products, they "live" it.

In its "Electric Trucks for Company Transport" pilot project, GROB shows that trucks with an electric drive are already commercially viable, at least over short distances, while taking another step on the path towards the long-term reduction of carbon emissions by GROB.

"On one hand we invest in the usage of renewable energies and support moving forward to carbon neutrality. On the other hand, we promote the use of electric vehicles at GROB and our transportation/ logistics partners. We use electric semi-trucks for the transportation of material between our global headquarters located in Mindelheim, Germany and Ulm, Germany, about 52 miles away. The semi-trucks which use electrical propulsion take this route multiple times a day without problems. Having worked in our China operations for five years, I can tell you we also use electric trucks for transport between our two plants in China, which are directly operated by GROB," Neubert said.

Additionally, GROB is increasing the share of electric and hybrid vehicles for the company car fleet worldwide. Many full EV vehicles are driven today even by executives and sales that typically cover a lot of miles.

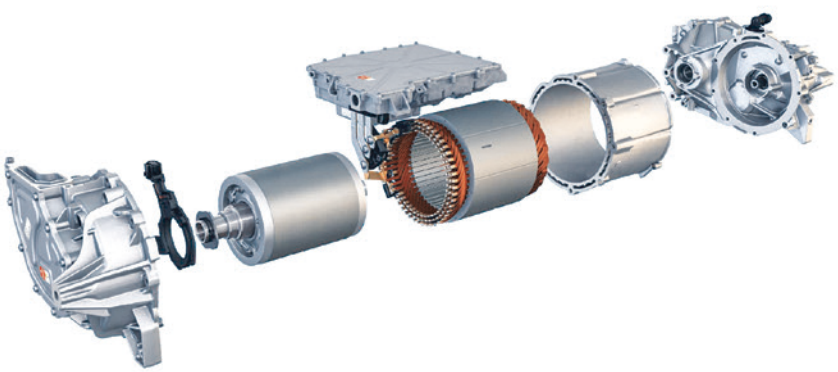
Long-Term Strategies

Sustainability is one of GROB's core values. They even changed their headline from "Advanced Technology Worldwide" into "Sustainable Technology Worldwide."

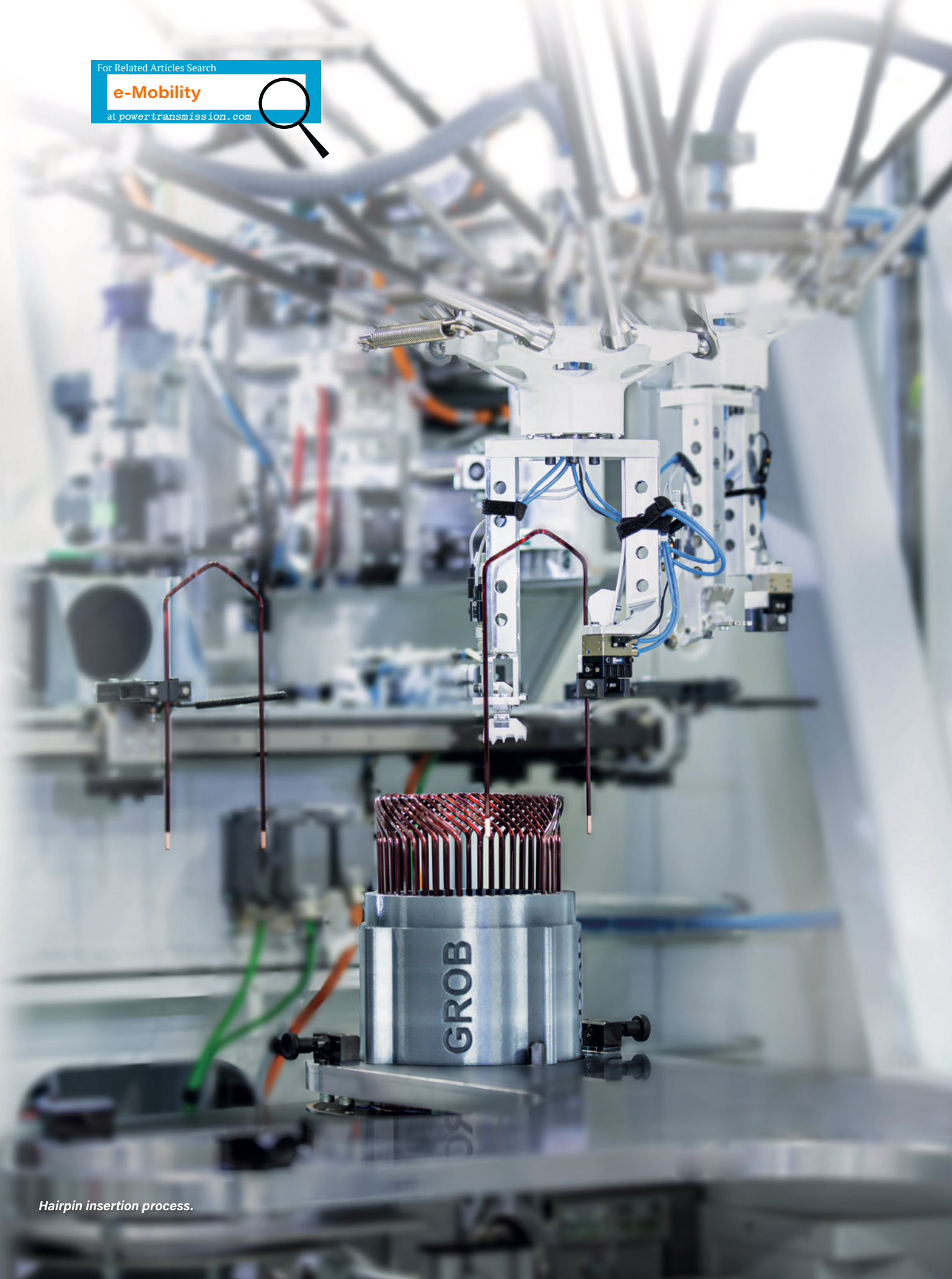
"We started using a certain amount of renewable energy in our headquarters in Germany and even added an "energy center" to our campus. Sustainability is also one of our core KPIs which we constantly strive to improve. For example, we are monitoring our CO_2 emission footprint and actively reducing it," Neubert said.

GROB masters all winding and assembly technologies to produce various electric drives and has extensive knowledge and experience in the production of highly complex battery module systems. For example, GROB has delivered more than 50 assembly lines for battery modules and packs, for all kinds of different cell types, such as prismatic, pouch and cylindrical. GROB assembly systems use highly automated complex process steps to assemble, fix and electrically connect battery modules in large, trough-like housing components. These battery pack systems represent a large part of the underbody of new electric cars.

When it comes to the construction of so-called gigafactories for battery cell production, GROB has been able to supply state-of-the-art



Principal components of an electric motor.



Hairpin insertion process.

machines and production systems for these groundbreaking technologies for several months. At the same time, GROB is continuing to invest in the improvement and evolution of battery technologies. Additionally, GROB is prepared for future fuel cell assembly opportunities.

The demand for e-Mobility projects continues to rise though in a slightly different direction than expected. "GROB is expanding its capacities for battery assembly equipment in the American and Chinese plants. In addition to ongoing investments in the Mindelheim main plant, the localization efforts at both the GROB plant in Bluffton, OH, and the GROB plant in Dalian, China, are being pushed forward at high pressure so we can serve the key American and Chinese markets local-to-local," Neubert said.

The GROB plants in Mindelheim and Bluffton continue to lead the way in the company's electromobility future.

"They are part of our expansion strategy and driven by the need for more space that is required by the size of battery projects. To give you a frame of reference, a typical battery assembly line comes with an investment in the range of tens of millions of dollars and has a footprint of up to 656 ft. x 262 ft. (200 m x 80 m). By expanding our facilities, it enables us to handle more projects for our customers," Neubert added.

What's Next in the e-Mobility Journey—Battery Cell Production

In 2024, Dürr and GROB who have a strategic partnership, expanded their machine and system portfolios to produce battery cells and made them more efficient. Their partnership focuses on the automotive sector and the market for stationary battery storage systems. Stationary storage systems absorb surplus energy from solar and wind power so that fluctuations in the electricity supply can be balanced out. They also serve as home storage solutions for solar power from private systems.

Together, Dürr and GROB aim to minimize energy consumption in cell production and increase the quality of the battery cells produced. For example, Dürr and GROB are supplying a cell manufacturer with machines for the production of high-performance battery cells. As reported in March of this year, Dürr was installing systems for the conventional wet coating of electrodes and is planning a pilot system for efficient and sustainable dry coating. GROB supplies the complete cell assembly based on innovative lamination technology, which enables a significant increase in production speed, resulting in low manufacturing costs.

GROB offers a new generation of the Z-Folding Machine - with noticeable improvements in speed, efficiency and flexibility. The Z-Folding Machine offers safety standards for the handling of LFP and NMC cells, with an integrated inspection system that ensures quality in real time.

Complete Turnkey Solutions

GROB has always been setup to provide "turnkey solutions", yet the sheer size of e-Mobility projects has taken it to a new level. Neubert said GROB has adjusted and improved their project management structure accordingly and added additional layers, ranging from program managers to project managers, project coordinators and project assistants. This makes sure that every aspect of the project can be kept track of while still having a single point of contact for customers.

"On the operational side, we have expanded our plant(s) to have enough space such as a recent 135K sq. ft. expansion in Bluffton, OH, to support the production of manufacturing systems for new technologies in the U.S. including, most importantly, systems for battery production," he said.

Customer Evolution

GROB has developed several machines that can build fuel cell components and are looking into advanced battery technology. "We provide product and process SE's (Simultaneous Engineering) to our customers. We do not wait for the future to happen—we design the future!" Neubert said.

Outside of e-Mobility, the company draws from a diverse customer base, so they are not too reliant on any single industry.

"In the metal cutting CNC business, we especially serve the aerospace and defense industry, as well as the semiconductor and medical markets. The common requirements all these industries share is the need for highly complex 5-axis machining and the highest accuracy and quality. In fact, we invest as much in R&D for metal cutting machines as we do for e-Mobility products. We also developed a machine for additive manufacturing that prints metal 10x as fast as traditional processes. This new technology has had an impressive market launch, and we are working with several customers on delivering the first machines. We estimate that this technology will constantly evolve and develop into another 'pillar' of business for GROB," Neubert said.

For this article, however, we'll remain focused on GROB's long-term strategy on sustainability and electrification.

"I am a numbers guy and I'm always impressed when I see how many batteries and e-drives have been produced on GROB equipment," Neubert said. "Every hour, more than 2,000 battery modules and packs are produced on our equipment worldwide, that's 33 per minute or one every other second."

grobgroup.com/en

Corrosion and Its Challenges for the Mechanical World

Neville W. Sachs, P.E.

Sometimes corrosion is attractive. For example, the vivid colors on titanium jewelry are oxides, with the color difference the result of the oxide thickness and the refracted light. Also, from an artistically oriented viewpoint, the golden-brown appearance of many of the new high-voltage towers made from ASTM A 242 (Corten) steel is more appealing than their bright galvanized cousins, and that "pleasing brown color" is a tightly bonded coating of rust. But most of the time, and in several ways, corrosion presents difficulties that can greatly shorten the life of mechanical equipment.

Typically, as engineers and technical people, we know that steel corrosion involves oxygen atoms uniting with the iron atoms in the steel. We realize this reaction slowly thins the base metal, and that the steel or iron part could eventually crumble into a pile of rust. But there are also times when the very serious dangers from corrosion are almost invisible to the human eye.

Two general classifications for corrosion are:

- Dry—at elevated temperatures.
- Wet—where liquid is needed to conduct corrosion currents.

An example of dry corrosion is the scale that develops on grates of a barbecue grill. In those situations, the elevated temperatures supply the energy needed for the oxygen to unite with iron. Fortunately, dry corrosion is uncommon in the machinery world because the temperatures needed for it are in the range where specialty alloys and exotic lubricants are usually needed.

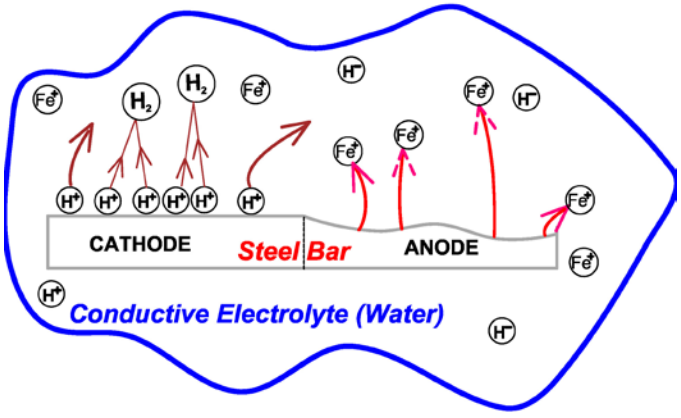


Figure 1—Microscopic view of a corrosion cell on a steel bar, illustrating how differing electrical potentials create an anode where iron ions are released and a cathode where hydrogen gas forms, initiating the rusting process.

To understand wet corrosion and the problems it can create, Figure 1 shows a microscopic view of what happens in a typical corrosion cell. This shows the corrosion of a steel bar, and because of minute differences in the electrical potentials within the bar, the anode area is being attacked while the cathode area is protected. At the anode, Fe+ (iron) ions are released. (An ion is an atom with an electrical charge.) They are off in the liquid, usually water, and will eventually pair up with some oxygen ions to form the various forms of rust that we see all around us.

Only a very short distance along the bar is the cathode, where the hydrogen ions, from the water H_2O molecules, are being liberated. As shown in the diagram, most of those ions rapidly find another ion and form hydrogen gas. However, there is always dissociation and some of those hydrogen ions wander off to do later damage.

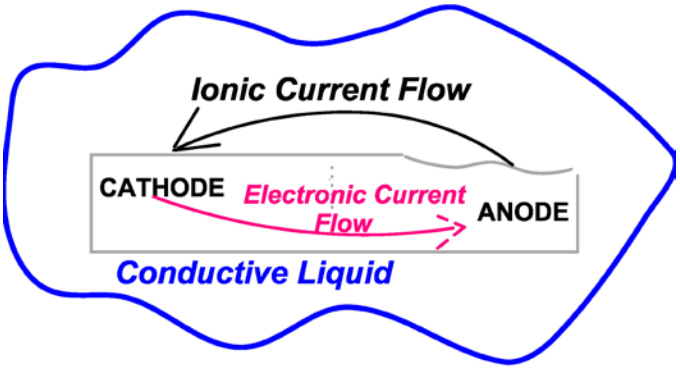


Figure 2—Corrosion circuit in a steel bar, showing electron flow through the metal and ionic current through a surrounding liquid, highlighting the necessity of moisture for corrosion to occur.

Going back to that steel bar, as shown in Figure 2, the internal electric charges flow from the cathode to the anode, and then, to complete the corrosion circuit, the ionic currents flow back through the liquid. From this figure we can see that there has to be liquid present to conduct the currents that result in the corrosion.

Unfortunately, that doesn't mean the part has to be dripping in water, and we've all had cases where a relatively clean piece of steel has emerged from a long seclusion in desk drawer with a light coating of rust. It turns out that, due to intermolecular forces, corrosion can begin at only 60 percent relative humidity.

It's also interesting that, the more conductive the liquid, up to a point, the more rapid the corrosion. That's

because a more conductive liquid, such as salt water, can more effectively carry the corrosion currents.

The problems that corrosion can cause are three-fold:

1. *Material loss*—There is a loss of material and contamination of the product surface. Usually this is readily visible and, although it can be expensive to correct, it is readily detectable.
2. *Hydrogen damage*—This type of corrosion damage goes by various names such as hydrogen embrittlement, hydrogen cracking, and stress corrosion cracking, and there are some differences in the exact mechanisms. However, the basic cause is those free hydrogen ions can result in unexpected and undetected fractures.
3. *Reduced fatigue strength*—Corrosion continually reduces the fatigue strength of the metal. The more severe the corrosion, the faster the fatigue strength is decreased, and that continual reduction in fatigue strength essentially goes on forever.

(It's important to realize that corrosion isn't the only source of the free hydrogen atoms that result in hydrogen cracking. Some of the other processes include steam leaks, plating processes, acid cleaning, welding, etc. Still, corrosion is unique in that it continually generates hydrogen and doesn't have the recognition and controls of the other processes.)

Scientists have been trying for years to understand exactly how hydrogen and the other chemicals, especially sulfur, interact to cause cracking and the reduction in fatigue strength, and the primary source of the problem appears to be those hydrogen atoms, their need to form hydrogen molecules, and the relative sizes of different atomic structures.

A hydrogen atom, with only one electron, is tiny compared to the rest of the atoms in our universe. A simple example of how a hydrogen atom can cause the cracking is to think of it as the size of a golf ball and the structure of iron and steel as being made up from neatly stacked atoms the size of bowling balls. The single golf ball, i.e., a hydrogen ion, can easily move in between the bowling balls with no problem. But then it meets another hydrogen ion and the atomic forces cause it to form molecular hydrogen, H_2, the gas we're familiar with. However, the hydrogen molecule is about five times larger than the hydrogen atom and that causes stress within that assembly of "neatly stacked bowling balls."

H_2 molecules tend to group together at irregularities within the metal's structure. Then, as more and more hydrogen molecules are formed, the stress inside the steel structure increases, and the material's ability to withstand external stresses decreases.

Hydrogen Damage and Cracking

With ductile metals, such as low carbon steel, the material can easily deform and the reduction in strength isn't terribly significant. Figure 3 shows a piece of SAE 1020 steel with a series of blisters that are about a quarter inch in diameter and are filled with hydrogen. It was part of some chemical process equipment and wasn't highly stressed so the blisters didn't cause any problems, but larger blisters can cause reduced ductility.

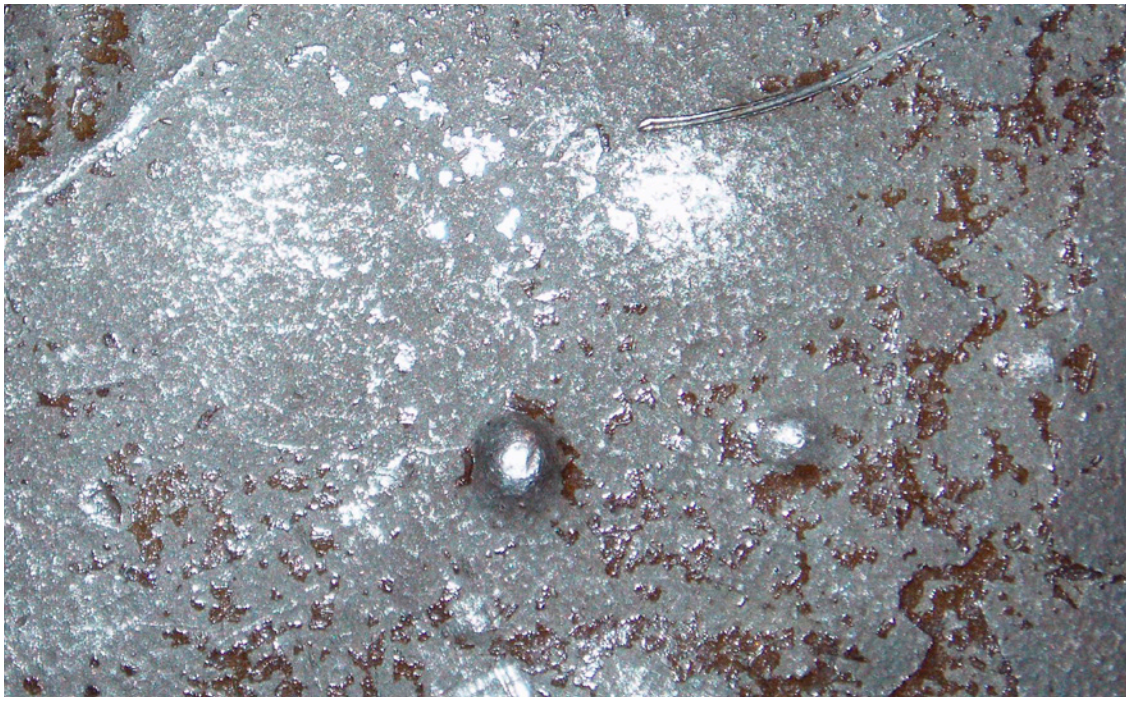


Figure 3—Surface blisters on SAE 1020 steel caused by trapped hydrogen—common in ductile metals and typically harmless under low stress, though larger blisters can reduce material ductility.

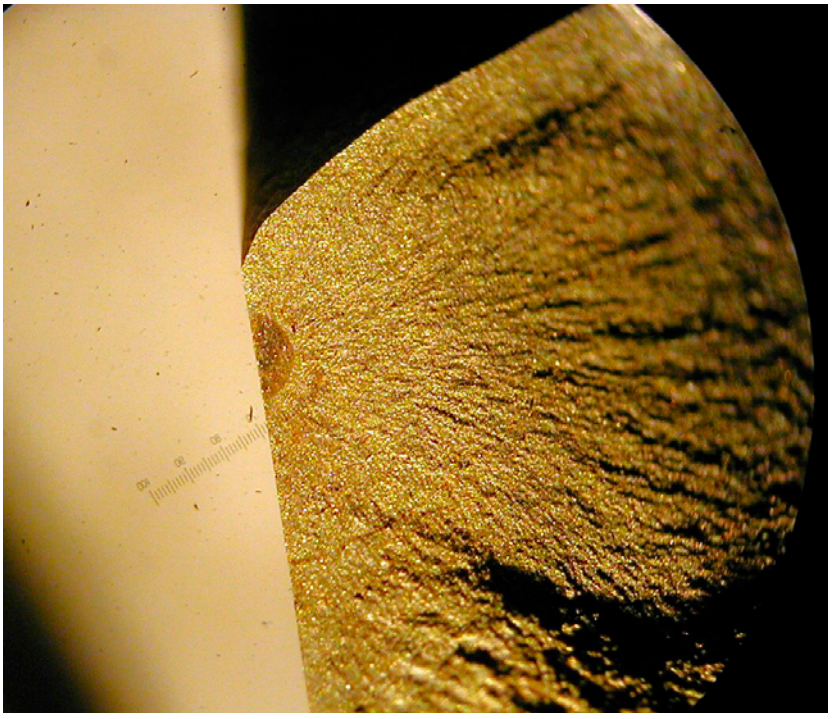


Figure 4—Magnified fracture of a high-strength steel spring (HRC 50), showing corrosion-induced cracking from hydrogen embrittlement—originating at a rusted area caused by cleaning and poor design.

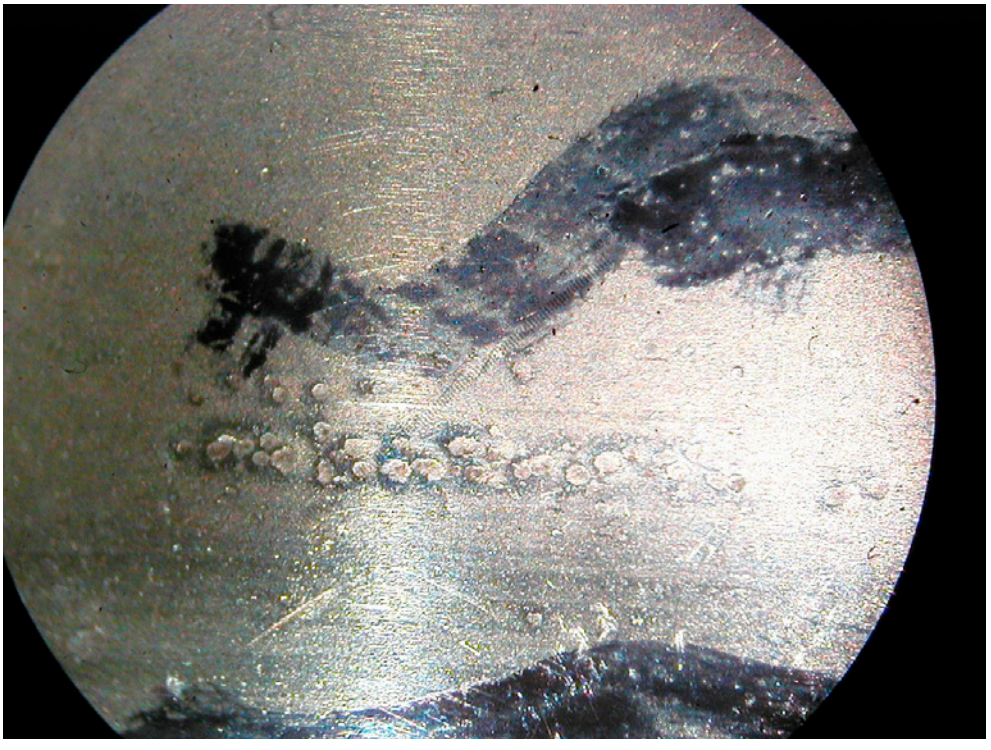


Figure 5—Microscopic view of corrosion pits on a roller bearing raceway, the small round pits between the two heavy black pen marks were caused by corrosion.

However, as steel is processed to become stronger, it almost always becomes less ductile and the effect of the atomic hydrogen becomes more critical. Figure 4 shows the magnified fracture of a steel spring used in a piece of pharmaceutical equipment. The bottom of this HRC 50 spring was rusted, the result of the cleaning process and a poor machine design. Looking at the crack face, the corrosion at the origin is readily visible, and a metallurgical analysis confirms that hydrogen was involved.

We know that hydrogen cracking is the result of a combination of metal chemistry, temperature, stress and time. Nevertheless, the only way for sure to know if hydrogen has contributed to a failure is to have the part analyzed for hydrogen content, but there is no hard and fast rule as to the effect that corrosion has on causing the failures.

One of my first lessons about the effect of corrosion involved a $200,000 roller bearing in one of our machines. This was before the era of predictive maintenance, and we had removed it from position and opened it up to inspect the condition of the contact surfaces. The cause of the problem was that, after removing it from a very dirty environment, we had washed it with hot water that managed to get past the seals. So, when we opened the bearing there were a series of black marks on the inner and outer rings, and Figure 5 is a microscope's view of the marks. They are corrosion pits and the technical staff from the bearing manufacturer told us that the hydrogen from the pitting had reduced the L10 life of the bearing to 10–20 percent of the original.

Black marks on the contact path of a rolling element bearing are almost always symptoms of corrosion that will greatly reduce ball and roller bearing life. With similar stress mechanisms and hardened steels, corrosion will also reduce the life of gear teeth and chain components.

Fatigue Life Reduction

While one type of corrosion-generated hydrogen damage usually causes relatively sudden fractures, we know that another causes a continuous reduction in fatigue strength.

In the book *Fatigue Design* (John Wiley & Sons, 1970) by Carl C. Osgood, he cites numerous tests showing how corrosion affects the fatigue strength of various metals. Ironic is that, with steel alloys, the stronger the alloy, the greater the reduction in fatigue life. One of the book's charts shows that a 60,000 psi steel has a 39 percent reduction in fatigue strength while, with identical conditions, a 130,000 psi steel has a 66 percent reduction.

From a practical standpoint, there is good data showing that even a humid atmosphere will result in a significant reduction in fatigue strength and eliminating that surface corrosion is beneficial. (With this knowledge, we wrapped a series of 145,000 psi (1 GPa) machine shafts with vinyl tape and found a five-fold increase in average shaft life.)

Most fatigue design involving steel alloys is based on a given fatigue strength that doesn't decrease after 10^6 or 10^7 cycles; however, corrosion will continually reduce the fatigue strength until the cyclically loaded part will eventually fail.

PTE

Neville Sachs, P.E., is a Stevens Institute of Technology graduate and renowned expert in mechanical failure analysis. He has authored three books, contributed to four others, published over 60 technical papers, and taught industrial failure analysis across North America and Europe since 1987. He is active in ASME, STLE, NSPE, and AMPP.

For Related Articles Search
corrosion
at powertransmission.com

The Path of Least Resistance—Roller Bearing Damage in VFDs

Norm Parker

Bearing damage due to electric current in variable frequency drives (VFD) is well understood as a general concept. What is not yet fully developed are the models that better predict when a system is at risk and where we should be looking for early signs of damage.

Aegis (grounding rings) has, for years, provided great documentation outlining the need for an insulated / conductive pairing in VFDs due to various currents involved. In the chart below, shaft voltage discharge and high frequency circulating currents are typically what we are looking for.

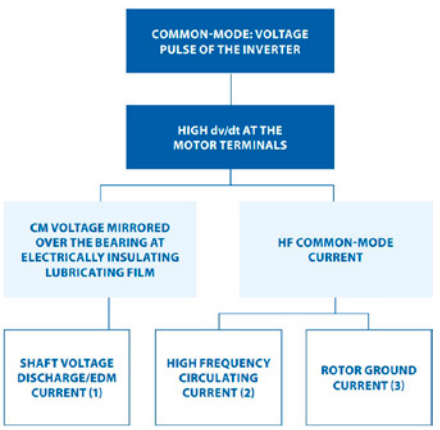


Figure 1—Aegis Handbook 4th Edition p. 4.

Rotor to ground current is often damage caused by an improperly grounded test cell.

The schematic below (Figure 2) provides a useful visual in understanding circulating current vs shaft voltage.

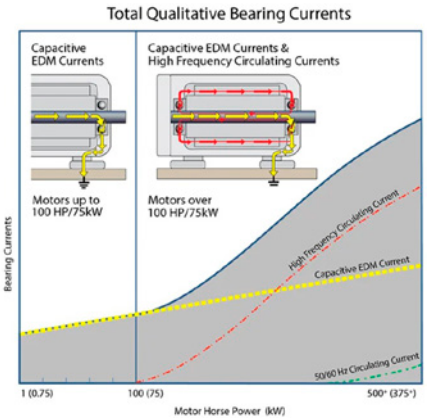


Figure 2—Current Paths AEGIS (6).

Adding the primary shaft of the gearbox to the image above and it becomes apparent that without mitigation, shaft voltage could be carried into the gearbox side bearings. It is less likely that circulating current would make it to the gearbox side as the path would need to include going through a gasket or bolts connecting the cover and housing.

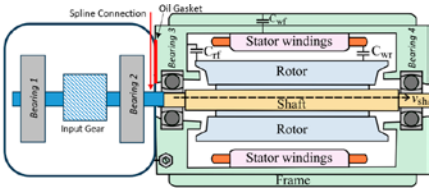


Figure 3—Layout of Motor + Input Gearbox Shaft.

To understand where the current would likely travel with an unprotected system, we must understand the loading conditions. The primary protection for bearing current is the lubrication film in each bearing. The thicker the film, the higher the capacitance. Film thickness is determined by temperature, speed and load—and other minor contributors such as age of oil, surface finish and specific grades of steel. With a connected main shaft like this, our problem is greatly simplified because speed among the bearings is the same and we can assume temperature is similar—at least at the bearing race locations. Now we just need to understand loading conditions. Though various proposals for formulas exist, generally everyone agrees with some form of the relationship:

$$Capacitance \propto \frac{Contact\ Elipse}{Film\ Thickness}$$

Image 1—Bearing Failure from an improperly grounded test cell.

One such model describes as:

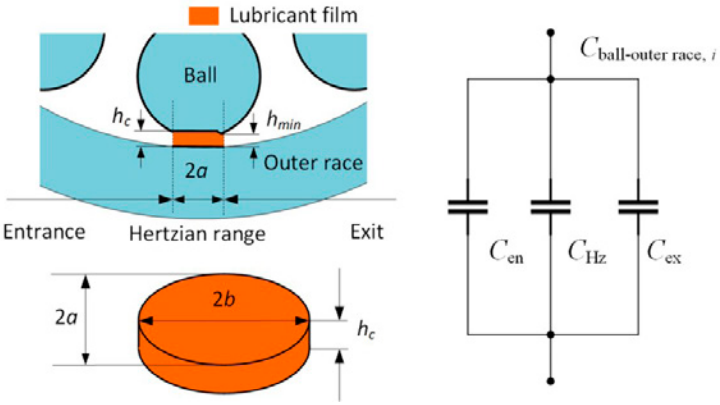


Figure 4—Bearing Capacitance Model: University of Kentucky (4).

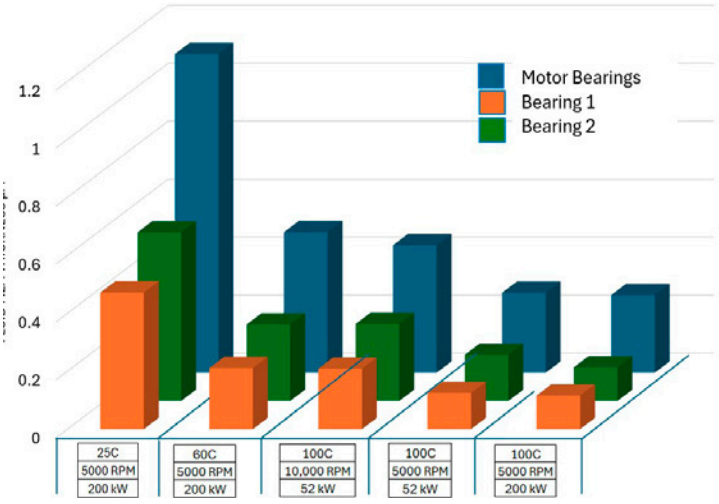


Figure 5—Film Thickness vs. Temperature, Load, Speed.

Figure 7—A Range of Ball Conditions: 7a (new), 7b (light dulling), 7c (opalescent).

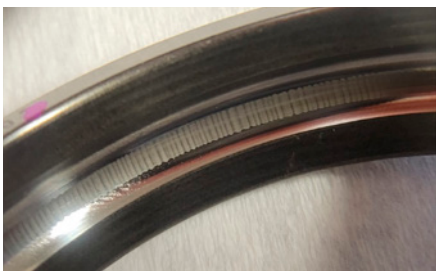


Figure 8—Heavy tactile fluting on motor bearing (picked up on vibration sensor).

Figure 9—Outer Race of Electrically Damaged Motor Bearing.

Running a few different scenarios through a full model gives us an intuitive relationship between the three primary drivers of fluid film thickness. Increasing temperatures reduces oil viscosity and reduces film thickness as a result. Increasing load reduces film thickness as the race and balls are forced together. Increasing speed increases film thickness as the hydrodynamic pressure increases.

The Hertzian range or ellipse is a function of the applied load and bearing geometry. This is directly proportional to the resulting pressure of each ball. Considering each ball in the load zone has a different load/pressure and every bearing has a unique geometry, we can see this problem can become quite complex. However, if we only look at the maximum pressure of each bearing in our simplified model, it becomes easier to understand.

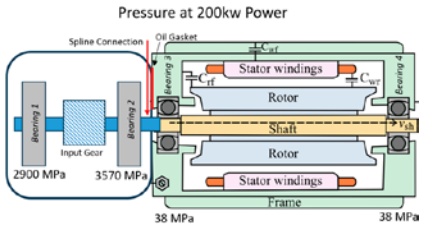


Figure 6—Bearing Pressures at 200 kW.

If we assume our capacitance model is correct and we have enough shaft current to damage a bearing, we can see that, under load, there is potential for the current to travel through Bearing 2 as it has the highest pressure.

We now have some ideas of where to concentrate our efforts in looking for bearing damage to see if we have early sign of electrical damage. This is not just limited to the motor bearings, but also in the adjacent gearset bearings.

It is important to understand that not all electrical damage looks the same. We can see everything from a minor dulling of ball sheen to full tactile—audible noise—fluting.

Does the theory match reality? Can stray motor currents find their way to the gearbox? They absolutely can. In real testing with unprotected motor and gearbox bearings, a unit was exhibiting gearbox bearing noise signals. Upon inspection, Bearing 2 had clear indications of light fluting (could not feel with bare skin, but was picked up on vibration) along with the elusive "tiger stripes" found on the input gear.

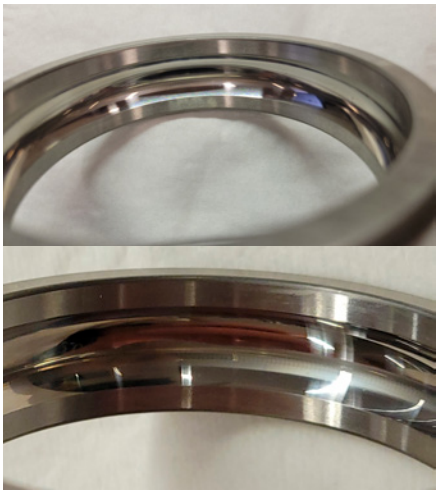


Figure 10—Light Fluting on Bearing 2.

Figure 11—Tiger Striped Input Gear.

Finding these early signs of damage gave an early clue that our gearbox was not properly protected and allowed adequate time to implement the corrections. Had these indications not been found early on by looking at the gearbox side, it could have risked launch timing down the road.

Conclusion

Any traction motor can pose a risk to unprotected bearings—though typically, severe damage is more common with motors above 100 kW. Depending on the overall power and individual motor characteristics, sometimes just a grounding ring OR an insulated bearing on the non-drive side of the motor is adequate protection. In higher power motors, both an insulated bearing on the non-drive end of the motor and a grounding ring on the drive side of the motor may be needed. Both are costly upgrades, so it is tempting to avoid adding the needed upgrades. At the very least, ensure you are package protected for a grounding ring and have a plan for implementation if or when it is needed. Many electrical damage signs may not manifest at lower temperature testing as the oil is thicker and may be enough to protect the bearing. Likewise, simply spinning an unloaded motor at high speeds may mask future potential issues. It is imperative that you test under high-load and high-temperature conditions to determine if the system is at risk.

PTE

Norm Parker is currently Technical Fellow at Stellantis. He has contributed articles to PTE since 2014.

For Related Articles Search
roller bearings
at powertransmission.com

References

1. Steffen Puchtler, et al. "Analyzing Ball Bearing Capacitance Using Single Steel Ball Bearings." *Tribology Letters/Tribology Letter,* Vol. 71, No. 2, 27 Feb. 2023, *https://doi.org/10.1007/s11249-023-01706-7. Accessed 28 June 2024.*
2. "Industrial Bearing Protection Handbook 4th Ed." Aegis, 2024 Electrostatic Technology, Oct. 2024, *www.est-aegis.com/*. Accessed 25 Apr. 2025.
3. He, Feng, et al. "Electrical Bearing Failures in Electric Vehicles." *Friction,* Vol. 8, No. 1, 23 Jan. 2020, pp. 4–28, *https://doi.org/10.1007/s40544-019-0356-5*.
4. "Modeling of Bearing Voltage in Electric Machines Based on Electromagnetic FEA and Measured Bearing Capacitance." *University of Kentucky UKnowledge*, Power and Energy Institute of Kentucky, 25 June 2021, *uknowledge.uky.edu/cgi/viewcontent.cgi?article=1068&context=peik_facpub*. Accessed 25 Apr. 2025.
5. Endika. "Advanced Power Inverter Topologies and Modulation Techniques for Common-Mode Voltage Elimination in Electric Motor Drive Systems." *Science Direct*, Elsevier, 26 Jan. 2021, *doi.org/10.1016/j.rser.2021.110746*. Accessed 28 Apr. 2025.
6. "Motor Bearings: Electrical Damage Simplified - a Further Examination and Clarification." Aegis, ITW, 2017, *blog.est-aegis.com/motor-bearings-electrical-damage-simplified-examination-clarification.* Accessed 25 Apr. 2025.

RENK GROUP AG

Completes Acquisition of Cincinnati Gearing Systems Inc.

RENK Group AG has successfully completed the acquisition of Cincinnati Gearing Systems Inc. ("CGS Inc."), a U.S.-based manufacturer of precision gears and power transmission technologies. Effective immediately, CGS Inc. will operate under the name RENK America Marine & Industry LLC. Founded in 1907, CGS Inc. has long been recognized as a leader in the design and manufacture of precision gears and power transmission equipment, components and spare parts for both military and industrial applications. Headquartered in Mariemont, OH, with an additional facility in Milford, OH, CGS Inc. adds approximately 15,000 square meters of production space and over 100 skilled employees to the RENK Group.

The acquisition marks a significant milestone in RENK's global expansion strategy, particularly in strengthening its presence in the North American market and deepening its focus on serving the US Navy and allied forces.

"The acquisition is a pivotal step in our efforts to build a stronger presence in North America," said Dr. Alexander Sagel, CEO of RENK Group AG. "RENK America Marine & Industry LLC will support our strategic growth initiatives and strengthens the basis for RENK's profitable growth in the naval sector but also strengthens our ability to deliver mission-critical solutions for customers worldwide especially."

With the addition of RENK America Marine and Industry LLC, RENK Group now employs around 4,100 people across 21 locations worldwide.

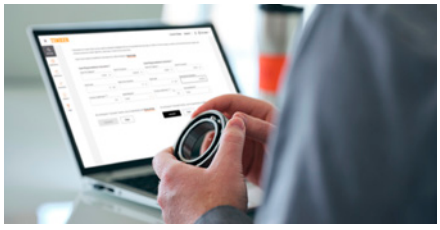
"We are excited to officially join the family and begin this new chapter as a part of the strong RENK Group," said Patrick Potter, president of RENK America Marine & Industry LLC.

The transaction includes all assets of CGS Inc., including the facilities in Mariemont and Milford, OH. The parties have agreed not to disclose the purchase price of the transaction.

renk.com

TIMKEN

Releases Suite of Online Engineering Tools to Streamline Design Engineer's Workflow



The Timken Company has introduced a comprehensive offering of online engineering tools—available at *engineering.timken.com*—for use by design engineers and others who specify bearings for new or existing applications.

"Timken expresses its 125 years of knowledge and experience through this full suite of online engineering tools. The tools help users learn more about bearings, access information quickly and connect to our team," said Mike Kotzalas, director—global customer engineering. "At Timken, we equip design engineers with the information they need to make informed design and purchasing decisions."

The site features 11 independent engineering prediction and calculation tools:

- Timken Syber Bearing System Designer
- Bearing Search
- Seal Search
- Bearing Tolerances
- Bearing Periodic Frequencies
- Bearing Fatigue Life
- Bearing Fitting Practice
- Bearing Clearance Calculations
- Bearing Installation Calculations
- Grease Lubrication Calculator
- Precision Bearing Selector

Data from the tools can be exported into common design programs, output into CAD drawings, or saved for future reference.

Among the many powerful tools available is the Timken Syber Bearing System Designer tool. This tool is a proprietary software program requiring users to register for access. This powerful tool equips users to search for, compare, analyze and model bearings within an application before final specification. It delivers fast, accurate bearing selection and system analysis in one easy-to-use tool, providing trusted results validated by Timken engineers and expert support when needed. This efficient solution empowers users to quickly simulate real-world conditions and optimize their designs, all in one place.

Another feature of Timken's online engineering tools is guided help. For those who do not know which tool is best suited for their design work, this tool walks users through a decision tree to lead them to the most appropriate resource.

Through Timken's array of online engineering tools and technical expertise, original equipment manufacturers can quickly and reliably develop new power transmission systems.

timken.com

SKF

Completes Divestment of its Ring and Seal Operation in Hanover, PA

SKF has completed the previously announced divestment of its ring and seal operation in Hanover, Pennsylvania to Carco PRP Group for a total enterprise value of USD 215 million, corresponding to approximately SEK 2.1 billion. The divestment will result in a capital gain amounting to approximately SEK 0.8 billion in Q2 and will be reported as Items affecting comparability.

"We are committed to create a more focused and resilient SKF to

serve our customers even better and to accelerate profitable growth. Divesting this successful but non-core business at accretive multiples is an important part of this. At the same time, we continue to invest and strengthen our position in core Aerospace segments," says Rickard Gustafson, president and CEO.

Aerospace will remain a large, strategic segment also after the divestment with a share of industrial sales corresponding to approximately 9 percent. Investments in strengthening core aeroengine and structure bearing offerings remain a priority for SKF.

The Hanover divestment is in line with SKF's strategic review of its aerospace business, communicated on October 27, 2023, to focus on core aerospace business and to exit areas that are non-strategic. As previously announced, the Group is exploring options to exit the precision elastomeric device (PED) aerospace operation in Elgin, Illinois, also identified as non-strategic but smaller than Hanover.

skf.com

INNOMOTICS AND DANFOSS DRIVES

Strengthen Partnership to Deliver Comprehensive Motor and Drive Solutions

Innomotics GmbH and Danfoss Drives A/S are pleased to announce the next phase of their strategic, non-exclusive partnership. This was announced at the Hannover Messe recently where Michael Reichle, Innomotics CEO, Mika Kulju, president of Danfoss Drives, attended the Innomotics booth.

This collaboration is designed to meet the growing demand for comprehensive motor and drive solutions, ensuring customers receive high-quality, efficient, and compatible products. By joining forces, Innomotics and Danfoss offer customers the flexibility to bundle low-voltage motors from Innomotics with Danfoss low-voltage drives in a seamless package. This approach is particularly beneficial for customers seeking a specific combined motor and drive solution as part of a delivery or project.

While both companies are aligning their go-to-market strategies for common customer approaches, they continue to provide separate quotes for its respective products, ensuring transparency and flexibility for customers. Additionally, both companies remain committed to brand independence, ensuring customers have the flexibility to choose the best motor-drive combination for their needs.

Michael Reichle, Innomotics CEO: "The strategic partnership with Danfoss Drives allows us to further extend our offering. Many of our customers require very specific motor and drive combinations with the highest standards of reliability and efficiency. This applies to fast-growing sectors such as the water industry. By combining our strengths, we can increase the competitiveness of both brands and conquer new markets. Mika Kulju, president of Danfoss Drives: "We are excited to take this next step in our collaboration with Innomotics. By offering tailored motor and drive packages, we are delivering competitive, efficient, and convenient solutions that directly benefit our customers. Our goal is to provide the best possible solutions while giving customers the flexibility to select the right motor-drive pairing."

innomotics.com

NTN BEARING CORPORATION

CEO Ukai Appointed Chairperson of World Bearing Association

NTN Bearing Corporation is pleased to announce that CEO Ukai has been appointed chairperson of the World Bearing Association (WBA). His term began in September 2024 and will last for two years.

Ukai

Founded in 2006, the WBA is a non-profit, unincorporated industrial association comprising three major regional bearing associations: the Japan Bearing Industry Association (JBIA), the American Bearing Manufacturers Association (ABMA), and the Federation of European Bearing Manufacturers' Associations (FEBMA). These organizations collaborate to promote the common, lawful interests of the global bearing industry, such as open economic engagement, sustainable development, and the protection of legal rights.

In recent years, the WBA has focused on measures against counterfeit products, a serious global issue. The industry is working to create a healthy market through educational activities, a dedicated website, and collaboration with governmental authorities worldwide.

Ukai also serves as chairperson of the JBIA. With this appointment, he will further contribute to the sound development of the global bearing market.

ntnamericas.com

June 15–18

PowderMet2025

PowderMet2025 (Phoenix) is dedicated to metal powder and particulate materials-based processes including press and sinter, metal additive manufacturing, metal injection molding and more. The show provides an energetic forum to showcase PM, metal AM, and MIM equipment, powders, products, and services. MPM2025, co-located with PowderMet 2025, is a technical conference and exhibition dedicated to metal additive manufacturing. Attendees can dive deep into the latest advancements in the field through insightful technical presentations and explore exhibits showcasing additive manufacturing technologies. Sessions include topics on material development, standards, metal density, and more.

powertransmission.com/events/powdermet-2025

June 24–27

Automatica 2025

Automatica 2025 (Munich) examines how robotics and smart automation is changing the future. Focus topics include digitalization and AI, sustainable production, and workforce development. Apart from concrete practical applications and product innovations, attendees can exchange ideas with key players and industry experts. Showcases include mobile robots, service robots, smart maintenance, AI technology, connected machines, testing, startups and more.

powertransmission.com/events/automatica-2025

July 9–10

Dritev 2025

The automotive congress Dritev (DRIvetrain Transmission Electrification Vehicles) offers the powertrain community an optimal platform for exchange. Every year, decision-makers, experts, and industry leaders from around the world meet in Baden-Baden, Germany. Here, vehicle manufacturers and suppliers exchange ideas and capture innovations, developments and challenges in drive technology. During the two-day congress, experts from OEMs, suppliers and universities present practical lectures on new trends as well as classical topics in drive technology.

powertransmission.com/events/dritev-2025

July 19–22

EASA 2025

The 2025 EASA Convention at the Gaylord Opryland Resort & Convention Center in Nashville focuses on companies involved in the service and sale of electric motors, pumps, drives, controls, gearboxes and other rotating machinery. Highlights include market trends, economic outlook, harnessing AI, rotor testing, new motor technologies, supply chain and more. The convention provides an opportunity to access a target market of electromechanical sales and repair professionals.

powertransmission.com/events/easa-2025-convention

August 19–21

ABMA Essential Concepts of Bearing Technology

This course (Rosemont, IL) is specially designed for engineers and others with technical backgrounds that have had limited exposure to bearings and need to adapt their technical training to bearings or seek an upgrade to their technical knowledge. The Essentials Course focuses on understanding basic internal geometry, tribology, bearing attributes and applications and explores the basic concepts around manufacturing methods, loads, internal load contacts, lubrication and failure.

powertransmission.com/events/abma-essential-concepts-of-bearing-technology-2025-04-18

AD INDEX

CALL FOR PAPERS!

Are you sitting on an idea for a technical paper but wondering where to present it? Do you have one already written, sitting on your desk, gathering machine dust?
How about *Power Transmission Engineering*? We are always looking for gearing- and power transmission component-relevant technical papers for publication in the magazine and in its digital version. Having your work appear in *Power Transmission Engineering* guarantees you an audience of the most experienced and discriminating industry players. You say your work has not been peer-reviewed? Not a problem, as we are lucky — and thankful — to have on-hand some of the most experienced and brilliant minds in the industry — our technical editors. So if your work "passes muster" and is published, you'll know you were reviewed by the best — and most demanding.
Chances are you'll be creating the paper under the auspices of the company for whom you work or own, or for one of the various industry-relevant associations. That means they as well will bask in the reflected glory that accrues with publication in *Power Transmission Engineering*.
For publication guidelines and more information, please contact Randy Stott at *stott@agma.org*

PTE™

FREE SUBSCRIPTION

☐ Renew my subscription ☐ NEW subscriber

25PTEALL

☐ **YES** I want to receive/continue to receive ***PTE*** ☐ NO

Name _____

Job Title _____

Company Name _____

Company Address _____

City _____

State _____

Zip Code _____

Signature: _____
(required)

Date: _____

Please send
☐ PRINT Version
☐ DIGITAL Version (E-mail required)
E-MAIL: _____
☐ BOTH Print and Digital
*You can OPT OUT at any time.

How isTHIS LOCATION involved with power transmission products?
(Check all that apply)

☐ WE **MAKE** power transmission products
☐ WE **BUY** power transmission products
☐ WE **SELL** power transmission products (distributors, sales reps, etc.)
☐ WE **DESIGN** products with power transmission components in them
☐ Other (please describe) _____

What is your company's principal product or service?

_____

Your mailing label on the cover looks like this:

X/Y - means you have recieved a complimentary copy. Please complete this form to continue receiving your FREE copy of PTE.

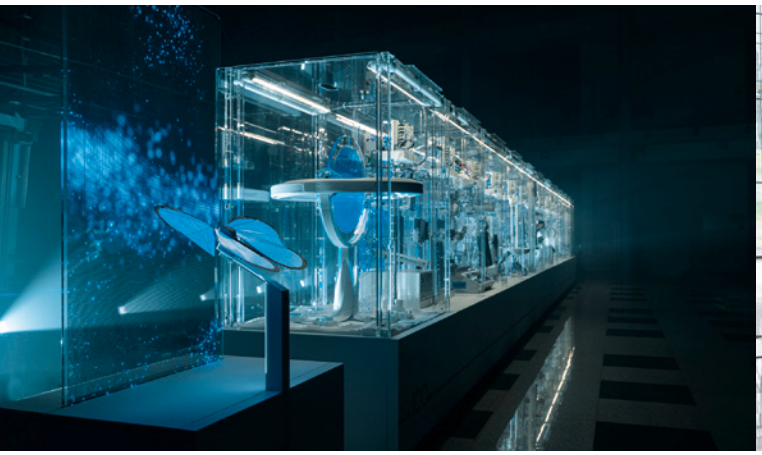
Q14 (shown above) - means you have 14 issues remaining in your subscription (a NEW subscription has 16 issues).

Q1 - means you have 1 remaining issue before your PTE subscription expires. Please complete this form to renew.

MAIL to: 1001 N. Fairfax St, Suite 500, Alexandria, VA 22314 USA | SCAN to: *subscribe@powertransmission.com* | FAX to: 1.847.437.6618

An Incredible (and Extraordinary) Machine

Festo celebrates 100 years of automation during Hannover Messe



Matthew Jaster, Senior Editor

To mark the company's 100th anniversary, Festo designed an Incredible Machine for Hannover Messe 2025. It does not manufacture a specific product, but works on the principle of a Rube Goldberg machine, in which one impulse triggers the next. The Incredible Machine demonstrates the history of automation technology from the past to the present and reflects Festo's fascination for motion technologies (pneumatic, electric, and digital).

Just as the flap of a butterfly's wings can trigger a chain of movements, sometimes a small impulse can bring about significant changes. Festo's eMotionButterfly set the machine in motion. During this journey, visitors were treated to a look back at Festo's history as well as its future.

In 12 modules, a motion impulse ran over a total length of 14 meters, triggering a chain reaction of different motion functions in the machine. More than 1,000 Festo products and more than 1.8 kilometers of tubing and cables were installed in the machine.

Each development in the Incredible Machine represents a wing beat, followed by many more innovations. It all started with one of Festo's first pneumatic products, an electronic controller FPC 606.

Festo's automation journey began 100 years ago in a workshop in Esslingen am Neckar. Festo founder Gottlieb Stoll asked himself how technology could make work easier. From the initial production of machines for woodworking, the company developed into the production of pneumatic and electrical automation technology for mechanical engineering in a wide range of industries. Today, Festo is one of the world's leading automation specialists.

With the Bionic Flower, Festo Didactic is targeting schoolchildren to get them interested in STEM subjects at an early age. This is followed by the basics of pneumatics and electrics for apprenticeships, then data processing for technical degree subjects through to lifelong learning in professional life. A central element is the digital learning platform Festo Learning Experience (Festo LX), which effectively combines theory and practice. Learning systems such as SkillsConveyor for basic training in automation technology and mechatronics offer valuable practical experience.

During a tour at the Festo stand, Germany's Federal Chancellor Olaf Scholz congratulated the company on its 100-year success story. In the anniversary year, Festo welcomed the Federal Chancellor accompanied by Stéphane Dion, special envoy of the partner country Canada to the European Union, and Stephan Weil, prime minister of Lower Saxony to view the Incredible Machine during Hannover Messe.

Festo's representatives said innovations can solve specific problems and have the potential to change entire sectors and create new industries. The journey in the machine leads through specific industries, such as battery production for electric cars, laboratory automation in the life sciences, intralogistics and the semiconductor industry. It delves into the company's history and ends with insights into the actuator technology of the future.

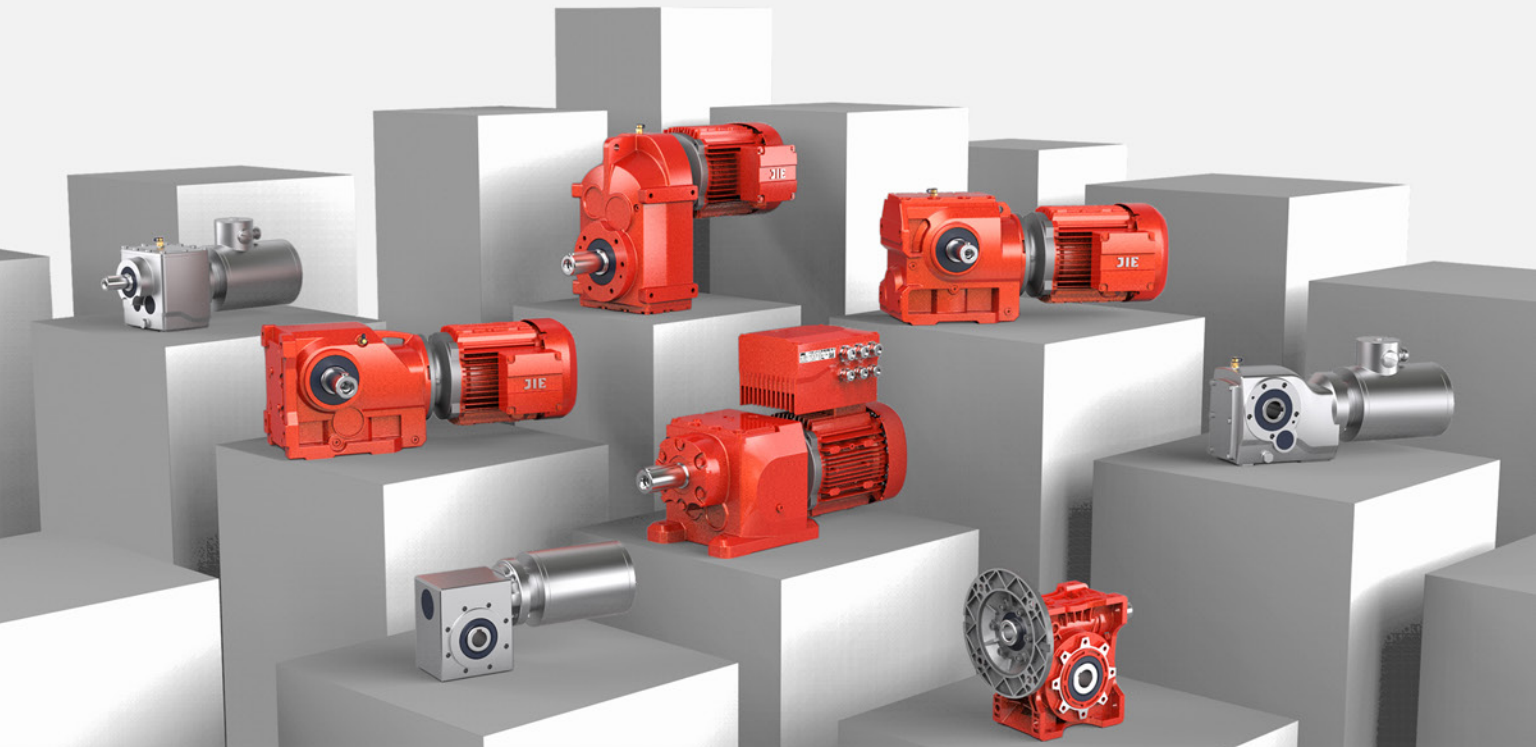
festo.com

JIE
JDRIVE

PTDA Channeling the Power of Industry

IP69K

- Quick Delivery
- Great Service
- Top Quality



Options are Worm gear unit; Helical inline, Parallel shaft, Helical bevel and Helical worm gearmotor; Available in aluminum, cast iron and stainless steel housing.

JIE USA

279 Madsen Dr Suite 101, Bloomingdale,
IL 60108
Tel.: +1 630 580 9986

JIE CANADA

130 Rue de l'Émissaire Drummondville,
Québec J2E 1S4 Canada
Tel.: +1 819 850 9886

info@jie-drives.com | www.jie-drives.com

PBC Linear

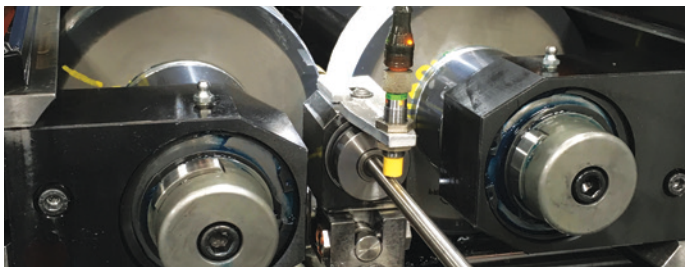
MINIATURE BALL SCREWS

Solve Supply Chain Issues with

American Manufactured Quality

Available Now

to integrate into your application



Built on 15 Years of Precision Rolling the Industry's Best Lead Screws

Request Your FREE Ball Screw Sample

bit.ly/BallScrew2025

- **Available Sizes**
  Flange and Cylindrical Nuts
  6 x 1 | 6 x 2 | 8 x 1 | 8 x 2 | 8 x 2.5 | 10 x 2
- **Accuracy Class 5, 7, & 10**
- **Machined Journals**

- **State of the Art Metrology and Inspection**

- **Integrated Ball Screw Motors**
  - NEMA 08, 11, 14, 17, & 23
- **Applications**
  - Medical Lab Automation
  - Optical Sensor Adjustments
  - Pick and Place
  - Packing Line Push Systems
  - Measurement Systems
  - Mechanical Automation
- **Customization Available**

PBC Linear®

6402 E. Rockton Road, Roscoe, Illinois 61073 USA
+1.800.962.8979 • pbclinear.com