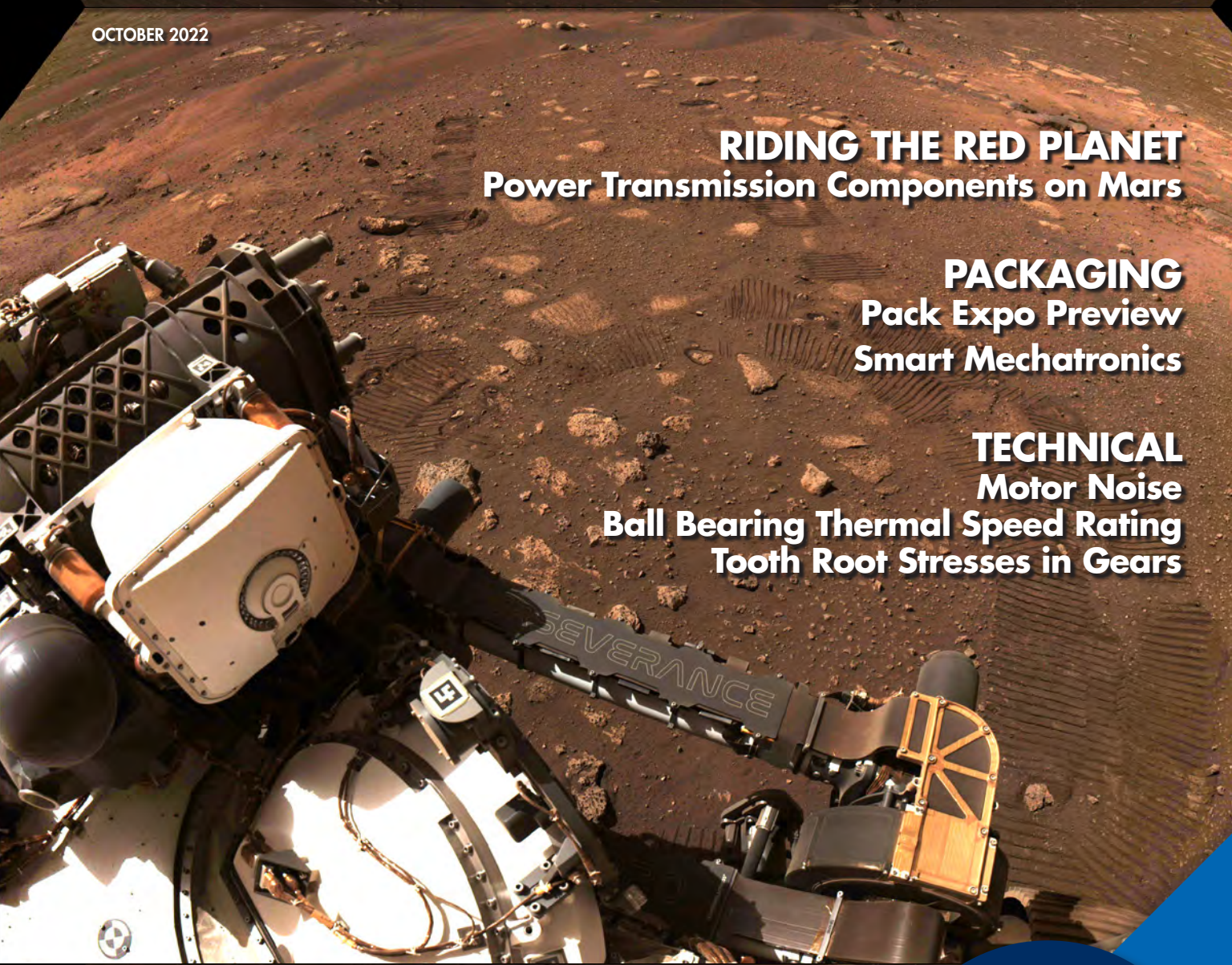
Power Transmission Engineering®

OCTOBER 2022



RIDING THE RED PLANET
Power Transmission Components on Mars

PACKAGING
Pack Expo Preview
Smart Mechatronics

TECHNICAL
Motor Noise
Ball Bearing Thermal Speed Rating
Tooth Root Stresses in Gears

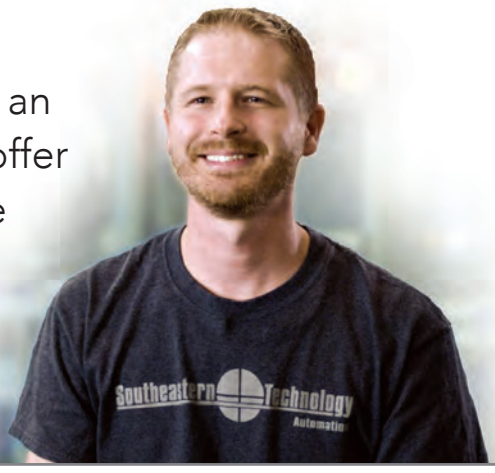
Power Transmission Engineering is POWERED by **The American Gear Manufacturers Association**

www.powertransmission.com

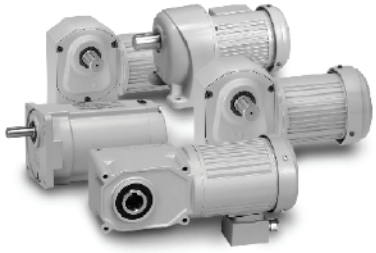
The best protection you may never need

"Brother Gearmotor makes such an outstanding product that they offer a 5-year limited warranty...we've never had to use the warranty.

RYAN MILLER,
Owner and Engineer Manager
Southeastern Technology Automation



Brother leads the way, by shielding its entire line of standard gearmotors with the industry's best warranty. No matter how far the journey or how rough the path, rest assured you've got the protection you need right "at your side."



Call us today for a sample gearmotor to try out.

brother
at your side

866.523.6283
BrotherGearmotors.com

Power Transmission Engineering

OCTOBER 2022

A Publication of
The American Gear Manufacturers Association

[22]

[42]

FEATURE ARTICLES

TECHNICAL ARTICLES

Stay Connected

Follow us on Twitter
twitter.com/PowerTransMag

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

Subscribe Online
www.powertransmission.com/subscriptions

Vol.16, No. 7. POWER TRANSMISSION ENGINEERING (ISSN 2331-2483) is published monthly except in January, May, July and November by The American Gear Manufacturers Association, 1840 Jarvis Ave., Elk Grove Village, IL 60007, (847) 437-6604. Cover price $7.00. U.S. Periodicals Postage Paid at Elk Grove Village IL and at additional mailing offices. Send address changes to POWER TRANSMISSION ENGINEERING, 1840 Jarvis Ave., Elk Grove Village, IL 60007.

Power Transmission Engineering VOL. 16, NO. 7

DODGE

Launch

Take your training to the next level.

Introducing **Launch**, the new interactive eLearning platform designed to streamline training on all things Dodge®. The one-stop-shop resource offers your entire team the flexibility for self-paced learning from anywhere, anytime.

Features include:

- Free registration
- Knowledge retention checks
- Remote accessibility
- Guided learning
- Live classes

Visit dodgelaunch.com

Scan to kick-start your learning journey!

Power Transmission Engineering

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

PTE Revolutions

Freudenberg Aids High Flying Wind Farm

Wind turbines are being installed on the high seas with nacelle heights of more than 100 meters and rotor diameters of nearly 170 meters. This increases both the electricity yield and economic efficiency. Freudenberg is aiding wind power's conquest with high performance components and materials.

powertransmission.com/blogs/1-revolutions/post/8798-freudenberg-aids-high-flying-wind-farm

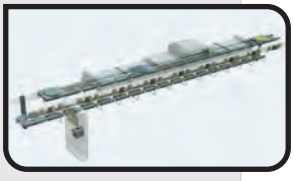
SKF Has Professional Skater Covered

According to his Dew Tour online profile, Oskar Rozenberg, or Oski as he prefers, comes to the skateboard world by way of Sweden where the first thing people typically think of when you say "skate" is ice.

powertransmission.com/blogs/1-revolutions/post/8788-skf-has-professional-skater-covered

PTE Videos

Flexible Transport System for Packaging Manufacturing



The flexible transport system (FTS) from Bosch Rexroth is a unique technical solution for transporting and positioning materials and workpieces in a variety of applications.

powertransmission.com/media/videos

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
Graphic Designer
Jess Oglesby
oglesby@agma.org

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

Materials Coordinator
Dorothy Fiandaca
fiandaca@agma.org

CIRCULATION
Circulation Manager
Carol Tratar
tratar@agma.org

ACCOUNTING
Accounting Manager
Luann Harrold
harrold@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 *michael@geartechnology.com*.

Cover image courtesy of NASA/JPL.

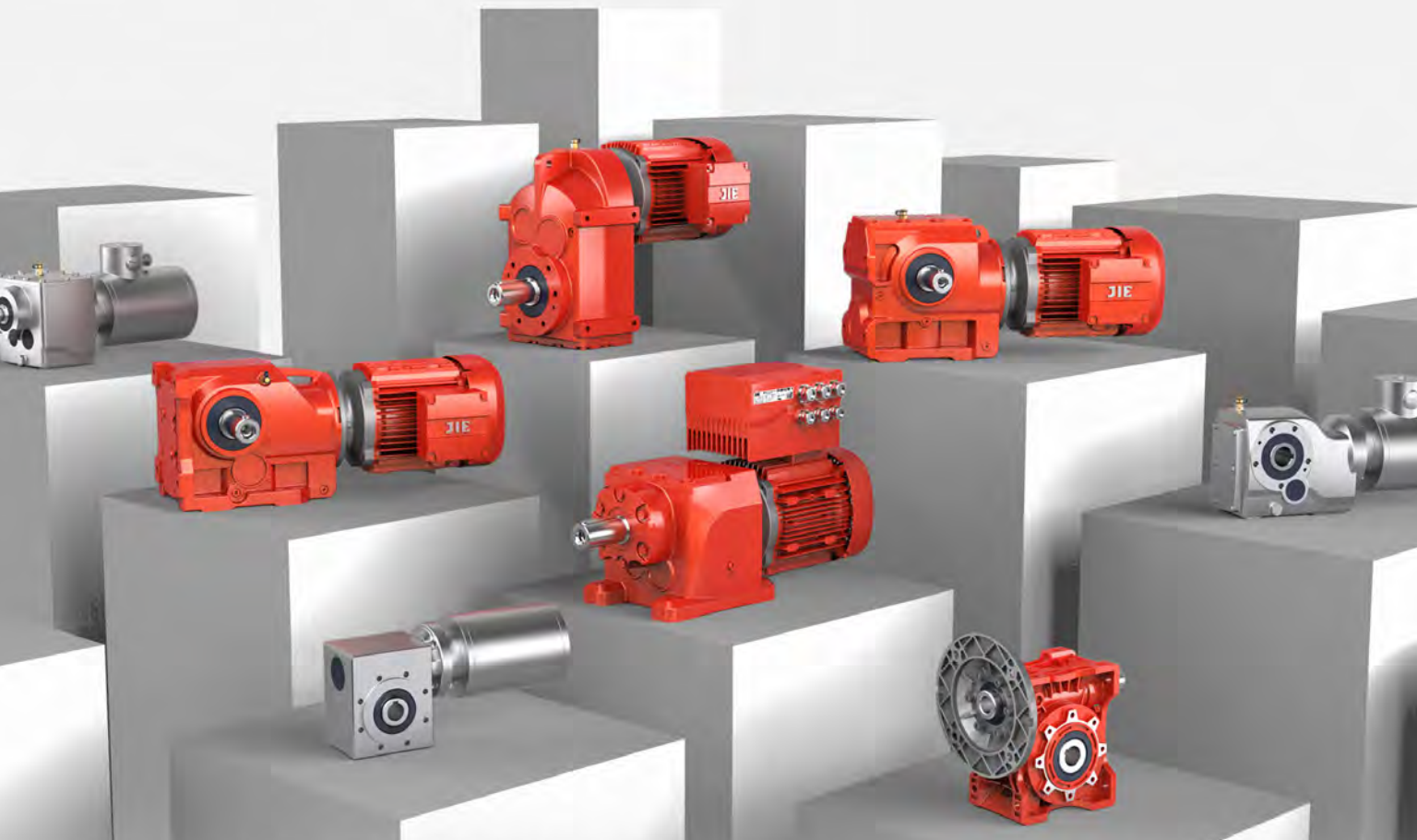
www.powertransmission.com

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 INC.

493 Mission St. Carol Stream, IL 60188
www.jie-drives.com | Info@jie-drives.com | +1 630 580 9986

Randy Stott
Publisher & Editor-in-Chief

We've Got You Covered

Our goal with *Power Transmission Engineering* is to provide you with the most complete coverage of mechanical power transmission and motion control systems available anywhere. We home in on the details of the components that make things move to give you the best possible resource, whether you are a designer, buyer or end user of machinery for virtually any industry that uses power transmission components.

I'm pleased to say this issue has a little bit of something for everyone.

Starting with our focus on aerospace, we've taken a look at several key suppliers who provided the moving components for the Mars Perseverance Rover. Read Senior Editor Matt Jaster's article on page 32 to learn more about how Forest City Gear, maxon and Cobham Advanced Electronic Solutions all contributed motion components to this complex project where failure was not an option.

With Pack Expo right around the corner (October 23-26 in Chicago), we also have a focus this issue on packaging equipment. Bosch Rexroth has provided an excellent look at how smart mechatronic systems are helping provide plug-and-play systems for packaging machinery developers (p. 22). Also, we invite you to take a look at Senior Editor Aaron Fagan's Pack Expo preview (p. 26), highlighting many of the power transmission component suppliers who will be exhibiting at this year's show.

We also have some really solid technical content this issue, starting with "Noises in the Night," by our regular contributor and motion control expert, Don Labriola. In his article, Don details the causes of electric motor noise and what can be done to reduce it (p. 38).

We're pleased to welcome back Norm Parker, who has been contributing to the "Bearings Blog with Norm" feature on our website since 2014. In his current article, Parker takes an in-depth look at bearing thermal speed rating and deciphering the differences between the standards and manufacturer catalog definitions (p. 42).

Lastly, we've got a serious research study from WZL-RWTH Aachen on the calculation of dynamic tooth root stresses in gears (p. 46).

Of course, that's not all. As always, we round out our coverage in our news sections by providing information on the latest technology from leading suppliers of power transmission components so that you can make informed decisions when it comes to buying or specifying the right gearboxes, couplings, motors and more.

Last issue, I implored you to consider writing for us. We're working hard to continue developing our roster of experts, and those efforts are definitely beginning to pay off. But I'd like to reiterate that suggestion by pointing you toward our 2023 Editorial Calendar and Contributor's Guidelines, which you can find online at *powertransmission.com/adinfo*. We welcome your contributions. Maybe next issue, you'll be one of the experts I'm talking about here.

P.S. If you found this issue's content to be interesting, helpful and important to you, I urge you to renew your subscription by visiting ***powertransmission.com/subscribe2022.***

PRECISE. ROBUST. AVAILABLE.

Keyless Shaft Bushings

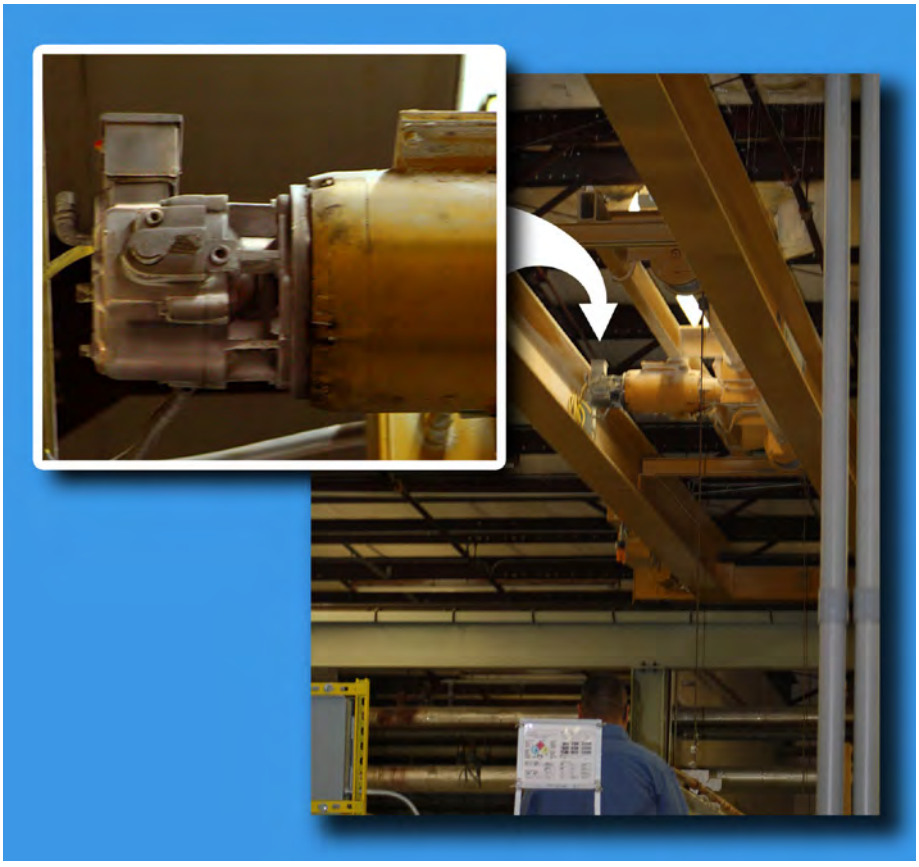
- Precise & Reliable Shaft Component Mounting
- Single-Screw Models for Fast & Frequent Use
- Steel, Nickel-Plated, and Stainless-Steel
- Variety of Mounting Styles Available
- English & Metric Sizes in Stock
- Engineering Assistance / ~~Fast~~ ***Fast*** Delivery

www.zero-max.com 800.533.1731

ZERO-MAX®

Force Control

CRANE BRAKES ELIMINATE DOWNTIME



Force Control Industries presents a maintenance-free, no-adjustment crane brake that virtually eliminates crane downtime as well as the need to perform maintenance and adjustment at height. The MagnaShear motor brake employs oil shear technology, providing longer service life in demanding applications like the frequent start/stop cycles seen on cranes, hoists, and winches. Proven oil shear technology transmits torque between lubricated surfaces—thereby eliminating wear on friction surfaces. A patented fluid recirculation system dissipates heat—eliminating heat build-up which is the most common problem in dry braking systems. Elimination of the wear significantly increases service life and virtually eliminates adjustment which also elongates maintenance intervals. MagnaShear Oil Shear Crane Brakes are proven in demanding applications like anodizing plants, foundries, critical-line manufacturing plants, and more.

The oil shear technology also provides a smooth "cushioned" stop which reduces shock to the drive system, further extending service life of downstream components.

The totally enclosed MagnaShear brakes are impervious to moisture, dirt and dust that is common in concrete block plants as well as asphalt shingle manufacturing, coal, bulk materials handling, forest products manufacturing, and more.

How Oil Shear Works

Unlike dry brakes, oil shear technology includes a layer of automatic transmission fluid between the brake disc and the drive plate. As the fluid is compressed, the fluid molecules shear—thus imparting torque to the other side. This torque transmission causes the rotating discs to decelerate against the stationary plates bringing them down to stop. Since most of the work is done by the fluid particles in shear, wear is virtually eliminated. Elimination of wear also eliminates the need for adjustments which are common for dry braking systems.

In addition to transmitting torque, a patented fluid recirculation system helps to dissipate heat which is the major problem with traditional dry brakes. Along with heat removal and torque transmission, the fluid serves to continually lubricate all components of the oil shear brake, elongating their service life. MagnaShear brakes with oil shear technology provide significantly longer service life, characterized by virtually maintenance-free operations.

Suitable for a Wide Range of Motor Sizes

These proven motor brakes are available to accommodate a wide range of applications. Spring set torque ratings from three to 1,250 foot-pounds are available. MagnaShear motor brakes are available in multiple torques for the same motor frame.

MagnaShear motor brakes feature "quick mount" features for quick and easy mounting to drive motors in NEMA frame sizes 56 to 449. They are shipped ready to install, with no assembly or adjustments required. They are also available pre-mounted on a motor for severe duty applications. MagnaShear motor brakes can be furnished to fit a NEMA or IEC frame motor, as a complete motor and brake assembly, or to mount on a machine frame or other special mounting configuration.

These proven motor brakes are totally enclosed from outside contaminants, with seal integrity for harsh and washdown environments. A modular design/assembly allows for ease of servicing and maintenance.

forcecontrol.com

PBC Linear

EXPANDS MINIATURE METRIC BALL SCREW ASSEMBLIES

PBC Linear has expanded its comprehensive portfolio to include Miniature Metric Ball Screw Assemblies. Building on their lead screw technology, this combination of precision-rolled screw and compact nut is driving

Not Making the Cut?

We're Here to Help.

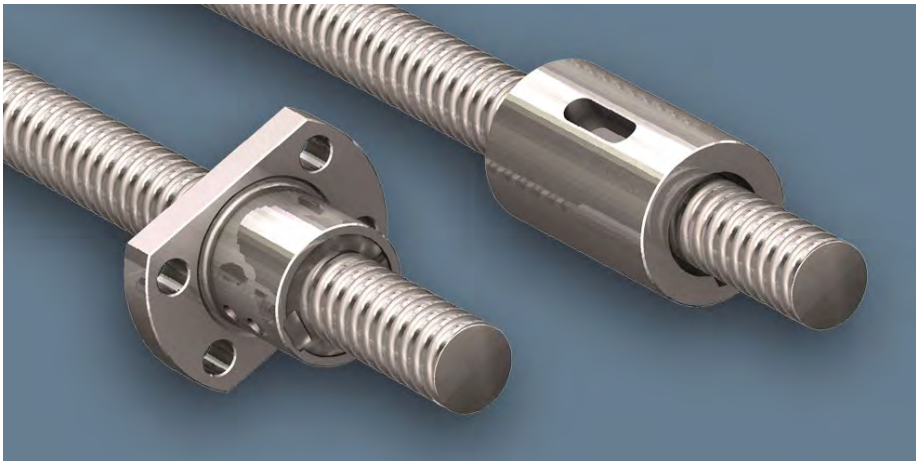
Quick-turn, High-precision, World-class, Cut Teeth Only Gears

FOREST CITY GEAR™

AGMA | WBENC | ISO 9001 | AS9100 | ISO 13485 | ITAR Certified

Spur • Helical • Spline • Worm • Worm Gear • Sprockets
Ratchets • Threads • Ball Screw • Keyways • Face Gears

forestcitygear.com 815.623.2168



exceptional performance from an economical package. Manufacturers of sophisticated laboratory equipment, medical devices, semiconductors, and other automation applications will find these high-precision ball screws a valued solution to their small-scale linear motion needs.

In addition, PBC Linear offers shorter lead times, which is accomplished through their ball screw production process and central Midwestern location, where many of their products are engineered and produced.

As with lead screws, ball screw assemblies are used to convert rotational motion to linear motion. They typically include a ball nut, threaded shaft, and a recirculating system that utilizes a continuous movement of balls to transfer forces and propel the nut along the screw. Each ball screw and nut are engineered with gothic arch threads that define the track of the nut and screw thread, offering high rigidity, durability, and duty cycles. The main benefit of ball screws is higher efficiency and accuracy, making them ideal for a variety of industrial and automotive applications.

PBC Linear currently offers miniature ball screws in diameter sizes of 6 mm, 8 mm, and 10 mm, with options for lead length and nut type. In addition, standard and special machined journals can be provided for unique customer requirements. Other options include fixed or floating end blocks.

The other half of the ball screw assembly consists of the nut. Miniature metric ball screw nuts from PBC Linear feature two types of ball return systems to accommodate shorter or longer leads. Short leads are synonymous with internal multiliner returns, and long leads are represented in the company's endcap return system. Each are available in flanged or cylindrical configurations, with optional end support blocks and bearings. Flange style nuts can often be easier to remove and install in an assembly, provided the assembly can be designed so that the mounting screws or bolts can be easily accessed. Cylindrical nuts allow for a more compact assembly design as there is no flange.

Dynamic load ratings are an important factor when determining the correct miniature ball screw for an application. PBC Linear will provide conservative dynamic load rating values within this product family, based on 1,000,000 Rev (N). This ensures trusted, reliable performance for those looking to implement miniature ball screws into their systems. Ball screws from PBC Linear come standard without preload (backlash clearance held to 0.05 mm). They offer a preload option that offers higher rigidity and better positional accuracy, but at the expense of slightly diminished load capacity. This P-type preload uses oversized balls to preload the assembly up to three percent of dynamic capacity.

PBC Linear ball screw assemblies meet the standard ISO accuracy for grades 10 and 7. In addition, customers can contact an application engineer regarding Class 5 accuracy. To meet industry requirements, PBC Linear utilizes high-end testing equipment such as Keyence optical comparators, Mitutoyo thread form tracers, and custom dynamic lead

Industrial powertrains that drive endless potential

The new Regal Rexnord introduces engineered-to-order industrial powertrains, delivering power for the most demanding of applications

It took the combined strengths of our new company to develop complete industrial powertrain solutions, custom designed and built for applications across the full spectrum of horsepower and torque. From start to finish, Regal Rexnord™ electromechanical industrial powertrains are designed, configured, integrated and optimized for your unique applications, opening the door to new ideas and unlimited possibilities.
Read about Regal Rexnord and our prominent brands:

regalrexnord.com/powertrain

Rexnord® | Sealmaster® | Stearns® | Kop-Flex® | Link-Belt®

Falk® | Marathon® | Perceptiv™ | Browning® | Tollok®

Regal Rexnord™

Creating A Better Tomorrow

checkers that analyze up to 15,000 points per meter.

PBC Linear uses a high-precision CNC roll threading process for the most consistent thread forms and high accuracy rate. They also measure and record 100 percent positional accuracy along the entire travel length of the screw.

pbclinear.com

Mitsubishi Electric Automation

RELEASES SERVO AND MOTION SOLUTIONS

Mitsubishi Electric Automation, Inc. has introduced Economy Solutions, packaged servo and motion bundles that allow for high precision motion control in a way that is quick and affordable to integrate.

Three different bundles are currently available—compact motion, basic motion, and pulse motion. Compact motion delivers premium performance and is available in up to 7.0 kWs. It offers up to eight axes of synchronized motion per module and operates on the new CC-Link IE Time-Sensitive Network (TSN) allowing for improved communications speed.

Basic motion is the most affordable option and uses the integrated networking of the iQ-F compact PLC to control servo amplifiers and motors at a very low cost. It operates over the CC-Link IE Field Basic network and allows the integration of other IE Field Basic compatible devices. It is best suited for small systems and supports up to 16 stations.

Pulse motion allows for easy integration with third party PLCs. It operates over pulse train communication, which makes it able to communicate with almost any PLC. Also suited for smaller systems, it does not require a motion module.

"This is our first step towards building our portfolio of solutions to improve the customer experience," said Curtis Sylliaasen, associate product manager at Mitsubishi Electric Automation. "By offering preconfigured options, we will be able to target specific customer pain points with solutions that can be customized to each individual project."

us.mitsubishielectric.com/fa/en

REGENT

ADOPTS SIEMENS DIGITAL PORTFOLIO FOR SEAGLIDER

Siemens Digital Industries Software recently announced that REGENT has adopted the Siemens *Xcelerator* portfolio of cloud-based software and services to help pioneer a new category of vehicle called the seaglider. The seaglider is a high-speed zero emission vehicle that operates exclusively over the water to drastically reduce the time and cost of moving people and goods between coastal cities.

With 40 percent of the world's population living in coastal communities, REGENT's electric seagliders will be the first vehicles to offer safe, low-cost, high-speed, zero-emission vehicles for this segment. As a manufacturer or OEM, REGENT's launch customers span aviation, ferry, and logistics transportation operators.

ISO 9001 + AS9100
CERTIFIED

SDP/SI offers the industry's most comprehensive selection of precision gears, timing belt & pulley drives, mechanical components, motors, gearheads, and motion control products.

Facing a design challenge? SDP/SI engineers provide problem solving, customized solutions. With over 70 years of engineering development and precision manufacturing experience, SDP/SI is a proven partner to the most recognized names in medical, aerospace, defense, and robotics industries.

From prototype to high-volume production, SDP/SI high-quality components and subassemblies provide the reliable performance your application requires. Our products are found worldwide in surgical gear drivers, pharmaceutical processing & packaging, robotic surgery, patient positioning, drug delivery, pumps, and aerospace & defense applications including actuation/positioning systems, instrumentation, door releases, stabilization systems, camera positioning, weapons targeting, and cargo movers.

- **88,000 Stock Components**
- **Custom Gears and Gearboxes**
- **Custom Timing Belt & Pulley Drive Systems**
- **Couplings**
- **Bearings & Linear Motion Products**
- **Brushless DC Motors**
- **Integrated Motor Drive Controllers**
- **Frameless Motors**
- **Miniature Gearheads**
- **Planetary Gearheads**

Call Us at 516-328-3300 or Shop SDP/SI at www.sdp-si.com
We have the expertise, state-of-the-art CNC machinery and world-class manufacturing facility you need.

SDP/SI
STOCK DRIVE PRODUCTS/STERLING INSTRUMENT

The REGENT seaglider operates exclusively over the water as an all-electric wing-in-ground-effect (WIG) vehicle. It travels the sea in one of three modes—floating on its hull near the dock, foiling on its hydrofoils at up to 40 knots (kts) as it comes in and out of port, or flying above the waves at 160 kts while cruising to its destination.

When in flight, it operates a few meters off the surface of the water, relying on the ground effect phenomenon, flying on a cushion of air. It combines the high speed and comfort of an airplane with the low operating cost of an electric vehicle. Seagliders differ from past WIGs due to their hydrofoils, distributed electric propulsion, and aerospace fly-by-wire controls. These elements enable safe harbor operations, increased wave tolerance, and a comfortable passenger experience.

At the heart of its design, engineering and development toolset is the Siemens *Xcelerator* portfolio, which has been fundamental to REGENT since its founding in 2020.

"At REGENT we are focused on bringing a revolutionary new vehicle to the transportation market with the potential to change how both people and freight move over the water," said Mike Klinker, CTO and cofounder of REGENT. "As our seagliders approach certification and full-scale commercial production, we need a robust, modern digital tools platform that supports the pace of our innovation cycles with the rigor to encompass a product as complex as ours. Siemens *Xcelerator as a Service* was a perfect fit for a digital-first startup like ours. Cloud native solutions, such as

Teamcenter X, minimize administrative overhead and allow us to focus 100 percent on design, engineering, manufacturing, and innovation. Siemens' valued collaboration and the subscription model provide significant cash flow benefits that are vital to any startup."

REGENT's flagship seaglider, the 12-passenger Viceroy, will be built to the highest safety standards. It will be able to service routes up to 180 miles with existing battery technology and routes up to 500 miles with next-generation batteries, all via existing dock infrastructure. Additionally, its operation as a wing-in-ground effect vehicle above the water enables maritime testing and certification. This is an efficient pathway to entry-into-service, allowing customers to experience high-speed, zero-emission coastal mobility sooner than electric aviation options, while maintaining similar levels of safety.

"The revolution of both mobility and electrification is continuing at an exciting pace across the entire spectrum of the industry, but it's not often that the two combine with such spectacularly innovative product design to address a specific challenge like the one faced by coastal communities across the globe," said Dale Tutt, vice president of industry strategy, Siemens Digital Industries Software. "REGENT is pioneering innovative high-speed coastal transportation while targeting net zero from the very beginning. Our *Xcelerator* as a Service portfolio is instrumental in helping them get there faster."

sw.siemens.com

KISSsoft and Timken

COLLABORATE ON BEARING CALCULATION AND DESIGN

KISSsoft and Timken have teamed up to add more value and insight for design engineers.

Bearing calculations from Timken can now be easily generated in KISSsoft for the software's registered users. Although the data is not visible in KISSsoft, it can be used in the background for calculation and design purposes.

In the *KISSsoft Release 2022*, Timken is now providing internal macrogeometry for more than 7,000 Timken tapered, spherical, cylindrical roller and deep groove ball bearings. This allows KISSsoft users to perform more accurate ISO TS 16281 life calculations, giving them more confidence when designing and specifying bearings for their equipment. The inner geometry data for the rolling bearings in use is retrieved via Timken's cloud service solution.

kisssoft.com

SKF
INTRODUCES HYBRID DEEP GROOVE BALL BEARING

SKF has developed a new hybrid deep groove ball bearing for high-speed applications. The new bearing is aimed at applications such as rail industry traction motors, as well as electric machines and drives. SKF already has three pilot customers, all of them OEMs.

A new lightweight cage helps to boost the limiting speed by at least 60 percent compared to traditional designs. Additionally, the polymeric cage helps to reduce friction, leading to quieter operation and allowing higher power density in the application.

"Our new cage design helps our customers to get more power from electric motors, which enables down-sizing," says Andreas Pichler, business and project engineer at SKF.

By improving the efficiency of electric machines and drives, the new bearing can cut energy consumption, increase reliability, and reduce the total cost of ownership.

Its two-piece cage is made from PEEK and PA66, making it 80 percent lighter than a brass cage. As well as running more quietly, the bearing operates at a lower temperature, which prolongs grease life and extends relubrication intervals. This can give engineers more flexibility in their design choices.

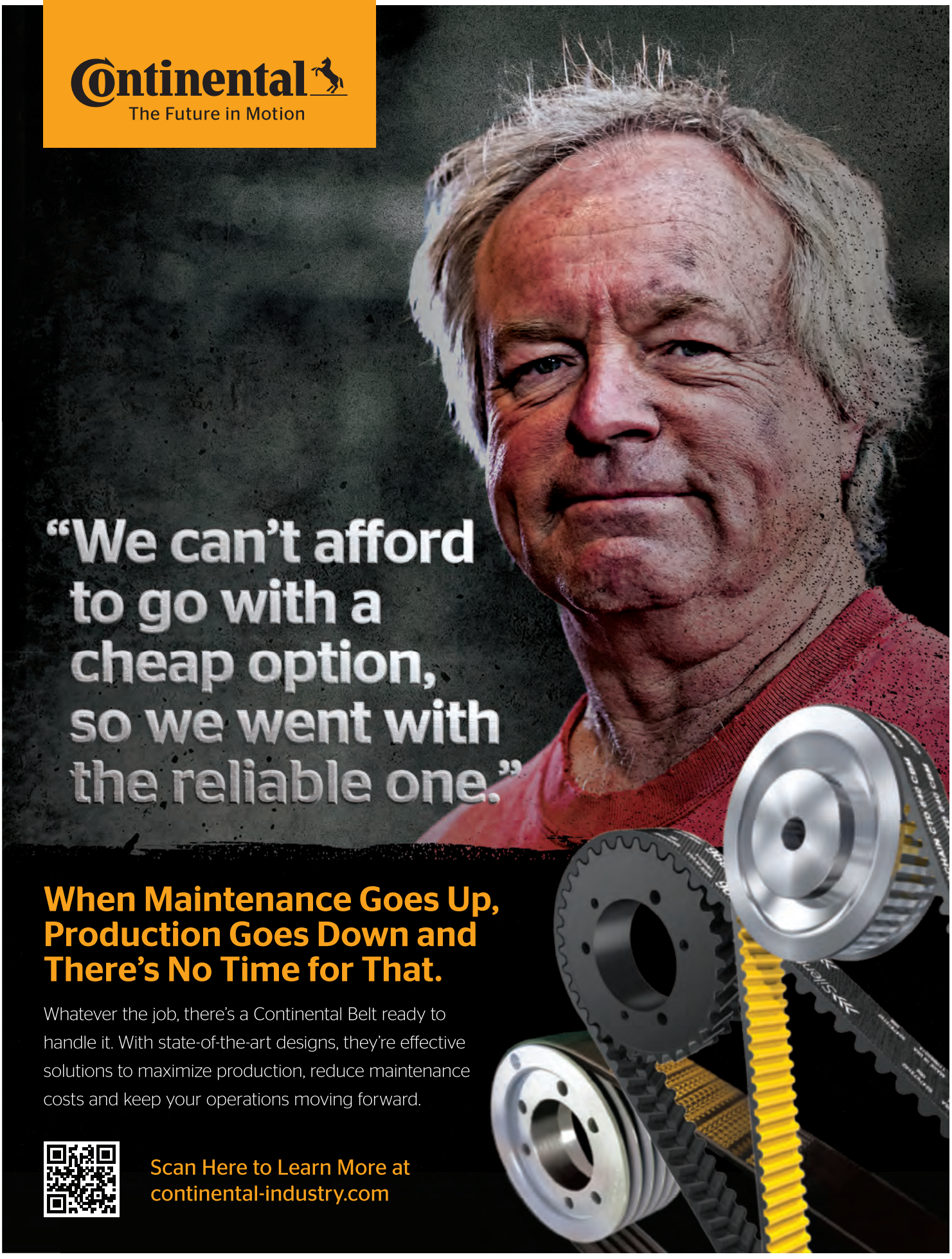
In addition, its limiting speed is twice that of a single-piece polyamide cage, and 60 percent higher than a brass one.

Rigidly connected cage bars ensure robustness, which helps to lengthen service life in harsh conditions. The optimized geometry also eliminates radial deformation from high centrifugal forces, the 'umbrella effect', that typically occurs on snap-type cages running at high speed.

The new bearing is targeted at OEMs in rail, off-highway vehicles, e-mobility, and industrial/electrical applications.

skf.com

Continental
The Future in Motion



When Maintenance Goes Up, Production Goes Down and There's No Time for That.

Whatever the job, there's a Continental Belt ready to handle it. With state-of-the-art designs, they're effective solutions to maximize production, reduce maintenance costs and keep your operations moving forward.

Scan Here to Learn More at
continental-industry.com

Curtiss-Wright

EXTENDS HYBRID AND PURE ELECTRIC VEHICLE RANGE WITH TRACTION INVERTER PORTFOLIO

Curtiss-Wright's Industrial Division recently confirmed its continued commitment to its long-term strategy of advancing the electrification market with the extension of its traction inverter product portfolio. These latest CWTIs offer the most highly efficient and innovative design for use in hybrid and pure-electric applications for on-highway and off-highway commercial vehicles.

"Having successfully logged over two billion on-road kilometers since launching the first production units, these second generation CWTI models have been engineered to be the very best performing and most efficient IGBT inverters on the market today, using state-of-the-art technology to design and ensure end users receive peak performance from a CW engineered solution," said Jason Watkins, general manager, Curtiss-Wright Industrial Division.

The advanced motor control software within a CWTI ensures adaptive tuning works to create the highest efficiency between the inverter and motor, delivering a system that is both powerful and superior in performance. Results from extensive testing on some of the world's most powerful and efficient electric motors have demonstrated improvements of up to 38 percent on peak torque and power. Furthermore, using the CWTI can improve the efficiency of the drive system (motor plus inverter) by two percent resulting in an increase of up to 14 percent in vehicle range from a single battery charge.

The latest CWTI models launch as 420 kW vehicle-grade traction inverters for single (CWTI-S420) or dual (CWTI-D420) motor applications. To provide ultimate flexibility, the enhanced functionality of both models operates with multiple motor technologies, including AC induction, permanent-magnet synchronous (PMS) and interior permanent-magnet (IPM) types, to ensure improved range, longer battery life and lower running costs.

CWTIs offer full fault protection and a high level of self-protection with both current and temperature measured directly on the IGBTs. These accurate temperature measurements deliver higher power from the motor, while current measurements offer superior short circuit protection to the system.

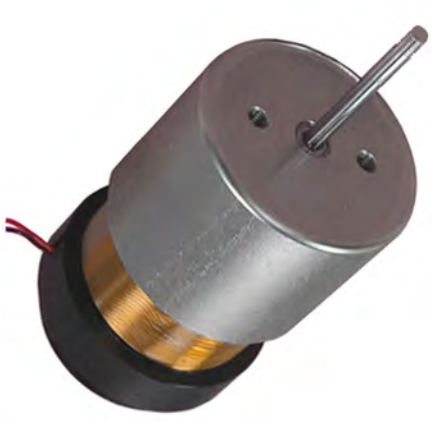
curtisswright.com

Moticont

RELEASES LATEST MINIATURE VOICE COIL SERVOMOTOR

Moticont has released the miniature GVCM-016-019-01M Linear Voice Coil Servo Motor. Smaller in diameter than a U.S. Dime this 15.9 mm (0.625 in.) diameter servomotor, also called an electric cylinder, features a high force-to-size ratio of 1.5 N (5.3 oz) continuous force and 4.6 N (16.6 oz) of peak force. The compact housing is just 19.1 mm (0.63 in.) long and in the fully extended position the shaft extends 20.0 mm (0.79 in.) beyond the face of the housing. The end of the shaft has an M2.2X0.45 thread by 4.0 mm long for backlash free connections.

Non-commutated, these brushless miniature linear servomotors are clean, quiet, and feature high acceleration/deceleration, high speed, high reliability, cog free linear motion and improved reliability. The ideal choice for: heptic feedback and pipetting in medical devices, laser, machining and drilling, work holding and clamping, scanners and laser beam steering and filtering, optical focusing, dynamic vibration absorption, testing, sorting, and assembly. Additionally, they should be considered as low-cost replacements for pneumatic linear actuators.



The housing and coil end of the GVCM-016-019-01M has two M2.2X0.45 threaded mounting holes on 6.4 mm centers for easy integration into new and existing applications.

moticont.com

NORD

RELEASES LATEST INDUSTRIAL GEAR UNITS

NORD DRIVESYSTEMS has announced the latest addition to their industrial

YOUR SIDEKICK FOR ROLLER CHAIN SOLUTIONS THAT OPTIMIZE OPERATIONS.

No matter how tough the challenge, our complete range of innovative roller chain products can help you keep your business running smoothly. That's what you can expect from your trusted, reliable sidekick.

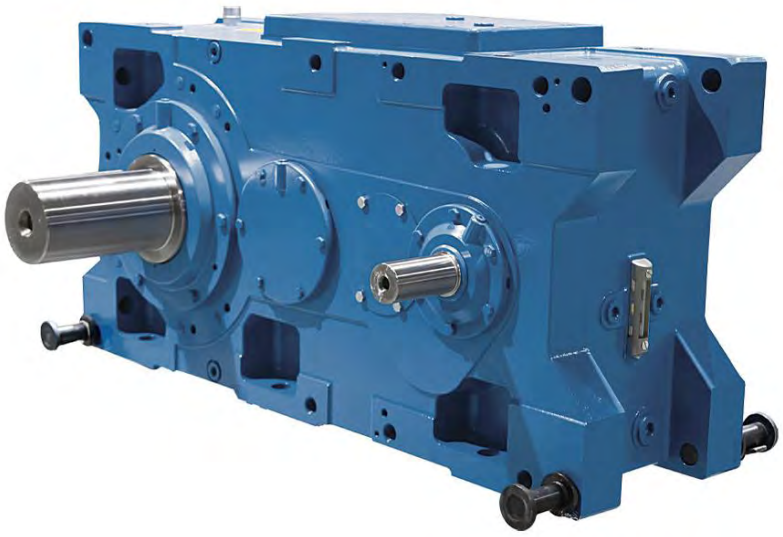
A PERFECT USE FOR THE NEW...

SUPER STAINLESS™ CHAIN

- *Stainless steel chain with carbon steel strength*
- *Up to 6x stronger than ordinary stainless chains*

Want us to optimize your operations?
That's what we do. *Call us today to schedule an on-site visit 800-323-7790*

TSUBAKI®
LEADING THE MOVEMENT



gear unit family, MAXXDRIVE XD. These new, parallel shaft industrial gear units have extended center distances engineered specifically for reliable operation of cranes and hoists. Compared to NORD's MAXXDRIVE G1050 industrial gear units, the center distance of the XD has been increased by 35 percent to allow maximum space for the U-shape arrangement of the motor and rope drum on the same side of the gearbox. The new series also features five case sizes, three-stage and four-stage reductions, and torque output up to 991,300 lb-in.

MAXXDRIVE XD industrial gear units utilize NORD's proven and trusted UNICASE housings to deliver long service life and low maintenance, as well as reduced standstill times for increased efficiency and availability of the entire system. The single-piece housing ensures precise positioning of bearing and shafts, protects internal components, and is FEA-optimized for overhang load—especially with downwards forces. An inspection cover is also included on top of the gear unit for easy maintenance and service access. Three-stage and four-stage reductions share the same overall unit dimensions and center distances for a standardized design that reduces system variants and lowers Total Cost of Ownership (TCO). The new MAXXDRIVE XD gear units also deliver stable nominal torque ratings throughout the total ratio range, reducing drive weight up to 60 percent. This decreases the number of moving parts for lower energy consumption and requires fewer inventoried wear parts.

A variety of add-on options are available with the MAXXDRIVE XD series, including foot or shaft mounting with additional torque support, NEMA/IEC motor adapters, and various input/output coupling options. They can also be equipped with thruster brakes, brake consoles, or an input flange for flange-mounted brakes. Solid input shafts with keyways can be single or double extended and output shafts include solid or hollow options with multiple shaft configurations for each. Additional options can also be included from NORD's standardized modular system such as oil heaters, PT100, taconite seals, monitoring devices, and sensors.

Crane applications require robust, reliable gear units that won't break down. MAXXDRIVE XD industrial gear units are engineered to function in a wide range of ambient conditions including dusty atmospheres and environments with high humidity, heat, and large temperature differences. Heavy duty paint can also be applied to the drives for additional protection and extended surface life. When paired with NORD's high-efficiency electric motors and intelligent variable frequency drives, MAXXDRIVE XD gear units form a specialized solution capable of high precision, smooth operation, and dynamic control.

nord.com

SKF

MAINTAINS FARM EQUIPMENT WITH AUTOMATIC LUBRICATION SYSTEM

A new automatic lubrication system from SKF Lincoln helps maintain the performance of farm equipment by increasing chain reliability.

The OCL-M system, which was developed specifically for equipment such as balers and combines, dispenses precise amounts of lubricant to the moving chain. This reduces wear on the chain – giving it a service life up to five times longer than one that is manually lubricated.

"Farmers don't want distractions – they just need their baling machines to last the duration of the harvest," said Daniel Gonzales, SKF's global lubrication manager agriculture. "By reducing chain wear, the OCL-M automatic lubrication system lessens the chance of downtime."

As well as improving safety, by avoiding manual lubrication, OCL-M includes brushes that clean the chain during operation. This further improves equipment reliability by resisting the effects of large amounts of dust and hay. Accurate dispensing controls costs in several ways: it reduces lubricant use; it requires no manual application; and it reduces maintenance by improving chain reliability.

OCL-M is available as pre-configured kits, which vary in size depending on the number and type of chains that need to be lubricated. It

is mechanically driven, requiring no hydraulic or electrical fittings and is therefore easy to install.

The system is mounted directly onto a machine's shaft. A variety of pump elements and outlets allows a wide range of lubricant dosage. Dosage is easily adjusted by moving an adjustment disk. This helps the system to cope with varying demands, such as larger machinery or more extreme conditions.

While the farmer is the ultimate beneficiary of the system, it can be installed earlier in the process, for example by the OEM. Here, it will give the OEM a competitive advantage, backed by SKF's engineering network. In addition, it allows dealers to offer a simple, saleable product with no aftermarket issues.

skf.com

Plug-and-Produce

The faster, smarter way to put mechatronics solutions to work in packaging automation

Richard Vaughn, Automation Engineering Manager, Bosch Rexroth

For Related Articles Search
packaging
at www.powertransmission.com

A new approach to creating mechatronics solutions, called "smart mechatronics" is widely available and leverages an array of online design tools and advances in mechatronics controllers and software.

One of the most constant and consistent challenges consumer packaging companies face is to find new manufacturing technologies that can help them be responsive and ready to face rapidly shifting consumer trends and preferences. They need technology that can help them improve productivity, achieve faster changeovers and more sustainable production—while keeping their production line footprints lean and flexible.

This isn't all they're looking for: consumer packaging companies also want manufacturing systems with interfaces, integrated sensors and software features that make it easier to leverage the intelligence, connectivity, and productivity enhancements that Industry 4.0 technologies and automation solutions promise to deliver.

As a result, many packaging automation OEMs are incorporating smart, connected components and subsystems into their next-generation machines. Built upon an array of online design tools and advances in mechatronic control, hardware and software, a new technology concept called "smart mechatronics" is becoming more widely available. Smart mechatronics focuses on intelligent ready-to-use systems that are more sophisticated, yet easier to specify, order and deploy.

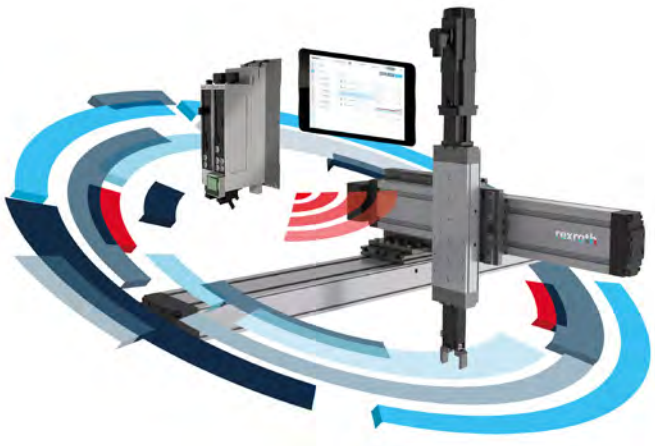
This new approach in automation can be used to improve packaging machine applications such as package sealing, embossing and package forming. It also has the potential to improve the development and performance of Cartesian robot handling and pick-and-place systems, which are critical elements in many automated packaging operations.

Mechatronics Packages Multiple Technologies into Single Solutions

Mechatronic systems are already an essential part of this manufacturing landscape—extending and expanding the value of linear motion and automation technology. This integration of linear components, electronic controls, software, electric motors, and sensors provides a versatile toolbox for machine builders to engineer and commission complete manufacturing systems for demanding applications.

Mechatronic technology suppliers like Bosch Rexroth are leveraging the advantages of intuitive interactive design tools and improvements in digital controller technologies to give packaging OEMs and end users the capabilities that let them "plug-and-produce, perform and proceed."

This outcome is driven, in part, by packagers who, more and more, seek production machinery that offers both



As part of its new Smart MechatroniX family of mechatronics solutions, Bosch Rexroth recently launched the compact, plug-and-produce Smart Function Kit for Pressing.

versatility and simplicity. The goal is to achieve quicker time to market by simplifying the engineering task for systems that can quickly shift to make different variants or add new functionality on the same production line.

To satisfy this demand, packaging machinery OEM engineers want to streamline how they specify, purchase and commission mechatronic components, using online tools that deliver complete, intelligent systems ready to operate "out of the box" with minimal or zero machine programming.

At the same time, next-level mechatronics must support transparent production processes, with features that automatically capture process data and enable real-time condition monitoring and predictive maintenance.

Smart mechatronics technology is now available to satisfy many of these requirements. Used widely in other applications ranging from product assembly and metal forming to single- and multi-axis robots for material handling, these systems are also particularly well-suited for packaging end-of-line functions.

New Smart Mechatronics Solve Pressing and Sealing Challenges

This coming-of-age for smart mechatronics is opening more possibilities for customization in packaging equipment. For example, Bosch Rexroth recently developed a compact, plug-and-produce smart "function kit" for pressing. Suitable for many different industries, it can be easily implemented for use in packaging applications such as bag sealing in form, fill and seal (FF&S) production lines.

This type of smart mechatronics system can greatly reduce the time, cost, and complexity of implementing new or custom FF&S capabilities. The kit is offered as a complete mechatronic system, from one supplier, that seamlessly integrates an electromechanical cylinder (EMC), electric servomotor and drive, motion controller and industrial PC, power and communications interface and browser-based HMI software compatible with standard HTML platforms.

The concept allows for versatility as needed, but it can be used, for example, to precisely control electromechanical pressure to seal filled bags or to join multiple bags in a single group. Embossing product logos or promotional labels onto existing containers is another application.

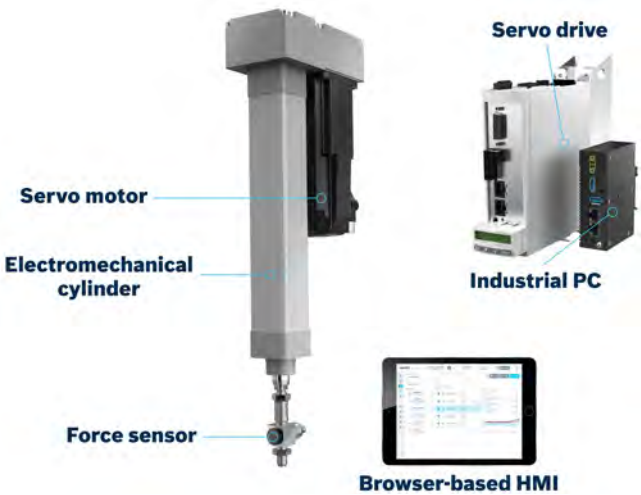
Until the advent of smart mechatronics, machine builders may have developed their own mechatronic assemblies by ordering and integrating separate components. However, this process is often cumbersome and time-consuming.

In a typical scenario, the mechanical engineering group may be responsible for specifying and ordering one set of components, while the electrical group orders its components. Not only is this more challenging for the purchasing department, but the engineering staff is then tasked to make it all fit together physically and program the functionality. Smart mechatronics can eliminate that complexity, providing a complete realization of the plug-and-produce concept.

Bosch Rexroth has simplified the process to achieve this concept. First, they are deploying advanced, well-designed online configuration tools that make it possible to specify and order all the components as a single part from one supplier.

The engineers at a packaging OEM can enter parameters such as stroke, workpiece size, and cycle time, which then generates an output that can be verified and includes a complete set of CAD drawings that can be integrated into the overall digital plan of the FF&S system. In this way, a complete bag-sealing tool or subsystem can be ordered as one part number with a single mouse click and shipped with preprogrammed motion sequences ready for implementation.

In addition, a system like this can come with preinstalled operating software and automatic parameterization of the servo drive, so no motion control programming knowledge is needed to bring it online. It features a drag-and-drop graphical user interface that lets operators build production sequences—e.g., for sealing together a set of juice bags—simply and intuitively.



A key advantage the Smart Function Kit for Handling offers for packaging systems integrators and end-users is its intuitive online configuration and ordering tools.

The "smart" in smart mechatronics includes more than just simplifying ordering, integration, and startup. These systems can also incorporate force sensors that can track and report each motion sequence: was the proper force applied, for the proper length of time, to ensure a correct seal?

As this sequence is typically repeated hundreds or even thousands of times per hour, the system's controller can measure and record each motion cycle for quality control purposes. This kind of information can give warning about malfunctions or other issues, which can be used to drive preventive maintenance programs, as well as incorporated into overall equipment effectiveness (OEE) analysis.

This is the kind of critical, real-time data that's essential to Industry 4.0 production systems—and it is as easy to implement and utilize as the rest of the smart mechatronics kit operating software.

Versatile New Handling Systems with Smart Mechatronics

Many packaging lines use automated mechatronic handling systems extensively, both linear robots and multi-axis systems. Whether for transferring material from one part of a production line to another, or for end-of-line applications such as case packing and palletizing, linear robots and multi-axis mechatronic systems provide high performance and reliability.

They are commonly built-in similar fashion to other mechatronic systems: linear modules, servomotors, drives and controllers ordered separately, along with individual orders for items such as power and communications cabling and the HMI (often pieced together from different vendors at the best cost for each item).

Then the systems need to be integrated. One common challenge for handling systems is connecting the x, y, and z axis linear modules, especially if their physical connections don't incorporate well-engineered physical interfaces. Another time-consuming engineering step is planning and implementing the cable runs in the system—including all the engineering drawings that document these steps.

Similar to the Smart Function Kits from Bosch Rexroth for pressing and sealing operations, the new generation of smart mechatronic handling systems will also provide true "plug-and-produce" platforms for Cartesian and multi-axis systems.

Smart mechatronic handling systems will utilize intuitive, well-engineered online configuration and ordering tools that streamline the process for specifying all the components needed for a given packaging application. This is particularly useful when multiple linear modules of different sizes and weight-bearing capacities need to be ordered and integrated.

Without smart mechatronics commissioning systems, it can be time-consuming to capture all these key specification details when ordering linear modules and servomotors separately. Equally valuable, smart mechatronics for handling systems will come with preinstalled operating software and automatic parameterization of the servo drives. Drag-and-drop programming of motion sequences to configure a range of common pick-and-place functions can also be provided.

This will make it possible for packaging system OEMs to quickly design and integrate single-axis or multi-axis handling systems as part of a new installation. They will also be able to rapidly update existing packaging end-of-line systems when changes in production or product mix call for Cartesian functionality.

And as with other smart mechatronics solutions, these smart mechatronic handling systems will support real-time data capture and integration with higher-level machine controls, as well as the ability to export data via interfaces such as OPC UA to provide valuable productivity and quality information.

Plug-and-Produce Technology Transforms Mechatronics

Smart mechatronics offers a new, Industry 4.0–ready way to simplify the effort required to configure, order, integrate and begin using high-value mechatronics systems in packaging machine applications. Complete solutions, delivered in a single package or "kit" that's ready to plug-and-produce, has the potential to reduce the time and cost required to build packaging machines.

For packaging companies, as well as the OEMs supplying their production systems, there are advantages to working with a single mechatronics supplier with a complete portfolio of products and components, easy-to-use online configuration tools and a proven record of creating high-performance smart mechatronic solutions specifically for the demands of today's packaging industry.

boschrexroth-us.com

PTE

Similar to the Smart MechatroniX function kits for pressing and sealing operations, the new generation Smart Function Kit for Handling systems will provide true "plug-and-produce" platforms for linear robot and multi-axis systems.

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

Keep Up with Change at Pack Expo International 2022

After four years, the packaging and processing show returns

For Related Articles Search
Pack Expo
at www.powertransmission.com

Aaron Fagan, Senior Editor

At Pack Expo International, to be held at Chicago's McCormick Place from October 23–26, you'll find the full spectrum of what the world has to offer in innovative packaging and processing technology, automation, robotics, printing, supply chain solutions, and more all at one show. The show delivers the opportunity to build relationships with suppliers; engage with the experts behind game-changing technologies and discuss applications for your business; and expand your network of peers. Nothing beats being able to examine technology in person to assess the quality, try out the control panels and see how it functions, so you can determine the best solutions for your line. Assembled below is a sampling of the companies that will be present and the solutions they have to showcase.

NORD DRIVESYSTEMS—#N-4974 (North Building)

DuoDrive Integrated Gear Unit and Motor

DuoDrive is an ultra-modern integrated gear unit/motor concept with a hygienic washdown design. It combines a high-efficiency IE5+ motor with a single-stage helical gear unit in one housing. Due to its optimized system efficiency, high power density, and very low noise emissions, it is extremely well-suited for packaging systems. Together with its simple plug-and-play commissioning, the complete DuoDrive solution results in a significant reduction in total cost of ownership (TCO) compared to other drive systems.

- Latest generation permanent magnet synchronous motor (PMSM) integrated in a single-stage helical gear unit housing
- Reduced Total Cost of Ownership and fast Return on Investment
- Compact, smooth body design for durability and space savings
- Available with IP69K surface treatment and nsd tupH Sealed Surface Conversion System

Nordac On/On+ Variable Frequency Drives (VFDs)

Nordac On/On+ VFDs were developed to meet the special requirements of horizontal conveyor technology and for use with the new IE5+ synchronous motor (Nordac On+). They are characterized by an integrated Ethernet interface, full plug-and-play capabilities, and a very compact design. Nordac On/On+ variable frequency drives are a reliable, economic solution for IIoT environments.

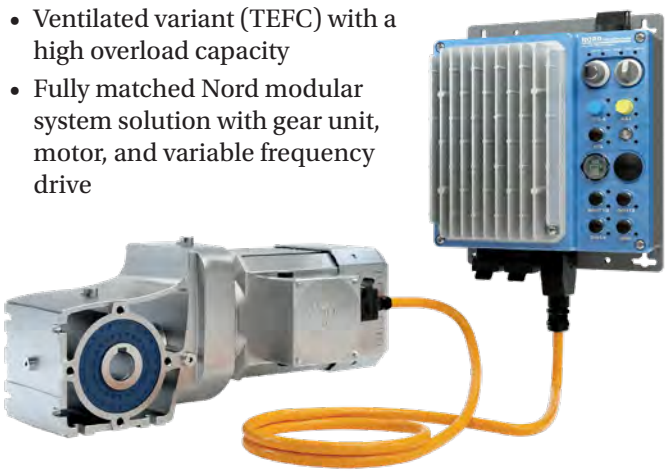
- Performance: Up to 1.27 hp
- Protection class: IP55, IP66
- Wall-mount or motor-mount
- Plug-and-play solution for fast commissioning
- Operation of asynchronous and synchronous motors
- PLC functionality for drive-related functions (PLC onboard)
- Compact, space-saving design due to integration of Ethernet communication

IE5+ Ultra High-Efficiency Synchronous Motors

The new generation of NORD IE5+ synchronous motors feature a compact, hygienic design with smooth surfaces for high corrosion resistance and easy cleaning (TENV design) or a finned version for optimized heat dissipation (TEFC design). These motors are available with nsd tupH Sealed

Surface Conversion or IP69K surface treatment (when supplied as a complete gear unit). A motor-integrated encoder comes standard and an integrated mechanical brake is optional.

- Performance: 0.5–5.5 hp
- Worldwide approvals and acceptance
- Flexible motor mounting: direct mounting, NEMA, IEC
- Highest operational efficiency with IE5+ technology
- Reduction of variants through constant torque over a wide speed range
- Easy to clean and corrosion-resistant
- Fanless motor design
- Available with nsd tupH Sealed Surface Conversion System
- Reduced TCO and fast ROI
- Non-ventilated variant (TENV) for hygienic wash-down areas
- Ventilated variant (TEFC) with a high overload capacity
- Fully matched Nord modular system solution with gear unit, motor, and variable frequency drive



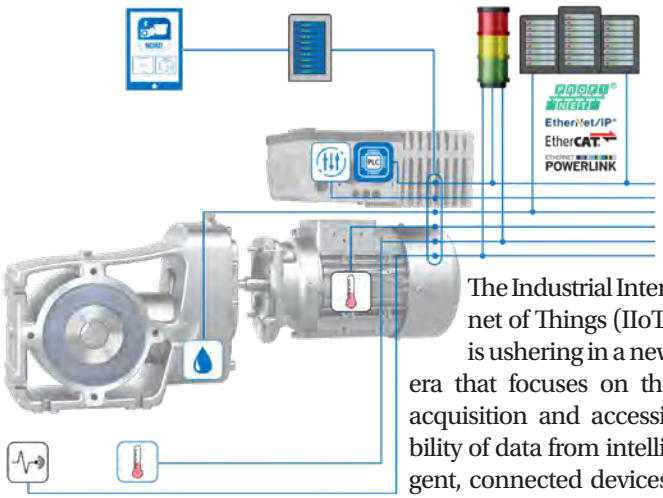
LogiDrive

With LogiDrive, NORD delivers an energy efficient, low maintenance solution with a flexible, modular design and maintains efficiency event at partial load and low speeds. This makes LogiDrive especially effective for high-volume warehousing, manufacturing, and packaging systems. The LogiDrive solution includes:

- High-efficiency 2-stage bevel gearbox
- IE4 or IE5+ permanent magnet synchronous motor
- Decentralized variable frequency drive
- Power plug connector
- M12 connectors
- Incremental encoder
- Pre-assembled cables
- High overload capacity
- Standardized hollow shaft diameters

As a complete package, LogiDrive provides flexibility, increased energy efficiencies, and can reduce variants to improve ROI. The VFDs and IE5+ motors support large speed ranges to deliver automation for stacker cranes, automated guided vehicles, a wide variety of conveyors, and more.

Condition Monitoring for Predictive Maintenance



The Industrial Internet of Things (IIoT) is ushering in a new era that focuses on the acquisition and accessibility of data from intelligent, connected devices. Analyzing this data can provide valuable insight to increase operational efficiency, reduce costs, and accelerate processes.

With condition monitoring, drive and status data are recorded periodically or continuously to optimize the operational safety and efficiency of machines and plants. Important information can be derived from the data analysis to proactively maintain systems, reduce downtime, and increase the efficiency of the entire plant.

- Early detection and avoidance of undesired operating conditions
- Avoidance of unplanned downtimes
- Time-based maintenance is replaced by status-based maintenance
- Machinery and plant downtimes can be planned based on drive and process data
- Reduction of service and material costs
- Longer service life of components and machines
- Increased system availability

nsd tupH Sealed Surface Conversion System

This patented solution is not paint; it's a chromate-free chemical process that changes the physical properties of NORD's aluminum housings, creating a surface that is up to seven times harder than the original aluminum. After the process is complete, the housing receives an additional sealant that is resistant to contact corrosion from acids and alkalis (entire pH range), will not flake, and will not propagate damage when impacted or scratched. This solution is ideal for harsh environments involving chemicals or wash downs, and where sanitation and cleanliness are the highest priority.

- Conforms to FDA Title 21 CFR 175.300
- Lightweight compared to stainless steel
- Does not flake or chip like paint
- No penetration of corrosion, even if damaged
- Cost-effective alternative to stainless steel
- Easy-to-clean surfaces

nord.com

Festo—#N-6213 (North Building)

Meeting the degree of protection IP65/67 for factory digitalization, the decentralized IO system CPX-AP-I allows compact and lightweight I/O modules as well as the decentralized valve terminals from Festo to be integrated into major host systems in a flexible and scalable way. Another advantage of CPX-AP-I is its seamless connectivity from the field level right through to the cloud, providing access to features such as predictive maintenance. This makes digitalization incredibly easy.

CPX-AP-I lets users from the general machine building, automotive or electronic sectors transmit their machines' process data in real-time. Up to 500 participants can be connected to the main systems with a cable length of up to 50 m between the modules. The benefit is that existing valve terminals from Festo can be easily integrated into the new system, so that nothing changes in terms of the pneumatic control sequence. An aspect that is forward-looking but already a reality is the system's connection to the IoT gateway CPX-IOT from Festo, enabling status data to be exchanged in cloud systems.

This all-rounder among remote IO systems is equipped with IO-Link technology as well as IO-Link device tool, simplifies commissioning without the need for additional software tools, and has a plug-in for the Festo Automation Suite and for using a web server, all tailored to each customer's needs.

The system is designed for applications in which installation space, decentralization, and digitalization are key. Based on the new AP system communication from Festo, CPX-AP-I ensures fast and seamless communication in all common host environments. This gives users a machine design that meets the requirements of the digital factory of the future.

festo.com

JIE USA, INC.—#LU-7512 (Lakeside Upper)

Established in 1988, JIE produces gearmotors and reducers that serve the needs of their business partners through reliable designs and supply. Their ISO 9001 certified factories employ more than 650 people and produce over 800,000 units annually. From their US headquarters in Chicago, JIE offers a variety of gearmotor options that can be assembled in custom configurations and with short lead times from their extensive inventory of finished and component parts.

The JRTK helical bevel gearmotor is part of the JRT series of gearmotors from JIE.

The JRT series of inline helical (JRTR), helical bevel (JRTK), helical worm (JRTS), and parallel shaft (JRTF) gearmotors can be configured with NEMA, IEC, or servomotor inputs. This series allows JIE to quickly provide interchangeable solutions to the marketplace. The whole series comprises AD-type solid shaft, AM-type IEC motor, AQS-type servomotor, and AN-type input interfaces; solid shaft, spline hollow shaft, locking disc, and flange output modules; and foot, flange, and torque-arm installation. This product supports the modular combination and integration of multi-stage gearboxes with different types of adapters.

The JRWND series worm reducer, like all of JIE's solutions, follows the concept of modular design.

The JRWND series of worm reducers offer customers fast access to universally adaptable solutions with various input and output configurations. Applied in printing and dyeing machinery, machine tools, textile machinery, automation equipment and other industries.

The JRE series of stainless-steel motors and gearmotors provide IP69K protection and are available in a wide range of gearing styles from worm to helical bevel, all from stock at JIE headquarters. JIE stocks NEMA motors in both aluminum and stainless-steel construction from ¼ hp–10 hp. The stainless steel gearmotors are useful wherever machines and systems are subject to particularly intensive cleaning.

Regardless of whether the gearmotors are used for materials handling, intralogistics or hygienic applications, their hygienic properties, long operating life and maintenance friendliness make them optimally suited to the specific production conditions in the food and beverage industry, pharmaceutical industry, and permanently wet environments.

jie-drives.com

IKO International—#N-6069 (North Building)

Cam Followers

IKO cam followers feature exceptional rigidity, high load capacity, easy mounting, and excellent rotational performance thanks to an optimized design for outer ring revolution. IKO offers a comprehensive lineup of products that fit a wide range of industrial applications such as robotics, elec-

tronic parts production, and office automation equipment. We also offer two unique technologies: ThrustDisk and ThrustDisk Seals—a synthetic resin thrust washer that handles axial loads with exceptional wear and heat resistance—and C-Lube options, either built-in or as an attachment that provides long-lasting, maintenance-free operation. IKO also carries a large inventory of off-the-shelf cam follower products stocked in multiple U.S. locations to ensure delay-free availability and worry-free ordering.

ML Series Linear Guides

IKO ML Series ball-type linear motion rolling guides feature stainless steel construction as standard. The series also comes standard with C-Lube—a self-lubricating system with a built-in capillary element to provide long-lasting maintenance-free operation and cost savings. ML Series guides also provide stable accuracy and rigidity—even if your application presents variable load directions and sizes, or complex loads.

Crossed Roller Bearings

IKO Crossed Roller Bearings are designed with rollers alternately crossed at right angles to each other between inner and outer rings. This arrangement creates greater roller contact with the raceways, allowing the bearings to take radial, thrust and moment loads from any direction at the same time with less deflection under load. IKO Crossed Roller Bearings also come in a variety of styles to meet the needs for varied applications including robotics, medical, semiconductor and food and beverage to name a few.

ikont.com

JW Winco—#LU-8249 (Lakeside Upper)

Longtime exhibitor at Pack Expo International, JW Winco, is a leading supplier of standard industrial machine components and assembly hardware for the industrial and commercial equipment industries, including OEMs, packaging, medical equipment, automation, and more. JW Winco also specializes in offering value-added services to engineering, purchasing, and maintenance departments.

This year, JW Winco will feature their hygienic design (HD) family of products, along with their standard parts made of detectable plastics, and standard parts with antibacterial surfaces. They offer a comprehensive selection of metal and plastic, metric and inch size standard machine components, hand-operating, and assembly hardware.

Standard parts are extremely versatile in their application. Increased use of standard parts greatly reduces the costs of product development and in turn, provides the engineer with more time to devote to larger project requirements. The engineers can concentrate on the actual machine or equipment design, as standard parts can cost-effectively be procured externally.

All standard parts of the HD product family combine high surface quality, freedom from dead spaces, nonscooped outer surfaces, and sealed bolting areas. A sealing concept based on FEM calculations ensures reliable contact pressure after installation. HD also means that the time and material needed for regular cleaning are significantly reduced—which also noticeably lowers operating costs.

JW Winco's HD product family continues to grow, which includes knobs, U-handles, hand levers, indexing plungers, latches, cover sleeves, leveling feet, screws, and more.

Standard parts with visual detectability are made of light blue plastic making them especially visible to the human eye and, perhaps more important, to optical monitoring systems. Especially in milk, dairy, and meat products, but also in most other areas of food production, blue colors are rarely encountered and therefore stand out well.

Metal detectable standard parts are made of dark blue plastics that contain additives such as iron oxide. As a result, they are detected by metal detectors as of a particle volume of 0.125 cm^3, meaning that even hidden plastic chips can be detected. Also, the metal detectable plastic standard parts are made of FDA-compliant plastic granulate as per FDA CFR.21 and EU 10/2011. The plastic can therefore be used safely in contact with food and in pharmaceutical production.

The antibacterial standard parts of the Sanline product family can prevent bacteria and germs from propagating on an operating element, actively reducing their spread and preventing bacterial illnesses that could otherwise result.

Two different active principles can be found in the Sanline product family: Plastic standard parts with additives based on silver ions and metal standard parts with a powder coating based on zinc molybdate. Both principles destroy the cell walls of the microorganisms, causing them to die. The antibacterial effectiveness is retained for a long time, even after frequent cleaning cycles, and is safe for the user.

jwwinco.com

PTE

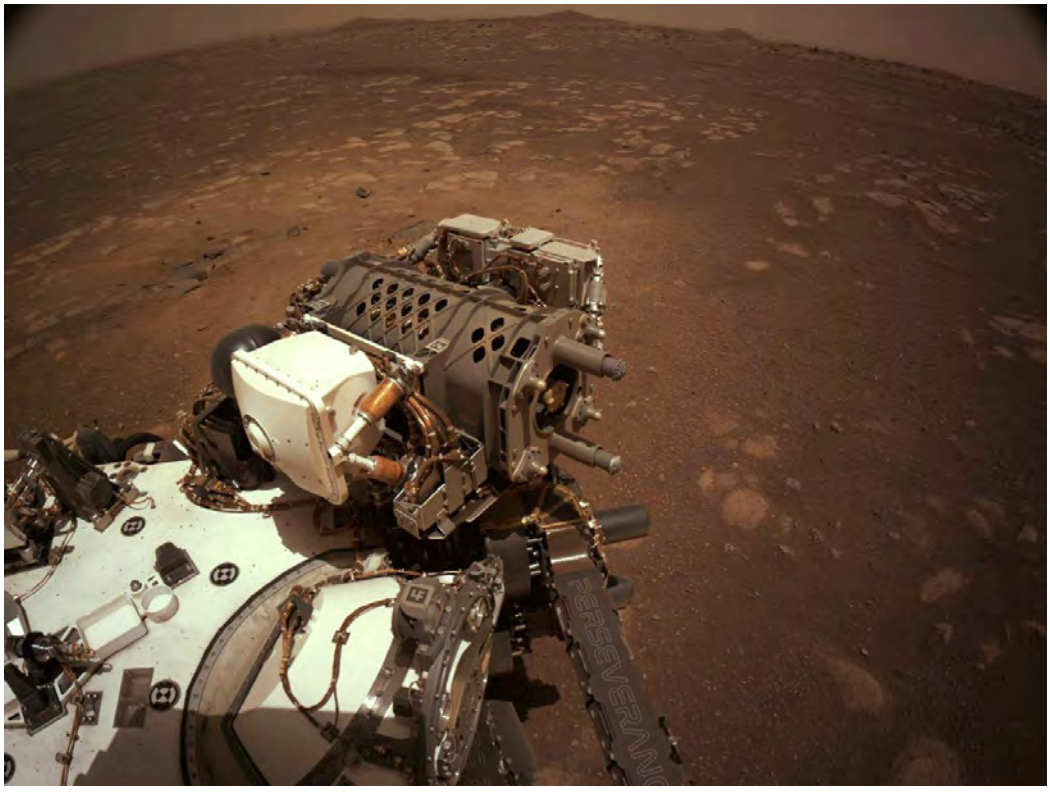
Engineering sMart is your resource for the latest in great ideas from our advertisers. Check this section every issue for sMart Engineering ideas and technology.

For information about advertising, contact Dave Friedman at **(847) 437-6604** or ***friedman@agma.org***

Riding the Red Planet

Perseverance traverses Mars to answer questions about the future of space exploration

Matthew Jaster, Senior Editor



This image shows parts of the robotic arm on NASA's Perseverance rover flexing and turning during its first checkout after landing on Mars. Photo courtesy of NASA/JPL-Caltech.

Mistakes happen. We can pore over the details 120 times, yet errors can still slip through the cracks. This is how the wrong MLB player appears in a photograph on the cover of a Chicago newspaper or why a public relations department begs political figures to 'stay on script' to avoid viral video clips. Fortunately, we can fix these errors by publishing a new version of an article or retaping a video interview. I thought about this in great length as I watched the Perseverance Mars rover landing back in Feb. 2021.

There are no second chances in a project of this magnitude. At the time, you could see it on the faces of all the NASA employees watching the landing from Mission Control. If you were involved in any technical aspect of the rover mission, there was little to do but watch, observe, breathe, and hope for the best.

The level of uncertainty and panic in that moment was felt far beyond Mission Control. Engineers and manufacturers across the globe were involved in Perseverance's drive system, controls, electronics, robotics, etc. Miraculously, the rover landed without complication. Today, it continues to ride around the red planet collecting data, soil samples and giving Earth new insights on our solar system.

Making Another Trip to Mars

I sat down with Forest City Gear's Fred Young back in 2012 to discuss his team's work on the Curiosity rover. Back then, he was thrilled the FCG staff was participating in a groundbreaking engineering experience.

"It's exciting, it's challenging and most importantly it's a great learning experience," Young said at the time. "To imply that we had a major role in this project is a considerable leap of faith, but bottom line, the gears had to work and the Jet Propulsion Laboratory (JPL) had to select the best ones to make the trip."

Fast forward to the Mars 2020 Perseverance rover and FCG was tasked with supplying and creating components for nearly every actuator on the vehicle including the drive systems, articulating arms, science drills, and camera focal gear sets. The components were planetary gears, sun gears, single and multi-stage housings, and armature shafts.

Forest City Gear was tasked with supplying and creating components for nearly every actuator on the vehicle including the drive systems, articulating arms, science drills, and camera focal gear sets. Photo courtesy of FCG.

"What's most memorable about the project is the realization that you are working on parts that will be going to Mars," said Jared Lyford, director of manufacturing operations at FCG. "As you work through the project, no matter what level, you get wrapped up in the nuances of your responsibility in that moment. Then, at some point you stop and realize, this particular item is going to Mars to do very specific and unique work. This is not a commodity and is very much a one-off. You really appreciate being part of something much larger than your own contribution."

Lyford said that the rover programs leverage as much previous design elements as possible. "This allows for efficiencies to be had in tooling design and production. The customer's requirements tend to become more sophisticated over time, and there are always a few new challenges, by way of part design, to keep things interesting," Lyford added.

He said the most difficult part of the latest rover project was program management. The development of the process plans and associated engineering requirements was very rigorous. Combining that with the project management required to track through process development and into production made it even more demanding.

"The timing required to meet a production end goal is critical as the components need to be delivered in order for the actuator assembly, test, and final build," Lyford said. "The culmination of all of this must align with NASA's launch timing. There is a very specific window for the entire project to be finalized. If that window is missed, I believe it was approximately two years for the next launch window due to Mars' and Earth's alignment."

Lyford has enjoyed following the exploits of Perseverance since the landing. "I recall this being very exciting. You almost hold your breath as you feel so connected to the project and its success. The moment the rover landed on the surface of Mars, the entire company celebrated. The enthusiasm was similar to what you see in Mission Control while watching it live!"

The FCG team understood the challenges they faced during these historical aerospace programs and are consistently working to improve operations to address projects in the future.

"FCG is preparing by remaining current in both technology and training. It's our dedication to human resources and the latest equipment that allows us to perform for customers with 'out of this world' challenges," Lyford said.

forestcitygear.com

High Level Engineering Expertise

Robin Phillips, head of maxon SpaceLab, discussed the company's role with Perseverance and the unique helicopter, Ingenuity. Motors and gearboxes were provided by maxon for the project including seven motors and one gearbox inside the rover, two motors on the science arm and one motor utilized for helicopter deployment. Ingenuity needed six maxon DC motors to control the movement of the vehicle.

"Our customer (JPL/NASA) pushed us to develop the highest technology actuators we are capable of," Phillips said. "When you take on a project like this you know you will always have some issue you didn't think of at the beginning—the known unknowns—solving these issues as they arise is a key part of the project management work (as examples, this can be a design that doesn't assemble as we had expected, or a part that turns out to be harder to manufacture than we expected, or some failure that occurs in testing)."

The organizational aspects of running projects like this within a company set up for mass production is also a challenge.

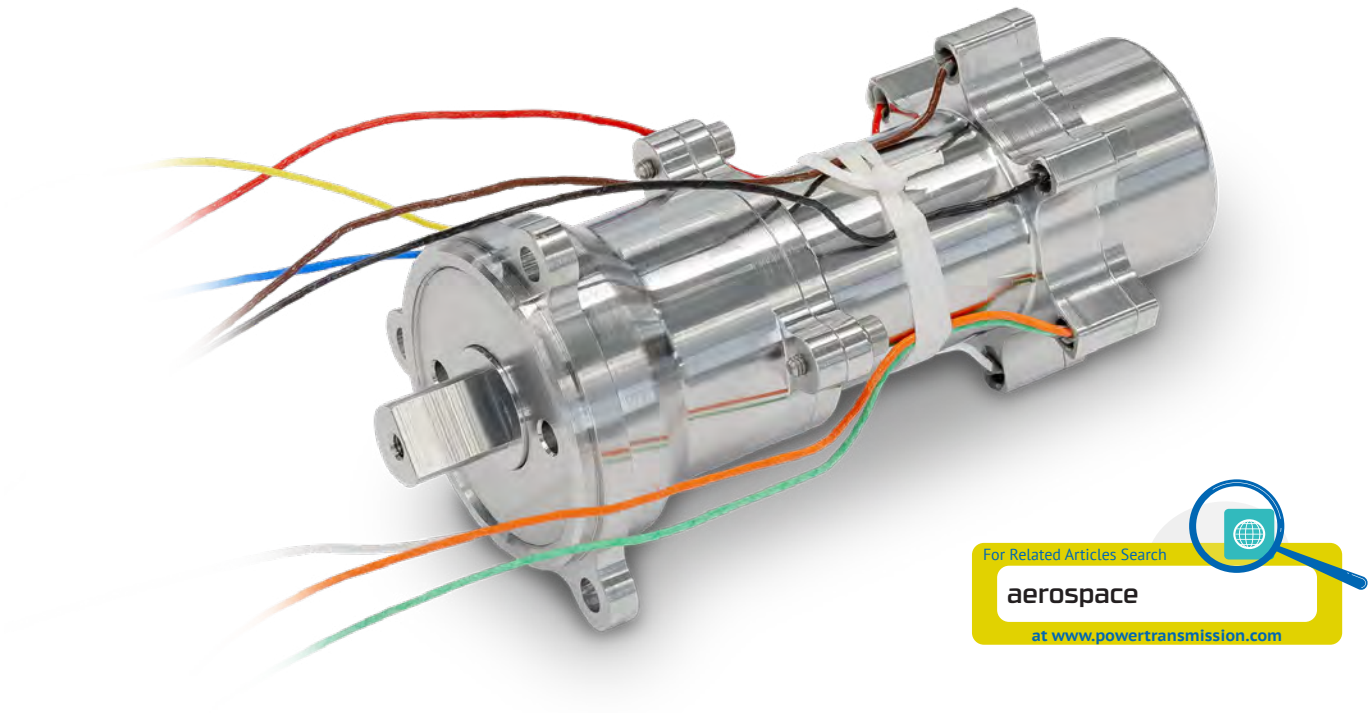
"This needs a different skill set from the assembly staff. It causes projects like the Mars rovers that need special production runs and a high level of engineering input to be viewed as disruptive for the main work of the company," Phillips added. "Our solution has been to copy the well-known Lockheed 'Skunk Works' organizational structure where a small team is broken out from the main company and can work independently whilst still tapping into the knowledge and resources of the main company. This is our SpaceLab."

When maxon started doing these projects nearly 30 years ago, JPL would tell the company what to change in the designs and monitored every production step.

"Then about 15 years ago when we started working with the European Space Agency (ESA) for ExoMars we decided to try and learn all the necessary processes on how to design and build space standard actuators ourselves. This was a painful process where we had to learn by making mistakes," Phillips said. "Now I think we know what we are doing at a basic level, but each new project then brings new challenges at the detail level. Using these new technologies (design features, material, manufacturing processes) that we already know will work in such applications and environments, allows us to increase our reliability and focus on more complex products/projects."

While the pressure and technical challenges can be harrowing, Phillips and the maxon team learned to embrace the unknown.

"Since we spend so much of our life at work, I am very much of the opinion we need to enjoy our time at work! In the case of the Mars 2020 mission (Perseverance and Ingenuity) it was working with the JPL team, who are the world's best spacecraft mechanism engineers, that I enjoyed



Motors and gearboxes were provided by maxon for the project including seven motors and one gearbox inside the rover, two motors on the science arm and one motor utilized for helicopter deployment. Photo courtesy of maxon.

the most. They are a great bunch of people with whom we got on with very well both at a professional and a personal level. They spent a total of several months in Switzerland over three years and we spent a lot of time with them both in and out of maxon."

The EDL sequence (Entry, Descent and Landing) is not called the "7 minutes of terror" for nothing. The sky crane design that puts the rover down on the surface of Mars is a technological tour-de-force but has so many steps that can go wrong that you can't help but be incredibly nervous until you see the signal that says the rover has made it down in one piece. "It's a rollercoaster ride where you breathe a sigh of relief as every key step occurs, only to immediately transition back to nervous anticipation for the next step," Phillips said.

As to the products delivered, knowing that Perseverance's critical sample handling system has now worked for over a year on Mars is the greatest satisfaction, according to Phillips. "It means all the work we put in over those years has paid off. In the case of our Ingenuity motors, as is the case for the entire helicopter, they have exceeded our wildest expectations of how well they would work and how long they would last," he added.

The maxon SpaceLab will continue to participate in exciting space science and exploration missions such as the Mars Sample Return program and the upcoming Artemis manned lunar mission. The company will also become the "go to" actuator supplier for the "new space" commercial satellite industry.

For the commercial opportunities, Phillips noted that the revolution in access to space caused by SpaceX and its competitors finding ways to reuse their launches and hence lower the cost of access to space by an order of magnitude is opening new markets.

"We are positioning ourselves as an actuator supplier for this new and growing market by creating a catalog of standardized space-rated motors, gearboxes, and encoders. These are being qualified against representative specifications by us and will then be available as stock items that can be purchased at much lower prices than custom designs and with much shorter lead times. We believe this will fulfill the needs of this new industry where numerous startups are trying to disrupt what has become a very conservative market."

maxonworld.com

A Little Motion Control on Mars

Cobham Advanced Electronic Solutions (CAES) actuators drive the Perseverance rover wheels and provide steering motion, move the high-gain antenna, and perform remote sensing mast deployment. CAES actuators and radiation hardened (RadHard) microelectronics are currently working to understand Mars' atmosphere and geology, in addition to seeking signs of ancient microbial life.

They are also featured in the instrument pack designed by Malin Space Science Systems. The Perseverance rover's electronics and payloads are based on the CAES UT699 LEON microprocessor, which handles the computing functions for the motor controls as well as the UT54LVDS217 LVDS Serializer, UT54LVDS218 Deserializer and a variety of memory devices.

Space is one of the key passions for the CAES engineering team. The company worked previously on the NASA Mars Curiosity mission where CAES actuators and radiation

hardened integrated circuits completed a 350-million-mile journey and three years of daily tasks while withstanding the challenges of the grueling Martian atmosphere, including -120°C temperatures and a volatile dust environment.

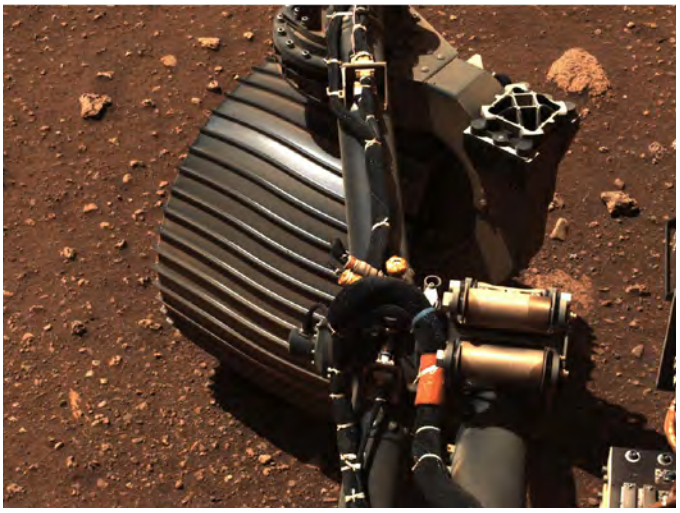
"CAES is honored to serve on the Perseverance Mission and explore Mars once again," said Mike Kahn, president and CEO, CAES. "Our components on the rover are designed specifically for the extreme environmental conditions ahead. We are excited to watch the mission unfold and to continue pioneering electronics that cultivate the future of space exploration."

caes.com

Research, Research, Research

While we've discussed some of the technology found in previous missions to Mars in *PTE* (powertransmission.com/search?q=mars) here is some data on what the latest rover is carrying:

- Mastcam-Z is an advanced camera system with panoramic and stereoscopic imaging capability with the ability to zoom.
- SuperCam is an instrument that can provide imaging, chemical composition analysis, and mineralogy at a distance.
- Planetary Instrument for X-ray Lithochemistry (PIXL) is an X-ray fluorescence spectrometer and high-resolution imager, which maps the fine-scale elemental composition of Martian surface materials.
- Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals (SHERLOC) is a spectrometer providing fine-scale imaging and uses an ultraviolet (UV) laser to map mineralogy and organic compounds.
- The Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) is a technology demonstration producing oxygen from Martian atmospheric carbon dioxide.



NASA's Perseverance rover wiggles one of its wheels in this image obtained by the rover's left Navigation Camera. Photo courtesy of NASA/JPL-Caltech.

- Mars Environmental Dynamics Analyzer (MEDA) is a set of sensors providing measurements of temperature, wind speed and direction, pressure, relative humidity, and dust size and shape.
- The Radar Imager for Mars' Subsurface Experiment (RIMFAX) is a ground-penetrating radar providing centimeter-scale resolution of the geologic structure of the subsurface.

In a few years, NASA and the JPL will conduct the next rover mission. Someone, somewhere on a shopfloor will be watching with great anticipation, hoping the gears, motors, actuators, and controls exceed expectations. Mistake-free engineering; just another day at the high stakes, industrial office.

Interested in following the exploits of Perseverance as it navigates Mars? Check out the *Mission Rover* update blog at *mars.nasa.gov/mars2020/mission/status/* to learn the latest exploration news and research.

PTE

Members of NASA's Perseverance rover team react in mission control after receiving confirmation the spacecraft successfully touched down on Mars, Thursday, Feb. 18, 2021, at NASA's Jet Propulsion Laboratory in Pasadena, California. Photo courtesy of NASA/Bill Ingalls.

Napoleon Engineering Services
NES Bearing Co., Inc.
EMPOWERING OUR CUSTOMERS WITH BEARING SOLUTIONS

At NES our goal is to empower you with specialized bearing solutions related to custom bearing manufacturing, inspection, and testing. We are a leading high end US custom bearing manufacturer and the largest independent bearing inspection and testing facility in North America. With over 100 years of generational bearing knowledge and experience NES is the one-stop shop you need to make your bearing projects streamlined and efficient.

Diverse Industries & Applications
- Aerospace
- Aviation & Vertical Flight
- Defense & Military
- Oil & Gas
- Power Generation
- Marine
- Industrial
- Transportation
- Gear Drives
- Medical
- Agriculture & Lumber
- Pumps & Turbines
- Generators
- Off-Highway
- OEM's
- MRO stations

Custom Ball Bearings:
- Deep groove
- Deep-groove fractured race
- Angular contact
- Two-piece inner ring Gothic arch
- Double-row
- Thrust
- Ceramic Hybrid

Custom Roller Bearings:
- Needle
- Cylindrical
- Thrust
- Ceramic Hybrid

NES is THE Solution:
- Corrosion Resistance
- Temperature Extremes
- Load Extremes
- High Fatigue Life
- High Life Materials
- Cost Effective Solutions
- Bearing Size Range 20–350 mm
- Shorter Lead Times
- Small and Large Production Runs
- High Precision Capabilities
- Advanced Design Technologies
- Precision Modifications

ISO9001 CERTIFIED QMS

AS9100 CERTIFIED QMS

NADCAP CHEMICAL PROCESSING

Custom Bearing Manufacturing
NES's design engineering and US manufacturing capabilities provide you with custom bearings without the long lead times of other bearing manufacturers. Our knowledge and expertise allow us to analyze your application conditions and develop an advanced product that will meet or exceed your needs.

Bearing Inspection & Testing
NES is the creator of inspection & testing programs that support global bearing sourcing & bearing qualification. We have been leading OEMs through the global bearing qualification process for 25 years. We provide technical information through bearing inspection, modeling and testing programs to evaluate bearing design, manufacturing capability, overall quality of workmanship, and the relationship these attributes have on bearing life. No other source has the experience, capacity, or capability to expertly service your bearing qualification needs.

MADE IN THE USA

Napoleon Engineering Services NES

FOR MORE INFORMATION
1601 Johnson Street, Olean, NY 14760
Phone: 877-870-3200
Fax: 716-372-1448
Email: sales@nesbearings.com
www.nesbearings.com

Stock Drive Products/ Sterling Instrument

Standard Parts or Custom — One Single Source

Stock Drive Products/Sterling Instrument (SDP/SI) makes it easier for OEMs to get their products to market by designing and delivering precision components and complex drive assemblies while managing costs and inventories. Well known as the one-stop-shop, we provide mechanical and electromechanical components, engineering development, precision manufacturing, and problem-solving customized solutions.

SDP/SI has over 70 years of experience in engineering development and precision manufacturing for a diverse range of industries, including medical, aerospace, robotics, and industrial automation. Combining our engineering expertise in power transmission and motion control applications with a state-of-the-art-manufacturing facility ensures our customers receive components and assemblies that meet their specific needs. SDP/SI is ISO 9001:2015 + AS9100D certified, ITAR, Reach, and RoHS compliant.

Offering a comprehensive selection of mechanical and electromechanical components, SDP/SI products are available with a wide range of standard features for easy integration intended for all applications. Shaftloc® and components featuring the Fairloc® Hub Design are exclusive to SDP/SI and provide added benefits.

Beyond standard components, SDP/SI offers significant custom manufacturing capability to set your ideas into motion. Our engineers are always available for engineering and design support, and we look forward to helping with your next project.

Visit www.sdp-si.com to find detailed product specifications, custom capabilities, 3D CAD models, product literature, and quality certifications. Check out our Engineering Resources for useful calculations, gear design, timing belt and pulley design, and helpful calculators.

Shop SDP/SI 24/7.
Download 3D CAD models and product specifications.
Request a quote online.

- Timing Belts and Pulleys
- Precision Gears and Gearboxes
- Couplings
- DC Motors
- DC Gearmotors
- Integrated Motor Drive Controllers
- AGV Gear Motors / Kits
- Gearheads
- Motion Control Products
- Bearings

SDP/SI
STOCK DRIVE PRODUCTS/STERLING INSTRUMENT

FOR MORE INFORMATION
250 Duffy Avenue, Hicksville, New York 11801

Phone: 516-328-3300
Toll Free: 800-819-8900
Fax: 516-326-8827

Email: sdp-sisupport@sdp-si.com

www.sdp-si.com

Noises in the Night

The factors leading to ultra-quiet electric motors

Donald Labriola

Most motor applications produce audible noise, ranging from a slight hum to a mildly offensive whine or even something loud enough to endanger health or require hearing protection. Like many technology issues, the sources as well as the solutions are multidisciplined. Key to finding solutions is an understanding of how the noises arise.

In applications such as medical instrumentation, the acoustic noise level may be a strain on the physician and may unsettle the patient. In industrial applications, higher noise levels may require hearing protection. In other applications, like animatronics or magic show tricks, even a minimal noise may completely upset the illusion.

Motor

Let's start with the mechanics of the motor. Although the rotor and stator can often be swapped (so-called inside-out motors), we will keep the discussion focused on the conventional design with an outer fixed stator and an inner moving rotor; the same insights can be applied to different topologies.

Most motors include iron or other magnetic materials (ferromagnetic) in either their rotor or stator or both. Many magnetic materials have magnetostriction properties, meaning that they change their shape or dimensions as a function of the magnitude of the applied magnetic field. The effect arises at the microscopic as the boundaries of and magnetic vector within domains are varied in response to the applied field. The domains try to align with the applied field so as to minimize the free energy of the system. The hum of a common transformer is mostly caused by magnetostriction. The commutation process of a motor involves causing the magnetic fields to vary to cause a torque to be generated between the rotor and the stator, leading to the rotor turning. These changing fields also give rise to changing dimensions, which can cause surfaces of the motor to act as speakers.

In addition to magnetostriction, there is also the simple magnetic attraction between portions of the rotor and stator due to the interaction of their magnetic fields. These forces do not require ferromagnetic materials to be present; the wires themselves will generate forces that result in motion. The coils in many motor designs are dipped in lacquer to help keep them rigid as vibration between wires not only can make noise but also can abrade the insulation. The resulting forces from attraction and repulsion give rise to strains (deflections) in the structures. The design of the

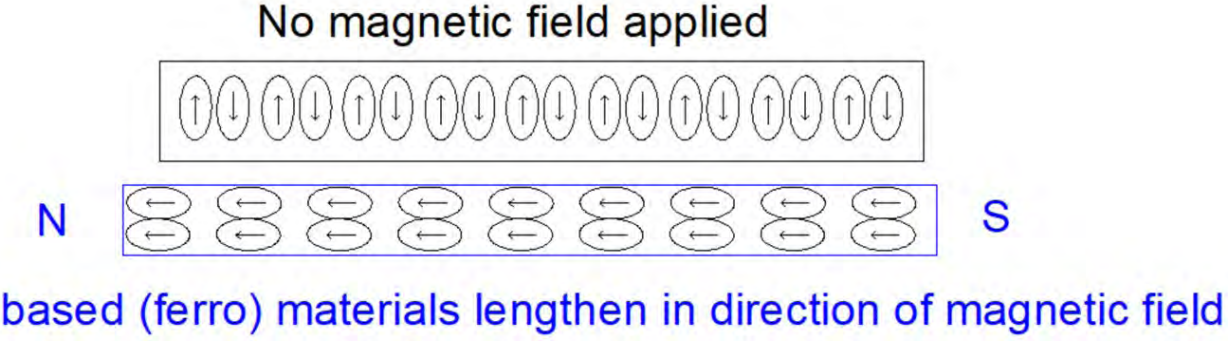


Figure 1 Magnetostriction
Ferromagnetic materials will have their domains align with the magnetic field, causing the physical dimension of the material to expand in the direction of the magnetic field. Some other materials, such as cobalt, contract in the direction of the magnetic field due to different crystal lattice structures.

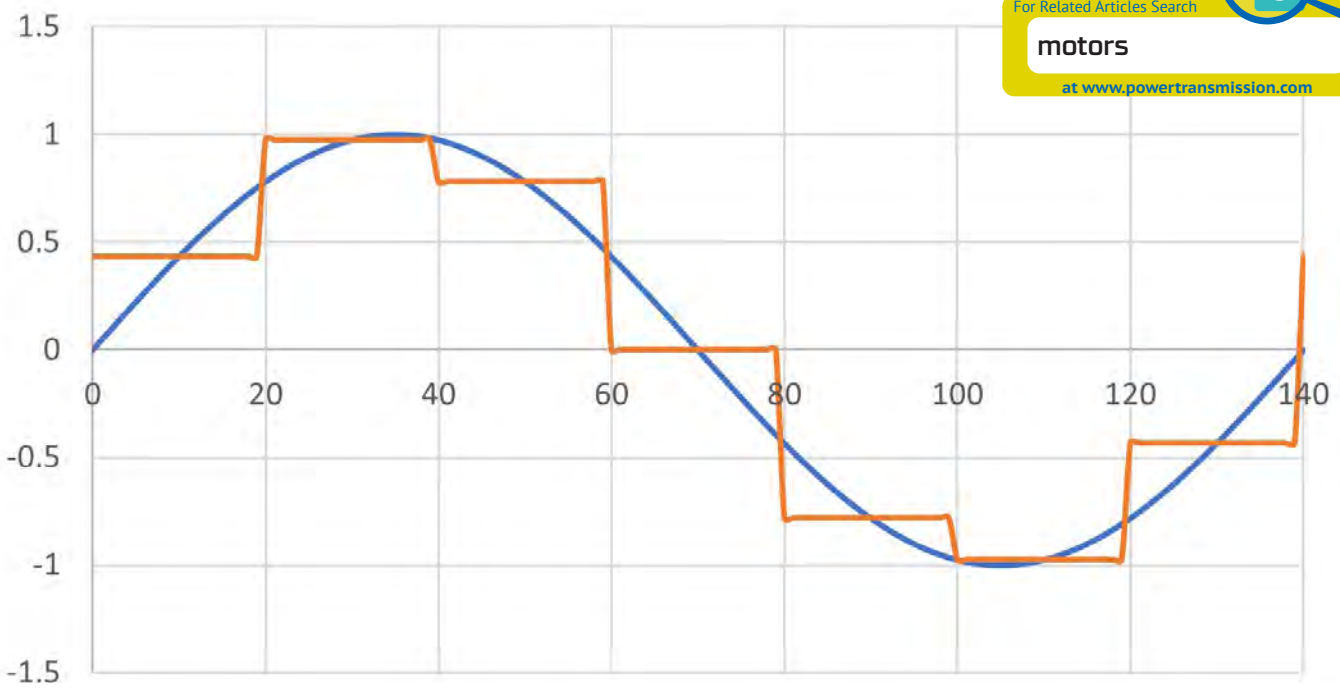


Figure 2 Commutation Smoothness
Driving the current as fast as possible for the next requested current causes an abrupt change in torque resulting in jerk in the system as compared to a smooth change in current.

structure of the different motor types affects the distribution of these forces and the resulting structural deformations. These deformations may also make the motors effectively function as speakers. Note that both magnetic attraction strains and magnetostriction strains will generate acoustical noises according to the way the magnetic field varies, which in-turn follows the winding currents associated with the driving waveforms. The driver and control methodology will be discussed as to how they affect the characteristics of the acoustical noise.

The bearings may also be a source of mechanical noise within the motor. Preloading of the bearing removes the excess play in the bearing, which helps the bearings to have sufficient contact forces to cause the bearings to roll rather than to slide (skidding). Proper preloading also increases the stiffness in the system and extends bearing life. Springs/wave washers are a common method to provide preloading, although solid preloading may also be used, especially in motors with lead-screw shafts built in. Designs that do not adequately preload the bearings often produce significant acoustical noise when the motor is rotating.

The shape of the spaces in the rotor and stator may also give rise to acoustical noise. Hybrid motors typically have sharp teeth on both the rotor and stator and small rotor-stator gaps. Full-step optimized step motors have matching tooth pitch for the rotor and stator (50:50 laminates), whereas microstepping optimized motors have different pitches (typically 48:50 or 52:50 laminates). Some brands of motors will fill in the rotor teeth gaps with epoxy prior to centerless grinding to minimize the noise generated as the rotor teeth pass the stator teeth. A similar effect may be seen with face magnet servomotors versus internal magnet (IPM) designs which have smooth outside diameters on the rotor.

Electronic Drive

The method of commutation and the way in which the drive controls the shape of the current and the rate-of-change of current can have significant effects on the noise levels generated. For servo systems, the control system tuning and damping can further help or hurt the acoustic noise in the system.

The nominal shape of the waveforms driving the motor can substantially affect the acoustical noise. For a 3-phase motor, 6-step commutation with a trapezoidal drive abruptly switches the current forward or reverse for a particular phase, with common drivers only limiting the rate of rise of current by the inductance of the winding and the applied voltage. A 12-step trapezoidal commutation technique adds a zero current step for each phase before reversing the direction of the current. For hybrid motors, the equivalents are full-stepping and half-stepping. The abrupt current changes give rise to acoustical noise both at the fundamental and at many harmonics of the commutation rate. The noise is not only caused by the previously mentioned magnetostriction effects and deformation of the case, but also by the sudden jerk (high rate of change of torque) associated with rapid changes in the winding current torquing the shaft, often with the resulting ringing each time the motor commutates to the next phase combination.

In the hybrid motor realm, there are microstep drives which more closely approximate a sine wave by adding many finer steps to the current waveform to reduce the magnitude of each step change. However, most of the drivers use a current control loop that

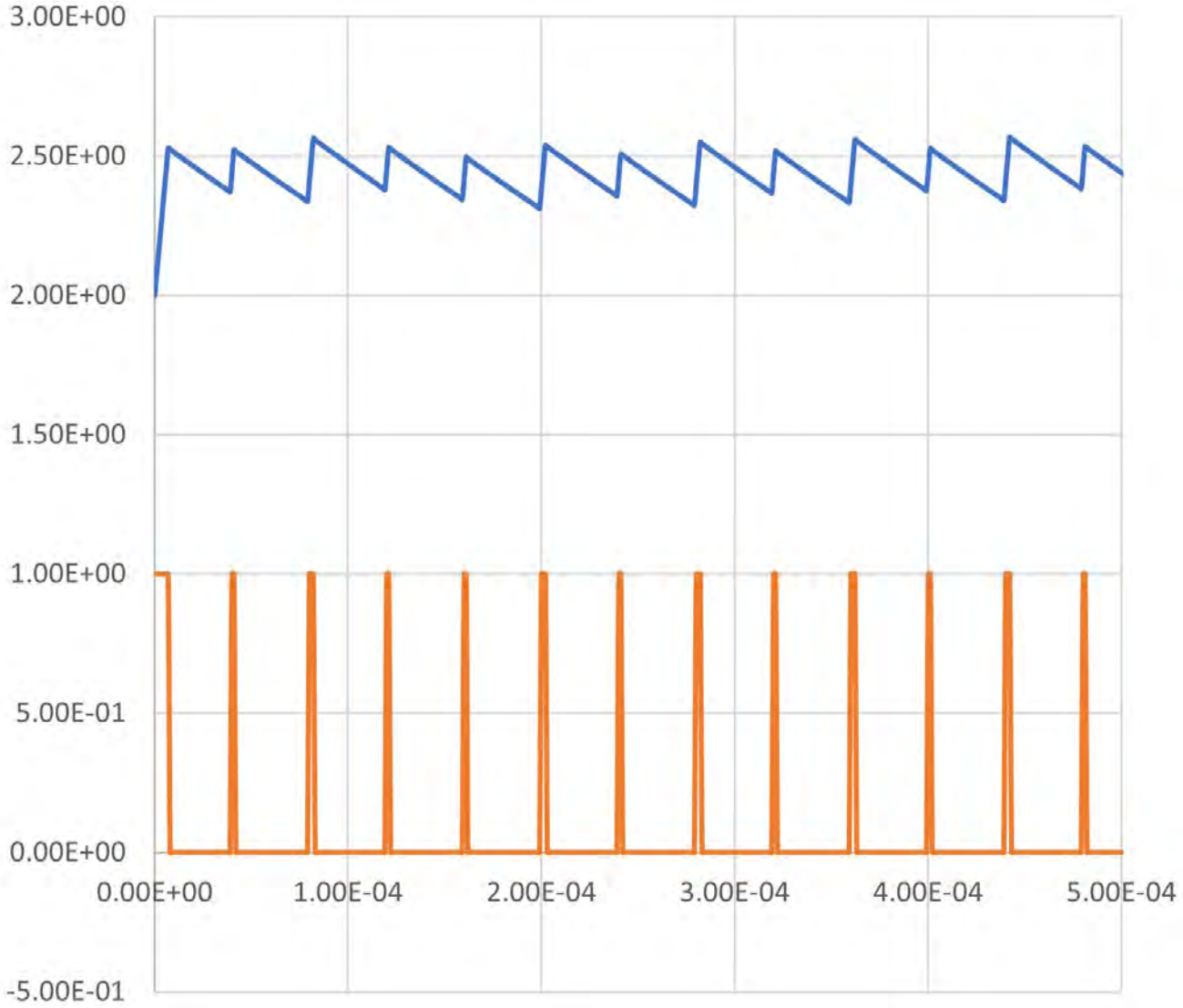


Figure 3 Subharmonic Oscillation
A shorter drive cycle results in more time in the decay portion of the cycle, requiring a longer drive cycle the following PWM cycle. That longer drive cycle results in a shorter decay portion, so the current starts higher and the following PWM cycle requires a shorter drive cycle. This results in a 10 kHz subharmonic which is audible even though the PWM is operating at 20 kHz.

still tries to achieve the next step in the minimum time possible, turning the driver full on until the next desired current plateau is attained. The conventional 3-phase brushless motors are similar with sinusoidal commutation. Note that the design of the motors for trapezoidal 3-phase operation are different than those for sinusoidal commutation, the former having back-EMF waveforms that are typically much squarer than the sinusoidal back-EMF waveforms associated with sinusoidal drive optimized motors. Hybrid motors, similarly, are optimized for either full stepping (50:50 laminates) or for microstepping (48:50 laminates or 50:52 laminates for the common 1.8-degree stepper). When plotting the back-EMF of phase A versus phase B, a full step (50:50 laminate) will plot as almost a square with slightly rounded corners, while a microstep optimized motor will plot as almost a perfect circle.

The noise level generated by a motor may be minimized by minimizing the rate of change of the current in the winding, making it a function of the motor speed, rather than having the current loop attempt to perfectly follow the square change with each new step on the microstep table. This may be done by altering the operation of the current control loop to also utilize a motor speed estimation such that at lower speeds, a lower rate of change is implemented, and saving the rapid changes for higher speeds where motor torque would suffer if the current were not changed at a sufficient rate.

Chopping Drives

Most modern drives use pulse width modulation (PWM) control to vary the currents in the motors. Most current control loops, for both hybrid motors and 3-phase brushless, are responsible for a couple of additional noise generation modes.

The first noise is called “sizzle” and is a caused by amplification of the noise from the measurement of the current being controlled. To minimize heating of the current sensing resistors, very low value resistors are typically used. The resulting voltage from the sensed current passing through the low value resistor is relatively low, so voltage gain must be set fairly high. The noise may be significant compared to the measurement, causing the control loop to

try to react to the perceived current rather than the actual current. The result is the current loop amplifies the measured noise, causing the motor to emit a hissing or sizzling noise.

The second noise related to the chopping drive is a squeal. Although it is common to operate the PWM drive at 20 kHz to 25 kHz, which is typically above human hearing, it is common to hear significant noise in the 6 to 10 kHz range, which is quite audible to humans. The cause of the noise is an instability called subharmonic oscillations. PWM drives for motors are typically operating as a form of buck converter, as the short-term average voltage needed at the winding to maintain a given current is commonly significantly less than the power supply voltage. It is common that these subharmonic oscillations occur at ½ or 1/3 of the chopping frequency, thus a 25 kHz chopper may easily produce significant noise at 12.5 kHz or 8.33 kHz, both of which are quite audible. There are many articles on subharmonic oscillations in buck converts that go into to significant detail, but here is a brief simplified discussion.

The PWM drive drives the winding either at the power supply voltage or shorts the winding or may drive the winding in the reverse direction with the power supply voltage (if the current is already too high). At the beginning of each PWM period, the driver determines if the measured current is higher or lower than commanded current. Assuming the motor is moving slowly or is stationary, the current will have generally decayed due to resistances in the transistors and windings, and the driver will need to turn "on" the drive for a period of time until the current measured again reaches the commanded current. The driver will then short the winding (regeneration mode) until the next PWM cycle begins.

To understand how the subharmonic oscillation sustains, assume this first cycle started with the current somewhat lower than average. The "on" time of the PWM will need to be longer than average to bring the current back up to the commanded level. The current will then decay until the next PWM cycle begins. Because the "on" time was longer than average, the decay time (recirculate mode) remaining for that PWM period must be shorter if the PWM frequency is constant. The shorter decay time will cause the starting current for the subsequent cycle to be higher than for the last cycle. The PWM on time will be shorter, as it does not take as much time for the measured current to reach the commanded current level before the driver goes again into recirculate mode. This means that more time will be spent in the recirculate mode for this cycle, resulting in a lower measured current at the start of the subsequent cycle. This long cycle, short cycle as described would be a second subharmonic, or would happen at half of the chopping frequency. By a similar process, you can also commonly cause a third subharmonic oscillation. The resulting periodic current variation causes an audible squeal (or "singing") which can be very irritating when exposed to it for a full work shift. The high frequency of this current variation generally makes motor a more effective speaker whereas very low frequency variations generate little noise.

A Smarter Current Loop

The rapid change in current at commutation, sizzle, and subharmonic oscillation may all be overcome by using a current estimator modeling the motor rather than directly measuring the motor current. The voltage applied to the motor, the motor inductance, the motor resistance, the motor back-EMF, and the motor speed and position may be used to estimate the current. The resulting current loop does not have sizzle, and does not have the subharmonic oscillation squeal, and may be further configured to limit the rate of change of current to only that required for the instantaneous motor speed.

Control Method

The motor noise may also be significantly affected by how the motor is controlled. An open loop step motor is typically driven at full current regardless of the load. The torque takes a step at each step or microstep change, resulting in a significant jerk at each transition. Both low speed resonances and mid speed resonances may create extra motion oscillations, resulting in significant acoustical noise. The magnetostriction and attraction forces are also maximized by using full current, again contributing to noisy operation. Servo control uses only the current needed to generate the desired motion. This minimizes both the current and the rate of change of the current. Electronic damping can further reduce the vibration of the load when rotating. When combined with a smart current loop, the motor acoustical noise can be greatly reduced.

Summary

The resulting motion, of both hybrid servomotors and 3-phase AC brushless servomotors—both using sinusoidal commutation—can be essentially silent operation up to a few hundred RPM. When testing one QuickSilver NEMA 17 frame hybrid servomotor, we used a sound meter that was designed to be used at a 5-foot distance for its calibrated measurement at only 3 inches (20x closer) in an attempt to get any sound to even register. As the sound energy halves for each doubling of distance (square law), so sensitivity doubles (~ 6 dB) for each halving of distance. We saw a meter reading of less than 50 db with the meter 20x closer than calibration distance, indicating the noise contributed by the motor was likely less than 24 dbA, virtually silent operating at a few hundred RPM.

PTE

Don Labriola, P.E.,
is President of QuickSilver Controls Inc., a producer of servomotors and controllers. (*quicksilvercontrols.com*).

Ball Bearing Thermal Speed Rating

Norm Parker, Stellantis

Hello folks, I hope all is well in bearing land. I had a chance to meet up with some old bearing pals over the weekend. We all worked in the same small bearing office at one time and had really developed a special relationship that is hard to find in a mega-complex corporate world headquarters. A few of us have left over the years, but we still all work together occasionally as customer/supplier. Even though we all work in different tiers of the business, we are all feeling the heat of the electrification revolution.

The expectations are high and workloads are substantial. We all understand that there is a backside to this mountain—one where there are not 10,000 engine part numbers, transmissions with four planetaries and clutches, no transfer case, independent axles, exhaust system, etc. With this potential massive part reduction, I have already seen two large, tapered bearing plants in the United States close with no replacement. Additionally, consolidation moves throughout the industry. The companies that supply traditional powertrain components are trying to pivot or prepare for the eventual diminishment—if not demise—of the 120-year-old model of building cars and trucks. This isn't going to happen overnight, but most real predictions see classic powertrain models at about 30 percent of today's numbers by 2030.

Today, we are not just talking about heat as a metaphor for workload, we are talking about physical heat generation in our bearings. We are going to talk about ISO 15312:2018 which discusses the thermal speed rating. Unlike the limiting speed we discussed last time, where we're concerned about the strength of the cage for high-speed dynamic, thermal speed ratings are focused on the ability to cool the bearing to maintain a steady temperature.

Physical heat generation plays an important role in bearing life and operation. Maintaining a steady temperature will be vital as the EV market grows in the future.

Different bearing catalogs have their own thermal speed rating formulas.

Thermal Speed Rating (from ISO 15312)

Inner ring or shaft washer rotational speed at which equilibrium is reached between the heat generated by the friction in the bearing and the heat flow emitted through the bearing seating (shaft and housing) under the reference conditions

Note 1 to entry: The thermal speed rating is one among various criteria which permit comparison of the different rolling bearing types and sizes with regard to their suitability for operation at high speed.

Note 2 to entry: Mechanical and kinematic criteria which could lead to further speed limitations are not taken into account by the thermal speed rating. (ISO 15312:2018(E), p2)

Literature from Schaeffler can be interpreted to have a different meaning, referring to the *thermal speed rating as an ancillary value to the thermally safe operating speed,* which is defined in DIN 732:2010.

The thermal speed rating $n_{\theta r}$ is used as an ancillary value when calculating the thermally safe operating speed n_{θ}. This is the speed at which, under defined reference conditions, a bearing operating temperature of +70°C is achieved.

The thermal speed rating is not a speed limit for the application of a bearing. It is primarily for the purpose of comparing the speed suitability of different bearing types under defined reference conditions.

*A speed limit taking account of the thermal balance can be calculated using the thermally safe operating speed. [*medias.schaeffler.us/en/speeds*]*

As I am going through these standards and bearing manufacturers' literature, I am finding different interpretations—or definitions—or both—between different sources. For instance, if you refer to the online catalog for Schaeffler's standard 6205 ball bearing; Limiting Speed: 19,600 rpm. Reference Speed: 14,400 rpm. Where SKF's similar 6205: Limiting Speed: 18,000 rpm, Reference Speed 28,000 rpm. Recall the limiting speed is that mechanical rating we discussed previously (which are reasonably close); however, it is obvious they are not referring to the same reference speed. Interestingly, SKF makes no definite statement about DIN 732 where Schaeffler does. I suspect these two standards play into part of this disconnect.

medias.schaeffler.us/en/product/rotary/rolling-and-plain-bearings/ball-bearings/deep-groove-ball-bearings/6205/p/354175

skf.com/group/products/rolling-bearings/ball-bearings/deep-groove-ball-bearings/productid-6205

The thermal speed rating is not a speed limit for the application of a bearing. It is primarily for the purpose of comparing the speed suitability of different bearing types under defined reference conditions.

If you are sufficiency confused, you are not alone. Let's just jump into some calculations and see if we can figure this mess out. I will stick with the 6205 (25x52x15 mm) as the reference for 15312.

To get started, there are some reference conditions to note.

- Operating temperature, or Reference temperature $\theta_r = 70°C$
- Ambient or external Reference temperature $\theta_{Ar} = 20°C$
- The applied load P_{1r} is five percent of the static load rating Cor. The SKF Cor is 7.8 kN. P_{1r}: 0.05 x 7.8 = 390 N
- A mineral oil *without* EP additives having the following kinematic viscosity v_r 12 mm^2/s at $\theta_r = 70°C$:
- Oil bath lubrication with an oil level up to the center of the rolling element in the lowest position.
- Size up to 1,000 mm bore
- Internal radial clearance N
- No contact seals

Let's start with the governing equation or work backwards. The thermal speed rating $n_{\theta r}$ is given as

$$\frac{\pi \cdot n_{\theta r}}{30 \cdot 10^3} \cdot \left[10^7 \cdot f_{0r} \cdot (v_r \cdot n_{\theta r})^{2/3} \cdot d_m^3 + f_{1r} \cdot P_{1r} \cdot d_m\right] = q_r \cdot A_r$$

Where:

$v_r = 12$ mm^2/s (reference condition)
d_m mean diameter = 1/2 (25+52)=38.5 mm
$d_m^3 = 38.5^3 = 57{,}066.63$ mm^3
f_{0r} - Coefficient for the load-independent frictional moment for the reference conditions
f_{1r} - Coefficient for the load-dependent frictional moment for the reference conditions
From Table A.1 for single row deep groove ball bearings dimension series 02
$f_{0r}=2$, $f_{1r}=0.0002$
$P_{1r}=390$N (reference condition)
q_r, reference heat flow density (Φ Reference heat flow W)

$$q_r = \frac{\Phi_r}{A_r}$$

Conveniently this is estimated for bearings under A_r 50,000 mm^2 as $q_r = 0.016$ W/mm^2
A_r heat emitting reference surface area
$A_r = \pi \cdot B(D+d)$
A_r (6205) $= \pi \cdot 15(52+15) = 3157.3$ mm^2

Plugging in the known values:

$$\frac{\pi \cdot n_{\theta r}}{30 \cdot 10^3} \cdot \left[10^{-7} \cdot 2 \cdot (12 \cdot n_{\theta r})^{2/3} \cdot 57066.63 + 0.0002 \cdot 390 \cdot 38.5\right] = 0.016 \cdot 3157.3$$

=

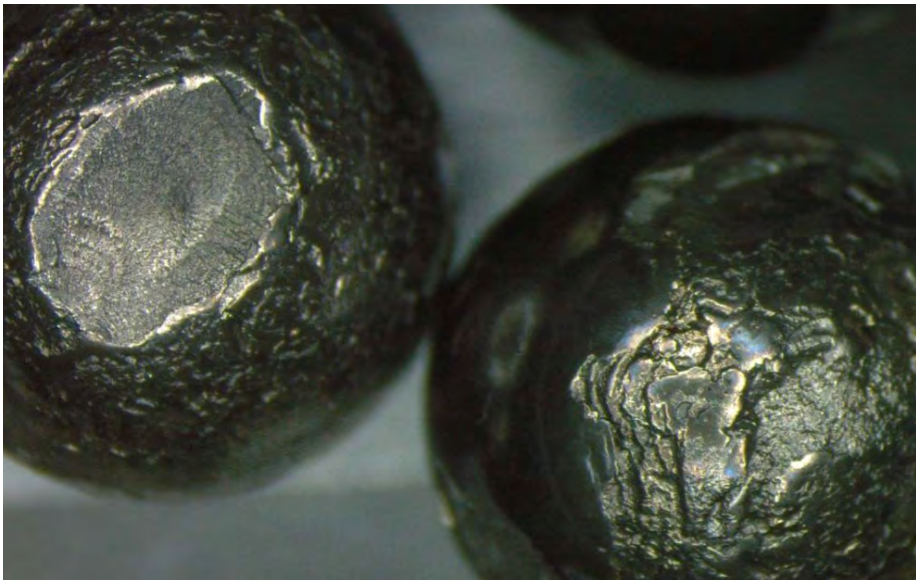
$$\frac{\pi \cdot n_{\theta r}}{30 \cdot 10^3} \cdot \left[0.0114 \cdot (12 \cdot n_{\theta r})^{2/3} + 3\right] = 50.52$$

(Hint: I had to break out the Ti89 numerical solver)
Which is: $n_{\theta r} = 13{,}300$ rpm.

Ok, so this is the thermal speed rating which is looking similar to Schaeffler's Reference Speed of 14,400 rpm (probably within rounding error) but nowhere close to SKF's 28,000 rpm reference speed. By this definition, this is the speed that would get you to 70°C from room temperature with no external heat with a very light load running in an oil bath. Recalling a line from earlier: The thermal speed rating is not a speed limit for the application of a bearing. It is primarily for the purpose of comparing the speed suitability of different bearing types under defined reference conditions.

We are going to have to leave this here for the next blog where we go into the DIN rating and compare several different suppliers limiting and reference speeds. The search for the true load rating is turning into quite the search, but we will get there!

PTE



Reference conditions are needed to determine the thermal speed rating for bearings.

Norm Parker is currently the Sr. Specialist Roller Bearings—Propulsion Systems at Stellantis. He's been contributing to *PTE*'s "Bearings with Norm" blog since 2014.

For Related Articles Search

bearings

at www.powertransmission.com

Validation of the Calculation of Dynamic Tooth Root Stresses

Moritz Zalfen

Introduction and Motivation

The development process for gear transmissions in the fields of electric mobility and turbomachinery is characterized by increasing requirements with regard to the transmitted power, the required installation space, and the operating conditions. On the one hand, the increasing electrification of powertrains is causing an increase in operating speed (Ref. 20). On the other hand, due to the high-efficiency requirements in aircraft engines, gearboxes with extremely high power requirements and operating speeds are used (Ref. 33). Due to the increasing speeds in the powertrain, the power transmitting components are loaded with a high number of load cycles and the load speed is increased Ref. 5). The gears used, achieve load cycles in the Very High Cycle Fatigue (VHCF) range with $10^7 < N_G < 10^8$ load cycles (Ref. 29). This can lead to a decrease in fatigue strength depending on the material and surface treatment (Refs. 6, 32). For gears in high-speed applications, methods for determining the remaining service life of a component in operation are necessary. On the one hand, the acquisition of condition data by means of suitable sensors for continuous monitoring is required. On the other hand, an intelligent evaluation of these data to assess the condition of the component must be developed. Crucial for a correct calculation is the material strength at the operating point and the real stresses in the high-speed range.

Investigations in materials engineering show that steels exhibit a pronounced dependence of the load-carrying capacity on the loading speed during plastic as well as elastic deformation (Refs. 1, 13, 24, 28, 31). The left part of Figure 1 shows the speed-dependent influences on the material stress and strength of the tooth root. On the one hand, variable, additional dynamic loads occur during operation due to the tooth excitation as a function of the rotational speed. These are taken into account in the load capacity calculation of the ISO 6336 using the speed-dependent dynamic factor K_V (Ref. 22). On the other hand, the increased speed leads to a significant increase of the strain rate in the tooth root, since the time interval of one gear mesh decreases while the maximum stress remains nearly constant. A classification of previous and future strain rates in gear applications in the state of the art shows that the strain rates in the tooth root of gears reach or exceed the values from the state of the art (Ref. 5). The investigation of the influence of the strain rate in the tooth root on the tooth root load capacity has not been carried out in the current state of the art.

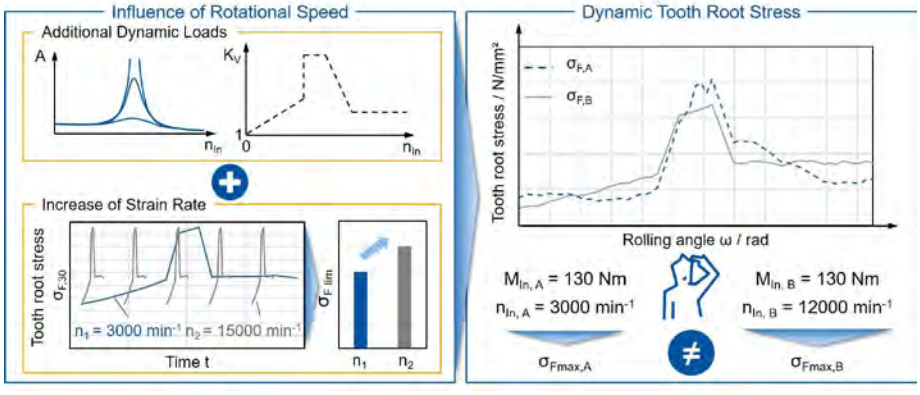


Figure 1 Speed influence on the fatigue strength.

The investigation of the strain rate influence on the tooth root load carrying capacity requires the consideration of different speeds in the test. The right part of Figure 1 shows the influence of the speed on the maximum tooth root stress in operation. Due to the speed-dependent tooth excitation, it is to be expected that the maximum tooth root stress will vary at different speeds as a result of the dynamics. Before determining the tooth root load carrying capacity in the test, it must therefore be ensured that the influence of the strain rate on the tooth root load carrying capacity is not superimposed by the influence of the dynamics and incorrect conclusions are drawn. A validated method for calculating the local and time-related tooth root stress at variable operating points, taking dynamics into account, is required to differentiate between these influences on the stress and strength in the tooth root.

State of the Art

Additional dynamic loads in gears result from internal and external excitations and have a significant influence on the load carrying capacity and service life of the gearing (Refs. 2, 22, 27, 34, 35). "Dynamic Tooth Loads" gives an overview of the relevant influencing variables on the vibration excitation and the previous work on the measurement of additional dynamic loads. "Standardized Calculation Approach for Dynamic Tooth Root Stresses" presents the calculation approach for dynamic additional loads according to ISO 6336. "Numerical Calculation Approaches" presents numerical methods for evaluating the vibration behavior.

Dynamic Tooth Loads

The varying tooth mesh stiffness, modified tooth flanks and external loads lead to a vibration excitation of the elastic drivetrain (Refs. 3, 25, 26, 30, 34,

35). During operation, this vibration excitation leads to additional dynamic loads which are superimposed on the load from the static torque. During the transition between the meshing areas at spur gears, e.g., from single to double tooth contact, there is a step in the tooth force due to the changed tooth stiffness (Refs. 17, 27). At high loads, the influence of a premature tooth mesh resulting from tooth deformation is also superimposed. The load magnification is maximal when the tooth mesh frequency coincides with the natural frequencies of the system (Refs. 3, 11, 19, 22, 23, 27, 30, 34, 35). In the case of these main resonances, the additional dynamic loads increase and can lead to premature failure of the gears. Flank form and pitch errors also lead to vibration excitation. The relative influence of the geometry deviations on the excitation is more pronounced for helical gears than for spur gears since the excitation caused by the stiffness variation is lower for helical gears due to the higher total overlap (Ref. 27).

The dynamic load increase due to the vibration excitation from the gear mesh has been investigated in numerous works on the basis of calculations and measurements. Bosch developed a model for calculating dynamic tooth loads taking into account the periodically varying tooth mesh stiffness for variable speeds (Ref. 3). The calculation results were confirmed by measurements of the dynamic tooth loads using strain gauges. Winkler carried out metrological investigations on the dynamic load of high-speed gears on a high-speed back-to-back test rig with up to n_{In} = 15,000 min^{-1} (Ref. 35). Based on the results of the investigations, Winkler developed a calculation model for quantifying the additional dynamic loads of spur and helical gears. Rettig carried out investigations on a back-to-back test rig up to $n_{In} \approx$ 6,000 min^{-1} on the pinion (Ref. 34). Based on the results of Rettig and Winkler, Rettig developed a simplified calculation method for determining the average additional dynamic loads in the sub- and supercritical speed range as well as the main resonance (Ref. 34). The corresponding calculation principles were later transferred to the standard calculation of DIN 3990 and serve as a basis for the calculation of the K_V factor of ISO 6336 nowadays (Refs. 10, 22).

Gold analyzed the gear stiffness and investigated the influence on the gear dynamics. The natural frequencies of multistage gears must be determined with the aid of a spatial computational model. Only in exceptional cases, e.g., low stiffness of the drive elements, the first natural frequency can be determined in a torsional vibration model. The results were confirmed by measurements of the radial and tangential vibration of the gear shafts (Ref. 19).

Gerber investigated the internal additional dynamic loads and the gear damping. A partial absorption of the vibration energy is caused by the damping in the drivetrain. Bearing friction, flow resistance and damping in the tooth contact play a role. The damping in the tooth contact is determined by the existing elastohydrodynamic conditions and is strongly dependent on the lubricant film properties. For conventional forged steels, material damping is negligible compared with lubricant damping. In this case, mesh geometry, velocity conditions and lubricant viscosity are the main influencing variables (Ref. 18).

Baud et al. used an electrical power circle test rig to investigate the additional dynamic loads. The simulation program for the calculation of the dynamic additional loads was successfully validated. The comparison between simulation and measurement shows that a detailed model taking into account all degrees of freedom is necessary for the correct calculation of the dynamic tooth root stress (Ref. 2).

Standardized Calculation Approach for Dynamic Tooth Root Stresses

The additional dynamic loads described can lead to premature failure of the gearing and to noise excitation during operation. In the standard ISO 6336, the influence of additional dynamic loads on the stress in the tooth root is taken into account by the K_V factor. Various methods with different degrees of abstraction are available for determining the K_V factor. Method A represents the most accurate variant, whereby the additional dynamic loads are determined on the basis of measurements or with the aid of validated simulation models (Ref. 22).

Method B makes it possible to estimate the additional dynamic loads without complex and expensive measurements and simulations. For this purpose, the gear stage is converted into a single-mass oscillator to enable classification with respect to the speed. A distinction is made between the four ranges shown in Figure 2. In the subcritical range, depending on the gear set, preresonances with corresponding local maxima can occur with regard to the additional loads. Method B assumes an additional load that increases linearly with the speed and approximates the actual additional loads. In the area of the main resonance, the additional load becomes maximum and is represented by a constant value. The transition region is characterized by a linear decrease of the additional load. In the supercritical region, the additional load is constant. The amounts of additional load are calculated separately for each range, taking into account the gear geometry (e.g., rotational inertia, meshing stiffness). Method C is based on method B and uses further simplifications (Ref. 22).

The described model approach of method B is often not sufficient, since the vibrations excite the entire drivetrain and thus influence the vibration amplitude and frequency. The course of the actual torque variation is approximated by a linear course of the K_V factor in the calculation according to ISO 6336. Drivetrain-dependent resonance points in the sub- and supercritical range are not taken into account. This can lead to critical resonance points not taken into account, especially in the case of multistage gearboxes and complex drivetrains (Ref. 22).

Numerical Calculation Approaches

Numerical calculation approaches enable the operating point-dependent calculation of the additional dynamic loads, taking into account the entire drivetrain and all resonance points. For an exact consideration of the dynamic tooth loads, the mapping of the entire system in six degrees of freedom (6 DOF) is necessary (Refs. 2, 19).

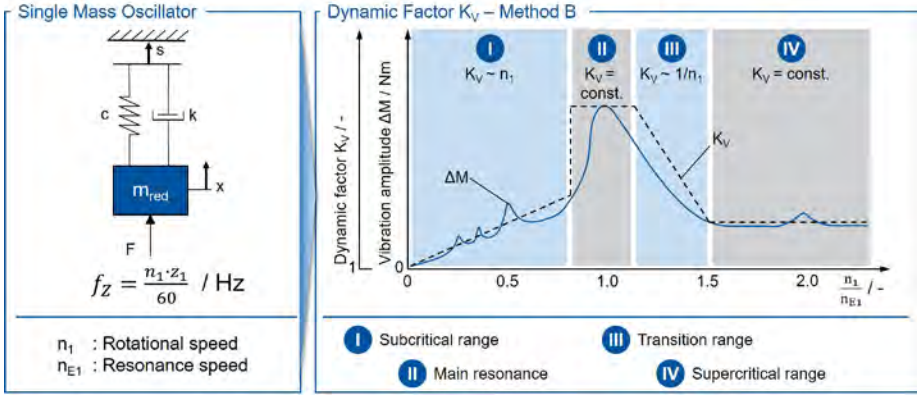


Figure 2 Estimation of the additional dynamic loads according to method B of ISO 6336 [ISO19].

Früh built a model for the representation of the gear excitation in the multibody simulation (MBS) and integrated it into an MBS model. The method was validated by means of experimental investigations on a gear test rig. It is shown that for the correct determination of the resonance points the detailed mapping of the tooth contact under consideration of misalignments and deformations is necessary (Ref. 14).

For the computational investigation of highly dynamic contact processes in gear sets, an FEM computational model exists, which allows the consideration of impact processes, but requires higher computation times than a quasistatic tooth contact analysis (Ref. 12). The program system DZP (Dynamic Tooth Load Program) allows the calculation of the dynamic load distribution of a single stage considering multidimensional rotational and translational degrees of freedom (Refs. 17, 21). In this case, the calculation of the tooth meshing stiffness is based on simplified analytical approaches.

With the MBS in connection with the force coupling element developed by Gacka and Carl, it is possible to simulatively map the dynamic excitation in the tooth meshing taking into account the drivetrain in the torsional degree of freedom (Refs. 7, 16). In this way, the dynamic tooth forces in all operating points can be calculated taking into account the drivetrain as well as the gear geometry.

Brecher et al. developed a method for the penetration calculation of curved tooth flanks, whose computational efficiency allows an application within the MBS. The method allows the consideration of the influence of displaced gears on the excitation behavior in the MBS. The method was successfully verified by means of a validated FE-based tooth contact analysis. The application of the method shows that manufacturing and load-induced misalignments have to be considered for the correct representation of the excitation behavior (Ref. 4).

Summarized, it can be stated that with the help of today's MBSs, the additional dynamic loads in operation can be quantified in detail as a function of the rotational speed. Depending on the selected discretization of the drivetrain, either the calculation of the maximum additional dynamic load or the progression of the additional dynamic load over a gear mesh is possible. Furthermore, it is also possible to consider the influence of modifications and deviations of the gear. Determining the course of the additional dynamic load over a complete tooth mesh enables the additional load to be converted into a dynamic tooth root stress. This has not been done before. With the aid of a validated method for calculating the dynamic tooth root stress, it is possible to take the influence of the dynamics directly into account when calculating the tooth root stress.

Objective and Approach

The state of the art shows that the speed-dependent dynamics have a significant influence on the stress in the tooth root. To determine the tooth root strength at different speeds, it is, therefore, necessary to calculate the tooth root stress taking into account the respective additional dynamic load in order to be able to separate the influences of the strain rate and the additional dynamic loads. MBS models offer the possibility of calculating the time-dependent load curves in detail, taking into account the individual vibration behavior of a powertrain. The tooth root stress can be calculated on the basis of the time-related load curves. Validation of the local and time-related tooth root stresses calculated in this way has not yet been carried out.

The aim of the report is to validate the calculation of the local, time-related tooth root stress curves. To this end, the tooth root stress is measured in operation using strain gauges and compared with the calculated values. In the first step, the test rig and the measurement setup and procedure for determining the tooth root strain in operation are presented. In the second step, the test setup is transferred to the *Simpack* MBS and the influence of the coupling stiffnesses on the tooth root stress in operation is evaluated. In the third step, the tooth root stresses calculated in *Simpack* are compared to the measured values in the area of quasistatics and dynamics, and the calculation of dynamic tooth root stresses in the MBS is validated. With the help of the validated calculation method, the tooth root stress occurring in operation at variable test speeds or at different test rigs can be evaluated and taken into account in the evaluation of the load capacity.

Test Rig and Measurement Setup

The measurement of the tooth root strain in operation and the conversion into the tooth root stress was carried out at the 30° tangent in the tooth root. For this purpose, a helical gear was equipped with a strain gauge and installed in a back-to-back test rig. The test gearing, the application of the strain gauge, the test setup and the test and evaluation procedure are explained below.

Test Gear and Strain Gauge Application

To investigate the tooth root stress, the gearing shown in Figure 3 with a center distance of a = 112.5 mm was

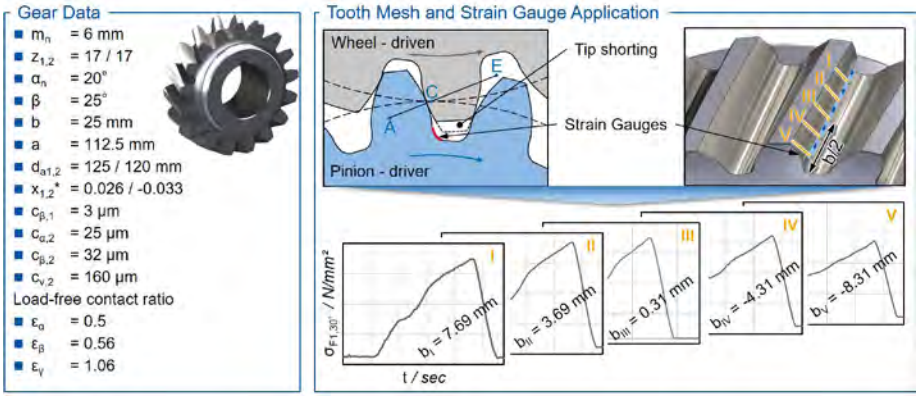


Figure 3 Test gear geometry and strain gauge application.

used. This was designed and manufactured within the framework of the IGF project 18085/N1 for the measurement of tooth root strain by means of strain gauges (SG) in quasistatic (Ref. 15). The relatively large normal module of m_n = 6 mm and the face width of b = 25 mm allow the application of a strain gauge chain with ten measuring points. This makes it possible to record the tooth root strain at different face width positions within one tooth mesh. The strain gauge chain was applied at the 30° tangent of the tooth root. The gear has a tip shortening of $k{\cdot}m_n$ = -2.5 mm. This is necessary to prevent damage to the strain gauges and the cabling in the root of the pinion. The pinion flank is modified with a lead crowning of $c_{\beta,1}$ = 3 µm. The gear is designed with a profile and lead crowning of $c_{\alpha,2}$ = 25 µm and $c_{\beta,2}$ = 32 µm. The manufacturing-induced twist is $c_{v,2}$ = 160 µm.

The tip shortening and modifications to the wheel result in a reduced load-free overall contact ratio of ε_γ = 1.03. At a torque of M_{In} = 238 Nm, the overall contact ratio increases to $\varepsilon\gamma$ = 1.24. Due to the low overall contact ratio for a helical gear, a pronounced single tooth contact area and an increased vibration excitation occur during operation. A spur gear with a number of teeth $z_{1,2}$ = 28, normal module m_n = 4 mm, and pressure angle α = 18° was used as a reference gear set. The overall contact ratio of the reference gear is ε_γ = 1.595.

The measurement signals were transmitted in the test rig with the aid of a slip ring transmitter. Since its size increases with the number of transmission channels, the number of evaluated measuring points in the tooth root was limited to five, see Figure 3. The strain gauge chain was applied in such a way that the third measuring point is located in the center of the tooth. The face width positions of the individual strain gauges measured after application are shown in Figure 3. The tooth mesh starts at measuring point I at the active tooth root diameter of the pinion.

Test Setup

The tooth root stress in operation was investigated on a back-to-back test rig according to DIN ISO 14635, see Figure 4 (Ref. 9). The test rig consists of a test gear set and a reference gear set, which are connected via a torque measuring shaft and a tension shaft with a clutch. By twisting the clutch, for example with the aid of a lever and weights, a torque can be generated in the power circle shown. The torque measuring shaft is used to measure the applied torque with calibrated strain gauges. The motor brings the test rig up to a defined rotational speed and only has to apply the losses of the gears, bearings, and seals. This makes this test concept very efficient since the drive power is only approx. 10% of the actual power in the power circle (Ref. 8).

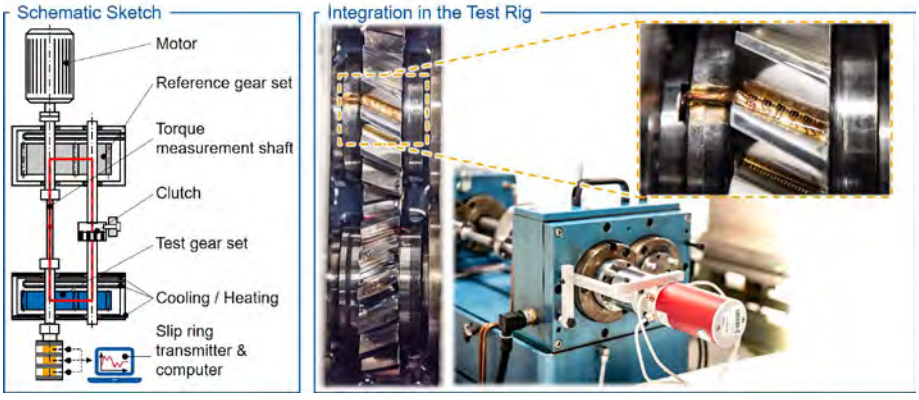


Figure 4 Test rig setup for the measurement of the tooth root strain.

The right part of Figure 4 shows the integration of the test gear into the test rig. The signal lines of the strain gauges on the pinion were led out of the test gear via a hollow shaft. By sealing the bore, the gearbox could be operated with splash lubrication. The slip ring transmitter was flanged to the end of the pinion shaft. The maximum test speed of the slip ring transmitter and thus of the entire test setup is limited to n_{In} = 2,000 min^{-1}. To measure the tooth root stress during operation, the test rig was tensioned to different defined torques, each torque was controlled by means of a torque measuring shaft and the tooth root stress was recorded at various constant speed levels.

Evaluation of the Strain Measurement

The measurement of the tooth root strain by means of strain gauges is carried out with the Wheatstone measuring bridge. Each strain gauge in the tooth root was supplemented with a supplementary resistor on the pinion shaft to form a half-bridge, see Figure 5. The voltage across the supplementary and strain gauge resistors was transmitted via the slip ring transmitter for each measuring point. With five measuring points and three signal lines per strain gauge, a total of 15 channels are required for transmission. The voltage signals were recorded using the *Labview* software from National Instruments and internally supplemented to form a full bridge. Based on the change in resistance and the proportional-

ity factor of the strain gauge chain, the strain at the strain gauge was calculated. For each time step, the strain was determined for the individual face width positions. In a subsequent step, the measured tooth root strain curves were converted into tooth root stress curves using Hooks law. Since the calculation methods of the quasistatic tooth contact analysis and the calculation methods in the MBS evaluate the tooth root stress over the pitch angle, it is necessary to transfer the measured data into the path domain for the comparison between calculation and measurement. For this purpose, the time steps of the measurement were converted into rolling angles using the formula shown in Figure 5. After the conversion, the tooth root stress related to the rolling angle for the face width positions is available.

Simulation Model for the Calculation of the Dynamic Tooth Root Stress

The test rig presented in "Test Setup" and the test gear set used were mapped in the *Simpack* MBS. In the following chapter, the topology and the model structure of the simulation model are described, the contact pattern under load from the tooth contact analysis is compared to the contact pattern from the test rig and the influence of modified tip stiffnesses and damping on the tooth root stress is evaluated.

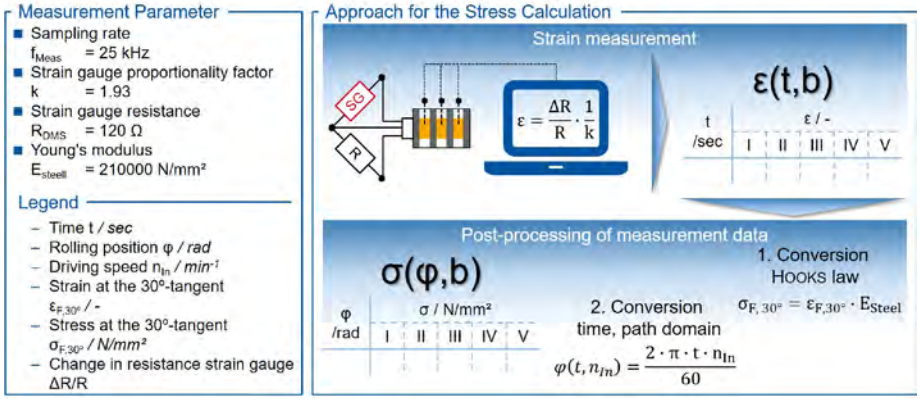


Figure 5 Conversion of the measured tooth root strain.

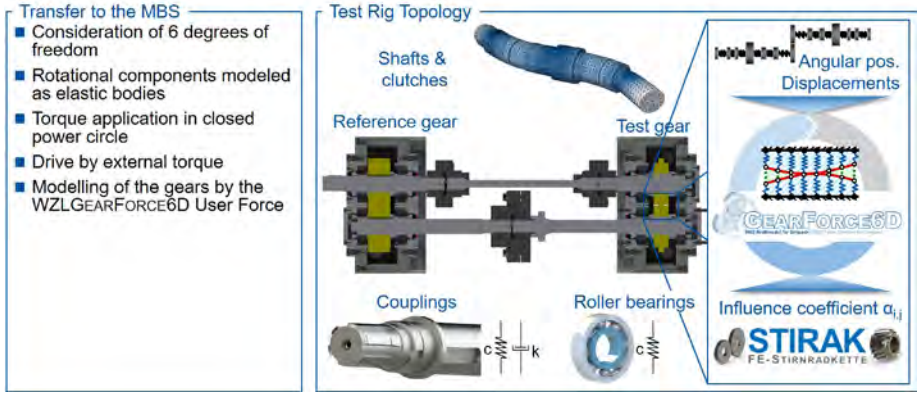


Figure 6 Transfer of the test rig to the MBS.

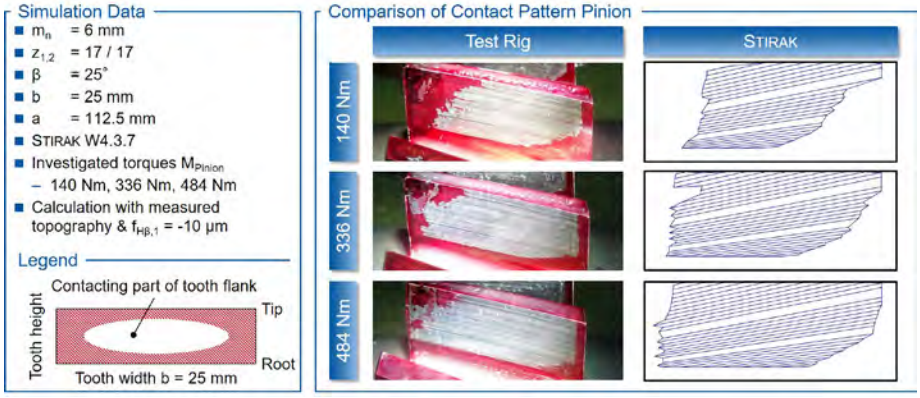


Figure 7 Comparison of contact patterns.

Topology and Model Design

The transfer of the test rig to MBS requires the simplification of the test rig. In the MBS, only rotating parts of the drivetrain are modeled. The shafts and couplings of the drivetrain are modeled as linear-elastic bodies with their eigenmodes. The test and reference gears are considered as rigid bodies. The dynamic excitation and vibration behavior of the gears is represented by the WZL *GearForce6D* user force, see Figure 6.

The dynamic tooth contact analysis *GearForce6D* was developed by Brecher et al. and is integrated into *Simpack* as a *Fortran* user force (Ref. 4). The calculation method uses the positions and rotation angles calculated by the MBS solver to completely define the contact conditions, see Figure 6. Based on these contact conditions, a penetration calculation is performed for the potential contact points. With the help of the previously calculated influence numbers and the penetrations, the spring model is solved, and the contact forces are converted to the gear centers. These forces and torques are finally transferred to the MBS solver (Ref. 4).

The coupling between gears and shafts as well as between shafts and clutches among each other is done with one degree of freedom in the direction of rotation. The coupling is parameterized as a torsion spring-damper element. The shafts are modeled with six degrees of freedom and constrained by the corresponding bearings. The bearing stiffness is calculated using the geometry data of the bearings in *Simpack*. The bearing damping is not taken into account. The load is applied by twisting the two clutch halves analogically to the real test rig. The angle of twist is adjusted iteratively until the desired torque is

achieved in the power circle. The operating speed is specified by applying an external torque at a defined speed.

Comparison of Contact Pattern

An initial comparison of the simulation model and the test rig is made on the basis of the contact pattern under load. For this purpose, the loaded pinion flank in the test rig was colored with contact pattern paint and the contact pattern was recorded at increasing torque levels. The calculated contact pattern was calculated using the *FE-Stirnradkette (Stirak)*. The results are compared in Figure 7. The drive torques M_{In} = 140, 336, and 483 Nm were considered.

The contact pattern in the test rig shows unloaded areas of the tooth flank at the top left and bottom right for all torques considered. These are due to the high amounts of profile and lead crowning as well as the twist. In addition, it can be assumed that there is a misalignment of the two gear axes in the test rig since the contact pattern is shifted to the right at low loads. It was not possible to measure the actual axes positions in the test rig.

The right part of Figure 7 shows the contact pattern of the *FE-Stirnradkette*. The calculation was performed taking into account the measured flank topography at the wheel. The manufacturing deviations at the pinion are < 5 µm and were therefore not taken into account.

The influence of the axes misalignment was approximated by a lead angle modification of $f_{H\beta,1}$ = –10 µm. The amount of correction was determined iteratively based on the contact pattern and tooth root stress at different width points. Also in the *FE-Stirnradkette*, the upper left and lower right regions of the tooth flank are not in contact. Furthermore, a shift of the contact pattern to the right-hand side can be seen. The contact patterns in the test rig and calculation agree to a good approximation. The deviations are due to the fact that the exact position of the axes relative to each other is unknown. The influence numbers required for the calculation using *GearForce6D* are determined on the basis of the microgeometry used for the comparison.

Influence of the Stiffness on the Dynamic Tooth Root Stress

The dynamic vibration behavior of powertrains is significantly influenced by the stiffnesses of the individual components and coupling points. The stiffnesses of the components, e.g., shafts, couplings and gears, are represented by elastic modeling. The stiffnesses and damping of the coupling points are specified by the user. Since uncertainties exist here, the influence of stiffness and damping on the tooth root stress at different speeds is considered. Figure 8 shows the calculated tooth root stresses from the multibody simulation (MBS) with rigid and elastic couplings. For the calculation of rigid couplings, the corresponding torsional degrees of freedom were constrained so that no relative torsion was possible. The elastic coupling points were modeled with a torsional stiffness of $c_{spline\ shaft}$ = 10^6 Nm/rad and $c_{feather\ key}$ = $5 \cdot 10^5$ Nm/rad as well as a torsional damping of k = 500 Nms/rad. The measuring points I and V are evaluated as examples.

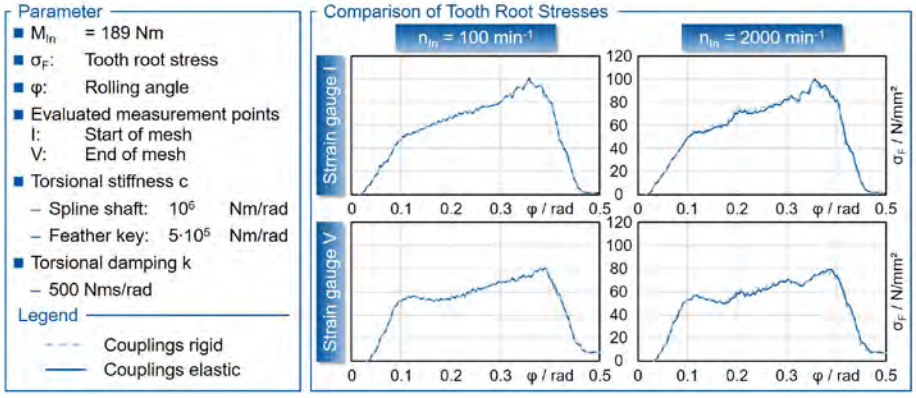


Figure 8 Impact of stiffness on the calculated tooth root stress.

At a quasistatic speed of $n_{In,1}$ = 100 min^{-1}, no significant influence of the coupling points on the calculated tooth root stress is discernible. At an increased rotational speed $n_{In,2}$ = 1,500 min^{-1}, an influence of the coupling points can be detected. However, the change in the tooth root stress is in the range of $\Delta\sigma_F$ < 2 %. Both operating points are outside the resonance points of the test setup. At resonance areas, a higher influence of the coupling points on the system behavior and the dynamic tooth root stress is to be expected. Since the test rig is not operated in the area of resonances, it can be assumed that the influence of stiffness and damping values that are not calculated exactly or determined experimentally on the calculated tooth root stress is negligibly small.

Comparison between Measured and Calculated Tooth Root Stresses

The comparison between measured and calculated tooth root stress is carried out in the area of quasistatics and in the area of dynamics. In quasistatics, the measured tooth root stress is compared to the calculated values of the MBS and the *FE-Stirnradkette (Stirak)*. In the area of dynamics, only the results from measurement (SG) and MBS calculation are compared. The tooth root stress of the respective measuring points from the calculation is interpolated using the face width positions presented in "Test Gear and Strain Gauge Application," since the resolution of the FE mesh does not match with the exact face width positions.

Quasistatic

Figure 9 shows the tooth root stresses from the measurement (SG), the MBS and the *FE-Stirnradkette* for the measuring points I, II, IV and V. The measuring point III is not considered, since an increased measurement noise occurred here due to a defect in the measurement chain of the strain gauge.

The calculated tooth root stresses from the MBS and the *FE-Stirnradkette* agree with regard to course and maximum value for all measuring points.

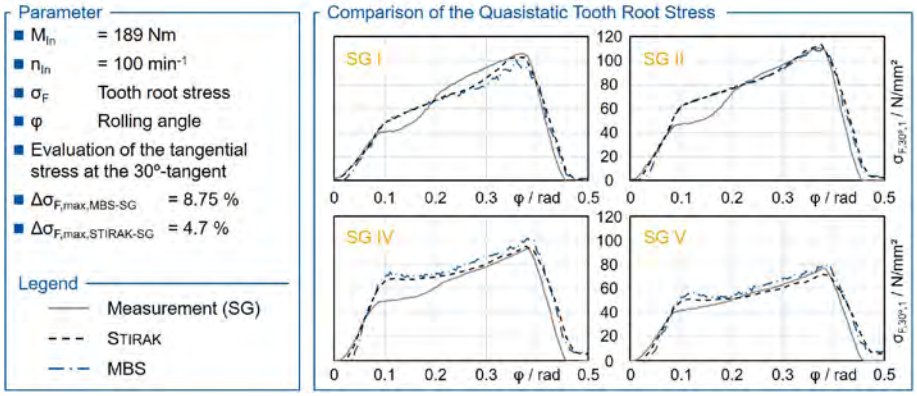


Figure 9 Comparison of the calculated and measured tooth root stress in quasistatics.

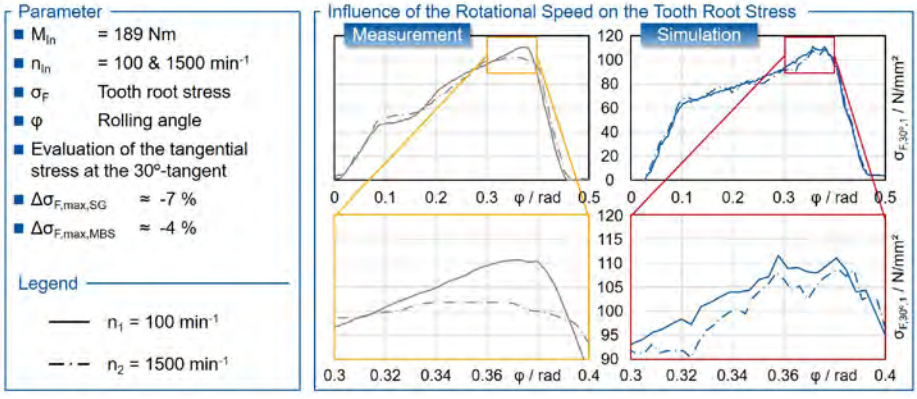


Figure 10 Comparison of calculated and measured tooth root stress at variable speeds.

This was to be expected, since the MBS method has already been verified using the *FE-Stirnradkette* and the point clouds of the gear teeth used are identical. Differences occur between the calculated and measured tooth root stresses. In particular, at the beginning of tooth mesh between 0.2 rad < φ < 0.3 rad, the calculated tooth root stresses increase faster than in the measurement. In the area of maximum tooth root stress in the range 0.3 rad < φ < 0.4 rad, the measured and calculated values converge. The maximum deviation of all measurement points at the maximum tooth root stress is between MBS and measurement $\sigma_{F,max,MBS-SG}$ = 8.75 N/mm² and between *FE-Stirnradkette* and measurement $\sigma_{F,max,Stirak-SG}$ = 4.7 N/mm². These deviations are $\Delta\sigma_F$ < 10% and thus represent a high level of agreement. The existing deviations are due to deviations of the strain gauge position in the profile direction, axis deviations in the test rig not taken into account and measurement uncertainties in the strain gauge measurement.

Influence of the Rotational Speed

The influence of the rotational speed on the dynamic tooth root stress in measurement and MBS is shown in Figure 10. The upper diagrams show the tooth root stresses at the speeds n_1 = 100 min^{-1} and n_2 = 1,500 min^{-1} over the tooth mesh for the measuring point II. The measurement shows that the tooth root stress increases at the increased speed n_2 in the region of the start of mesh at φ = 0.1 rad and decreases in the region of the maximum tooth root stress at φ = 0.35 rad. The tooth root stress of the MBS simulation also shows a similar curve.

The lower diagrams show the section of the maximum tooth root stress at 0.3 rad < φ < 0.4 rad. The measured tooth root stresses decrease by approximately $\Delta\sigma_{Meas.}$ = 8.8 N/mm² or $\Delta_{Meas.} \approx 7\%$ due to the dynamics. This can be explained by the subcritical operation points from the measurements. Only in the main resonance the excitation of the drivetrain, which corresponds to maximum tooth root stress, and the additional dynamic load occur at the same moment. In the MBS, the effect is less pronounced with a decrease of $\Delta\sigma_{MBS}$ = 5 N/mm² or $\Delta_{MBS} \approx 4\%$. The fundamental influence of the rotational speed on the dynamic tooth root stress is represented by the MBS. The differences can be attributed, among other things, to the fact that in the measurement, imbalances, pitch errors, and radial runout have an influence on the vibration behavior. These influences are not yet mapped in the MBS.

Summary and Outlook

The investigation of the strain rate influence on the tooth root load capacity requires the consideration of different speeds in the test. Due to the speed-dependent excitation, it is to be expected that the maximum tooth root stress will be different at different speeds due to the dynamics. Before determining the tooth root load capacity in the test, it must therefore be ensured that the influence of the strain rate on the tooth root load capacity is not superimposed by the influence of the dynamics. In order to differentiate between these influences on the stress and load capacity in the tooth root, a validated method for calculating the local and time-related tooth root stress at variable operating points, taking dynamics into account, is required.

The aim of the report is to validate the calculation of the local, time-related tooth root stress curves. For this purpose, the tooth root stress is measured in operation with the help of strain gauges and compared with the calculated values. In the first step, the test rig as well as the measurement setup and procedure for determining the tooth root stress in operation are presented. In the second step, the test setup is transferred to the multibody simulation *Simpack* and the influence of the coupling stiffness on the tooth root stress in operation is evaluated. In the third step, the tooth root stresses calculated in *Simpack* are compared with the measured values in the area of quasistatics and dynamics and the calculation of dynamic tooth root stresses in the multibody simulation is validated.

The measurement of the tooth root stress in operation was carried out with the help of strain gauges in the tooth root on a back-to-back test rig. The transmission of the measurement signals was carried out by a slip ring transmitter, which limited the maximum speed of the test set-up to n_{In} = 2,000 min^{-1}. The real position of the strain gauges in the tooth root was measured and taken into account in the evaluation of the calculated tooth root stresses. The measured strain in the tooth root in the time domain is converted into a tooth root stress in the path domain.

The test setup is transferred to the multibody simulation *Simpack*. There, the shafts and couplings are modeled as elastic bodies with their eigenmodes. The coupling points, e.g., between gear and shaft or between coupling and shaft, are modeled by torsion-spring-damper elements. The gears and their characteristic excitation are represented by GearForce6D. This also enables the calculation of the dynamic tooth root stress taking into account the dynamic displacements and loads. The comparison of the contact patterns under different loads does not show any significant differences between test rig and simulation. The coupling parameters torsional stiffness and torsional damping have no significant influence on the calculated maximum tooth root stress and the course over the mesh at the operating points considered outside the resonance points.

The quasistatic comparison between the measured tooth root stresses and those calculated in the *FE-Stirnradkette* and the MBS at n_{In} = 100 min^{-1} shows a high level of agreement in the area of the maximum tooth root stress. In the dynamic range at n_{In} = 1,500 min^{-1}, the measurement shows an increase in the tooth root stress in the area of the mesh start and a decrease at the maximum tooth root stress compared to the quasistatic case. The tooth root stress calculated in the MBS also reproduces this effect. However, the decrease of the maximum tooth root stress in the MBS with $\Delta_{MBS} \approx$ -4% is about half as large as in the measurement with $\Delta_{Meas.} \approx$ -7%. This is due, among other things, to imbalances, pitch and runout errors that are not taken into account in the MBS.

The results of the analyses show a high level of agreement between the calculated and measured tooth root stresses, both in quasistatic and dynamic operation. The calculation of the dynamic tooth root stress with the help of the MBS was successfully validated. *GearForce6D* can be used for the simulation of different test rigs or operating points to investigate the strain rate influence and enables the quantitative evaluation of the speed influence on the maximum tooth root stress at the operating point. The next step is the investigation of the strain rate dependency of the tooth root fatigue strength of gears regarding different operating speeds.

Acknowledgement

The authors gratefully acknowledge financial support by the German Research Foundation (DFG) [Ref.-Nr. DFG EXC2023/1—B1.II], the WZL Gear Research Circle and the Clean Sky 2 JU (Ref. No. 831832) within the Horizon 2020 Programme of the European Commission for the achievement of the project results. **PTE**

For Related Articles Search
tooth root stress
at www.powertransmission.com

Moritz Zalfen is a research assistant in the Gear Department of the Laboratory of Machine Tools and Production Engineering (WZL) of RWTH Aachen University and group leader of the gear power density group. His research focus is the load-carrying capacity of the tooth root and the influence of dynamics on the gear load capacity. Zalfen studied mechanical engineering at RWTH Aachen University and has a master´s degree in automotive engineering and transport.

References

1. Bathias, C.; Paris, P.: Gigacycle fatigue in mechanical practice. New York: Marcel Dekker, 2005.
2. Baud, S.; Velex, P.: Static and Dynamic Tooth Loading in Spur and Helical Geared Systems-Experiments and Model Validation. In: J. Mech. Des., 124. Jg., 2002, Nr. 2, S. 334–346.
3. Bosch, M.: Über das dynamische Verhalten von Stirnradgetrieben unter besonderer Berücksichtigung der Verzahnungsgenauigkeit. Diss. RWTH Aachen University, 1965.
4. Brecher, C.; Brimmers, J.; Westphal, C.: Einfluss der dynamischen Lastverteilung in Zahnkontakten auf das Systemverhalten. In: Tagungsband zum Dresdner Maschinenelemente Kolloquium DMK 2019 Dresdner Maschinenelemente Kolloquium DMK 2019. Dresden, 26–27 November 2019, S. 353–372.
5. Brecher, C.; Brimmers, J.; Trippe, M.: Einfluss der Dehnrate auf die Tragfähigkeit bei Hochdrehzahlanwendungen. In: Tagungsband zum Dresdner Maschinenelemente Kolloquium DMK 2019 Dresdner Maschinenelemente Kolloquium DMK 2019. Dresden, 26–27 November 2019, S. 321–341.
6. Bretl, N.: Einflüsse auf die Zahnfußtragfähigkeit einsatzgehärteter Zahnräder im Bereich hoher Lastspielzahlen. Aachen: Shaker, 2011.
7. Carl, C.: Gehörbezogene Analyse und Synthese der vibroakustischen Geräuschanregung von Verzahnungen. Diss. RWTH Aachen University, 2014.
8. Ciulli, E.: Experimental rigs for testing components of advanced industrial applications. In: Friction, 7. Jg., 2019, Nr. 1, S. 59–73.
9. Norm DIN 14635-1 (2006) Zahnräder—FZG-Prüfverfahren—Teil 1.
10. 1Norm DIN 3990 Teil 1 (Dezember 1987) Tragfähigkeitsberechnung von Stirnrädern. Einführung und allgemeine Einflußfaktoren.
11. Donath, B.: Berechnung der inneren dynamischen Zahnkräfte ein- und zweiflankiger Zylinderradgetriebe mit Schrägverzahnung. Diss. TU Dresden, 1983.
12. Eberhard P.; Ziegler P.: Berechnung von dynamischen Spannungen und Kontaktkräften ind. Abschlussbericht zum Forschungsvorhaben FVA-Nr. 950, Heft 927, Forschungsvereinigung Antriebstechnik e.V., Frankfurt a.M., 2011.
13. Emde, T.: Mechanisches Verhalten metallischer Werkstoffe über weite Bereiche der Dehnung, der Dehnrate und der Temperatur. Diss. RWTH Aachen University, 2009.
14. Früh, P.: Dynamik von Zahnradgetrieben. Modellbildung, Simulation und experimentelle Analyse. Diss. Universität Rostock, 2008 7–18 WZL Conference USA.
15. Forschungsvereinigung Antriebstechnik e.V.: Abschlussbericht Lokale Biegewechseltragfähigkeit. Lokale Zahnfußtragfähigkeit von Stirnrädern bei Biegewechsellast, Heft 1280, Forschungsvereinigung Antriebstechnik e.V., Frankfurt am Main, 2018.
16. Gacka, A.: Entwicklung einer Methode zur Abbildung der dynamischen Zahneingriffsverhältnisse von Stirn- und Kegelradsätzen. Diss. RWTH Aachen University, 2013.
17. Geiser, H.: Grundlagen zur Beurteilung des Schwingungsverhaltens von Stirnrädern. Diss. TU München, 2002.
18. Gerber, H.: Innere dynamische Zusatzkräfte bei Stirnradgetrieben. Modellbildung, Innere Anregung und Dämpfung. Diss. TU München, 1984.
19. Gold, P.: Statisches und dynamisches Verhalten mehrstufiger Zahnradgetriebe. Diss. RWTH Aachen University, 1979.
20. Gwinner, P.: Schwingungsarme Achsgetriebe elektromechanischer Antriebsstränge. Auslegung schwingungsarmer Stirnradverzahnungen für den automobilen Einsatz in hochdrehenden, elektrisch angetriebenen Achsgetrieben. Diss. Technische Universität München (TUM), 2017.
21. Heider, M.: Schwingungsverhalten von Zahnradgetrieben. Beurteilung und Optimierung des Schwingungsverhaltens von Stirnrad und Planetengetrieben. Diss. TU München, 2012.
22. Norm ISO 6336 Teil 1 (November 2019) Calculation of load capacity of spur and helical gears.
23. Linke, H.: Untersuchungen zur Ermittlung dynamischer Zahnkräfte von einstufigen Stirnradgetrieben mit Geradverzahnung. Diss. TU Dresden, 1969.
24. Mayer, H.: Fatigue crack growth and threshold measurements at very high frequencies. In: Int. Mater. Rev., 44. Jg., 1999, Nr. 1, S. 1–34.
25. Möllers, W.: Parametererregte Schwingungen in einstufigen Zylinderradgetrieben. Einfluß von Verzahnungsabweichungen und Verzah nungssteifigkeitsspektren. Diss. RWTH Aachen University, 1982.
26. Müller, R.: Schwingungs- und Geräuschanregung bei Stirnradgetrieben. Diss. TU München, 1991 Dynamic Tooth Root Stresses 7–19.
27. Niemann, G.; Winter, H.: Maschinenelemente. Band 2: Getriebe allgemein, Zahnradgetriebe - Grundlagen, Stirnradgetriebe. Bd. Nr. 2, 2. Aufl. Berlin: Springer, 2003.
28. Nonaka, I.; Setowaki, S.; Ichikawa, Y.: Effect of load frequency on high cycle fatigue strength of bullet train axle steel. In: Int. J. Fatigue, 60. Jg., 2013, S. 43–47.
29. Pyttel, B.; Schwerdt, D.; Berger, C.: Very high cycle fatigue—Is there a fatigue limit? In: Int. J. Fatigue, 33. Jg., 2011, Nr. 1, S. 49–58.
30. Rettig, H.: Dynamische Zahnkraft. Dissertation Technische Hochschule München, 1957.
31. Schneider, N.; Pyttel, B.; Berger, C.; Oechsner, M.: Influence of Frequency and Testing Technique on the Fatigue Behaviour of Quenched and Tempered Steel in the VHCF-Regime. In: Adv. Mater. Res., 891–892. Jg., 2014, S. 1430–1435.
32. Schurer, S.: Einfluss nichtmetallischer Einschlüsse in hochreinen Werkstoffen auf die Zahnfußtragfähigkeit. Diss. Technische Universität München (TUM), 2016.
33. Felix Stoffels: Rolls-Royce sucht beim Triebwerk den Quantensprung. *https://www.aerotelegraph.com/rolls-royce-getriebe-triebwerk-power-gearbox-was-ist-eigentlich-der-ultrafan* [Stand: 03.03.2020].
34. Weck, M.; Winter, H.; Winkler, A.; Rettig, H.: Innere dynamische Zusatzkräfte an Zahngetrieben. 1. Abschlussbericht zum Forschungsvorhaben FVA-Nr. 7, Heft 22, Forschungsvereinigung Antriebstechnik e.V., Frankfurt a.M., 1975.
35. Winkler, A.: Über das dynamische Verhalten schnellaufender Zylinderradgetriebe. Diss. RWTH Aachen University, 1975.

cti symposium

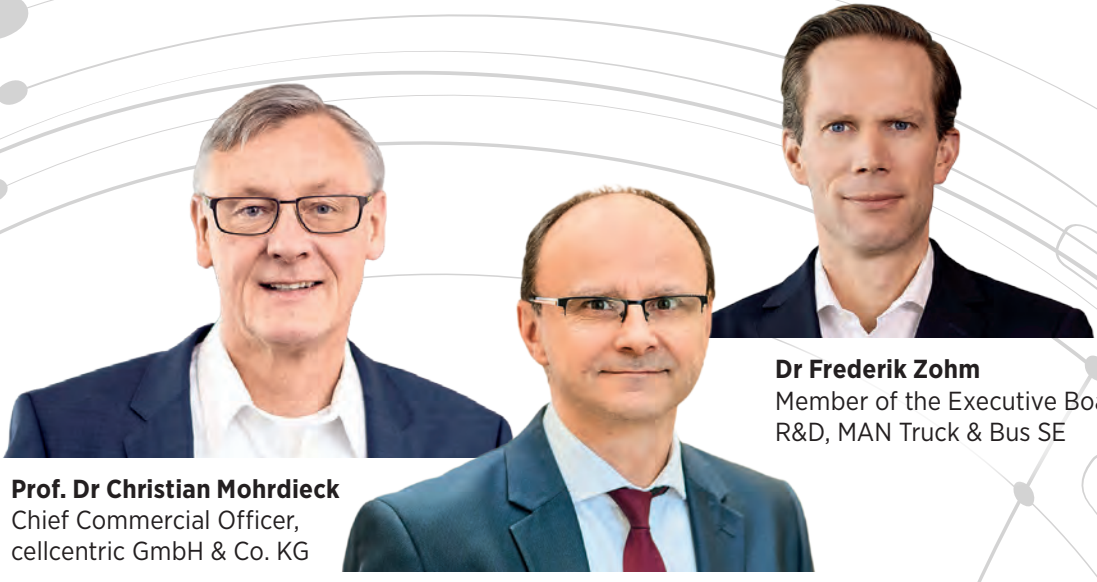
AUTOMOTIVE DRIVETRAINS
INTELLIGENT
ELECTRIFIED

International Congress and Expo I Estrel Hotel Berlin, Germany

5 December 2022	Introductory Seminar
6 - 7 December 2022	Main Programme & Exhibition
8 December 2022	CTI Test Drive

LIVE IN BERLIN

Keeping Pace During The Transformation Towards Electric Mobility



Prof. Dr Christian Mohrdieck
Chief Commercial Officer,
cellcentric GmbH & Co. KG

Dr Frederik Zohm
Member of the Executive Board,
R&D, MAN Truck & Bus SE

Gerald Killmann
Senior Vice President Purchasing
and R&D, Toyota Motor Europe

Detailed programme at
www.drivetrain-symposium.world/de
#cti_sym

ABB

TO ACQUIRE SIEMENS LOW VOLTAGE NEMA MOTOR BUSINESS

ABB recently announced it has signed an agreement to purchase Siemens' low voltage NEMA motor business. With manufacturing operations in Guadalajara, Mexico, this acquisition provides a well-regarded product portfolio, a longstanding North American customer base, and an experienced operations, sales, and management team. The business employs around 600 people and generated revenues of approximately $63 million in 2021. Financial terms of the transaction were not disclosed. The transaction is expected to close in the second quarter of 2023.

This transaction is part of the Motion business area's profitable growth strategy, and it will allow the NEMA motors division to enhance its product offering, expand its supply chain relationships, and improve support to its North American customer base. It also offers the opportunity to better support the customers in Mexico with local manufacturing and sales. ABB expects to benefit from identified synergies, and to use the R&D expertise, supply chain relationships, and market access to bring the combined portfolio to its full potential.

"This bolt-on acquisition creates strong value for ABB's NEMA motors division," said Tarak Mehta, president, ABB Motion. "Investing in the business and opening up sales opportunities in North America and especially Mexico will allow this business to be margin accretive to the ABB Motion business within 24 months."

"We have long appreciated the quality and design of these motors," Jesse Henson, president, ABB's NEMA motors division, added. "Now that we have met the leadership team behind them, I am even more confident that together we can grow our combined businesses faster than either of us could alone. We look forward to adding the Siemens low voltage NEMA motor portfolio to our existing offering of ABB and Baldor-Reliance industrial electric motors."

abb.com

Global Shop Solutions

CELEBRATES MICHELLE BROWN'S ANNIVERSARY

Global Shop Solutions, a provider of ERP software for manufacturers in nearly 30 industries, is proud to celebrate 10 years of dedicated service from Michelle Brown, project manager for the company's U.K. office.

Brown launched her career as an ERP specialist working for an aerospace company in the US where she implemented Global Shop Solutions' ERP software and oversaw its use and development for three years. When she decided to move back to her native country, Global Shop Solutions hired her to launch their new U.K. operations, which also serves Ireland, Europe, and Africa. She soon began overseeing implementations for new customers and quickly advanced to operations consultant and project manager. Brown also led the way in building an international team with the experience, expertise, and knowledge to support customers in Global Shops Solutions' growing European markets.

"Michelle is a perfect fit for our U.K. operations because she knows our ERP system inside and out," says Dusty Alexander, president and CEO of Global Shop Solutions. "She's an expert in manufacturing, quality, implementation, sales, customer care, and much more. Her friendly smile and 'get it done' attitude make her a favorite of customers and employees. And she listens to customers in a way that makes them feel heard and appreciated. We knew we were getting someone special when we hired Michelle, but she has exceeded our expectations."

As U.K. Project Manager, Brown oversees new ERP implementation strategies, schedules training for new customers, assists with change management, and works closely with new customers to ensure a successful ERP implementation. With current customers, she performs operational checks and assists them in implementing more sophisticated ERP capabilities to continuously improve their manufacturing and increase ROI.

globalshopsolutions.com

Timken

ANNOUNCES NEW EXECUTIVE APPOINTMENTS

The Timken Company recently announced new appointments for company executives Christopher Coughlin, Andreas Roellgen, and Natasha Pollock.

"Our long-term strategy has been successful, and as a result, Timken has grown and evolved into a leading diversified industrial company with a broad portfolio of products," said Richard G. Kyle, president and CEO. "We are focused

on accelerating the expansion of our portfolio to achieve greater scale, profitably, and today's leadership announcement will enable Timken's next phase of growth."

Christopher Coughlin has been named executive vice president and president of Industrial Motion. The Industrial Motion group includes Timken's diverse portfolio of solutions adjacent to bearings, including automatic lubrication, linear motion, drive systems, belts and chain, couplings, clutches and brakes, and industrial services. In this role, Coughlin will build on Timken's engineered bearing leadership by continuing to diversify and grow industrial motion offerings to serve customers' future needs. A seasoned Timken executive, Coughlin has diversified the company's business through organic growth initiatives, product innovation and strategic M&A. He previously led Timken's global engineered bearings business and the company's expansive growth in renewable energy. Coughlin joined Timken in 1984.

Andreas Roellgen has been named executive vice president and president of Engineered Bearings. Roellgen is responsible for the leadership and profitable growth of Timken's global Engineered Bearings business, which operates across 42 countries and serves a diverse industrial end-market mix and customer base. Most recently, Roellgen led the company's strategy to grow its global market share across Europe, Asia and Africa and is credited for significantly expanding Timken's position in China and India. Roellgen began his Timken career in 1997 and has held bearing business leadership roles in sales, manufacturing, supply chain, strategy and business development.

With the above changes, Hans Landin, group vice president, will be leaving the company. "We appreciate Hans' many contributions to the company over his 25-year career," said Kyle. "His strong sales and commercial background and customer-centric approach were instrumental in advancing Timken's strategy, and we wish him the best in his future endeavors."

Natasha Pollock, vice president of human resources, has been appointed an executive officer by The Timken Company board of directors. Pollock will continue to advance Timken as an employer of choice that attracts, engages and develops a world-class team of problem solvers. Since joining Timken in 2001, Pollock enabled the company's geographic expansion through her development of global HR strategy, talent and culture. Pollock is accomplished in leadership and talent development, complex organizational change management, employee engagement, and workplace diversity and inclusion.

timken.com

Steyr

WINS RED DOT DESIGN AWARD FOR HYBRID DRIVETRAIN

Steyr, a regional agricultural brand of CNH Industrial, has been awarded the 2022 Red Dot Design Award in the Design Concept category for its Hybrid Drivetrain—a hybrid diesel-electric drive system conceived to power lightweight, high-horsepower tractors.

The Steyr Hybrid Drivetrain was entered into the Design Concept category, for design concepts and prototypes. As a winner in this class, the Hybrid Drivetrain will feature in the next edition of the Red Dot Design Yearbook and be showcased in the winners' area of the *red-dot.org* website. It follows the Steyr Terrus CVT tractor, which previously won the Red Dot Design Award in the Product Design category.

The Hybrid Drivetrain can provide fuel savings averaging eight percent while delivering higher levels of performance in the field and on the road, offering enormous efficiency savings that will benefit both tractor owners and the environment. While still only a concept study it has many features that will enhance future Steyr tractors.

red-dot.org
steyr-traktoren.com

Motion

ANNOUNCES SENIOR VICE PRESIDENT APPOINTMENT

Motion Industries, Inc. is pleased to announce that Lisa Solomon has been promoted to senior vice president—corporate accounts.

Solomon joined the company in 2015 as a business development manager focused on an automotive industry account, before transitioning the same year into an automotive specialist role concentrating on a different automotive account. In 2016, she expanded her role to a corporate accounts manager overseeing the entire automotive segment. In 2021, Solomon was promoted to area vice president—corporate accounts, leading a team of 16 sales professionals in the Central Group.

In her new role, Solomon will lead all of Motion's corporate accounts in North America, plus other company teams, including the Corporate Accounts Support group, Corporate Accounts Development, P2 MRO, Onsite Solutions, Energy Services, and International Sales. She will report directly to James Howe, executive vice president—e-commerce, sales excellence, strategic pricing, and corporate accounts.

"Lisa has been very successful in the area vice president role and has emerged as a peer leader for our AVPs across North America," said Howe. "Her leadership and significant experience will further strengthen corporate accounts and maximize growth potential. She is well deserving of her new and expanded position."

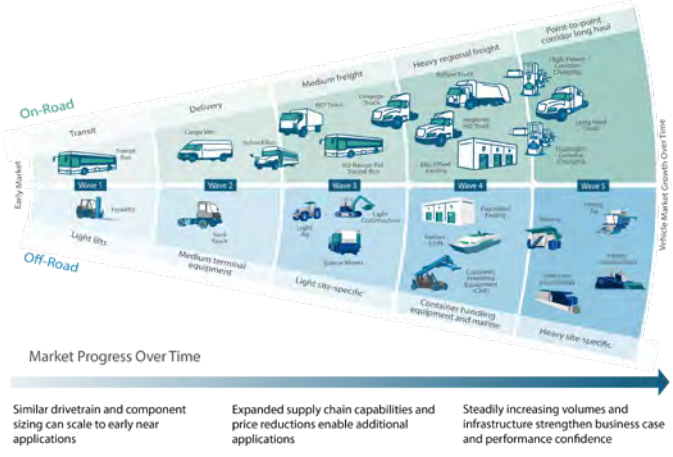
Motion's President, Randy Breaux, said, "Lisa is a talented executive with a wealth of experience and drive. We're excited to see her lead Motion's corporate accounts to new heights."

Originally from Michigan, Solomon graduated from Central Michigan University with a Bachelor of Liberal Arts in broadcasting, communications, and marketing.

motion.com

California CORE

EXPANDS SECTORS TO HELP REDUCE EMISSIONS



The California Air Resources Board (CARB) recently opened the second round of its Clean Off-Road Equipment Voucher Incentive Project (CORE), providing point-of-sale discounts on off-road zero-emission equipment. The project is administered by CALSTART and has $125M in funding available, more than double the amount allocated to the project when it first launched in January 2020. Originally only for freight, in 2022, CORE is expanding to include funding for the commercial harbor craft and agriculture and construction sectors.

Participation in the project has been streamlined for ease of use, and key elements include:

- Qualified participants will receive vouchers for point-of-sale discounts on off-road zero-emission equipment, up to a maximum of $500,000 per voucher
- There is no requirement to "scrap," sell, or retire existing equipment
- Additional funding may be available for charging/refueling infrastructure, equipment operated in disadvantaged communities, and small businesses

"California is backing up its commitment to clean the air in overburdened communities and carry out the direction of the Governor's Executive Order with a significant investment in zero-emission vehicles and sustainable transportation," CARB Deputy Executive Officer Craig Segall said. "CORE is specifically designed to assist industry sectors that currently use off-road equipment and can help clean up the communities hardest hit by air pollution."

"The streamlined process incorporates feedback from program participants, and we are anticipating significant interest in this second round," said Niki Okuk, deputy director at CALSTART. "The industry is continuing its transition to zero-emissions and CORE provides a clear market signal that helps bring new products to the market."

CORE supports the following nine equipment categories: On- and off-road terminal tractors, truck- and trailer-mounted transport refrigeration units (TRUs), large forklifts and cargo-handling equipment, airport ground-support equipment, railcar movers and switcher locomotives, mobile power units (MPUs) and mobile shore-power cable management systems, construction equipment, agricultural equipment, and commercial harbor craft

The first round of CORE resulted in over 460 vouchers for vehicles and electric vehicle supply equipment totaling over $62 million, with terminal tractors being the most requested equipment type.

CORE is part of California Climate Investments, a statewide initiative that puts billions of Cap-and-Trade dollars to work reducing greenhouse gas emissions, strengthening the economy, improving public health and the environment, and providing meaningful benefits to the most disadvantaged communities, low-income communities, and low-income households.

calstart.org

Kollmorgen

COLLABORATES WITH VANDERLANDE FOR AGV TECHNOLOGY

Vanderlande has selected Kollmorgen NDC Solutions as a technology and service partner for their automated guided vehicle (AGV) applications. Based on Toyota Material Handling forklifts equipped with the Kollmorgen NDC Solutions technology, Vanderlande aims to strengthen and grow their portfolio of complete logistic and warehouse solutions.

Vanderlande offers future-proof logistic process automation in the warehousing, airports, and parcel sectors. Its extensive portfolio of integrated solutions—innovative systems, intelligent software, and life-cycle services—results in the realization of fast, reliable, and efficient automation technology.

"Vanderlande and Kollmorgen share a very similar mindset. We both have a long history of advanced, industrialized, and proven automation solutions—with reliability, collaboration and the relentless strive for end-user success being our common cornerstones. We are convinced that this collaboration will drive strong growth for Vanderlande and Kollmorgen—but above all for our end-users," says Tobias Byfeldt, vice president, Kollmorgen AGV.

"Vanderlande strives to deliver the best fully integrated autonomous vehicle (AV) offering as part of our solutions for our warehousing, parcel, and airport customers. With this collaboration we are confident that by combining our expertise and solutions we can jointly deliver and continuously develop better AV solutions," adds Daan Stikkel, general manager AV Vanderlande.

kollmorgen.com
vanderlande.com

Smalley

WINS GM SUPPLIER QUALITY EXCELLENCE AWARD FOR 10TH CONSECUTIVE YEAR

Smalley received the 2021 General Motors Supplier Quality Excellence Award for the 10th consecutive year.

The award, which was created in 2012, is given to specific top-performing suppliers that have met or exceeded a stringent set of quality performance criteria. Smalley has now won the award every year since its inception.

"To win the award every year since it was created is a testament to our manufacturing, engineering, and quality teams and our company as a whole. We always put our customers and quality first," said Blanca Gerue, quality systems manager.

smalley.com/quality

SKF

ANNOUNCES SENIOR VICE PRESIDENT APPOINTMENT

SKF announces the appointment of Annika Ölme as CTO and senior vice president, technology development.

Ölme joins SKF from SAAB Radar Solutions, where she is CTO and head of engineering. She has also been managing director of Arcam, a subsidiary of General Electric. Between 2002-2017, Ölme held various positions within SKF.

She has a Master of Science in Electrical Engineering from Chalmers University of Technology and a Master of Business Administration from Waikato University.

Rickard Gustafson, president and CEO, says: "I'm happy to welcome Annika back to SKF and look forward to working with her as we continue to strengthen our technology development efforts for traditional and future applications around the rotating shaft."

She will join SKF in October.

skf.com

Velo3D

ANNOUNCES HERMEUS ACQUISITION OF SAPPHIRE PRINTERS FOR AEROSPACE APPLICATIONS

Velo3D, Inc. has announced Hermeus, a company developing hypersonic aircraft for defense and commercial applications, has acquired an original Sapphire and a large-format Sapphire XC that is designed for high-volume production. The printers, both of which will be calibrated for Inconel 718, will be used to build parts for Hermeus' Chimera engine and Quarterhorse aircraft.

"Metal additive manufacturing is a core component of our plan to vertically integrate production," said Glenn Case, CTO at Hermeus. "As we explore the capabilities of Velo3D's additive manufacturing technology, we'll be looking for ways to increase performance, consolidate components, reduce weight of our aircraft, and minimize external dependencies."

Hermeus was founded in 2018 to radically accelerate air travel with hypersonic aircraft. The company is an up-and-coming superstar in the aviation industry with more than $130 million in funding, including a $100 million Series B and contracts with the US Air Force. It also has strong support from NASA and other US government agencies as well as funding from aerospace innovators like RTX Ventures, the venture capital group of Raytheon Technologies.

The Chimera engine is a turbine-based combined cycle engine that will power Hermeus' first aircraft, Quarterhorse, an autonomous aircraft designed to touch high Mach speeds and prove reusability. Quarterhorse's first flight is planned for 2023.

"Hypersonics is an extremely challenging subset of the aviation industry and at the speeds that Hermeus will achieve, temperature, vibration, and aerodynamics play major factors in the flight of the aircraft," said Benny Buller, Velo3D CEO and founder. "There are not many teams with the deep experience in hypersonics, aviation, and space flight that Hermeus has, and we're truly honored to provide Sapphire printers to help them achieve their goals. I have no doubt that they will bring their vision to life and make hypersonic commercial flight a reality."

Velo3D's metal additive manufacturing technology has seen extensive adoption in the hypersonics and NewSpace industries due to its ability to build the complex, mission-critical parts engineers need without compromising design, quality, or performance. Customers can print existing designs without the need to design the parts for additive manufacturing or obtain specialized training. The company's solution also helps teams iterate on designs more quickly and greatly simplify supply chains.

velo3d.com

November 2–3—ATX Minneapolis

Innovation in automation starts here. Discover and collaborate on automation solutions that are revolutionizing the entire production lifecycle—from design to production to market—and sharpen your competitive edge. It's all available at ATX Minneapolis—part of Advanced Manufacturing Minneapolis. ATX Minneapolis is the sourcing home for hundreds of different types of suppliers. From accessories to assembly, it has everything, and more, under one roof. Topics include automation, 3D printing, robotics, assembly, manufacturing equipment and motion control. Exhibitors include Ametek, FANUC, Faulhaber Micromo, IKO International, maxon, and more. The show is colocated with MD&M, MinnPack, D&M and Plastec.

powertransmission.com/events/916-atx-minneapolis

November 16–18—Data Centre World Paris

The way in which we construct and work with data centers is in constant evolution. It is essential that we're able to adapt to the increasing digitalization of the economy and that we can meet the world's needs. Data centers are the cornerstones of our digital economy and Data Centre World Paris will give attendees the guidance, inspiration, and knowledge they need to navigate the latest technologies and evaluate how they meet the needs of today's market. At Data Centre World Paris, you will find a plethora of tools at your fingertips to help you optimize your data centre and anticipate its evolution. Join the largest trade show in France dedicated to the industry, meet the sector's expert suppliers, and discover the latest innovations. Case studies, panel discussions and specialist presentations will help develop your infrastructures and meet the challenges of tomorrow. Make the most of this opportunity to network with your peers and be inspired by renowned experts and speakers in the data field.

powertransmission.com/events/914-date-centre-world-paris

December 5–8—CTI Symposium Berlin 2022

CTI Symposium Berlin starts with two introductory days dealing with the basics and practice of automotive transmissions, hybrid, and electric drives for newcomers and those who want to refresh their knowledge. This is followed by the main program with keynote speeches, panel discussions and technical presentations. This includes the exchange of experiences, R&D results, and opinions with leading representatives of automobile manufacturers, suppliers, engineering consultants as well as officials. The Symposium offers active discussion of the latest technologies and strategies on automotive transmissions and HEV & EV drives for passenger cars and commercial vehicles. CTI Test Drives are available to experience automotive transmissions and drives in practice.

powertransmission.com/events/910-cti-symposium-berlin-2022

January 23–27—SciTech 2023

From its creation in 1963, the American Institute of Aeronautics and Astronautics (AIAA) has organized conferences to serve the aerospace profession as part of its core mission. Spanning over 70 technical discipline areas, AIAA's conferences provide scientists, engineers, and technologists the opportunity to present and disseminate their work in structured technical paper and poster sessions, learn about new technologies and advances from other presenters, further their professional development, and expand their professional networks that furthers their work. Focus areas include science and technology, aviation, space, propulsion, and energy/defense. The 2023 SciTech forum will be a hybrid event which will include both in-person and virtual components, offering attendees the flexibility and choice of how to participate.

powertransmission.com/events/911-scitech-2023

February 21–23—PowerGen International 2023

PowerGen is the largest network and business hub for electricity generators and solution providers engaged in power generation. Power producers, utilities, EPCs, consultants, OEMs, and large-scale energy users gather at PowerGen International to discover new solutions as large, centralized power generation business models evolve into cleaner and more sustainable energy sources. This year-round platform of digital education, current and breaking industry news, thought leadership articles, quality matched meetings, and industry-leading live events provide a hub for power generation professionals to learn and network. The exhibition and conference examine the clean energy transition through digitalization, decarbonization, and efficiency while continuing to feature unparalleled opportunities in equipment and manufacturing.

powertransmission.com/events/909-powergen-international-2023

BROWSE OUR BLOGS!

PTE features blogs to keep readers updated on the latest PT trends, technologies and industry solutions:

Bearing with Norm: After a several-years hiatus, we're pleased to welcome back our bearings blogger, Norm Parker.

Revolutions: Our editorial staff provides relevant and timely articles on a variety of PT industrial topics.

VISIT

www.powertransmission.com/blog/

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*

Power Transmission Engineering®

FREE SUBSCRIPTION

22PTEALL

Please Respond

Your response ensures that we deliver the magazine only to those who want it. It also gives us the vital information we need to serve you best.

☐ **YES** I want to receive/continue to receive ***Power Transmission Engineering***

☐ **NO** Thanks anyway, but I don't need the world's best publication on mechanical components.

Name _____ **Job Title** _____
(please print)

Signature _____ **Date** _____
(required)

How would you like to receive *Power Transmission Engineering?*

☐ PRINT Version (Verify mailing info below)
☐ DIGITAL Version (E-mail required)
☐ BOTH Print AND Digital (E-mail required)

E-mail _____
**You can OPT OUT of your e-mail subscription at any time.*

How is THIS 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?
_____

MAILING INFORMATION

NAME:
JOB TITLE:
COMPANY:
ADDRESS:
☐ Check if this is a home address
CITY:
STATE/Province:
ZIP/Postal Code:
PHONE:
FAX:

Put your business card here!

Mail to:
1840 Jarvis Ave., Elk Grove Village, IL 60007 USA

or

FAX to 1-847-437-6618
SCAN to: *subscribe@powertransmission.com*

Production May Vary

DeLorean gets back to the future with Alpha5 EV

Aaron Fagan, Senior Editor

It can't be easy starting a new car company let alone bringing back an old one that ended almost as soon as it began. The original DeLorean Motor Company (DMC) headed by John DeLorean went spectacularly bankrupt in 1982 due to issues of quality among other things. Yet DeLorean once said, "It's inevitable that the company come back," and despite many attempts by various parties to revive the company over the years, DMC is now back to the future of automobiles deep in the heart of Texas. The San Antonio–based company is partnering with Volkswagen-backed Italdesign—which helped develop the iconic DMC-12—to build the Alpha5. The new electric vehicle will retain some of the hallmark design features, such as rear-window louvers and gullwing doors.

Although John DeLorean is perhaps most remembered for the car *Back to the Future* made famous, in the early 1960s he was Detroit's golden child. As chief engineer at Pontiac, he transformed the division from a practical and conservative carmaker into a vanguard of muscle by dropping a 6.4-liter V8 engine into a Pontiac Tempest, and thus, the GTO was born, one of the most legendary cars of all time.

However, ironically, when launching out on his own—production of his namesake car began in Northern Ireland in 1981—drivers voiced their dismay from the get-go. While the DMC-12 looked amazing, anyone who drove one quickly discovered how woefully slow they were. The engine produced a scant 130 hp and the stainless-steel paneling that gave it such a singular appearance was so heavy it could only travel indolently from 0–60 in 10.5 seconds.

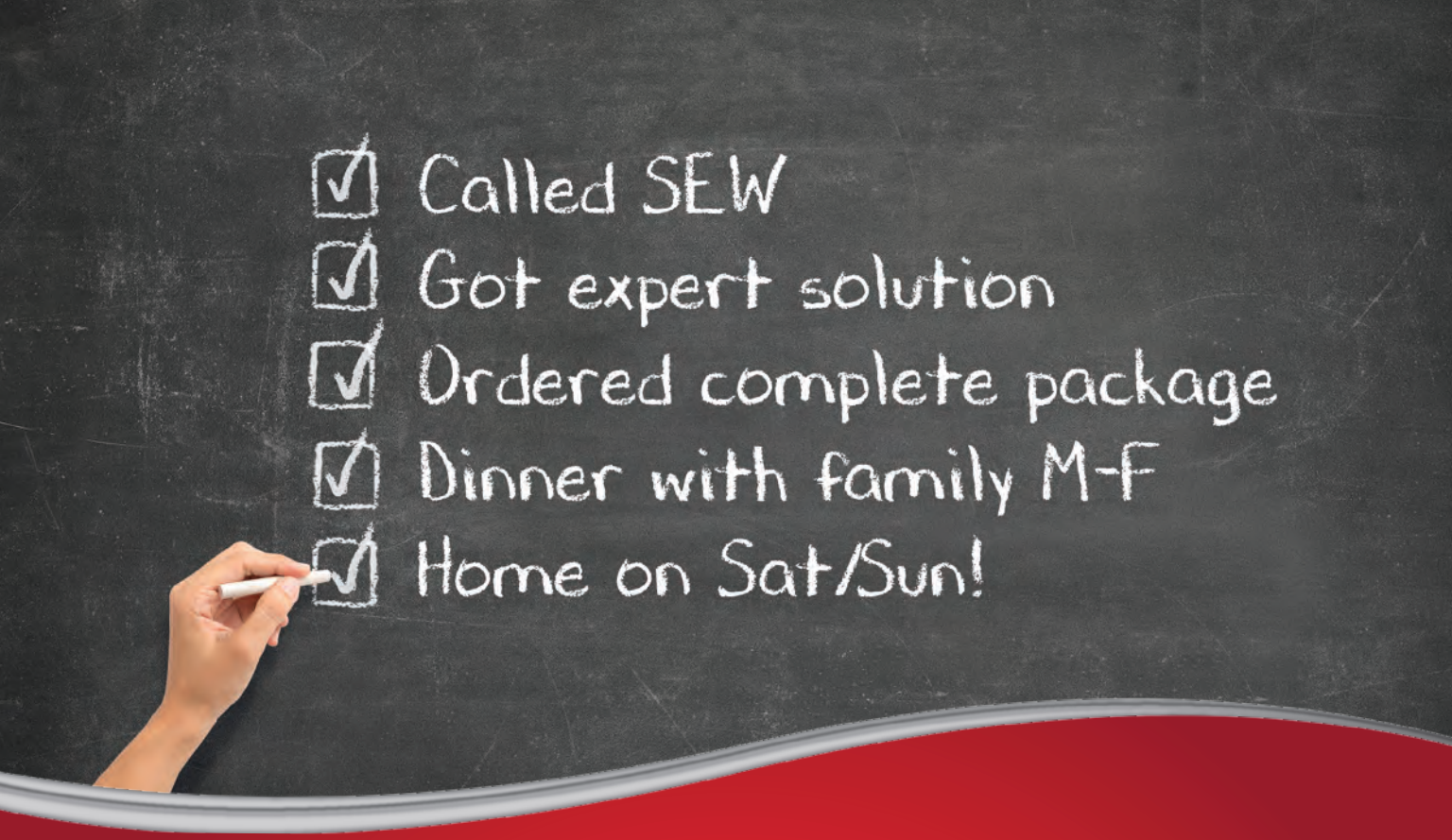
Low performance wasn't all. The gullwing doors would stick, the stainless-steel body was impossible to keep clean, and even the dye from the floor mats would bleed out of the fabric. In other words, the car was a nightmare inside, out, and under the hood. Absent a market for slow, expensive, and undependable cars, DeLorean ceased production after just three model years.

There are a lot of asterisks surrounding the performance and design of the forthcoming DeLorean Alpha5, but time will tell. According to their website, "Actual production vehicle performance may differ slightly. Some range and charge times are preliminary manufacturer estimates based on the EPA test cycle and are not official EPA values. All official EPA values are noted. Vehicle range varies with conditions including weather, driving behavior, vehicle condition and load, and battery age."

To be sure, the company indicates the car goes from 0–88 mph in 4.35 seconds, which of course is the speed required to activate a flux capacitor were one to equip the Alpha5 for time travel. And no need for plutonium from the corner drugstore or to be outfitted with a Mr. Fusion Home Energy Reactor for the 1.21 "jigowatts," the Alpha5 has a 100-kWh battery with a 300-mile range.

While no DMC factory has been selected, the company announced that only 9,531 of the Alpha5 will be made, exactly one more than DeLorean built of the DMC-12. CNET estimates a price of around $125,000. The Alpha5 premiered at Pebble Beach Concours d'Elegance Award ramp on August 18 and the Concept Lawn on August 21 and was publicly revealed on August 29, 2022. DeLorean expects Alpha5 to be in production sometime in 2024. The number 88 is also the initial number of EV units planned for production, which will apparently be tied to NFTs in some way. As I said, it can't be easy starting a new car company. If that is all too much gimmick for you, there is always the 1:64 scale version available from Hot Wheels, but like the full-scale version, Mattel, too, warns, "Production items may vary from the photos shown."

PTE



Honey, I'm home!

Tired of working nights and weekends on motion control projects? It's time to contact an automation specialist at SEW-EURODRIVE for help.

We provide a **complete package** from start to finish, including project planning, software, components, commissioning, troubleshooting, and worldwide support.

Get your free time back!

SEW EURODRIVE

— Driving the World —

seweurodrive.com | 864-439-7537

Robust Precision You Can Rely On

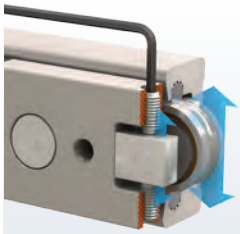
Now with 5 Wheel, 4 Wheel, and 3 Wheel Carriages

Increased Moment Load Capacity
Increased Radial and Axial Load Capacity
Increased Design Flexibility

Where two carriages might have been needed, now one can carry the load, saving space and cost.

Redi-Rail Advantages

Precision straight rails and hardened gothic arch rollers are ideal for high speed and moderate load linear motion.



Patented side adjusted preload simplifies assembly and installation.

Double row bearings sealed against contamination and maintenance free.

Rails are integrated with hardened steel races to ensure strength within a lightweight design.

Request Your FREE Sample

bit.ly/redirailPTE2022

PBC Linear™

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