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JUNE 2023

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High-Precision Brushless DC Rotary Motors for Pick-and-Place Robots
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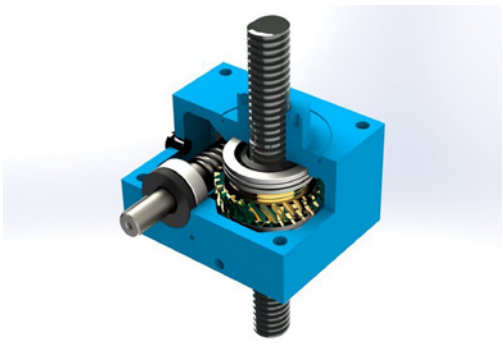

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FEATURE ARTICLES

TECHNICAL ARTICLES

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Power Transmission Engineering
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PTE Extras

Planetary Gear Rethought

Designers of robotics and automation solutions are often faced with a choice: cycloid or planetary gears? In the last few decades, the answer has often been cycloidal drives. But the planetary gears have caught up and are now superior in many ways. The Hamelin company Schaeffler Ultra Precision Drives (previously Melior Motion) has revolutionized the planetary gear and with its PSC series, produces extremely precise, quiet, and durable drive units.

powertransmission.com/blogs/1-revolutions/post/9212-planetary-gear-rethought

Conversations at Hannover Messe

Organizations like Flender, R+W, Bosch Rexroth and SEW-Eurodrive offered a variety of new products and technologies during Hannover Messe 2023. The following online article looks at some of the key developments that took place during Hannover Messe 2023.

powertransmission.com/blogs/1-revolutions/post/9221-conversations-at-hannover-messe

A Thirst for Automation

This article explores a new approach and considers the potential of automated lubrication systems and food-grade lubricants in beverage filling machines. These characteristics of beverage production demand efficient lubrication of moving parts. SKF customers in the sector often list lubrication as critical to the performance of filling machines.

powertransmission.com/blogs/1-revolutions/post/9204-a-thirst-for-automation

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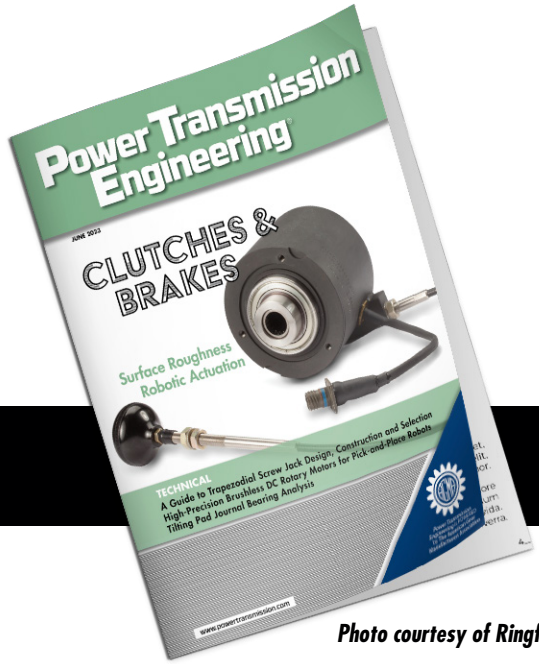
Michael Goldstein founded *Gear Technology* in 1984 and *Power Transmission Engineering* in 2007, and he served as Publisher and Editor-in-Chief from 1984 through 2019. Michael continues working with both magazines in a consulting role and can be reached via e-mail at *michael@geartechnology.com*.



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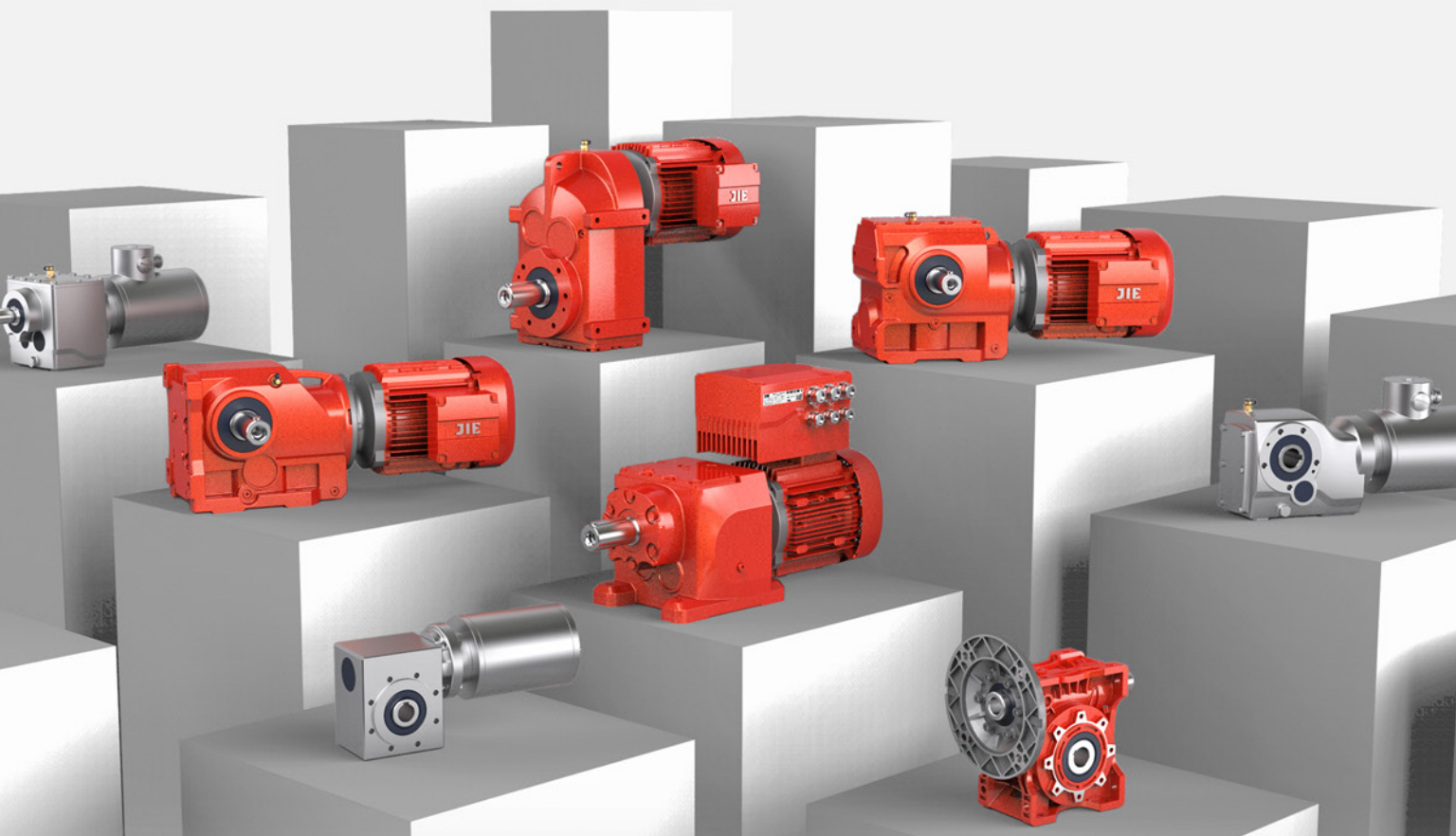

Options are Worm gear unit; Helical inline, Parallel shaft, Helical bevel and Helical worm gearmotor; Available in aluminum, cast iron and stainless steel housing.

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Randy Stott
Publisher & Editor-in-Chief

MPT Expo Is for Gear Buyers

Most of you who read this magazine have a close relationship with gears and gear drives. According to our most recent circulation data and reader surveys, 75 percent of you recommend, specify or buy gears and/or gear drives.

MPT Expo takes place October 17–19 in Detroit (*motionpowerexpo.com*). I think you should go. The show only occurs every other year, and in 2021, hardly anyone was traveling, so chances are, it's been awhile since you've attended. But the fact is, the show has continued to grow in relevance to become one of the hidden gems among trade shows, particularly for those of you who are gear buyers.

That's because MPT Expo is the only trade show in North America where you can find so many potential suppliers of gears and gear drives all in one place. Whether you need open gears, gearbox repair or custom gear assemblies, you'll find qualified suppliers to choose from at MPT Expo. You'll also find traditional gear manufacturers alongside manufacturers of plastic and powder metal gears, and you'll find them specializing in aerospace, automotive, off-highway and industrial gears. Here's just a sampling of the quality gear and gear drive manufacturers who have signed up to exhibit:

- Ancon Gear & Instrument
- Bevel Gears India
- Bomatec International
- Brelie Gear Co.
- Capstan Atlantic
- CGI, Inc.
- Cincinnati Gearing Systems
- Circle Gear and Machine Company
- Columbia Gear Corporation
- Croix Gear
- Dana Incorporated
- Delta Gear
- Doppler Gear Company
- Flender Corporation
- Forest City Gear
- Gear Motions Inc.
- Gleason Plastic Gears
- Great Taiwan Gear Ltd.
- Nichiei Co. Ltd.
- Omni Gear & Machine Corp.
- Philadelphia Gear
- Razzaq Engineering Works
- Reliance Gear Corp.
- Riley Gear Corp.
- Schafer Industries
- Triumph Geared Solutions
- United Gear & Assembly
- Want Win Precision
- Welter Zahnrad GmbH

So if sourcing gears or gear drives is on your agenda, you really can't find a better way to spend three days than to attend.

Of course, there's a lot more to MPT Expo. In addition to gear manufacturers, you can also find suppliers of bearings, lubrication, power transmission design software, and all of the machines, tooling and services required for manufacturing gears.

In addition, it's also a great opportunity to attend AGMA's Fall Technical Meeting, which takes place October 16–18 at the same venue (Huntington Place, formerly known as the TCF Center and Cobo Hall). There's a full slate of educational offerings, numerous networking events and much, much more.

We'll be there putting on our ever-popular Ask the Expert Live forum, with numerous topics and presentations throughout the show.

There's a lot more going on at MPT Expo than I have space to describe here, including many more exhibitors whose products and capabilities may be relevant to you. For complete information, visit the show website at *motionpowerexpo.com*. But don't just visit the show website. Visit the show October 17–19 in Detroit. I hope to see you there.

Randy Stott

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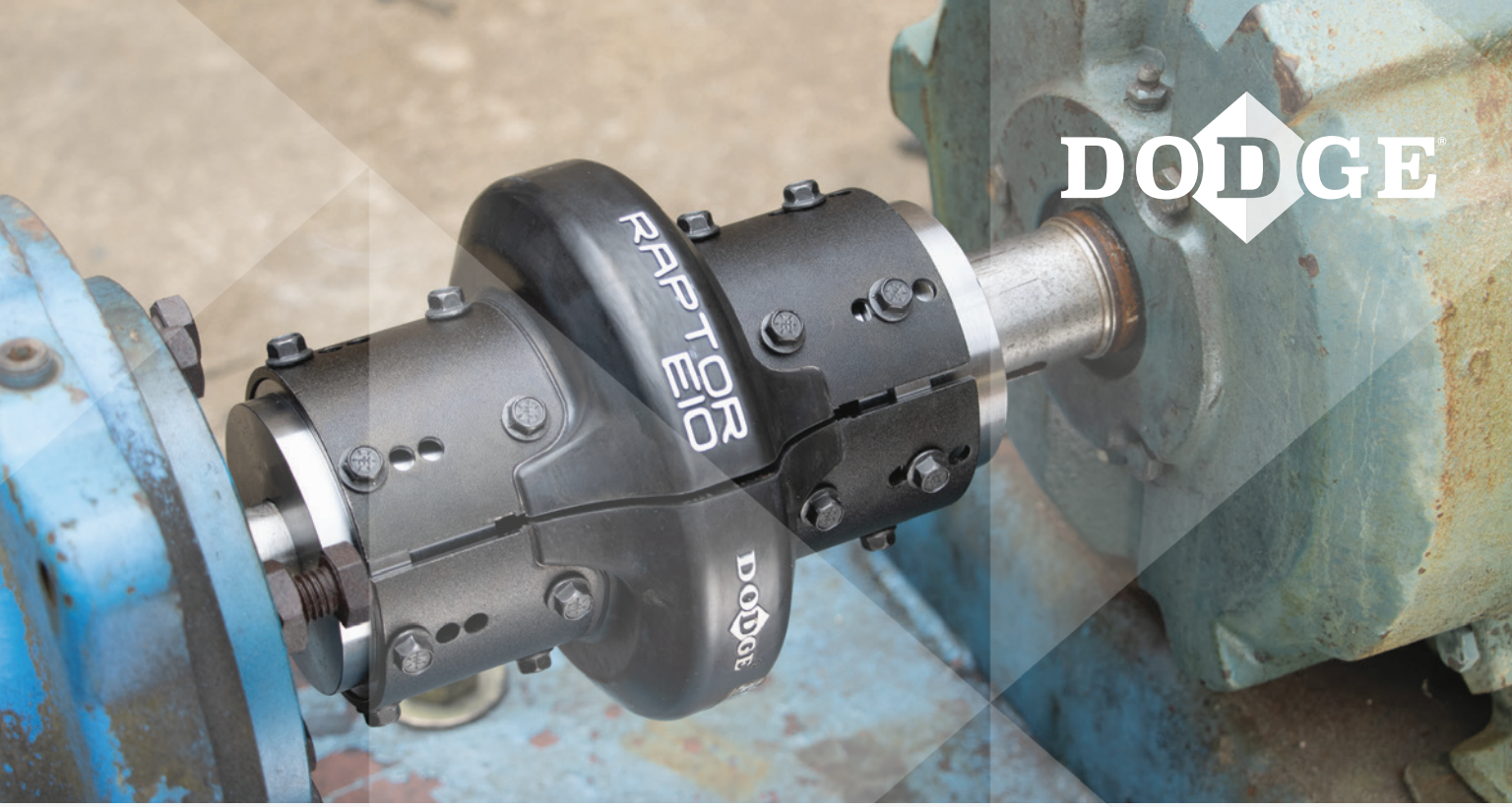

Tested. Proven. Ready.

Expand your application options with the Raptor Integral Spacer Coupling, which offers a wide range of distance between shaft ends. Built on the Raptor legacy of proven performance, the integral spacer design streamlines installation with flexible mounting options, outlasting the competition.

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- Natural rubber element construction maximizes vibration damping and misalignment capabilities
- Patented WingLock™ design increases surface area for material protection and to deliver high bond strength
- Interchangeable with competitive designs

Explore more about the Raptor Integral Spacer Coupling:
info.dodgeindustrial.com/raptor-integral-spacer

Liebherr

EXPANDS PUMP AND MOTOR OFFERINGS

Liebherr expands the existing product portfolio of open circuit pumps by the nominal size of 550 and as a double pump by the nominal size of 1,100 cc (1,100 cm^3). Moreover, the new nominal size of 100 adds to the LH30VO family.

DPVO 550i—on the pulse of current affairs with new nominal sizes of open circuit pumps

The mining and industrial sectors, as well as maritime applications place increasing demands on the availability and longevity of machines and technology. In order to keep up, the components product segment at the site in Bulle (Switzerland) is enlarging its product portfolio of open circuit pumps by the nominal size of 550, which can also be used as a double pump of 1,100 cc (1,100 cm^3).

"Like all pumps in this product family, the DPVO 550i is characterized by a particular robustness. In the view of digitalization, this product is ready to incorporate various sensor technologies," explains Guillaume Bonnetot, general manager systems at Liebherr-Mining Equipment Colmar SAS. "We look forward to seeing Liebherr's components in use in our own machines."

LH30VO100—the newest member of the pump family

Modularity is the signature trait of the LH30VO family with nominal sizes of 28, 45 and 85. Liebherr is further pursuing this approach with the inclusion of the nominal size of 100 cc (100 cm^3). Among other things, the LH30VO100 consists of a modular system of eight controllers with a variety of combination options. The variable drive-through concept allows the selection and addition of further pumps, when installing them on the machine. In doing so, Liebherr-Components fulfills the growing demand for products with a high degree of flexibility. With all its nominal sizes, the entire LH30VO pump family offers a wide range of applications from mobile machinery and stationary hydraulics, for primary work functions to secondary applications, such as in fans, auxiliary drives or steering systems.

DMVA 165-165—high power density and flexibility in control

The Liebherr axial piston double motor DMVA product family features a swash plate design for the use in open and closed circuit. It is especially popular for use in winch and drilling drives. Thanks to its back-to-back design, the two smaller rotary groups allow for significantly higher speeds as compared to a larger rotary group. Both swashplates can be swiveled independently or parallel to each other. The common connecting plate, in turn, makes the piping installation much easier. George and Peter Allpass of Alpine Logging based in South Africa, the manufacturer of cable logging winch systems for the timber industry worldwide, explain: "One of the advantages of the DMVA double motor is its impressive maximum speed. The inverse piston design with a swivel angle of 22 degrees is very efficient and has a high power density, making it ideal for applications that require a wide conversion range. Not only does the product perform with great reliability, but the support and service by Liebherr are above our expectations."

With these additions to the product portfolio, Liebherr is on par with current and future user requirements.

liebherr.com

Miki Pulley

ALS MACHINED COUPLINGS SOLVE MISALIGNMENT CHALLENGES

The latest designed ALS Couplings from Miki Pulley are available in three different types for more precisely handling parallel, angular or axial misalignment applications.

The key feature of this coupling design is its center element. Each of the three models center member has a unique durable material and shape. Also called a *spider,* it is designed to address and resolve the type of misalignment targeted thereby reducing reaction loads resulting from the misalignment.

Another nice feature of the the ALS Coupling design is its simplistic, three-piece construction. It is ideal for unidirectional continuous movement or rapid bidirectional motion. The coupling has precision machined aluminum hubs that diminish moment of inertia. And the center member is nonconductive providing electrical and thermal isolation between two shafts.

The coupling's aerodynamic profile decreases noise while optimizing performance at high speeds. Simple, economical and reliable, ALS couplings are available in two mounting versions: clamp style and keyed shaft.

mikipulley-us.com

Continental

EXPANDS BELTING OPTIONS WITH DIRECT X

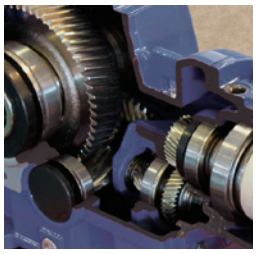
Continental recently added the patented Direct X conveyor belt to its line of industrial belting products with the 2022 acquisition of WCCO Belting.

The Direct X cleat profile increases conveyor capacity by capturing more

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.
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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.

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material across the belt width than standard industry patterns. Combined with the benefits of a specialized belt construction that is thinner yet stronger and more flexible in design, the product is a high value solution that reduces cover wear, increases energy savings, and improves belt life.

"The cleat profile of the Direct X provides multiple benefits for end users in aggregates and recycling, including increased durability, energy savings and material flow control," said Jean Voorhees, head of product management, business area conveying solutions, at Continental.

The Direct X is designed to directionally improve product flow control. The pocket-style cleat pattern captures conveyed material immediately upon loading, reducing the amount of product movement on the belt cover, which limits cover wear. The nested pattern also promotes a smooth, quiet transition on the return rollers, reducing noise and vibration in the field. In addition, the cleats are integrally molded onto the base belt, meaning no cleat separation or delamination will occur.

Direct X drives energy savings using a lighter, stronger, and more flexible belt carcass. Moreover, excess cover wear is reduced when used with the Direct X product flow control pattern.

continental.com

SKF

ADDS MICROLOG ANALYZER DBX TO CONDITION MONITORING PORTFOLIO

SKF has extended its Microlog Analyzer family of data collection devices with a new model that offers faster measurement collection and greater diagnostic power.

"The new SKF Microlog Analyzer dBX that is part of our broad portfolio of condition monitoring solutions, built on state of art technologies, is a powerful tool for standalone troubleshooting as well as being part of a comprehensive predictive maintenance program" says Janne Westerlund, director services and technologies EMEA at SKF. "SKF Microlog Analyzer dBX together with our analytic software is providing best in class information and insights of customers' rotating asset health."

This unique portable solution coupled with analytic software significantly improves the way to schedule maintenance of rotating machines establishing the right and fast diagnostic thanks to its embedded features.

When used as part of a condition monitoring solution, the SKF Microlog Analyzer dBX can detect issues with rotating machinery quickly and accurately.

"Our new SKF Microlog Analyzer dBX takes measurement with our MPA-in-a-flash method, which makes the device extremely powerful" says Christophe Andre, project manager at SKF. "Multi-Point Acquisition (MPA) is our fastest vibration analysis method. It is typically three times faster than the previous Microlog series, saving you time taking measurements and helps to collect data more efficiently."

The device allows the user to carry out a range of tasks including impact tests, digital recording, modal analysis, multi-plane balancing and cross channel phase. It can be applied in any type of industries including pulp & paper, food & beverage, renewable energy, mining, off-highway, metals, automation and marine.

The SKF Microlog Analyzer dBX is backwards compatible with SKF's proven existing Microlog CMXA Series and adds new technology including a high-resolution, 10.1-in. screen that can display up to six measurement windows at the same time, and an embedded camera. Furthermore, it features a hybrid touch and keypad control as well as a simplified navigation, making it more comfortable and easier to use.

skf.com

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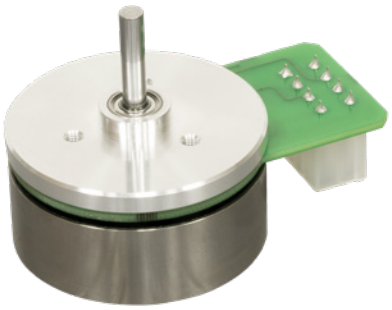
Formerly Gear Expo

Portescap

RELEASES BRUSHLESS FLAT MOTOR TO ECF SERIES



Portescap announces the release of the 45ECF brushless DC flat slotted motor, the latest addition to join its flat motor portfolio. The 45ECF features a performance optimized design that utilizes an outer rotor configuration with an overall diameter of 43.2 mm and a body length of only 22.5 mm. The motor features hall sensors to easily control speed and torque and can be provided sensorless based on application requirements. Additionally, the motor can be used in combination with existing gearbox designs to provide high output torque at required operational speeds.

The optimized design with maximum continuous torque up to 91 mNm in a compact package makes it an ideal choice for applications that demand high performance in tight spaces. The open body design of the 45ECF facilitates better body heat management. The 45ECF can be fully customized to meet precise application requirements.

The 45ECF's high torque capabilities and cost effectiveness make it an ideal solution in a variety of applications such as aerospace and defense (aircraft valve actuation, missile actuation, air cushion systems, flight control systems, military robots), robotics (wheel drive for AGV's, robotic grippers), and medical (surgical robotics).

portescap.com

LM76

INTRODUCES STAND-OFF BEARING FLANGE BLOCKS

FDA/USDA certified, two, three and four post, stand-off bearing flange blocks are setting a new standard for performance and hygienics. This new stand-off bearing flange blocks now available from LM76 reduce the surface area where mold and bacteria can thrive, even from the most through sanitizing operations. Long life hybrid stainless steel Si3N4 Silicon Nitride ceramic ball bearings in stainless steel bearing blocks are coated with a smooth non-water absorbing polyamide coating certified by EHEDG, USDA, and 3-A. These FDA/washdown flange bearings employ hybrid stainless steel/ceramic ball bearings that are sealed from contaminates and bacteria via a patented shaft seal system. The seals resist water, cleaning solutions—keeping lubrication from being corrupted and evacuated.

Designed for up to 2,000 rpm of continuous operation, they are available for .750 in., 1.000 in., 1.250 in., 1.375 in., and 1.500 in. shafts. Metrics range from 20 mm–40 mm. Both inch and metric flange blocks are available in open and closed end configurations. For engineering assistance, step files and pricing consult Mike Quinn from LM76.

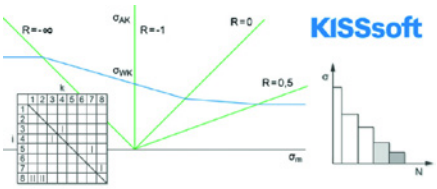
When downtime is not an option stainless/ceramic hybrid Si3N4 Silicon Nitride ball bearings are the only option. The very hard and smooth Si3Nn bearing balls have lower friction and vibration, lower thermal expansion and heat transmission, all but eliminating catastrophic failure. Additionally, optional mounting bolts, nuts, spacers, end caps, and seals have been meticulously designed to prevent the accumulation of any contaminates. These bearing flange blocks are a complement to the broad range of LM76 linear bearings, shafting and slides that are FDA/USDA/3A Dairy compliant.

lm76.com

KISSsoft

OFFERS FKM SHAFT STRENGTH CALCULATION

In the *KISSsoft* shaft calculation, the proof of fatigue strength can be performed by generating an equivalent stress verification according to the FKM Guideline.



FKM shaft rating with rainflow matrix

This verification is equal to the amplitude verification which has been performed up to now. With the equivalent stress verification, different stress ratios can be taken into account for each load case (for example, a Rainflow matrix). The load cases are defined in a load spectrum, which can be entered directly via a table or imported from a text file.

The influence of different stress ratios can now be considered on the load side of the verification by converting the load spectrum to mean stress Sm = 0 and the stress ratio R = –1. For this purpose, an amplitude factor KAK is calculated for each load case in the load spectrum. Overload case 2, i.e., constant stress ratio, is assumed.

As a result, the strength calculation for a shaft can now be performed according to the FKM Guideline, taking into account the influence of a Rainflow matrix load spectrum.

kisssoft.com

OES

ADDS GONIOMETER STAGES WITH FOUR MOTOR OPTIONS

Optimal Engineering Systems, Inc. (OES) has added four goniometers to their expanding catalog of high precision positioning stages. The new, AK160-30 Goniometer Series feature precision ground worm gears with a 400:1 ratio and pre-loaded cross roller guides offer ±30 degrees of travel with 30 kg of load.

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This series of goniometer stages feature four motor options. The -01 option (pictured) is Stepper Motor driven. The -02 option is Three Phase-Servo Motor driven with a Quadrature Optical Encoder, the -03 version is DC Servomotor Driven with a Quadrature Optical Encoder, and the -04 option is Stepper Motor Driven with Quadrature Optical Encoders for position verification. The highest resolutions, accuracy, and travel speeds are achieved with the servomotor options -02 and -03.

This AK160-30 Goniometer Series of Stages has a large 160 mm x 160 mm table with a precision pattern of mounting holes. The center of rotation is 136 mm above the surface of the table and the radius of rotation is 203 mm making them ideal for: Microscopy, crystallography, measurement of surgical cutting blades, laser positioning, light measurement, and inspection applications.

The large footprint of these stages, 160 mm x 384 mm (without the motor), and a load capacity of 30 kg allows for stacking of a second AK160-30 goniometer stage or can be used as a building block in a multi-axes stage. A calibrated indicator displays the angle of rotation. The stage can be ordered with a fully plug-and-play compatible controller from OES.

oesincorp.com

Dana

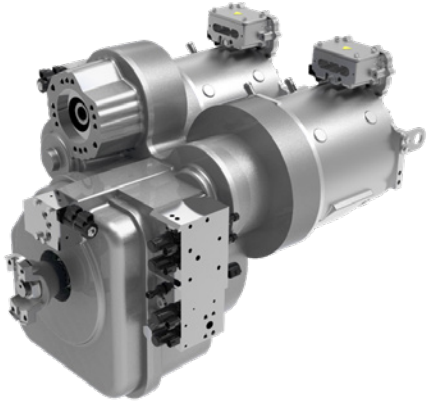
OFFERS NEXT GENERATION E-TRANSMISSION

Dana's eSP502 e-Transmission offers a dual-motor, two-speed design that is built on a flexible platform to enable optimized performance at maximum efficiency in a compact package. The modular approach to the transmission design allows for a single motor solution, as well as an optional power take-off, depending on the specific vehicle requirements. It recently made its North American debut at IFPE 2023.

Delivering high efficiency in a compact package that performs like a conventional powershift transmission, the dual-motor version supports continuous power outputs up to 326 hp (240 kW), while the single-motor configuration is engineered for 187 hp (140 kW) of continuous output.

The eSP502 is equipped with next-generation control software and functional safety readiness, enabling easy installation and smooth integration, and it features a patented clutch design that minimizes clutch drag to maximize efficiency.

It is equipped with field-proven Dana TM4 high-voltage motors of up to 800 V to improve efficiency, reduce total package size, and provide redundancy as needed.



The eSP502 e-Transmission's compact and modular design allows it to be adapted for use in 4x2 or 4x4 vehicle applications with a range of ratio options to support a variety of vehicle types.

dana.com

Festo

INTRODUCES ELECTRIC MOTION SIZING TOOL

Festo introduces the company's latest online productivity tool – Electric Motion Sizing—for error-free sizing of linear and rotary electromechanical systems. Electric Motion Sizing improves project efficiency by slashing the engineering time required for identifying and specifying harmonized electric motion systems. Multi-axis handling systems can be specified with Electric Motion Sizing's sister productivity tool Handling Guide Online, which offers similar benefits.

Festo developed Electric Motion Sizing because it recognizes that machine builders need solutions that help bring products to market faster with less engineering and purchasing overhead. Electric Motion Sizing compresses hours of toil down to minutes.

With this free online productivity tool, users simply input key parameters, such as mass, stroke/travel distance, and cycle time. Electric Motion Sizing performs the complex mass moment of inertia calculations. The tool identifies in real time the combination of components most effective for the application's parameters. Up to five optimum solutions and motor curves are presented for consideration. The specified components work together, so interoperability is not a concern. Designers can fine tune the selected system by choosing encoder type, brake, and mechanics.

Following selection, the Electric Motion Sizing tool transfers the selected combination of components to the Festo online shop, together with commissioning files. The online shop provides pricing and delivery information. The seamless process from configuration to order is an additional time saver.

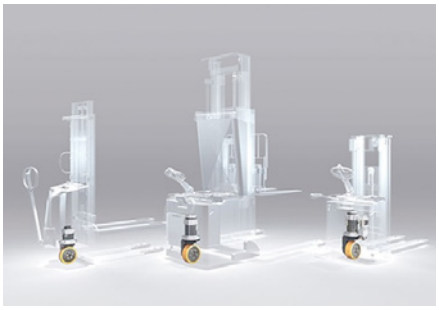
Festo integrated Electric Motion Sizing with the Festo Automation Suite for simplified commissioning. With the *Festo Automation Suite*, diverse products from remote IO to pneumatic valve terminals, PLCs, and servo drives are commissioned via a single free tool. *Automation Suite* automatically connects to the Festo cloud to download project specific documentation and

updates within the software. It also incorporates Codesys code for programming PLCs and motion controllers.

festo.us

ABM Drives

OFFERS BEVEL GEARBOX DRIVE UNITS



Electric drives in conveyor systems, lifting equipment, and forklifts are the motors that drive modern, efficient, and reliable intralogistics. ABM Drives Inc. develops and manufactures platform-based systems for stationary and mobile applications. ABM works closely with customers to build drive solutions, including motors, gearboxes, brakes, and frequency inverters tailored for specific applications.

"Traction, lifting, and steering in forklift trucks, for example, require both know-how and the right drive components," says Mayk Krüger, senior manager of material handling at ABM. "Our solutions consistently comply with strict environmental requirements, are particularly safe, and enable precise movements even at low speeds thanks to their high responsiveness."

ABM supplies all drive components, including motors, gearboxes, sensors, brakes and inverters for many applications. ABM develops and manufactures complete gearbox–motor drive units in-house. Additionally, ABM supplies the right modular system solution for the right vehicle type.

"Our drives make dynamic movement and precise maneuvering of industrial trucks possible for users, even in tight spots," Krüger says. "Also, our solution provides forklift trucks with excellent climbing performance." The TDB series easily integrates into a given application via plug-and-play. The two-stage, bevel-helical gearbox drive unit offers high performance and low energy consumption for manual and electric industrial trucks. Bevel-helical gearboxes have high power density and outstanding efficiency. Combined with a steering drive and equipped with a fully integrated and reliable sensor monitoring system, users receive a fully integrated traction and steering drive solution. "Through the vertical design, the small envelope size, and the numerous series options, this gearbox drive unit is ideal for many applications – for example, in reach trucks, tow tractors, automated transport systems, and sweeper/scrubbers,' says Krüger. Users can work reliably for lengthy periods, even with smaller batteries.

Various Steering Options

ABM offers bevel gearbox drive units for 9-in. and 10-in. wheel diameters based on power output, speed, and load capacity: Gearbox ratios and motor performances can be tailored precisely to given applications. The compact TDB series offers drive torques of up to 750 Nm. "It is equipped with various steering options," says Krüger. The manual steering system, for example, is suitable for direct mounting on the drawbar. The user receives a space-saving, robust, and long-lasting solution. ABM can supply a zero-position sensor for the steering position and an absolute encoder for steering right on the traction gearbox if necessary. A third possibility is an integrated electric steering drive. The user benefits from redundant steering monitoring, maximum ride comfort, and increased safety.

For the traction area, ABM offers temperature monitoring via a temperature sensor. Speed recording via an incremental encoder monitors up to 64 pulses per revolution. All AC traction motors offer energy recuperation via regenerative braking to save energy. These motors include an integrated electromechanical holding brake for parking and emergency stopping. Krüger says, "With this diversity of functionalities and possible combinations, we support both developers of individual applications and OEM project managers of cross-fleet platforms with suitable drives."

Systems Supplier with a High Level of Development Expertise

Customers agree ABM's extensive application development experience with customer-specific drives and platform concepts ensures customers quickly receive cost-optimized solutions. "However, we can also specifically address customer requirements," says Krüger. "Thus, we are not a standard supplier and offer our customers a measurable added value."

ABM's turnkey solutions include motors, gearboxes, and corresponding electronics.

abm-drives.us

Bonfiglioli

OFFERS SUSTAINABLE ELECTRIC SOLUTIONS AT LOGIMAT 2023

New automation, efficiency and sustainability needs have emerged in recent years, prompting industry players to embrace innovation in order to boost their speed, precision and productivity while reducing costs and inefficiencies. In this context, latest-generation technological solutions are the new protagonists of warehouse operations, aiming, on the one hand, to reduce the environmental impact of logistics processes and operating costs and, on the other, to speed up the handling of goods, optimizing movements in order to manage large volumes in shorter times.

Logimat was the perfect opportunity for Bonfiglioli to share the expertise and know-how capitalized in over 60 years of business with customers and to present its solutions for forklifts, warehousing trucks and automated storage.

More specifically, the 600F Series featuring high-efficiency planetary gears and drives with integrated electric motors for premium performance was on display in the forklift area. The 610 x3E model in particular, designed for machines capable of moving up to 16 tons on the fork, positions the company as a specialist on the market for large electric machines.

As regards warehousing trucks, the EL09 steerable powertrain for pallet trucks, stackers and reach trucks displayed ensures minimal noise and

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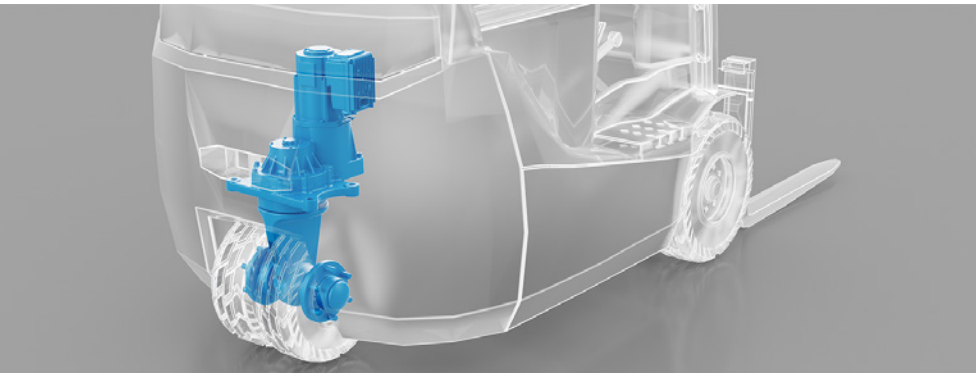

high maneuverability in tight spaces, thanks to a multifunction unit for the complete control of acceleration, steering and braking. In terms of production, the company has invested in a highly automated assembly line that guarantees high quality and process repeatability, with a takt time of 4 minutes. These solutions can be fully customized to meet manufacturer requirements. In the same area, BlueRoll completes the range that makes Bonfiglioli a full line supplier for intralogistics vehicles. This new platform of performing wheel-mounted gearmotors for AGVs and AMRs has an ultra-compact and energy-efficient design for a long operating cycle. The modular drive system comes in three configurations - Basic, Advanced and Compact - with a customizable single gearbox load ranging from 360 to 120 kg and a maximum speed of 2m/s.

Finally, Bonfiglioli showcased two solutions complete with gearbox, motor and inverter. The first solution, perfect for post & parcel use and airport baggage handling systems, consists of: a compact right-angle gear unit (A) available in a wide torque range, an IE4 certified synchronous reluctance motor (BSR), which guarantees an ecological and high-performance solution thanks to the absence of magnets, and the DGM MPM decentralized inverter with sensorless vector control operation for optimal dynamics control.

The second solution, designed for roller conveyors, includes the EVOX CP, a helical in-line gearbox with a smooth surface that can be fitted to any machine thanks to its compatibility with market standards, the MXN asynchronous low voltage e-motor (IE3) developed to be modular, reliable, energy-efficient and internationally certified, and a DGM MPM sensorless inverter.

bonfiglioli.com

Stock Drive Products/ Sterling Instrument

EXPANDS LINE OF DISK TYPE FLEXIBLE COUPLINGS

Stock Drive Products/Sterling Instrument (SDP/SI) expands their selection of flexible couplings to include the single disk type couplings (short type), series S50XHSMand the double disk type couplings (standard length type), series S50XHWM. The disk type flexible couplings are an economical option while providing greater torque capability and improved performance in a reduced size.

The compact design provides torque ratings of 0.6 Nm–12 Nm, an improvement over similar product. The single disk type flexible couplings, S50XHSM features 16.5 mm–32.8 mm lengths, 15 mm–39 mm diameters, bore diameter combinations 3 mm–12 mm and weights of 6.8 g–84 g. S50XHWM double disk type couplings feature lengths of 22.4 mm–46.6 mm, 15 mm–39 mm diameters, bore diameter combinations 3 mm–12 mm and weights of 9.4 g–123 g. Other bore combinations and bore sizes are available on special order to accommodate end-user requirements. The disk type couplings are constructed of anodized aluminum hub and spacer with stainless-steel disk and collar. The stainless-steel disk permits eccentricity, angular alignment and end play.

Device manufacturers can benefit from the smaller size and reduced weight while gaining greater torque capacity and power. As a high-performance motion control coupling, disk type couplings are well suited for applications where precise position accuracy is required. Because of its flexible design, zero backlash, high torque capacity and ability to accommodate shaft misalignment they are ideal for use with servo motors as an integral machine part in a variety of equipment where high-precision XY stages and index tables are used, such as welding machines, 3D printers and high-precision CNC equipment.

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Actuation Challenges in Robotics Today

Schaeffler's engineering experience provides a clear path toward off-the-shelf as well as customizable design projects for a variety of new and emerging applications.

Matthew Jaster, Senior Editor

The path toward success in mechanical power transmission today hinges on an organization's ability to provide smart and digital automation solutions. Customers are looking for system components boasting more performance, precision, and cost effectiveness in robotics and industrial automation applications. Schaeffler, the global technology company specializing in solutions for the automotive and industrial sectors, offers a strong and diverse product range not only for large industrial robots, but also for lightweight and collaborative robots (cobots).

Schaeffler, coincidently, uses robotics applications in global internal production, across 76 production locations, with well over 1,000 industrial robots and cobots along the entire value chain. These robots are used in both modular, flexible production environments, and highly automated production facilities. This versatility allows Schaeffler to collect invaluable product data during operations that can be incorporated into future product development.

Power Transmission Engineering recently had the pleasure of conducting a roundtable discussion on robotic actuation with four key members of the Schaeffler Group USA team. Our interview examined the evolution of component design, software needs, new products and technologies and future considerations.

Design Actuator for Purpose vs. Procure Actuator for Purpose

During the design phase, customers have the old 'make vs. buy' decision to consider. There are two potential paths: Design Actuator for Purpose (DAP) where customers play a role regarding in-house design, purchase and the assembly of bearings, motors, controls, screws, gears, seals, etc. or Procure Actuator for Purpose (PAP) where the customer purchases an actuator assembly (plug and play) and reduces the time from concept to prototype to fully built product.

"It depends on each individual customer," said Kyle Syndergaard, application engineer at Schaeffler. "Is the customer going to be doing all the heavy lifting? They know what they want this robot to be doing and so at that point they must dig down and determine the application requirements, the torque, speed, payload, etc."

Next, they'll need to specify what gearbox and motor they should be using for the application and select the right support bearings. They'll also look at sensors they may want to add to the system.

"In this case, they'll be going to the supplier—sometimes different suppliers—to pick out the components to build the full actuator. This method gives you a lot of control over the final design and provides an opportunity to make the selections you want. But it is a much larger engineering workload overall because you must take into consideration all these components and how they interact with each other," Syndergaard added.

For PAP applications, the customer already knows the torque, payload and design requirements and just needs to find a supplier that offers a fully built actuation solution.

"You don't necessarily have control over every single component, but it reduces the workload on the customer engineering side dramatically," Syndergaard said. "Off-the-shelf actuators will likely come with a few compromises because they're not designed to fit your specific application, but they can check off a lot of the boxes and reduce the time from concept to prototypes to fully built products."

The design criteria for both DAP and PAP can be heavily related to volume, according to Craig Hooker, director research and development, industrial and mechatronics at Schaeffler. "Do you have the volume and the business from a product standpoint that supports that level of development and can support those kinds of investments?"

Hooker suggested the environment can also drive customers toward a particular path.

"If you're putting a product in a harsh environment requiring a compact design—a medical device that needs to be put in a patient—this may force you to customize the design even further. There won't be an off-the-shelf product that will fit in a case like this. If you're simply putting an actuator on a machine tool, it may be easier to buy off-the-shelf components, attach them together and finish the project."

Brent Lyon, vice president, OEM sales, at Schaeffler said time plays such a huge factor in design decisions. "What's the time in which you must prove your concept? Today, I feel like you procure something that's readily available for prototype or initial development and then you refine it. This is sort of the direction in which the industry is moving. A customer begins on the PAP path for proof of concept and they evolve to the DAP path as application requirements are refined, cost targets are established, and the volume increases."

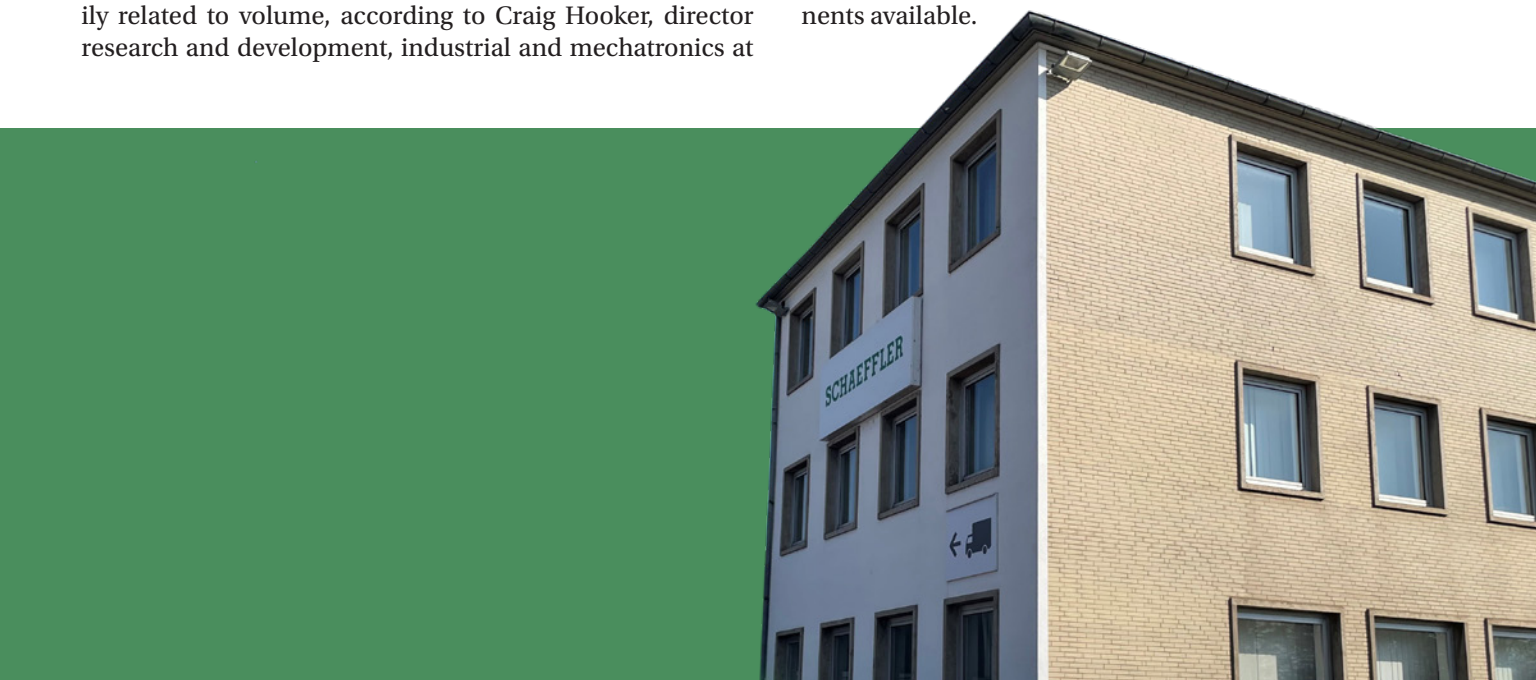
"There are compromises and decisions that need to be made during the entire development process," added Mike Paschke, industrial automation national sales manager at Schaeffler. "A customer might want a highly customized product that meets their application needs, but they don't want to make a sacrifice to their internal timeline. This is where working back and forth between development partners is where we find what works for both parties."

Design Requirements Continue to Evolve

Who, what, where, why, and how goes beyond simple communication tools when engineers discuss potential design factors.

"What's the market segment? Is the part going to be inside something else or is the part going to be externally exposed to the environment? Are there certain aesthetics that need to be considered? Where does the actuator actually sit?" Lyon said.

Highly customized products are so important because customers want the most efficient and practical components available.

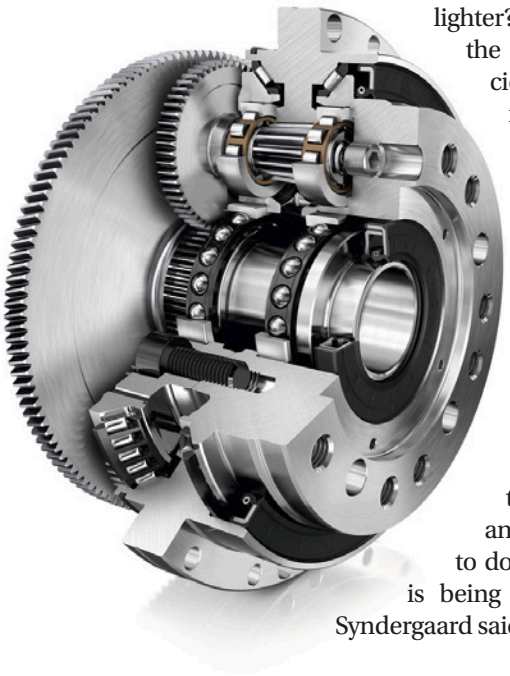


"Traditional performance requirements are a given, but you also have space constraints, right? Let's pack this into the tightest little box we can. When you do this, if it's in an enclosure, thermals will inevitably come into play. How efficiently this actuator can dissipate and remove heat from the system is critical because this is what ultimately drives the rated torque values for motors based on their current flow. If the motor heats up too much, efficiency crashes and the system you designed to operate at a certain speed and torque is not going to be able to perform as expected," Paschke said.

Power consumption is also increasingly critical in 2023. Paschke said that in the past customers didn't need a comprehensive overview of power consumption. "They're looking at every single power draw from each component in the system even for the small accessory-based sensors. A lot of those things are being more heavily considered today because efficiency is not only important to the OEM, but to the end customer as well."

Design considerations continue to focus on smaller, faster, and stronger components, a move toward lower weight, higher power, and better efficiency.

"When you get into the actuation side, reducing weight comes into play. This regularly comes up in engineering discussions. How do we make this lighter? How do we make the motor more efficient? How do we reduce the friction in these bearings? How do we make sure this joint is stiff enough that it will maintain accuracy? How do we make it lighter and more efficient but maintain the strength and rigidity we need to do the job the robot is being designed to do," Syndergaard said.



Hooker compared it to a packaging exercise.

"How do you package the functionality in a way that fits the equipment? Typically, that's all about size and weight."

The other factor is simplification and smarts, adding intelligence into the device, for example.

"A customer would rather have smart functionality built into it—you can do your own motor control, diagnostics, read the sensors, etc.—versus having to develop these as a second step. This is also one of the more complicated things to integrate into the design as well, so it's easy to see the value in providing these capabilities to our customers," Hooker added.

As robotic technologies evolve, so too must Schaeffler's design range.

"In 2023, we're facing new challenges with the movement toward smarter robotics, smarter components, sensors that tell you exactly where you're at regarding torque, etc. In addition, the types of robots are changing. We're seeing a greater emphasis on cobots interacting with human workers. There are a lot of opportunities here instead of the old caged robotic arms designated for a single task on the shop floor. Cobots offer increased flexibility and additional capabilities and will continue to evolve in the future," Hooker said.

Hand guidance—the ability for a human to grab the robot arm and teach it a certain task—that's a great feature, but it requires so much more in terms of adding sensors. Safety is an issue, of course, and you'll also need some amount of torque sensitivity in the joints. Syndergaard said Schaeffler's strain wave gearbox portfolio contains a built-in sensor that minimizes the tradeoffs with other factors such as strength,

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>
> —Craig Hooker, director research and development, industrial and mechatronics at Schaeffler.

weight constraint, etc. These capabilities are so important for cobot applications.

"This technology is really interesting regarding both the weight and space requirements," Hooker said. "Torque sensing is needed at the output of the gearbox so that you don't hurt someone. You can't sense it on the input side as easily because of the high ratio gearbox. The traditional way to do this is to attach a torque sensor to the output of the gearbox and then that's connected to the load and you can determine the force feedback from the robot very accurately within a few newtons or less."

Sensotect is a coating developed by Schaeffler that allows the measurement of the load condition at locations where classic sensors such as adhesive bonded strain gauges cannot be used. The functionality is achieved by means of a strain-sensitive metal coating with a thickness measured in the sub-micrometer range that is structured by micro-processing. This measurement structure allows the continuous measurement of force and torque during operation.

With the aid of modern thin film technology, the component becomes a sensor and the sensor becomes a component. Due to this measurement technology, it is possible for example to determine the torque of drive shafts or in vehicle gearboxes very quickly and precisely.

"We apply this coating to a surface and measure the strain on the part," Hooker said. "The benefit is maintaining highly torsional stiffness. We can integrate this and check all those boxes in a way existing technology just doesn't do."

Software Considerations

Even though a customer has a distributed system, what they want is to be able to command an actuator to react to their host message. If it's a joint on an arm, it needs to turn at a certain position and speed, for example.

"Our customers typically don't want to do the motor control. They want a device they can command, and it reacts to these commands. When we're involved in many of these robotic applications, we develop within the device to control motor function, read sensors as feedback, and report out—or listen to a host as the third step," Hooker said. "This gives us the ability to add value and still be plugged into a system where the customer can determine what the machine does. They need to have the next-level control in those kinds of systems."

And how is this different between the DAP and PAP design paths?

"When you PAP," Hooker said "you buy an existing controller, for example, and you'll buy a specific software set. This will give you an advantage when it comes to speed to market. You don't have to develop drivers and all these sub-level interfaces that are required. You don't have to understand too much about motor control. However, you lose some flexibility, pay more for it and it doesn't integrate as well.

On the other side, if you said, 'I'm going to make a million of these devices and I really want it to be a perfect product for my application,' then you'll probably want to take that to a much more complex level—what microchip do I want to use? I want to write my own firmware and really drive it down to a highly specific design which will allow you to save space, add features that add a specific value, and it will allow you to get to a much better cost point," Hooker said.

Editor's Note: *I recently toured the facility in Spring 2023 and was amazed at the high level of machining and automation taking place at the facility. I'm excited to learn more about their future expansion into the robotics and industrial automation market segments.*

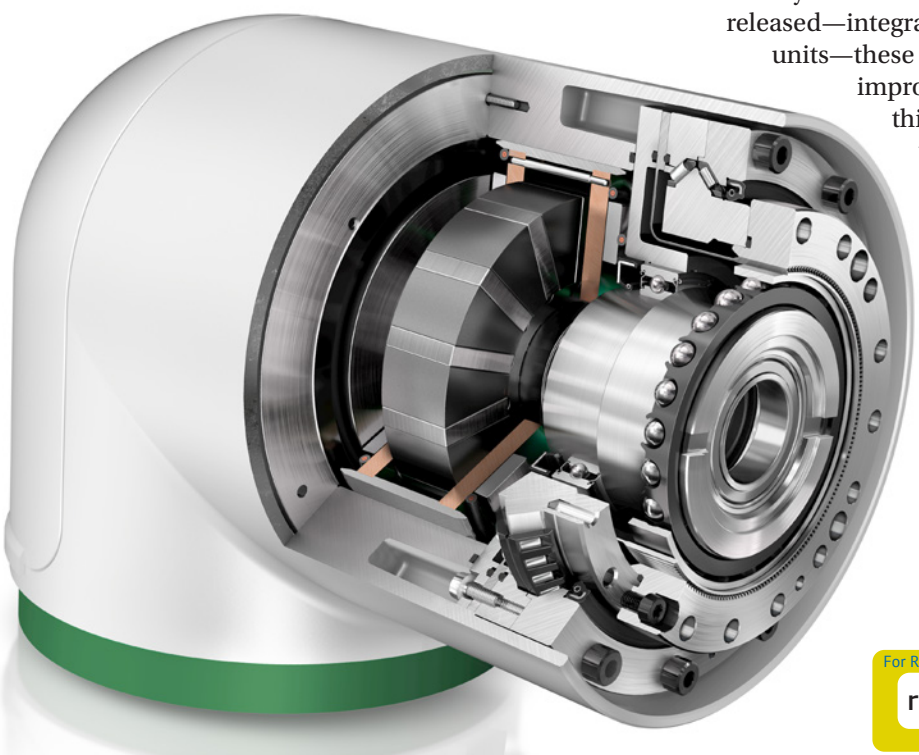
"It all comes down to in-house engineering power," Paschke said "Designing the system from the component level or going deeper down and choosing your own materials is going to take quite a bit of mechanical engineering design. You're also going to need to consider the software side, motor control, etc., which means you must be able to understand both the hardware and software side of things. So, PAP may save you in terms of your internal engineering resources."

"We're facing an application right now where we have a significant cost-savings opportunity on the table and the hang-up is that their mechanical guys want to do it, their purchasing guys want to do it, their operations guys want to do it, but they don't have the horsepower on the controls or software side to really accommodate the changes," Lyon said.

Field Notes in Robotic Actuation

Robotic arms have multiple axes and backlash has become increasingly important. Everybody wants these robotic arms to go quicker and faster. They want to know how to get the most efficient and robust technology on the shop floor.

In 2022, Schaeffler acquired Melior Motion GmbH (now Schaeffler Ultra Precision Drives) a company based in Hamelin, Germany, that develops an innovative planetary gearbox for industrial robots that is highly precise, features outstanding repeat accuracy, low noise emissions as well as very sound robustness.



Compared to traditional planetary gears, gearsets from Schaeffler Ultra Precision Drives are a lot more precise. In concrete terms, this means: You have a torsional backlash of ≤ 0.1 angular minute and a lost motion of ≤ 0.6 angular minute. Even many cycloid gears are limited to a torsional backlash of ≤ 1 angular minute – Schaeffler's PSC gears are up to ten times more precise. This very high accuracy has its origin in the conical toothing of the second stage. This presses the teeth of the planetary gears into one another and ensures that the transmission is free of backlash and will remain so for the life of the gearbox. The company has been developing precision gears for robotics manufacturers and applications in industrial automation for over 30 years.

After many years of collaborating with Kuka, Schaeffler's new, innovative precision gearbox was qualified for two industrial robots as well and is currently installed in two axes of the KR Cybertech and six axes of the KR Iontec. As a result of these products' success in the market, which is driven by the features of the new drive concept, Schaeffler Ultra Precision Drives will continue to expand its capacity in the coming years.

powertransmission.com/blogs/1-revolutions/post/9212-planetary-gear-rethought

Future Approach

The market potential of robotics and industrial automation continued to expand in areas such as industrial robots, cobots, AGVs, mobile professional services, stationary professional services and more. A consumer-driven demand for faster, lighter, and more efficient systems will advance a variety of robotic applications in the coming years.

In short, technology is going to drive costs.

"If you look at some of the products we've recently released—integrated torque sensors or planetary gear units—these are fundamentally new things that help improve robotic applications," Hooker said. "I think there's much more room to grow in these areas and I think as we see continued growth in cobots working side by side with people you're going to need a structure that can produce those robots cheaper than they're produced today.

We see a pathway to produce precise robotic equipment at high volume, and we're eager for this market to develop because we think Schaeffler can bring some innovative new products and technologies to the table."

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Surface Roughness Is More than a Number

Powertrain components are affected by vibration, noise, wear, thermal characteristics and more

Mike Zecchino and Mark Malburg, Digital Metrology Solutions

It's common to hear "surface roughness" described as a number that can be measured on a gage. But describing surface texture with a number is a lot like describing a concert in decibels: loudness is just part of the story. A rock band, an orchestra, and a chainsaw can all produce 100 decibels, but the full picture is much more complex and interesting.

Surface roughness (or more generally "surface texture") is more than a number: it is the shape of the surface. For powertrain components, texture affects all aspects of performance, from vibration and noise to sealing, wear, thermal characteristics, etc. To create durable surfaces that perform well, we need to understand which aspects of the texture matter for the given application. The finish of a gear, say, will have different requirements than that of a cam, or a sensor component.

In this article we look at the nature of surface texture, how it's measured and analyzed, and what we need to control to produce high-performing components.

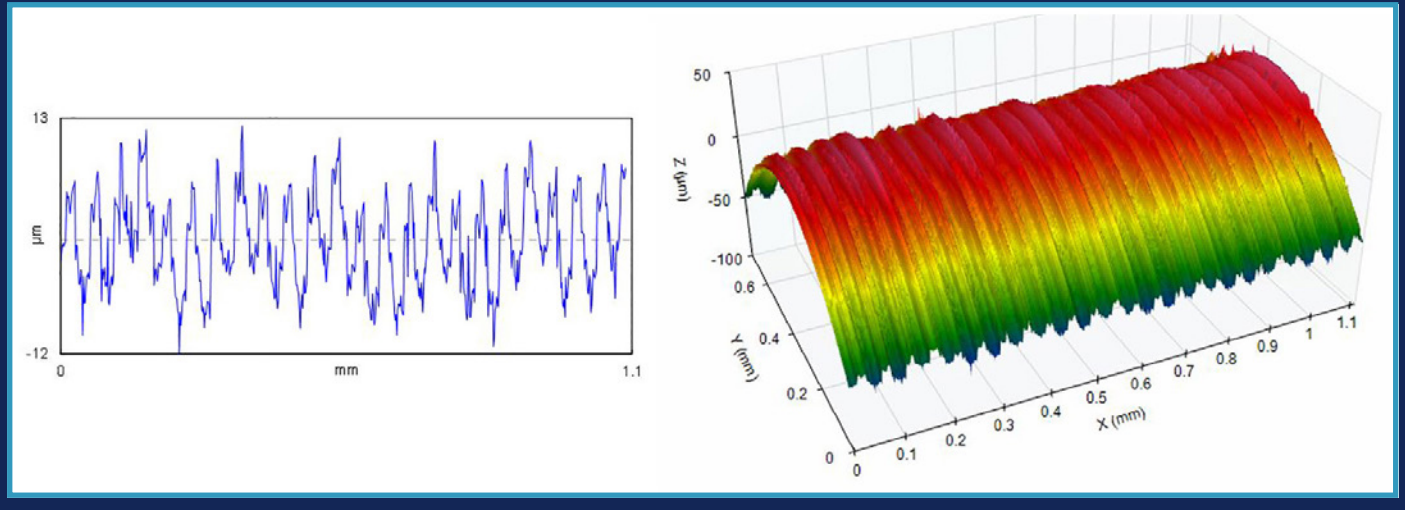

Figure 2—A stylus measurement of surface roughness on a shaft (left), and a 3D measurement of the surface texture (right). These measurements show both the roughness and a larger, residual tooling pattern, both of which may impact the performance of the part.

Surface Texture Consists of Roughness, Waviness, and Form

As measurement equipment and software have advanced, the technology has shaped our understanding of surface texture. Rather than thinking of a surface as having a generalized "roughness," we can more properly describe surface texture as a range of features of varying sizes. We describe the size of these features in terms of "wavelengths," from short-wavelength roughness to longer-wavelength "waviness" and "form error."

Roughness testers, or roughness gages, are the most widely used instruments for measuring surface texture. These typically handheld gages measure texture by moving a stylus across the surface. The stylus follows the surface texture, resulting in a two-dimensional "profile" (Figure 2, left). Non-contact, optical measurement techniques produce 3D texture data (Figure 2, right).

The measurements in Figure 2 show the finer roughness peaks, but also a larger, periodic shape remaining from machining. Both aspects of the texture may affect the component's performance, and both may need to be controlled independently.

Same Roughness—Very Different Surfaces

Surface roughness is often specified using parameters such as average roughness (Ra), which describes how much the surface deviates from a mean height. A "rougher" surface generally has a larger Ra value.

The challenge, however, is that very different surfaces can produce the same Ra value. Figure 3 shows five surfaces with the same Ra but very different characteristics. All these surfaces might pass a specification for Ra. But will the component leak or seal? Will it run quietly or chatter, or squeal? Ra may not help us to tell the difference, because it does not differentiate peaks from valleys, or narrow spacings between peaks/valleys from wide spacings. If these aspects of the texture will affect the component's function, then other surface texture parameters than Ra may need to be specified and tracked.

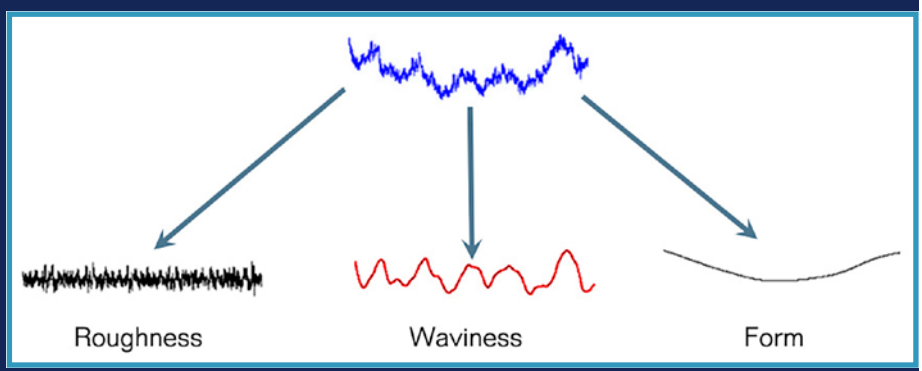

Figure 1—Surface texture consists of roughness (left), but also waviness (center) and form error (right).

Waviness May Be as Important as Roughness

To examine roughness and waviness, we separate surface texture into its component wavelengths through the process of "filtering." A filter attenuates texture above or below a set wavelength. The "roughness cutoff," for example, separates the data into shorter-wavelength roughness and longer-wavelength waviness (Figure 4).

Filtering allows us to control the texture that matters for the application. For the milled surface in Figure 4 (top), we can filter out the roughness wavelengths to clearly see the pattern of tooling marks. When we remove the longer wavelengths corresponding to the tooling marks, we see the finer roughness.

"Roughness" and "Waviness" Are Based on the Application

"Roughness" and "waviness" are not fixed ranges of wavelengths—they vary based on the application. For example, the profile measured along a shaft in Figure 5 shows larger structures in the waviness and fine tooling marks in the roughness. Both will affect loading and durability of the shaft as it rotates inside a bushing. However, even those larger structures in the waviness here would be small compared to the roughness of, say, a clutch plate or brake rotor.

It's critical to understand that altering the roughness may have little or no effect on waviness, and vice versa. Polishing a cam to a mirror finish, for example, may not impact the

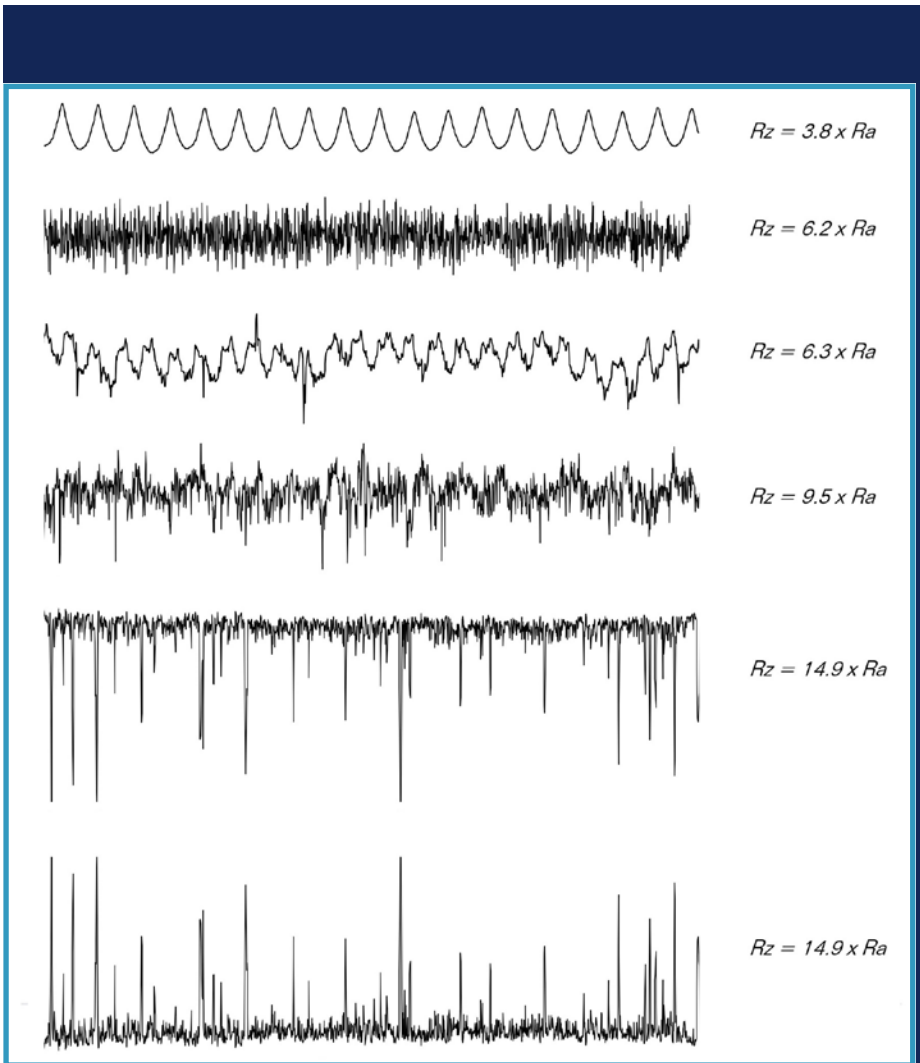

Figure 3—Very different surfaces, all with the same Ra value. Courtesy of The Surface Texture Answer Book.

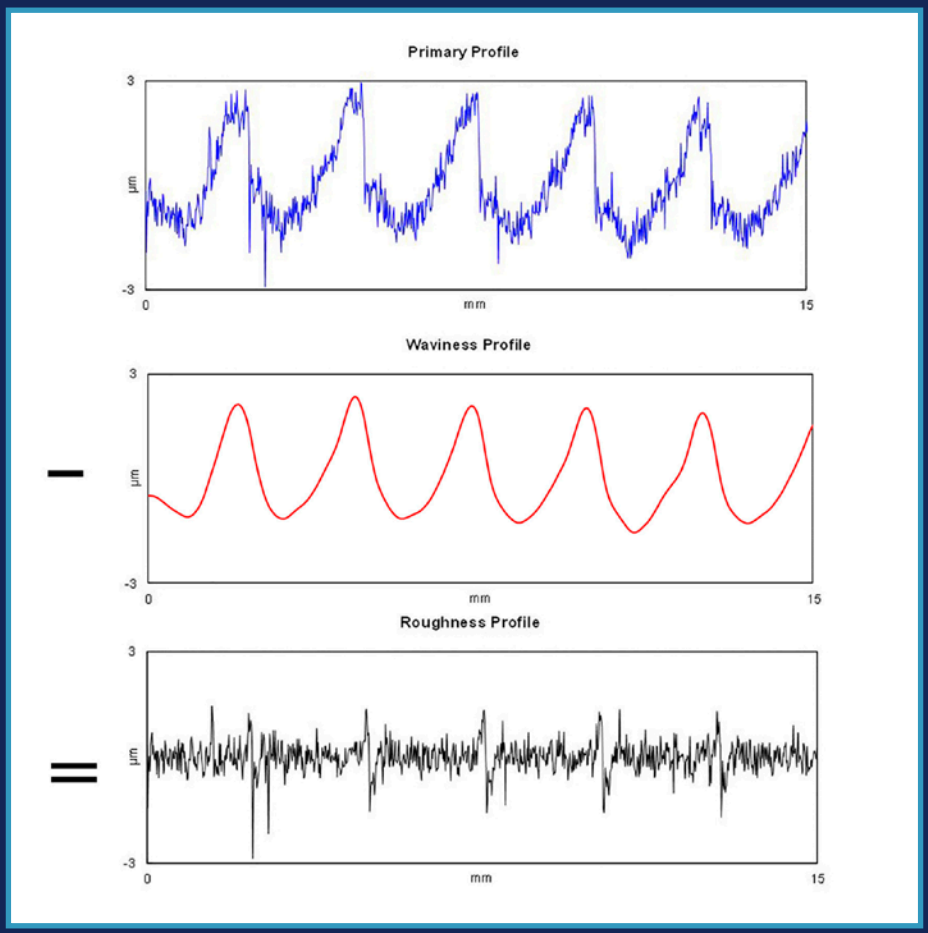

Figure 4—Separating surface texture (top) into longer-wavelength waviness (middle) and shorter-wavelength roughness (bottom). Both aspects of the texture may be critical to the part's function. Courtesy of The Surface Texture Answer Book.

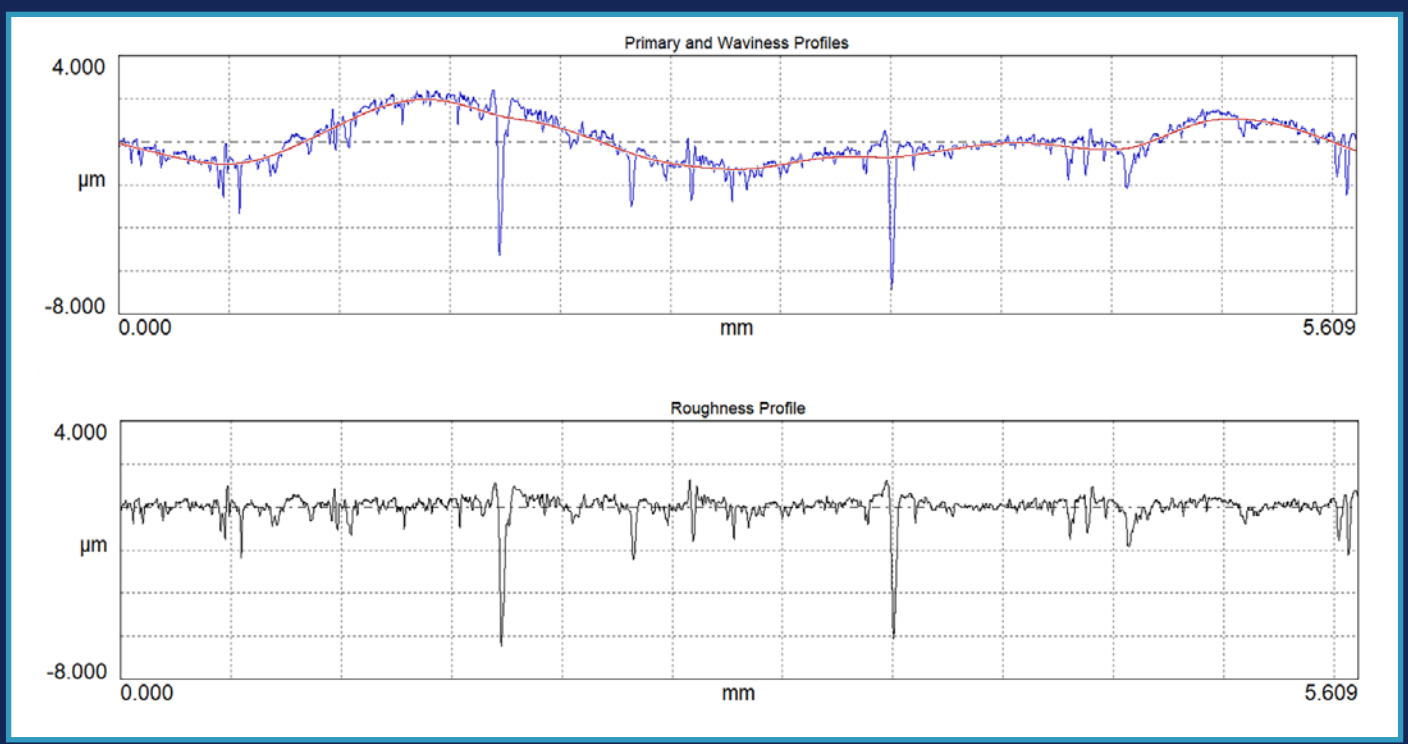

Figure 5—A profile measurement of a shaft section. The top plot shows the waviness (red) superimposed on the primary profile. The bottom plot shows the roughness (with waviness removed).

waviness at all, and that waviness could lead to chatter and premature wear. For seals and other components, this kind of polishing could result in parts that pass roughness inspection but fail in actual performance, because larger-scale waviness may create leak paths that a roughness measurement would miss.

Parameters for Controlling Surface Texture

Early measurement systems only provided a handful of roughness parameters such as average roughness, RMS roughness, maximum peak-to-valley height, and possibly waviness. As measurement technology and processing capability have advanced, dozens of parameters have been developed to track additional aspects of the texture, such as spacings between peaks, the ratio of peaks versus valleys, etc. (Figure 6). All these parameters were developed to track aspects of texture that affect part performance but could not be discerned by more basic parameters.

The choice of which parameters to specify and control depends, again, on the application. If rough peaks represent a potential issue for sealing, or sufficiently deep valleys are required to retain lubrication, then parameters can be specified to control these aspects of the texture.

Learning More About Surface Texture

The world of surface texture goes far beyond a single number definition. To produce quality surfaces, we need to be able to see and understand what matters about the texture for the application. Many resources are available to learn about surface roughness/texture, including short videos, tutorials, books, and sample data available through *digitalmetrology.com*.

PTE

Mike Zecchino has been creating resources and technical content related to measurement and surface texture for over 20 years. His articles have appeared in dozens of publications, and his training materials and videos support numerous measurement instruments and technologies.

mzecchino@digitalmetrology.com

Dr. Mark Malburg is the president of Digital Metrology Solutions. With over 30 years in surface metrology, he is the chief architect of a range of standard and custom software for surface texture and shape analysis. Dr. Malburg has consulted in numerous industries ranging from optics to aerospace. He is a frequent participant in standards committees and has helped shape many of the standards that govern surface specification and control.

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Figure 6—Analysis software includes many parameters to control various aspects of the surface texture. TraceBoss software courtesy Digital Metrology.

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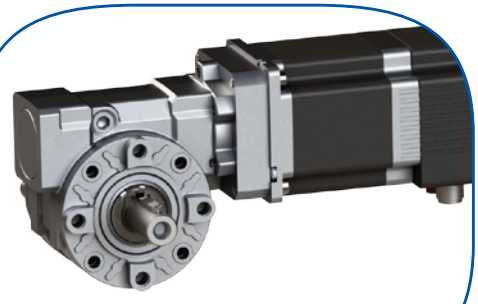
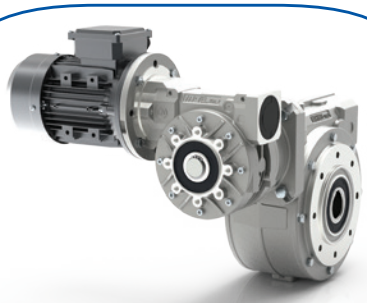


Custom Servomotor Flange

Precision Worm



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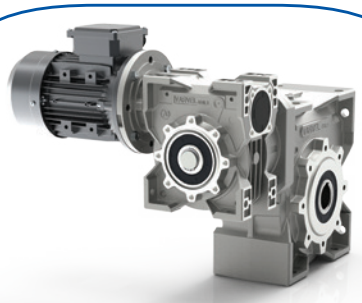

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Brakes and Clutches for Integration into OEM Applications

Flexible solutions from Force Control, Miki Pulley, and Ringfeder

Aaron Fagan, Senior Editor

Brakes and clutches play a crucial role in various applications, and their importance lies in their ability to control motion and transmit power with precision and accuracy and enhance the safety and protection of personnel and equipment. They also optimize energy consumption and reduce downtime. The ability to integrate these components into OEM applications is essential. Below we focus on the brake and clutch solutions provided by Force Control, Miki Pulley, and Ringfeder.

As these manufacturers demonstrate, brakes and clutches offer versatility and adaptability to different operating conditions. They can be customized to specific requirements, allowing for compatibility with a wide range of machinery, systems, and applications. This flexibility enables manufacturers to optimize performance and meet diverse operational needs. These essential components provide control, safety, efficiency, reliability, and adaptability. Their proper selection and integration contribute to improved productivity, reduced costs, and enhanced overall performance of machinery and equipment.

Force Control Helps Wysong Improve Accuracy and Cuts Costs

Wysong USA is a manufacturer of industrial press brakes, hydraulic shears, and mechanical shears for sheet metal and plastics that have been around for nearly 120 years. Like many companies, their motto was "If it ain't broke, don't fix it," so their product remained essentially the same for quite a while. But during a customer visit that motto clashed with another company saying, "The customer is always right." This customer had changed out the dry clutch brake for an oil shear clutch brake that was more accurate. Well, "the customer is always right" won out, so Wysong updated their product line and not only increased accuracy but also reduced costs, making it a win all around.

Wysong Shears cut sheet metal and sheet plastic for companies making large automotive components, tractor hoods, and lawnmower hoods, among others. Often the presses run 24/7, so accuracy, repeatability, and durability are key factors. As the business has shifted from sheet metal to plastic sheets, customers have been looking for increased accuracy.

Their shears are used to cut plastic from 60-in. wide to 10-ft. wide, in thicknesses from 30-thousandths of an inch to five-eighths inch, like those used for lawn tractors. They typically operate from 60 strokes a minute to upwards of 200 strokes a minute.

During a routine customer visit with Primex Plastics, Wysong production engineer Linton Summers noticed that the clutch brake originally installed had been replaced with a Force Control clutch brake. Summers was impressed with the increased accuracy and repeatability as he watched the machine shear section after section of sheet plastic. While the Primex results were impressive, Summers knew they'd have to make some changes to the set-up for OEM scale productions. For instance, removing a gearbox and replacing it with couplers and turning shafts is fine for a one-off project, but a keyed shaft was required for production volume.

Originally the shear was designed to run even if the mechanism is slightly out of position. "When you told it to go if it skipped a tooth, it would still go," said Summers. This breakdown caused a wrong-sized part and wasted material—both undesirable outcomes.

Out with the Old

Wysong formerly used a clutch brake in their shears. These shears are designed to run at 60 strokes a minute and include a flywheel to overcome inertia and an encoder on the chain drive cam switch. Depending on the speed, the flywheels could get rather large, up to 40-in. tall in some cases. Because there is inherent fluctuation with a chain drive, the accuracy of the encoder was not optimal. The encoder certainly helped, but slight inaccuracies over time meant manual adjustments were typically required, either by an operator or by maintenance personnel. The old-style designs also needed maintenance every year, to the tune of about $4,700 for the parts, plus two to three hours to change out the parts. Once reassembled, the shear had to be manually finessed to ensure it was running properly before production could resume.

The new Force Control clutch brakes are very different and require far fewer auxiliary components to operate. There are no flywheels, and one Force Control Posidyne model 3 clutch brake replaces a pair of clutch brakes, so the cost savings add up quickly. The old-style design required a D-style motor with high slip to allow the motor to accelerate the flywheel up to speed. Eliminating the flywheel allowed Wysong to utilize a much more common (and less expensive) B-style motor.

"We use just one Force Control, and we connect to a worm drive gear which we mount to the side frame," said Summers. "Then we have a motor sitting on top. It's all caged in. We've designed it to mount to a plate that we can easily remove."

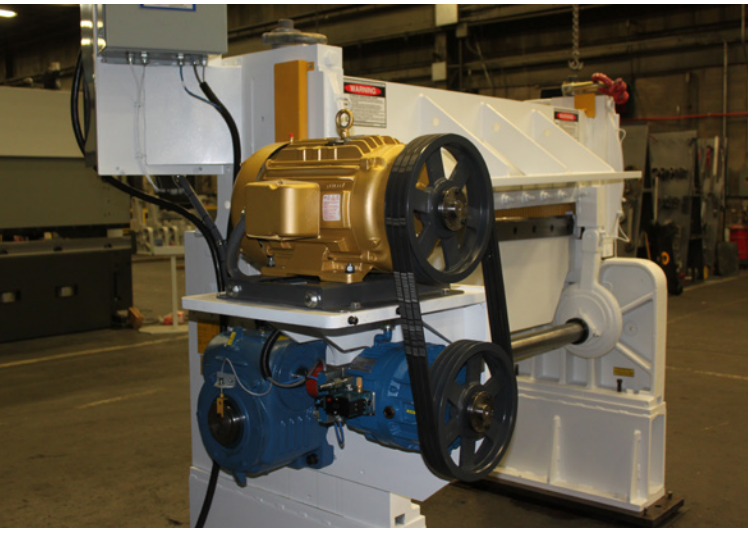
Old design with original clutch brake.

By replacing the dry clutch brakes with Force Control brakes, the shears achieve much greater accuracy and repeatability and are far more cost-effective in terms of manufacturing and maintenance. "The repeatability standpoint is a night and day difference. On the old version, you've got the brake and then you've got the clutch that's on a flywheel. It's all one set of air," says Summers, "so there is only so much adjustment available. With the Force Control, we have the manifold with the air adjustment for the brake and the clutch. You can run more air on the brake and less on the clutch. It's separate, whereas on the original it's all one. With the Model LC, the Force Control corrects itself automatically."

The Force Control Model LC is a form of closed-loop positioning control. It reads the machine position on each stop and adjusts, in real-time, where to signal the stop for the next part/cycle. This compensates for any frictional, wear, or thermal changes that occur over time, and greatly improves accuracy. Adding the Model LC eliminated the cam switch and chain drive from the old design, simplifying assembly while improving accuracy.

Designed with low inertia cycling components makes the Posidyne clutch brake more efficient, requiring less motor horsepower to accelerate the load, and less torque to stop the load. Their totally enclosed design is impervious to dust, chips, chemicals, coolants, caustic washdown, weather, and more, making them ideal for hostile environments.

Their multiple-disc design produces high torque from a small package. Recirculating the fluid dissipates the heat of the engagement, which is a common cause of downtime with other clutch/brake assemblies.



Posidyne retrofit with worm gearbox.

A simple actuation system allows torque in the clutch and brake to be precisely controlled. Adjustment for rapid or soft starts and stops is easily accomplished. Manifold-mounted control valves reduce response times by eliminating hoses and fittings and are recommended for high-cycle applications. By reducing the high starting inrush currents and the associated power factor imbalance in the motor these unique clutch/brakes can also reduce energy costs.

The Posidyne clutch brake can be actuated by air or hydraulic pressure for use in a plant or outside remote applications. The hydraulic actuation package includes a hydraulic pump, solenoid valve, regulators, and a filter. A heat exchanger can be added for additional cooling. It's also inherently explosion-proof with the addition of an explosion-proof actuation valve or locating the valve in an explosion-proof cabinet. Multiple sizes are available to suit particular applications from one-half to 350 hp (99 lb. in. to 79,000 lb. in.) with cooling options, control logic, and mounting arrangements to simplify and speed installation.

Oil shear technology is the reason that clutch brakes by Force Control last up to 10 times longer than standard dry friction clutch brakes and do not need maintenance, adjustment, or disc replacement. Oil Shear Technology is the function of a boundary layer of transmission fluid in shear between the friction discs and drive plates. As the parts come together, the fluid in shear will transmit torque between the two parts, as well as absorb heat. This eliminates direct contact of the friction discs and drive plates during high-speed slip. Heat from the friction surface is dissipated as the fluid circulates to the housing.

Heat dissipation is a major component when selecting a clutch brake. The Posidyne clutch brake basic unit dissipates heat through a unique internal design pumping system which causes the transmission fluid to be drawn into the center of the hub, flow through the friction stack, and by centrifugal force is pulled out of the stack to the housing. Cooling occurs as the fluid flows down the housing walls. Additional heat can be dissipated by adding internal water-cooling or pulling the fluid out to external-oil-to water or oil-to-air heat exchangers. This also allows for the use of an oil filter extending the life of the fluid. These cooling options allow the same compact size Posidyne clutch brake to be used on high inertia loads, or in extremely high or low temperatures.

The Force Control brake also saves money, both in manufacturing costs and ongoing maintenance costs, so it's a winning proposition not only for Wysong but also for the customers who will be using them. The company has also designed modular retrofit kits so that older-style flywheel models can be upgraded to enhance accuracy and reduce maintenance costs.

forcecontrol.com

Miki Pulley BXR Spring Applied Brakes Ideal Safety Brake for Robotic Arms

Miki Pulley is introducing their BXR Spring Applied Brakes for direct sale to OEMs in North America. The BXR safety

BXR Brake's low-profile design is two-thirds the thickness of most other brake models. Lightweight and energy-saving, this fast-response brake is ideal for servomotor applications.

brake may serve as an emergency brake, as well as a holding brake. Its low-profile design is two-thirds the thickness of other brakes in their lineup. In addition to saving space, weight is also dramatically reduced.

The BXR is an ideal safety brake for robotic arms. In these applications, when a catastrophic power failure occurs, robotic arm movement must be halted immediately to prevent mechanical system collapse and equipment damage. In the event of power failure using the BXR safety brake, compression springs engage and capture the brake's rotor hub immediately stopping arm movement. Designed with a very thin profile, the BXR saves space in articulating joints. Idling wear is also reduced significantly because of its lightweight construction. The BXR brake may also be installed on the output face of a servomotor, serving as a power-off holding brake. This can be an advantage when the overall assembly size must be contained in a small envelope.

Additional design benefits include a single friction plate, which provides fast response in high-cycle applications. Armature engagement is smooth, quiet, and operates with no chatter.

Sleek, extra thin-designed Miki Pulley BXR Brake blends perfectly into this compact articulating robotic arm joint application.

Successful in articulating joint applications where a cantilevered load must be minimized, the extra thin BXR brake operates in this way: to open the brake and allow free rotation, voltage flows to the coil. When power is disengaged from the coil, internal compression springs push the armature plate toward the rotor disc, halting it against the top plate. The square/splined rotor hub affixed to the input shaft interfaces with the rotor disc holding rotational movement.

The Miki Pulley BXR brake is also a space and weight-saving option for servomotor applications. Operating specifications are:

- Brake torque: 3.688 ft. lb. ~ 40.566 ft. lb.: (5N · m ~ 55N · m)
- Brake outer diameter: 3.287 in. ~ 7.280 in.; (83.5mm ~ 185mm)
- Ambient Temperature: 14°F ~ 104°F; (-10°C ~ 40°C)

Miki Pulley also makes available even smaller sizes with the designation BXR-LE, (low energy) for miniature applications 0.06 Nm to 3.20 Nm.

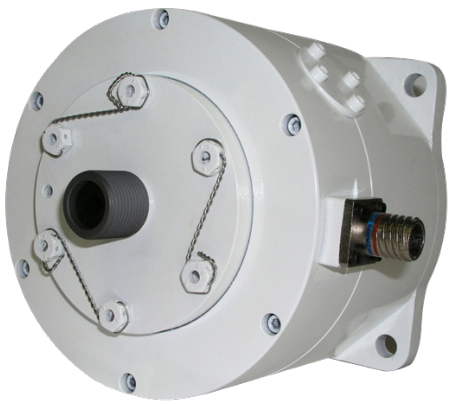
mikipulley-us.com

Ringfeder's Customizable Solutions for Precise Power Transmission Requirements

The MTL Bidirectional, One-Way Clutch

A clutch that is both bidirectional and one-way might sound like a contradiction. But in fact, Ringfeder offers just such a clutch. As a bidirectional clutch, the MTL can transmit torque from input to output shaft in either rotational direction. And its one-way functionality prevents output shaft loads from backdriving into your other power transmission components. These capabilities make the MTL bidirectional one-way clutch excellent at sustaining torque overloads and shock loading.

Choose from three standard models with torques ranging from 15 to 120 ft. lbs. and bore sizes ranging from seven-eighths to 1⅞ in. The clutch's driving end achieves smooth rotation regardless of the direction of the load, and it is self-locking—made possible by a friction disc and ball ramp design.



The MTL bidirectional one-way clutch can sustain substantial torque overload and shock loading while preventing the output shaft from backdriving the input shaft in either direction.

You can easily integrate the MTL bidirectional one-way clutch with other Carlyle Johnson clutches, brakes, and torque limiters, creating lighter and more compact designs depending on the component combination. For example, pair the MTL clutch with a Carlyle Johnson spring-applied clutch for braking, torque limiting, and manual driving functionalities—all without having to worry about backdriving.

We can even include a torque limiter as part of the MTL bidirectional one-way clutch. If you place it on the input side, it will limit the driving torque. If you place it on the output side, it will allow slipping in the stationary

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The FEA clutch is ideal for heavy-duty applications and provides a long service life. Its powerful electromagnetic disengagement force ensures a low-drag neutral.

component if there is an excess load, protecting either upstream or downstream components. Both the internal torque limiter and spring-applied clutch are available customization options. Another option is the ability to set a firm slipping point.

Our experienced engineers can customize the MTL bidirectional one-way clutch to meet your design and application requirements. We can also alter any of our standard products or design an entirely new clutch.

The FEA Fail-Safe Spring Set Electromagnetic Clutch

When developing fail-safe systems for precise, delicate, or heavy-duty machine applications, components that deliver extreme reliability and high performance are invaluable. The FEA Fail-Safe Spring Set Electromagnetic Clutch features a durable design with high-strength components to provide high torque in a compact, easy-to-install, completely assembled package.

Our FEA unit is a spring-applied, positive-acting electric clutch with high repeatability. A powerful electromagnetic force disengages the discs to provide a low-drag neutral, and the radial magnetic flux path provides maximum torque throughout the clutch's lifespan. To extend the clutch's lifespan even further, a unique, adjustable end-plate design facilitates easy wear compensation.

The FEA's coil is sealed within a stationary housing—enabling operation in both wet and dry environments—that is supported by ball bearings. For additional protection, internal compressive forces are contained within the clutch and not transmitted through the bearings. With a focus on dependability, the FEA's design contains no levers, cams, or other highly stressed parts.

Because there are few moving parts and no slip rings, brushes, or complex wiring that make repair difficult, this clutch can be rebuilt without requiring any special tools. Like all their electromagnetic clutches, the FEA is precision-engineered and undergoes thorough testing to ensure proven, dependable performance across a diverse range of applications.

Custom Solutions

Ringfeder dedicates a significant portion of its production efforts to designing and manufacturing special clutches, brakes, and integrated systems that are custom-tailored to exact user specifications. If you need a custom electromagnetic clutch solution, Ringfeder has the experience and skills to meet your toughest power transmission challenges. Some common modifications include increased torque or adding electronic controls to achieve different actuation and release speeds as well as acceleration and deceleration control.

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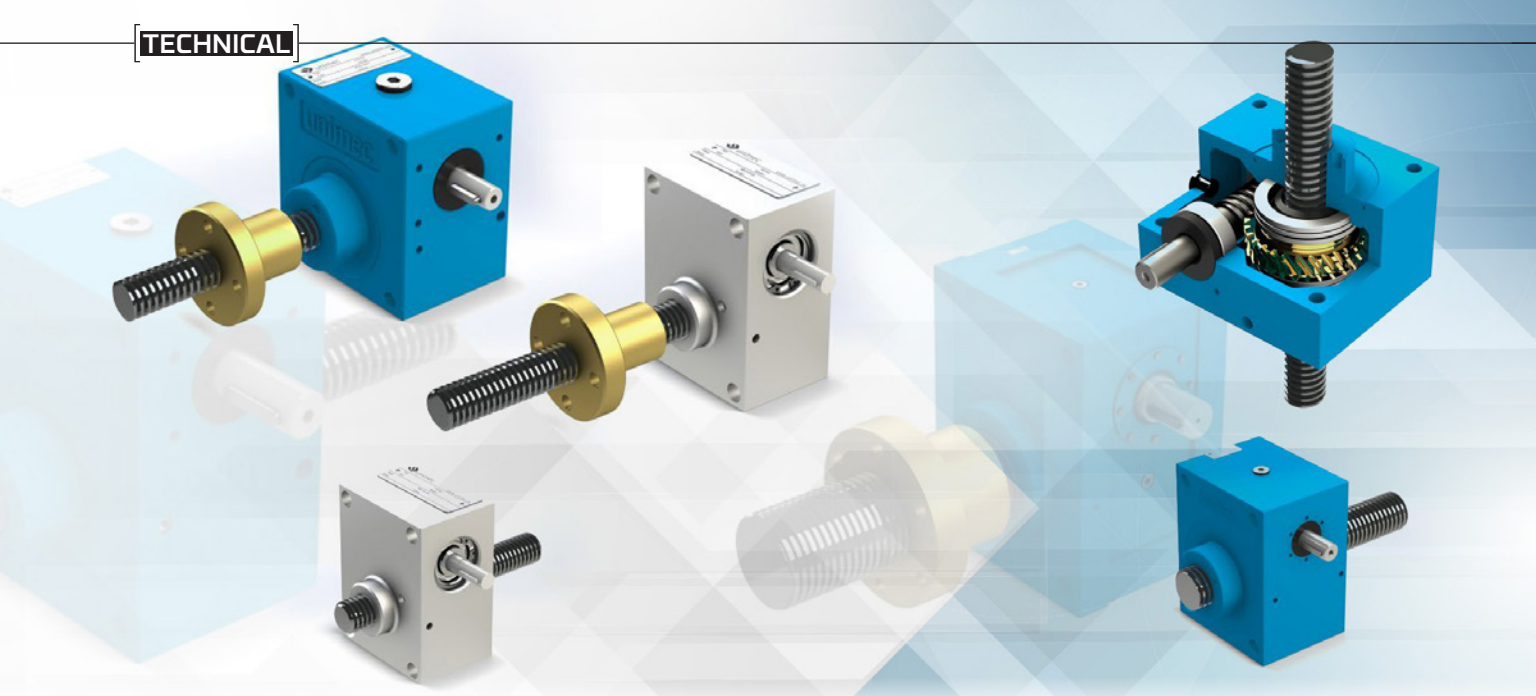


When specifying a trapezoidal screw jack pay close attention to load capacity, input speed and duty cycle. All photos courtesy of Unimec.

A Guide to Trapezoidal Screw Jack Design, Construction and Selection

Alex Bronzini, Unimec North America

When you need to move a heavy load with a high degree of accuracy and safety, a trapezoidal screw jack is hard to beat. Because trapezoidal screw jacks are a well-established technology with an enduring design, you'll find many high-quality units to meet your basic design needs. It is also easy to assume that there's no difference among the many products available. However, not all screw jacks are created equal. When performance counts, some factors can make the difference between a good screw jack and an exceptional screw jack.

This article will provide an overview of some of the basic considerations to remember when you select a trapezoidal screw jack, and it will explain how screw jack design, construction, manufacturing, lubrication, and other factors can help your gearbox perform at its best.

Review the Basic Specifications

When specifying a trapezoidal screw jack, make sure you check the manufacturer's datasheet for the following information:

- **Load capacity.** Refer to the screw jack's datasheet for its static and dynamic load handling capabilities. Keep in mind that there is more to specifying a screw jack than knowing its load capacities. You will need to specify whether the screw jack will be configured for a compression or traction load.
- **Input speed.** Input rpm and gear ratios will help determine how fast the load can travel. Unimec offers standard ratios of 1:5, 1:10 and 1:30. Due to the friction that occurs between the internal gears and within the threads of the spindle, a high travel speed can overheat the unit. Using our testing machines, we have accurately calculated that trapezoidal screw jack input speeds should never exceed 1,800 rpm x 60 Hertz. Check your screw jack manufacturer's reference charts for acceptable heat limits.
- **Duty cycle.** Screw jacks require intervals between uses to dissipate heat and do not operate continuously. Duty cycle indicates the frequency at which the screw jack moves the load.
- **Other factors.** These may include environmental conditions that affect the screw jack's operation such as temperature and vibrations.

When lifting a load in compression configuration, the spindle may be susceptible to so-called buckling or deformation

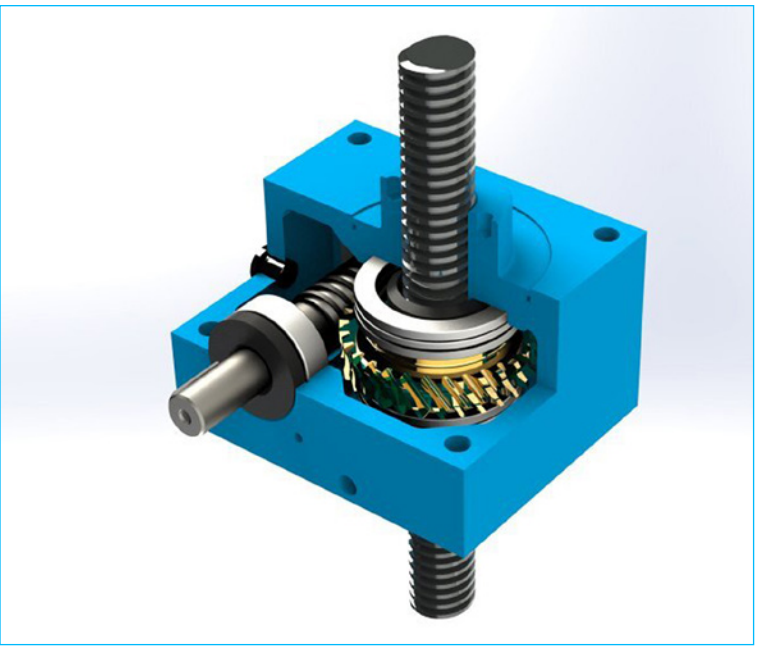
under the weight of the load. In this type of situation, refer to Euler's laws for guidance on how to reduce the load. In traction mode, the buckling of the spindle is negligible. Also note that screw jacks are not designed to handle lateral loads. If your load is not perfectly centered, you must use a linear bearing to absorb the moment and thus prevent premature wear or possible failure.

An Enduring Design Versus a Fresh Approach

The traditional screw jack design consists of a metal plate supporting a rounded gearbox with a trapezoidal screw on top. Although this design is well-established, it has a drawback: To install the gearbox, it must connect directly to the metal plate and users must specify the screw jack's orientation based on whether it will be subjected to either a compression or traction load. The flanged design also presents a potential weak point where the metal plate connects to the round section of the gearbox.

To obtain more orientation flexibility, consider a less conventional design. One such design not only offers orientation flexibility, but also exceptional sturdiness and easy installation. This design is characterized by a square shape and six machined surfaces, which allow the screw jack to be installed in multiple configurations. Unimec trapezoidal gearboxes feature this square design with through-holes that allow top-to-bottom installation as well as side installation.

A pair of collars—each with an integrated bearing identical to and having the same load capacity in both directions as the other—guide the spindle and eliminate the need for specifying the load direction and operating configuration. This innovative dual-guide and dual-axial bearing concept also provides inherently more precise motion since the spindle is guided by two points instead of one. The result: a single system for all configurations.



This square gearbox design features a dual-guide with dual bearing and precision machined surfaces on all six faces, allowing the screw jack to be installed in multiple configurations.

Materials and Manufacturing

While there is little variation among screw jack manufacturers regarding the materials used in screw jack construction, some materials are more appropriate than others in certain situations. The material is also closely related to how the screw jack components are manufactured. In fact, high-quality materials in combination with superior manufacturing processes typically produce the best-performing screw jacks. Here's a summary of the various materials used in screw jack construction, their characteristics and some of the manufacturing factors that can distinguish a high-performance unit.

Gearboxes/Frames

- **Machined aluminum.** This material is commonly used for smaller units due to its heat dissipation properties, good durability, and high tensile strength.
- **GJL cast iron.** Well-suited for mid-size frames, cast iron offers excellent rigidity, durability, and good damping characteristics.
- **Electro-welded S355 steel.** Carbon manganese—a non-alloy steel—is recommended for large units used in the most demanding applications. Features include high strength and excellent weldability.
- **Technopolymer.** An advanced technopolymer is not only cost-effective, it also boasts a variety of advantages. To learn more, refer to the sidebar, *Technopolymer Allows Screw Jacks to Work Dry in Food Applications.*

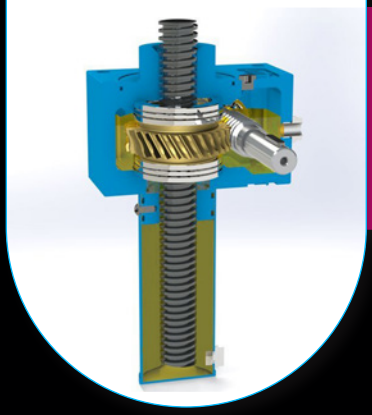
Screw Jacks and Bevel Gear Reducers

- **AISI 316 stainless steel.** This widely used stainless steel offers good corrosion resistance and excellent defense against salinity as well as good tensile strength in both low and high operating temperatures.

Internal Gears and Worm Screws

- **Tin bronze.** Known in the industry as the go-to material for gears, tin bronze can resist wear and offers some corrosion resistance, good machinability and low- to medium load capacity.
- **Aluminum bronze.** Aluminum bronze has higher tensile strength and greater wear resistance compared to generic tin bronze. Unimec's aluminum bronze complies with EN-1982-2017 standards and obtains its properties thanks to permanent chill mold casting manufacturing. This process creates gears with a finer, more homogeneous microstructure and an inherently more accurate coupling with other gears. It also results in higher reliability over time and a longer life, plus quiet operation and excellent sliding properties.
- **Case-hardened steel.** This material is known for its ability to withstand heat treatments with minimal deformations. Worm screws made from case-hardened steel exhibit greater wear resistance and exceptional structural consistency. When a case-hardened worm screw is also cemented and precision-ground, it couples precisely to the worm wheel and is more durable.

Explore Your Lubrication Options



This completely sealed, oil-bath assembly provides constant, continuous lubrication of all moving parts.

While today's screw jacks offer exceptional durability and strength, proper lubrication is still critical to ensuring reliable operation and good value on your investment. After all, screw jacks last a long time when properly maintained. When you choose Unimec's proprietary lubricants, you can extend maintenance intervals up to two to four times, thereby significantly reducing your maintenance needs.

However, there are many situations that call for more than a standard lubricant or a conventional lubrication system. For example, special environments may also require special grease formulations. And, shutting down important machinery and sending maintenance personnel to harsh or remote environments is time consuming and expensive. Fortunately, the right manufacturer can help ease the burden of lubrication so you can get more out of your screw jack.

Unimec offers many lubrication options for critical applications and environments, from forced lubrication systems to single-chamber construction, oil-bath lubrication and programmable units. One such device, the CU Single Chamber Assembly—available as an option on the TP Series—is a completely sealed, oil-bath configuration for applications where the duty cycle requires constant, continuous lubrication for all moving parts. The lid is programmable, so users can input their lubrication specification.

Another option, Oil Bath Rigid Protection, protects the trapezoidal screw against dust and debris. The unit is completely sealed and is filled with oil. Every time the spindle dips down, it dips into the oil bath for permanent lubrication. For special applications, Unimec can provide non-standard lubricants for food applications, high and low temperatures, clean room and biological environments as well as nuclear applications and explosive applications.

Technopolymer Allows Screw Jacks to Work Dry in Food Applications

In today's food and beverage industry with ever-faster production and throughput goals, you can't afford maintenance downtime. However, maintaining screw jacks in food and beverage manufacturing machinery can be difficult since you cannot simply choose an off-the-shelf lubricant. Regulations require lubricants that can resist degradation from food products, chemicals, water, and steam as well as prevent microorganism and bacterial growth. You will need to consider many variables when selecting an appropriate food-grade lubricant, and you may still have to cope with an undesirable maintenance schedule. Innovative screw jack materials and manufacturing processes can solve this dilemma.

Technopolymers are high-strength plastics that outperform conventional plastics, especially when it comes to resisting heat and mechanical stress. When reinforced with fiberglass, they offer very high strength and rigidity as well as good creep resistance. In addition to these advantages, a technopolymer can work without lubricants—a desirable trait in many food industry applications.

Unimec's Aleph Series trapezoidal screw jacks are made from a fiberglass-reinforced technopolymer that gives molded component surfaces excellent sliding properties for dry operation.

Unimec's Aleph Series of trapezoidal screw jacks are made from polyarylamide—a glass-fiber reinforced technopolymer. Polyarylamide's properties are well-suited for Unimec's manufacturing processes. During molding, a pure polymer film forms on the molded component surfaces, giving them excellent sliding properties. These sliding properties, along with other factors, allow the Aleph Series to operate dry. Although the technopolymer is not self-lubricating, the sliding layer of the spindle can significantly reduce maintenance downtime and even extend the screw jack's life.

Aleph Series screw jacks are cost-effective and have nearly the same mechanical functions, self-locking features and 1:5, 1:10 and 1:30 ratios as a Unimec TP trapezoidal screw jack with translating spindle and the TPR trapezoidal screw jack with rotating spindle and translating nut. For applications that undergo washdowns using harsh chemicals, Unimec also offers the X Series made completely of stainless steel.

Spindles

- **C45 steel.** A medium-grade carbon steel that is typically more cost-effective than alloy steel.
- **AISI 316 stainless steel.** (See previous.)

Depending on the size of the spindle, both materials can be manufactured by cutting or thread rolling. Cutting typically offers good precision as well as the ability to manufacture special threads, multiple starts, left-threaded spindles or other features, but it also results in higher surface roughness. Thread rolling, however, produces a smooth, high-quality surface.

A more advanced thread rolling option—Unimec's 3-Die thread rolling—not only produces a smoother surface than cutting, it creates a more rolling-friendly thread surface with quieter operation, reduced wear and better longevity.

Note that if your application is intended for critical operations such as in extreme environments or where human safety is essential, be sure to partner with a manufacturer that certifies its materials and is capable of meeting specific industry or regional protocols.

Don't Overlook Lubrication

In any system with moving parts, proper lubrication is a must. Although many gearboxes are lubed for life, the trapezoidal screw jack does require lubrication. The appropriate amount of lubricant for your spindle and the proper frequency will depend on the diameter of the screw, the stroke length and your machine's duty cycle. If your machine operates in a special environment, be sure to use a lubricant formulated for that environment.

Keep in mind that deploying maintenance personnel can be costly, especially if your gearboxes must operate in a hard-to-access location. A screw jack manufacturer that makes lubrication easy and helps minimize maintenance needs can add value to your screw jack investment while reducing headaches.

Select a Screw Jack Manufacturer That Meets All Your Requirements

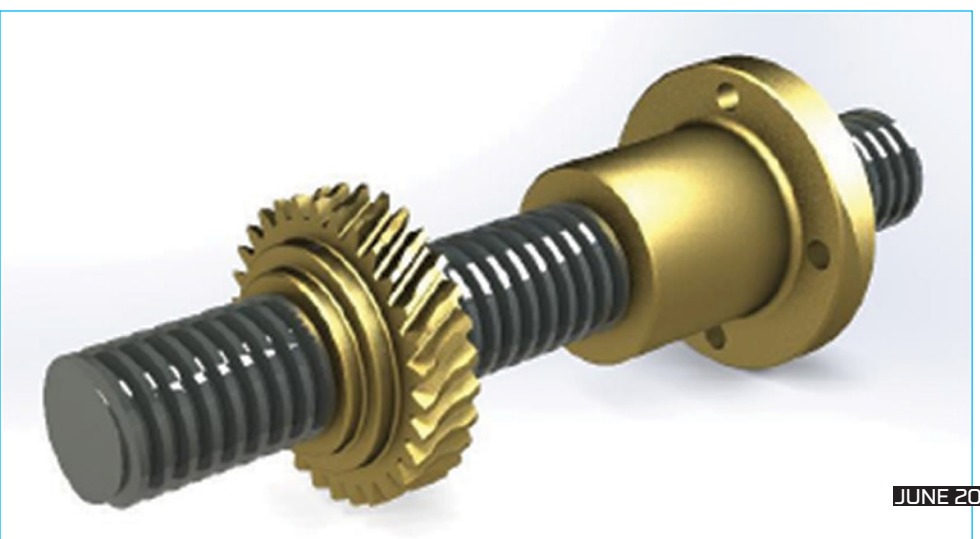
Although there are many screw jack manufacturers to choose from—including many that base their products on a longstanding, reliable flange-type design—not all suppliers are equal. The right screw jack manufacturer will partner with you to meet all your reliability and performance requirements. Be sure to look for the following attributes in a screw jack manufacturer:

- **Certified materials and testing.** The right screw jack manufacturer will ensure your unit is constructed to the highest integrity by using fully certified, traceable materials. It will also make certain it will perform in your intended application. Unimec, for example, goes beyond the typical simulation and uses proprietary, in-house test machinery to replicate the application by applying the same load weight, cycle, speed, and stroke, as specified, and presents the results to the customer. Not only can Unimec certify the screw jack's calculations and lifetime estimates, but we can also certify that the unit is manufactured to the application's required protocols.
- **Vertically integrated production.** When you need a quality screw jack, it makes sense to partner with a supplier that controls its manufacturing processes. When a screw jack manufacturer produces its components in house, quality is assured and customization is not only easier, lead times are shorter. You'll also get a quicker response when you need to solve a problem.
- **Custom Solutions.** Although there are numerous screw jack manufacturers offering many standard products, many applications present special requirements that off-the-shelf screw jacks cannot satisfy. In these cases, a special unit is the best means of solving a problem, maximizing performance or adapting to a special environment.

Obtain Superior-Performing Screw Jacks

Screw jack technology goes back more than 100 years, so your selection process will turn up an abundance of suppliers that create a good-quality unit—typically with the same time-tested design. When you consider a radically different design and emphasize certified quality materials along with the supplier, its manufacturing and testing processes and other factors, you can obtain highly reliable, superior-performing screw jacks and optimal value.

unimecusa.com



Compared to regular tin bronze used in worm wheels and lead nuts, Unimec uses an EN-1982-2017-compliant aluminum bronze that is harder and presents a finer and more homogeneous microstructure, offering a higher tensile strength and superior wear resistance.

High-Precision Brushless DC Rotary Motors Optimal for Pick-and-Place Robots

Edward Neff, Founder and CEO, SMAC Moving Coil Actuators

In electronic automation precise movement is a basic requirement for successful assembly. Both linear and rotary motion demands a high level of precision needed in circuit board assembly, assembling camera lenses and speakers in smart phones and other electronic assembly applications.

The best linear motion solution uses linear motors. Small, precise brushless motors are most often used for rotation.

There have been several recent technical advances in the design and production of precision linear and rotary pick-and-place robots that meet the ever-tightening requirements of the consumer electronics and back-end electronic assembly industries.

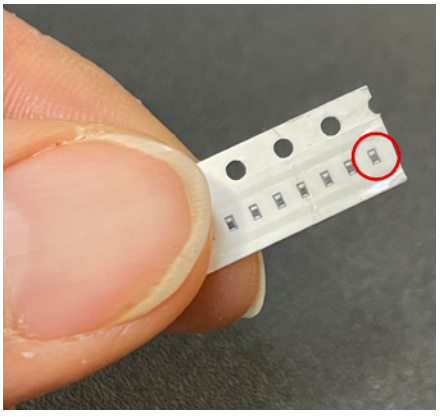
The Requirements

The general trend for assembly is the need for more precision. This is the

The SMAC LAR31 Linear Rotary Actuator has 17 micron true position tolerance for dowel holes, making it ideal for high-precision circuit board assembly.

result of the continually shrinking size of electronics and even mechanical parts. As electronics get smaller, so does the margin for error in assembling them. In rotary motion, the accuracy of placement must increase.

Most electronic assembly today involves the inspection of parts by camera or laser before they are added to the smart phone, computer, or other device. No part is perfect; they all vary because the world really is non-Euclidian! Therefore, the placement position of each part must be slightly and variably adjusted before assembly. This also occurs in camera lens assembly, for example, where part-tolerance variation is large but the stack up tolerance is small.



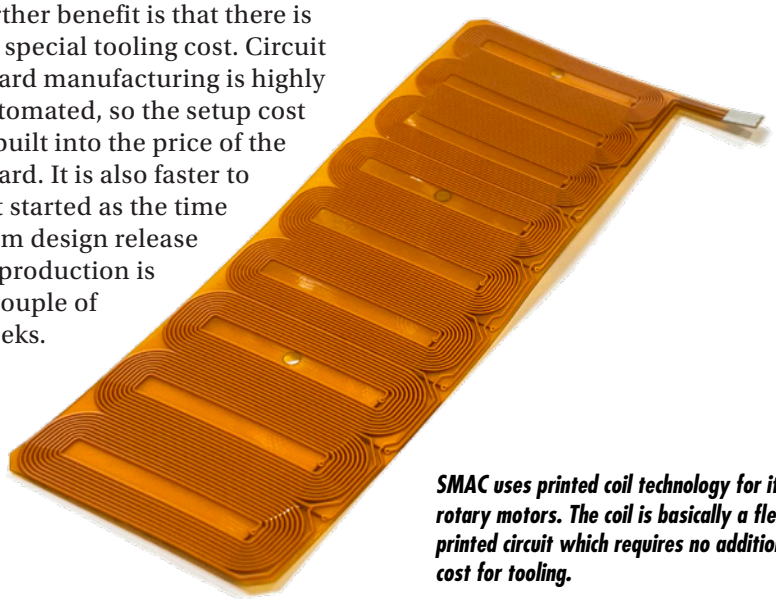
Assembling resistors and capacitors requires extreme precision due to their small size.

Rotary motor positioning requirements call for accuracy of ±0.1 degree or better. Rod runout must be less than 10 microns and the diameter of the motor must be less than 15 mm, and that is moving toward 8 mm.

These demand constraints put pressure on motor and encoder manufacturers to improve their design and manufacturing methods. To meet demands, manufacturers can do several things:

1. Improve the electrical design of the motor. This can be accomplished in a couple of ways.
   A. Use printed coil technology rather than winding coils using wire and electromechanical winders. Motor wire for these types of small motors is very thin, which makes precision winding a challenge. A printed coil is basically a flexible printed circuit. The "wire" is replaced by printed circuits on a strip. "Printed" wire is like square wire used in high-end speakers. The wire width and height are not tied to set gauge sizes, which means higher torques can be achieved, especially because speed is not critical.

      This strip is then wound and formed into a resulting coil. The process is very precise as it is essentially the same as that used in circuit boards. The coil resistance is very repeatable and, since there is no wire fed from a spool or tensioning to worry about, is a factor of 10 tighter than conventionally wound coils. A significant side benefit is greatly reduced cogging effect compared with that seen in conventionally wound brushless motors. A further benefit is that there is no special tooling cost. Circuit board manufacturing is highly automated, so the setup cost is built into the price of the board. It is also faster to get started as the time from design release to production is a couple of weeks.



SMAC uses printed coil technology for its rotary motors. The coil is basically a flexible printed circuit which requires no additional cost for tooling.

   B. Use molded soft laminations, which are rapidly replacing stacks of stamped lamination rings. Again, the effect on cogging and the cost of production are drastically reduced.

2. Improve the accuracy of the encoder.
   A. Build the disc and hub directly onto the shaft of the motor. Many encoders are coupled to the motor shaft, which causes error and can add side-load to the shaft increasing its runout. If the hub-disc assembly is press-fitted onto the shaft, error is reduced.
   B. Use laser technology to make the disc. Lasers are rapidly replacing old mechanical manufacturing methods like mills and saws. Lasers that run on linear motors are extremely precise and can hold disc size/track variation to less than 5 microns, easily a factor of 10 times better than conventional methods. This eliminates the need to make mechanical placement adjustment, which includes precision cameras that can detect down to a micron.

Molded soft laminations eliminate stacked rings, reducing cogging and cost of production.

Stator housing holds both bearings in line, keeping lathe bore diameter and straightness variance to within 1 to 2 microns.

3. Reduce the rod runout.

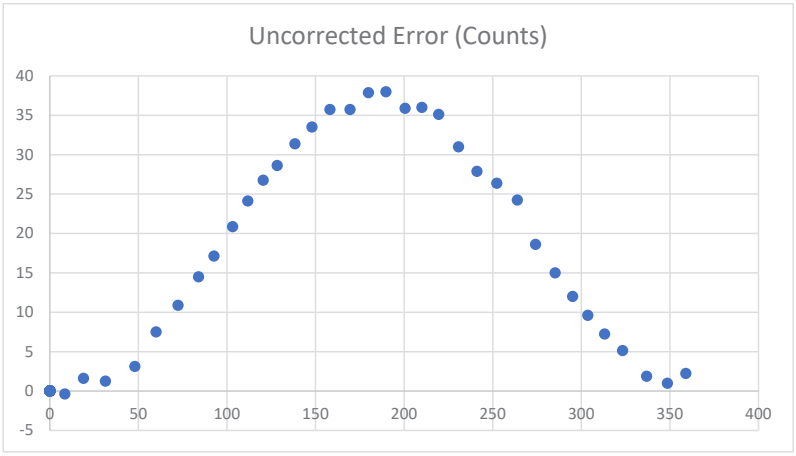
A ground shaft can normally meet a straightness requirement of less than 5 microns. Bearings have a positive effect on runout however, greatly reducing runout.

A. Mount both the front and rear bearings in a stator bore that has a single diameter. The single bore lines up the bearings precisely with each other. It is possible on certain lathes to hold that bore to within 1 to 2 microns of diameter and straightness variance.
B. Use a threaded bearing preload adjuster and wave spring to precisely set the preload. Until now, most designs use spacers and wave springs. There may be several thicknesses of spacers and wave springs stacked. An adjustable threaded spacer, combined with a single wave spring, is screwed into position while monitoring the effect on motor starting torque to reach a target close-loop preload.

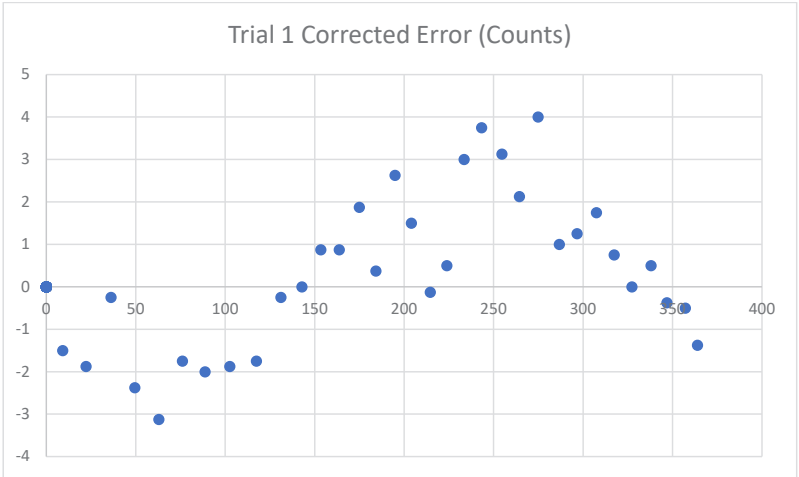
Adjustable preload can be closed looped to set extremely precise load.

Error correction testing 12/16/2022

The test encoder is set to 40960 instead of 409600. This should not change the results in any meaningful way. This test also used a code disc offset of 100 microns. The results of the control trial are shown below.



The error from this level of misalignment was a sinusoidal curve with an amplitude of 0.35 degrees of error, or 38 counts. The correction procedure was then followed and applied to the encoder yielding the results shown below. This marked improvement reduced the error significantly to a sinusoidal curver with amplitude of 0.006 degrees of error or 5 counts. This improvement shows that the error correction process can make a large improvement in eccentritiy error when the minimum error is above a certain threshold. Further testing will be needed with a smaller disc to determine what the minimum threshold of error will be for our application.



Accuracy testing shows error well under 0.1 degree.

The result is a rod runout of less than 10 microns, and often even less than 5 microns.

4. Add vacuum pick-up / gripper operation capability.

Although the use of pneumatic devices is coming to an end in electronic assembly, there still are several limited application areas.

The first is a vacuum, the most common way to pick up small, fragile parts. The vacuum flow also picks up dust that is on and around the components to be picked up. A good design for the motor is to have a shaft with a hole that runs through the motor to direct dust outside the motor and into the vacuum device which has filtration.

Grippers are often used for larger components. Grippers tend still to be pneumatic, mainly due to the lower cost. The same through-hole shaft design, combined with correct sealing, means that pressurized air can move through the motor and into the gripper.

In conclusion the long-term trend in electronics is moving toward higher-density components in smaller and smaller package sizes. Pick-and-place robots now have nominal widths of 13 mm which move to 10 mm, and very soon 8 mm. Robot makers must keep up the development pace to meet the challenge. This means 8 mm motors with 10 millinewton-meters (mNm) of torque and encoders with 20,000 steps per revolution.

Invention combined with never-ending improvement is the key. Brushless motors are following this trend for rotary motion just like linear motors are for linear movement. And this technology is spreading into robotics, particularly in end-effector evolution. That's where there really is a need for a helping hand. Practical robotic fingers and hands will soon be a reality.

smac-mca.com

Edward Neff is the founder and CEO of SMAC Moving Coil Actuators. He founded SMAC Corporation in 1990 in Carlsbad, Calif. SMAC has grown to become a global leader in moving coil technology and the largest manufacturer of moving coil actuators. Neff has spent more than 40 years in the automation field and has managed automation companies in Belgium, Japan and the USA. He holds more than 40 patents. Neff grew up in Birmingham, Mich., and is a graduate of the University of Michigan. He's a retired international rugby player and enjoys watching the Wales national team.

Numerical and Experimental Analysis of Starvation in a Tilting Pad Journal Bearing

Cori Watson-Kassa, Bruce Fabijonas, Roger Fittro,
Scan DeCamillo, Minhui He, Houston Wood

Nomenclature

A = *Area (L2)*
r = *Radius (L)*
γ = *Area ratio (-)*
HPOTP = *High-pressure oxygen turbopump*
SSME = *Space shuttle main engine*
TOR = *Teeth on rotor*
CFD = *Computational fluid dynamics*

Introduction

Fluid film bearings are used in a variety of turbomachinery to transmit loads from the rotating shaft to the stationary structure. Titling pad journal bearings support the radial loads and are used in a wide variety of machines due to their superior rotordynamic characteristics. Cavitation, starvation, and aeration are critical considerations in the physics of journal bearing performance as diverging regions of the film can cause cavitation or entrain air (Ref. 2). Starvation can also occur at the leading edge of the pad when the supply flow rate is insufficient to fill the gap between the journal and the pad (Ref. 5). Typically, Reynolds equation-based thermoelastohydrodynamic (TEHD) bearing codes assume that this starved region near the leading edge is axially constant (Ref. 4) as shown in Figure 1.

San Andres, et al. (Ref. 11) also use this leading-edge assumption in the prediction of low-frequency shaft motions. The basis for this assumption was the experimental results of Heshmat and Pinkus (Ref. 6) who tested journal bearings under a variety of flow conditions. Their results showed that streamlets form across the starved region of the film and that these streamlets coexist with the ambient air, producing no meaningful hydrodynamic pressure.

A byproduct of this starvation assumption is that pads opposite the loaded direction are likely to be predicted as fully starved before starvation is predicted in the loaded pads (Ref. 5). Lower hydrodynamic forces in the upper/unloaded pads suggest an increase in the film thickness on the loaded pads (Ref. 12). This prediction also suggests a significant change in bearing rotordynamic coefficients under starvation. Specifically, Whalen, et al. (Ref. 13) found dramatically reduced stiffness and damping coefficients under starved operating conditions. Starvation is also known to affect the performance of the bearing by reducing power loss (Ref. 3). Critically, reduced oil flow is also known to increase pad temperature (Brockwell 1997[QTA: No REF Info.?]).

Understanding flow starvation and correctly modeling it is therefore of great importance to the turbomachinery industry. This work evaluates the accuracy of the current starvation model popular in TEHD bearing codes and establishes shortcomings in the current theory that need to be addressed by those working in the field. The critical distinction that will be discussed in this work is that when a single large streamlet forms in a converging region of the film, hydrodynamic pressure can be generated. For this purpose of understanding the distributions of temperature, pressure, and phase during flow starvation, only the unloaded pad is discussed in this work.

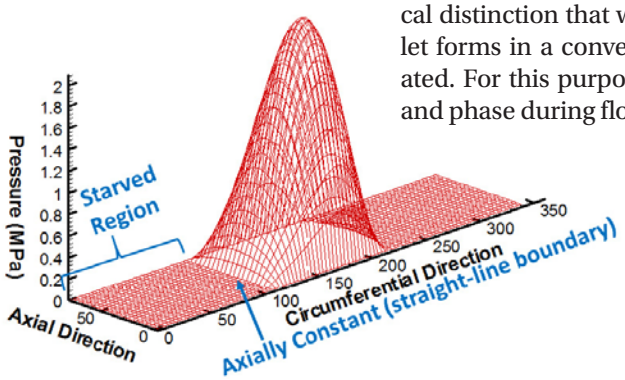


Figure 1 — Starvation assumption of TEHD bearing codes used by He (Ref. 4).

Experimental Work

A series of heavily instrumented tilting pad journal bearing tests were performed by Kingsbury R&D in 2012. Select pads were fitted with arrays of probes to acquire more detailed information on the behavior of the individual pads. The tests provided unique insight into the complex behavior of the pads under various operating conditions. One behavior, in particular, was an indication of aeration at the axial edges of the pad in the case of insufficient lubricant flow rather than starvation at the leading edge which is a typical assumption in direct lube-bearing code development. The second key observation was that in the side-aerated state, the peak temperatures were measured on the axial edges of the pad rather than the trailing edge. Results are presented later in this paper. The simultaneous existence of side aeration and the increased temperature was difficult to envision until a recent CFD analysis of a slider bearing conducted by the University of Virginia predicted similar behavior.

Preliminary CFD Work

Preliminary work was done by the University of Virginia in 2016 on a slider CFD model with adiabatic wall conditions as shown in Figure 2. The question this model sought to answer was whether even with axially constant supply flow, starvation occurs following the straight-line assumption.

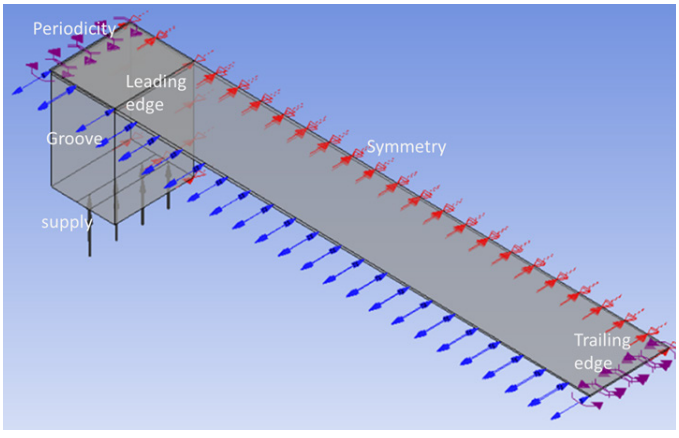


Figure 2—Slider bearing used for preliminary work.

In this model, oil was supplied in an axially constant supply opening as seen in the figure to allow for the best possible chance of matching the straight-line assumption. The boundary conditions are depicted in Figure 2, with the blue arrows showing the region of air ingestion as well as air and oil exit, the black arrows showing the oil supply, the red indicators showing symmetry, and the purple indicators showing the periodicity of the single pad model. Results for temperature and pressure for the unstarved case yielded predictable results. However, when the supply pressure was reduced, an increase in air volume fraction was observed at the axial edges of the pad rather than starvation at the leading edge as demonstrated in Figure 3.

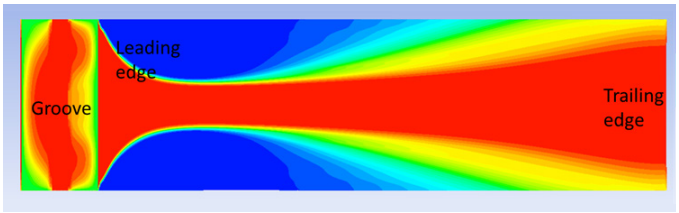


Figure 3—Volume fraction on the groove and pad surfaces for starved slider bearing case (blue represents air and red represents oil).

Additionally, in this starved case, the temperature profile was unexpected. Figure 4 shows the temperature on the pad and groove surfaces.

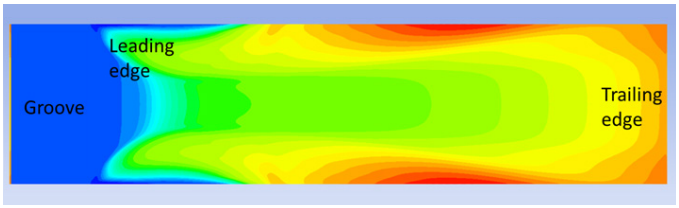


Figure 4—Temperature distribution on the pad and groove surfaces under starved conditions. (blue represents cold oil and red represents hot oil).

The results indicated that the hottest point on the pad surface was not at the trailing edge of the pad, but instead at the axial edges. Similar CFD results for temperature and volume fraction were also recently reported by Sakai, et al. (Ref. 10) and Ochiai, et al. (Ref. 8) for a plain bore journal bearing. These results of peak temperature at or near the axial edge can be understood from the CFD models in terms of where the carried-over hot oil exits on the pad but was not known to be physical without the experimental correlations.

Objective of Study

Given the similarity of the experimental tilting pad test results and the preliminary slider-bearing CFD results, the authors agreed to collaborate on a joint project. The goal is to match the experimental tilting pad results with an exact CFD model to lay the groundwork for future studies explaining these phenomena of side aeration and peak temperature on starved pads.

The next two sections will describe the experimental and computational methodologies. Detailed comparisons of the results will then be presented. Finally, conclusions and future work will be discussed. Ultimately, it is desired that this project will form the basis for the development of more accurate TEHD bearing codes for starvation, aeration, and thermal modeling.

This study focuses exclusively on the unloaded pad (Pad 4 in Figure 5) due to having the greatest starvation. The CFD model was found to match broadly across all center-line temperature and pressure probe measurements. Discussion of these results will be the subject of future work as not to dilute the discussion of the unloaded pad and the relevant physical phenomena observed.

Experimental Methodology

Test Bearing

The test bearing is shown in Figure 5 and is described in Table 1.

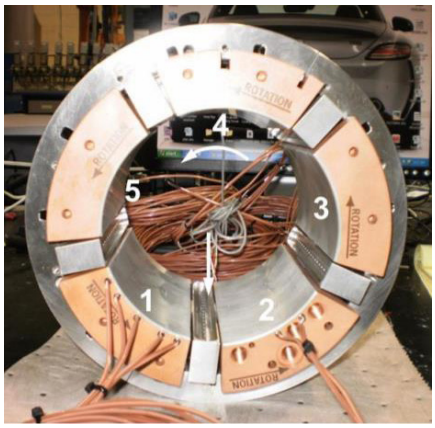


Figure 5—The test bearing numbers indicate pad positions used throughout the paper.

Bearing Diameter	5 in (127 mm)
Bearing Axial Length	5 in (127 mm)
Number of Pads	5
Pad Offset	60%
Assembled Bearing Clearance	3.77 mils (96 μm)
Bearing Preload	0.17

Table 1—Test bearing geometry.

Select pads in the test bearing were fitted with arrays of probes to acquire detailed information on film thickness, film pressure, hydrodynamic film force, and pad temperature of the individual pads in the bearing. Although all pads have thermocouples, one in particular was instrumented with an array of fifteen thermocouples that allow construction of pad temperature isotherms. For simplicity, we refer to this pad as "Pad A." The locations of these sensors are indicated in Figure 6.

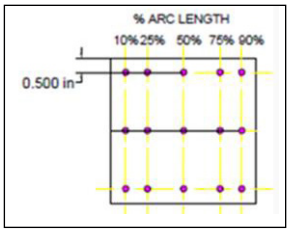


Figure 6—Locations of temperature sensors in heavily instrumented Pad A. Direction of shaft rotation is left to right.

Another pad, which we call "Pad B," was instrumented with five pressure transducers to record film pressure. The locations of these probes are indicated in Figure 7.

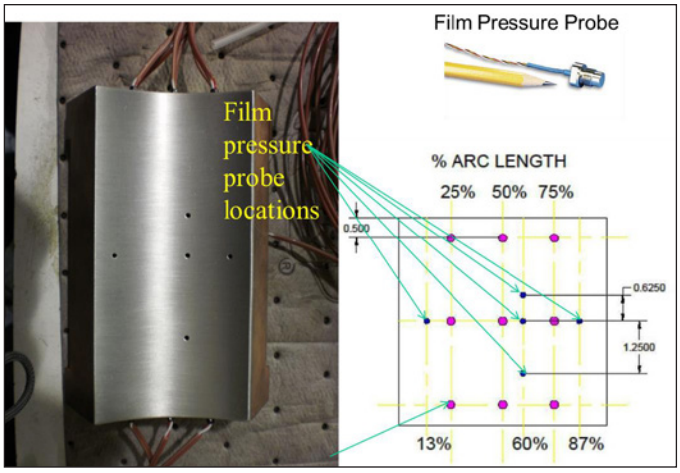


Figure 7—Locations of the five pressure probes (in blue) and nine thermocouples (in purple) in Pad B. Again, the direction of shaft rotation is left to right.

A third pad, "Pad C," was instrumented with five capacitance probes and a load cell to capture film thickness and hydrodynamic film force. The locations of these are indicated in Figure 8.

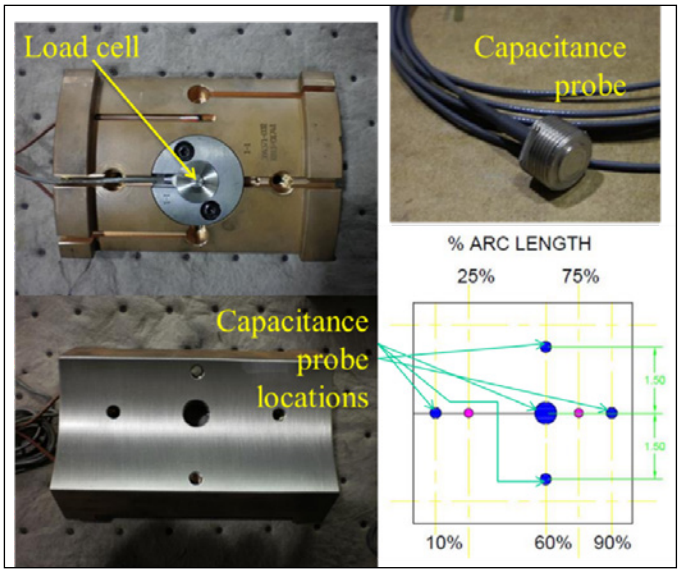


Figure 8—Locations of the five capacitance probes (in blue), two thermocouples (in purple), and load cell (in the shoe support) in Pad C. Direction of shaft rotation is left to right in the schematic, and bottom to top in the lower left-hand picture.

The range and precision of the instruments used are given in Table 2.

Instrument	Manufacturer
Thermocouples	FEP
Film Pressure Probes	Omega PX600
Capacitance Probes	MTI Instruments APS-10-ILS/SP
Load Cell	Transducer Techniques SLB-1K

Table 2—Description of instruments used.

For the first test in each series, the measured data include pad temperatures in position 1 from Pad A (Refer to Figure 5), film pressures in position 2 from Pad B, and film thicknesses and hydrodynamic load in position 5 from Pad C. After the first run, the bearing was physically rotated one pad position and the test was repeated. The second test yielded pad temperatures in position 5, film pressures in position 1, and film thicknesses and hydrodynamic load in position 4. This was repeated for a total of five tests so that each of the three specially instrumented pads (Pad A, Pad B, Pad C) were tested in all positions in the bearing at identical operating conditions. With temperature, pressure, hydrodynamic load, and film thickness data for each position, it is possible to examine all of the data at any of the pad positions for a particular set of operating conditions.

Test Cases

The results presented in this paper are limited to the conditions shown in Table 3 and focus solely on the unloaded pad position, pad position 4 in Figure 5. Plots of pressure, temperature, and film thickness acquired in these tests are presented later in side-by-side comparisons with the CFD results (Figures 11–16).

Oil Grade	ISO VG 32
Oil Inlet Temperature	120°F (48.9°C)
Oil Flow	45 & 8 gpm (170.3 & 30.3 l/m)
Operating Speed	11,500 rpm
Surface Speed	250 fps (76.2 m/s)
Operating Load	500 lbf (2224N)
Unit Loading	20 psi (0.14 MPa)
Loading Direction	Load Between Pads 1 & 2 (Refer to Figure 5)
Pad Material	Chrome-Copper
Oil Supply Method	Groove Inserts with Central Supply Hole

Table 3—Operating conditions of the test case.

CFD Methodology

CFD analysis was conducted at the University of Virginia using the computational cluster Rivanna and the commercial CFD software ANSYS CFX. Computational fluid dynamics solvers, like ANSYS CFX, solve the Reynolds-averaged Navier-Stokes (RANS) equations using numerical techniques such as finite element or finite volume methods. The computational model of the test setup is shown in Figure 9.

Accuracy	Range
±2°F (1.1°C) or 0.4% of reading	24°F-1400°F (0°C -760°C)
±1% of Full Scale	0-5000 psi (0-345 bar)
±0.02% of Full Range	0.5-20 mils (12.7-508 µm)
0.25% of Rated Output	0-1000 lbs (0-4448 N)

The model is half the bearing since axial asymmetric loading is negligible and therefore the model is symmetric about the centerline. This reduces the computational time by half. As can be seen in Figure 9, only a sliver of the full journal is modeled due to the periodicity applied at the circumferential edges. ANSYS CFX employs a "frozen rotor" option to then translate the sliver to a full cylindrical journal during computations. This allows for circumferential averaging of the temperature on the fluid side of the journal surface as it moves relative to the fluid. This is based on the assumption that due to the rotation of the shaft, the temperature on the shaft is axisymmetric. Conduction is modeled with a flux-conservative interface between all the solid and fluid components. The outside of the bearing shell is modeled as adiabatic.

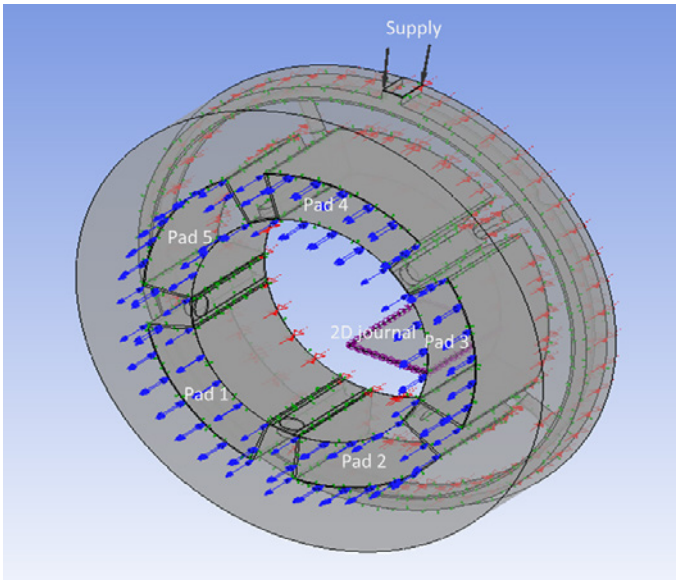


Figure 9—Numerical model used in CFD analysis.

The surface speed of the rotor is applied as a no-slip wall at the fluid surface where it touches the journal. The fluid surface where it touches the pad is also no-slip, but stationary. A mass flow rate is specified at the supply to the supply annulus (top of the model) that corresponds to flow rates in Table 3. The end of the journal is modeled as adiabatic where it would connect with the rest of the shaft. The boundary conditions are depicted in Figure 9, with the blue arrows showing the region of air ingestion as well as air and oil exit, the black arrows showing the oil supply, the red indicators showing the symmetry, green dots showing the regions of connection between the solid and fluid surfaces, and the purple indicators showing the 2D periodicity of the journal. The thermal effects are modeled using the thermal energy model in ANSYS CFX and the problem was considered laminar as the Reynolds number is low. The multiphase problem is treated as homogeneous in both thermal and flow fields. Air is allowed to enter the bearing at the axial edges, which is modeled as incompressible air at 77°F (25°C). The convergence criteria, which is the root-mean-squared differential between the nodes of subsequent solutions in pressure, velocity, temperature, and phase were set

to 1e-06. A conservation target, which measures the change in total quantities of mass, momentum, temperature, and phase between iterations, was specified as 0.01. The numerical scheme was high resolution.

Because the CFD model requires a film shape to be specified, but the known quantity in the experiment was load, Fluid-Structure Interaction (FSI) iteration was used to determine the correct loaded position of the journal and the pads. The FSI iteration was deemed to have converged when the load reached within five percent of the predicted load and the torque on the pads was less than 8.85 lbf-in (1 N-m). These criteria for force and moments were set based on further reductions in their magnitude not leading to meaningful changes in the eccentric position or pad tilt angles. Deformation of the pivot only was imported from a Reynolds equation–based TEHD solver. Deflection of the pads was ignored in the numerical analysis due to the relatively low bearing load.

Mesh independence was performed in both cases. Comparison of pressure, temperature, and volume fraction profiles for meshes of 0.360, 2.01, and 4.79 million elements were conducted. The results showed that the intermediate mesh had a sufficient number of elements. The mesh utilized is structured everywhere except the groove region to allow for fewer elements in the model. The mesh with 2.01 million elements is shown in Figure 10. The 2.01 million element mesh utilized 10 radial elements, and 0.0394 inch (1 mm) elements in the circumferential and axial directions.

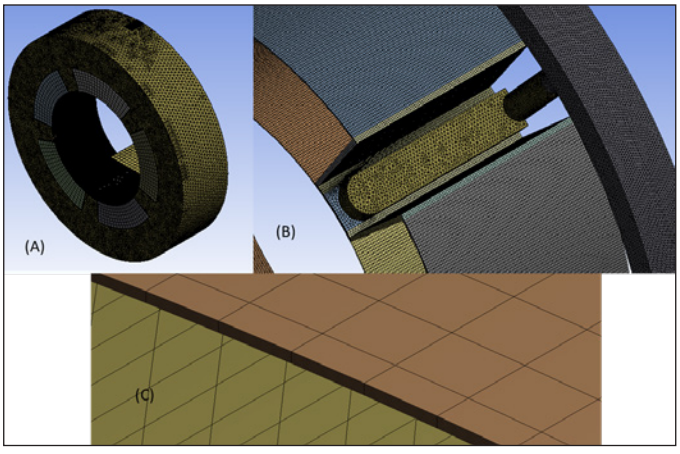


Figure 10—Intermediate mesh density: (A) overall mesh; (B) fluid domain mesh; (C) mesh in the thin film.

Detailed results comparing the CFD based on the intermediate mesh and experimental data are presented in the next section.

Results and Discussion

Experimental results are given in part A of Figures 11–16. The unique data acquired regarding hydrodynamic film force, air volume fraction, oil film thickness, and pad temperature are represented by results for operating conditions stated in Table 3. Part B of Figures 11–16 show the corresponding CFD results. Note that shaft rotation in Figures 11 through 16 is right (leading edge) to left (trailing edge). The experimental plots shown in Figures 11–16 show a mix of interpolated and extrapolated values of the measured data. The interior white dots in these figures indicate sensor locations. The white dots on the periphery of Figures 11(A) and 14(A) indicate additional points at which we impose a zero-pressure boundary condition. Note that similar boundary conditions for film-thickness and temperature cannot be imposed on the peripheries of the pads in Figures 12(A), 14(A) and Figures 13(A), 16(A), respectively. We use the open-source visualization software ParaView (Ref. 1) to generate a two-dimensional Delaunay triangulation of the data. Values whose spatial coordinates fall inside the triangulation are interpolated and appear as surface plots in Figures 11–16. To extrapolate the experimental data exterior to the Delaunay triangulation, we construct a radial basis function fit to the data. The contour plots in Figures 11-16 are level surfaces of these fits. Finally, the color schemes in each plot were chosen to have agreement between surface and contour plots within a figure, and closely match the maximum and minimum values of the corresponding CFD simulation.

Figures 11 and 14 show a reduction in the pad pressure profile, correlating to a drop in hydrodynamic load on Position 4 from 1500 lbs to low levels as flow was reduced from 45 to 8 gal/min (2.83 to 0.505 l/s). (Hydrodynamic load is not shown in the figure.) Figures 11 and 14 also demonstrate a strong agreement between the experimental and numerical peak pressures with an error of about 3%. This error is likely due to the CFD's iterative method for finding the correct loaded position. As stated above, the acceptable error in force was set to 5 percent, so a 3 percent error in peak pressure is very reasonable. The CFD results indicate a narrowing of the pressure profile axially as the supply flow rate is decreased. This is not as clearly observed in the experimental contours simply because the experimental pressure profiles were generated based on curve fitting the 5 pressure measurements and the outer most pressure sensor is 1.25 inches (0.0318 m) away from the axial edge. However, this trend is obviously consistent with the cavitation observed along the axial edges as indicated in Figure 15.

Figure 12 (A) indicates a reasonable film shape at 45 gal/min with a film thickness of 14 thousandths of an inch (0.3556 mm) at the leading edge, down to 3 thousandths of an inch (0.0762 mm) at the trailing edge. Figure 15 (A) requires some explanation. Capacitance probes were specifically chosen for film thickness measurements in these test series because their design depends on and is calibrated for the medium, in this case ISO VG 32 mineral oil. Should the medium change, the capacitance changes giving a false step change in measurement. Capacitance probes, therefore, become a suitable indicator for aeration.

Figure 15 (A) indicates a 0.012 in. (0.3048 mm) variation across the axial length of the pad which is physically impossible with the low load and temperature of this case.

The butterfly shape is the result of a step change in measurement at the side detectors (Figure 7). In other words, the shape represents aeration of the oil at the location of the side detectors. That the step change appears to be smooth in Figure 15 (A) is a consequence of a finite amount of data points used in the plotting software. The center line film thickness, on the other hand, measures approximately eight-thousandths of an inch (0.2032 mm) at the leading edge and 6.5 thousandths of an inch (0.1651 mm) at the trailing edge, which is reasonable based on the clearances of the test bearing.

Given this indication of aeration at the axial edges, volume fraction (volume of oil to air) distributions on the side surface are shown in part B of Figures 12 and 15. Figure 12 (B) demonstrates low aeration, which is logical given the high supply flow rate. Small amounts of axial end leading edge aeration is observed. However, Figure 15 (B) shows that over half the pad surface has ingested air along both axial sides. The capacitance sensors on the axial edges are in this aerated region, thus explaining the butterfly-shaped film thickness in Figure 15 (A).

Part A of Figures 13 and 16 contain the measured pad temperature plots for the conditions under consideration. Figures 13 (B) and 16 (B) demonstrate close matches in the temperature across the pad between the CFD and experimental results within approximately 2°F (1.11°K) of the measurement temperature points. Figure 13, at

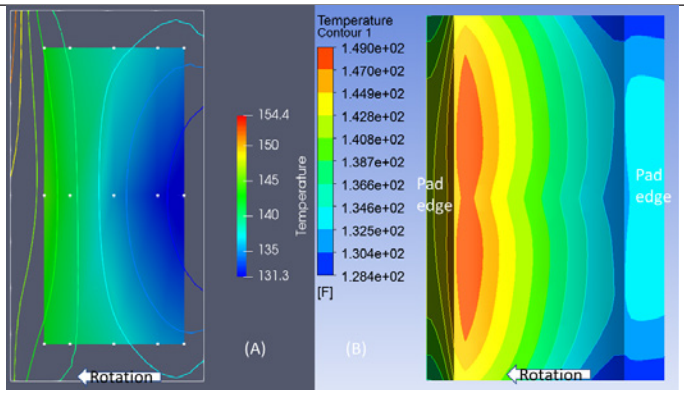


Figure 13—45 gal/min (2.83 l/s) temperature results (F) at position 4 (A) experimental (B) CFD.

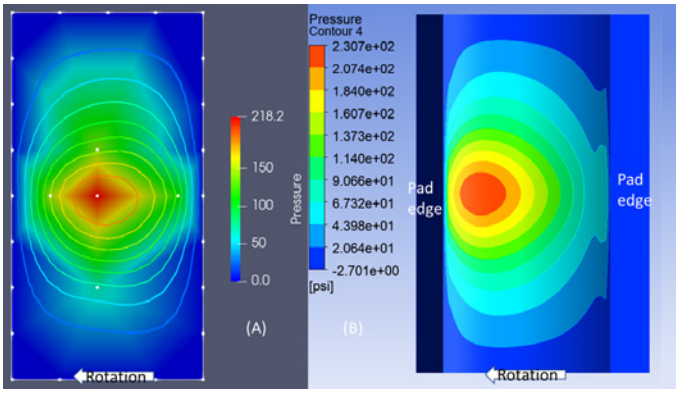


Figure 14—8 gal/min (2.83 l/s) pressure results (psi) at position 4 (A) experimental (B) CFD.

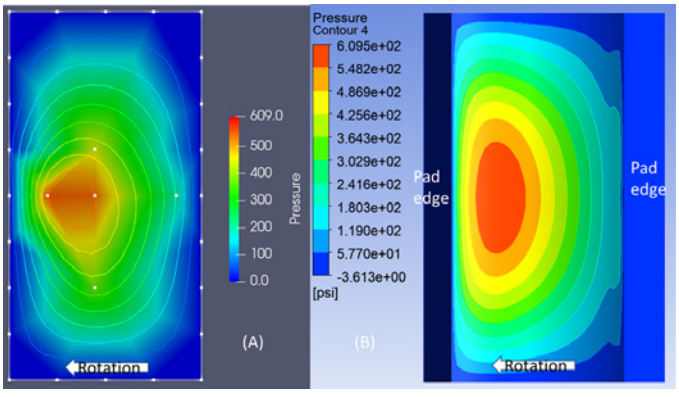


Figure 11—45 gal/min (2.83 l/s) pressure results (psi) at position 4 (A) experimental (B) CFD.

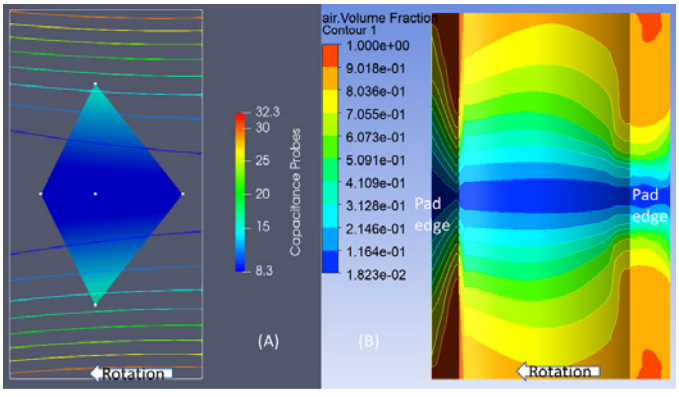


Figure 15—8 gal/min (2.83 l/s) experimental film thickness results (mils) and CFD air volume fraction at position 4 (A) experimental (B) CFD.

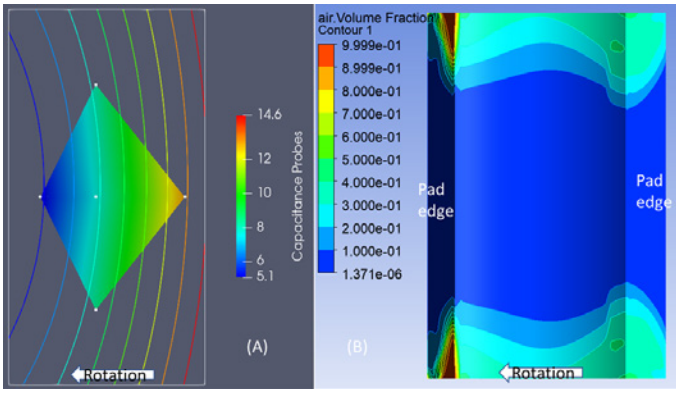


Figure 12—45 gal/min (2.83 l/s) experimental film thickness results (mils) and CFD air volume fraction at position 4 (A) experimental (B) CFD.

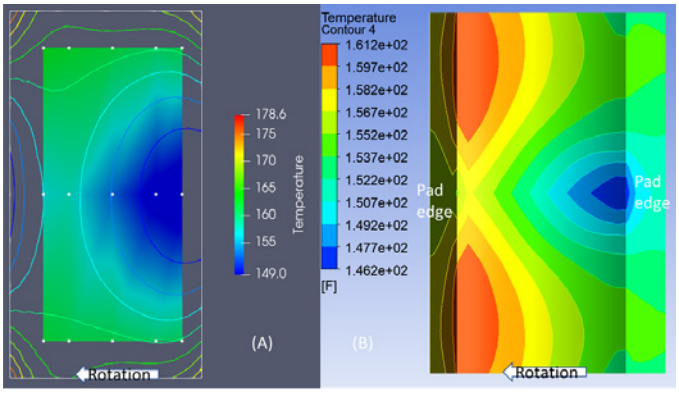


Figure 16—8 gal/min (2.83 l/s) temperature results (F) at position 4 (A) experimental (B) CFD.

45 gal/min (2.83 l/s), displays isotherms typical of those expected and found in most technical papers, experimental and theoretical. Temperatures are low at the leading edge and increase in the direction of rotation toward the trailing edge of the pad. Figure 16 (A), on the other hand, displays maximum temperatures at the axial edges of the pad, a result that formerly seemed contrary to expectations of the pad temperature in a highly aerated region. Similarly, the CFD results depicted in Figure 16 (B) show that in the starved case, the highest temperatures exist at the axial edges. This is despite Figure 15 indicating the oil in this region is highly aerated.

Mechanisms of High Axial Edge Temperature During Starvation

A detailed review of the CFD results could provide an explanation as to why the highest temperature occurs in a highly aerated region. The work is beyond the scope of this paper, but a basic understanding involves the axial variation of the leading-edge oil temperature and the cross-film distribution of phase in the region.

First, the results show that, in the case of aeration, the cold supply oil stays centralized near the supply hole and the hot carried-over oil bifurcates to either side as can be envisioned in Figure 16 (B). Second, the cross-film distribution of phase in the aerated regions shows a higher volume fraction at the pad surface. This runs counter to the theoretical understanding that the oil adheres predominately to the shaft in cavitated regions (Ref. 2). However, the CFD results include centrifugal force, which forces the oil towards the pad surfaces at the high-speed operating conditions under consideration. In other words, the hot oil is flowing over the pad surface in this region. Therefore, the hot oil carry-over from the previous, more loaded, pad is producing the high axial edge temperatures observed in both CFD and experimental results. If the pad were adiabatic, the temperature would be fairly constant along the axial edges, but conduction through the pad from the center moderately cools the sides of the leading edge.

With these two mechanisms in mind, experimental observation of high axial edge temperatures can be envisioned as hot carried-over oil convecting to the pad surface and heating it along the side edges. It is the authors' intention to present the mechanisms of high axial edge temperature during starvation in more detail in future publications.

Conclusions

A series of heavily instrumented tilting pad journal bearing tests were performed by Kingsbury R&D where select pads were fitted with arrays of probes to acquire more detailed information on the behavior of the individual pads. The effort was in response to industry challenges regarding the accurate prediction of bearing performance and vibration characteristics.

A computational fluid dynamics (CFD) analysis of the test was conducted at the University of Virginia using the computational cluster, Rivanna, and the commercial CFD software, ANSYS CFX.

This paper compares the results of a CFD model with experimental data for an unloaded pad in a directed lube journal bearing under regular and low oil supply flow conditions. The nominal flow case is used to calibrate the CFD model. In the low flow condition, both the experimental data and the CFD model exhibit the same two phenomena: first, the axial edges of the journal pad in question aerate on the axial edges rather than cavitate at the leading edge; and second, the hottest pad temperatures move from the trailing edge of the pad to these aerated regions on the axial edges. These results can be used to evaluate the accuracy of current starvation models popular in TEHD bearing codes and allow for the development of more accurate codes regarding starvation and thermal modeling. Critically, it was found that under flow starvation, the unloaded pad produced a single large streamlet with meaningful hydrodynamic pressure, which is currently unaccounted for in most TEHD bearing codes.

Future Work

This paper focused solely on the unloaded pad of a certain test bearing. Data exists for all pad positions, so the next step is to correlate the performance of the other pad positions and operating conditions.

The complete series of tests also investigated other parameters such as load-on-pad and load-between-pad orientations, steel and chrome copper pad materials, oil distribution configurations, and evacuated vs flooded housing configurations. Future correlation of experiment vs. CFD models will be useful in distinguishing the influence of such parameters and others. For example, the complete series of tests were performed for a 1.0 length-to-diameter ratio bearing. A validated model would better allow a prediction of how shorter L/D bearings affect the cavitation and temperature characteristics.

Future work also intends to further demonstrate the cause of these phenomena through systematic CFD analysis and determine the conditions under which they occur. This will aid in the development of an improved Reynolds equation TEHD bearing code that will better predict film shape and temperature, thus providing better overall performance predictions.

Long term, it is the authors' objective that the observations and modeling of the phenomena presented in this study will lead to more accurate prediction of bearing performance and vibration characteristics, enabling the industry to design better, more efficient, and safer turbomachinery.

Acknowledgments

The authors would like to acknowledge the financial support of the Rotating Machinery and Controls (ROMAC) consortium and thank Kingsbury, Inc. for their tests and permission to present the associated results. The authors also thank Dr. Seckin Gokaltun for his invaluable assistance and Dr. Luis San Andrés for his critical review and input. Scan DeCamillo passed away in February 2021 after completing his portion of this paper. Our thoughts are with Scan's family.

PTE

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Salim Haffar

DISCUSSES EUROTRANS PRIORITIES IN 2023 AND BEYOND

Matthew Jaster, Senior Editor

Salim Haffar, deputy general manager at I-MAK, was reelected as president of EUROTRANS in 2022. This is Haffar's third term in this role. *PTE* recently caught up with Haffar to discuss the evolution of EUROTRANS, the focus of the International Drive Conference at Hannover Messe and the current state of I-MAK's gearbox business in Turkey.

***PTE:* Describe your first two terms as EUROTRANS president and what accomplishments you're most proud of during this period.**

Haffar: The first few years were very busy as we were transitioning to digitalization so I'm very happy that we managed to come together online and we did not lose any of the momentum we had during the pandemic.

I was elected just after COVID started. We didn't take a break. We immediately began doing more within the organization. Online training has been a key focus and we continue to put an emphasis on this work today. I'm most proud of our commitment and dedication to moving forward during these challenging years.

***PTE:* What are your top three priorities during your third term as president?**

Haffar: First, we'd like to continue to bring the power transmission community together for fruitful networking and discussions on understanding the challenges we face and the solutions we can provide here at EUROTRANS.

Second is to continue working on our standards, continue working on advancing the power transmission segment in Europe. Our goal is to support all our large, medium, and small enterprises that are working toward improving their quality and advancing their products and technologies toward digital solutions.

Third, is to continue to train young professionals. We need to make sure we have a large pool of talent available for our European members. This is accomplished by diversifying our training and educational offerings from companies as well as universities. It's important to share as much knowledge as we can and exchange ideas with our member companies to obtain skilled talent for the future.

***PTE:* How has EUROTRANS evolved since you first participated in the organization?**

Haffar: We've made a significant push toward digitalization. We've also strengthened our ties with other organizations—like AGMA, for example—to create a larger international reach and share new ideas and solutions on a global level.

***PTE:* What were some of the highlights of the International Drive Conference at Hannover Messe 2023?**

Haffar: We tried to seamlessly connect a diverse range of subjects to help our members prepare for changes taking place in manufacturing today. We started by analyzing how digitalization can help with sustainability. How these digital tools can be implemented in their products. Then we transitioned to see how to improve sustainability from the production point of view. Next, we examined the risks many of our companies are facing today and how digitalization can help combat these challenges such as counterfeit bearings. Finally, we gave a comprehensive overview of the European economy and new manufacturing

regulations that our members need to be prepared for in the coming years. The event provided a nice overview of things not only happening in Europe but around the globe.

PTE: **Why is it so important to conduct face-to-face meetings like the International Drive Conference in 2023?**

Haffar: The open discussions, the exchanging of new ideas, and having different organizations coming together to speak on the challenges they're currently facing. These are just a few of the reasons face-to-face meetings are so crucial. It is vital to get people from different backgrounds, countries, and manufacturing segments in one place to discuss current and future events.

PTE: **How has the gearbox market evolved in the last five years?**

Haffar: The gearbox market has evolved in several different ways. I-MAK, as an organization, has grown internationally. We're bringing in a more diverse workforce to help balance our international plans. Also, in the last year we've seen more collaboration with other manufacturers. We're getting involved with other international organizations to face the issues of today with manufacturers that share the same global challenges.

From the end user perspective, we see more demand in mining as well as agriculture. There's a need to produce more in both these areas. We see new silo installations and people that are trying to transform the food industry, for example, to bring key resources closer to home. Our diverse line of products is key to the success we've had in the intralogistics market.

We're a key player in hoist technology today. We produce solutions in this global market segment. With the workforce shrinking, we're also helping to provide new automation solutions, gearboxes that are easier to install and maintain. We're always focusing on providing more reliable equipment for our customers.

PTE: **How has your work with EUROTRANS helped your gearbox business in Turkey?**

Haffar: EUROTRANS helps provide a better understanding of the dynamics of the market. It helps you get closer to other manufacturers and producers to see how we can best solve current industry challenges. In addition, our work with EUROTRANS helps our engineers get a better understanding of the standards. Our technical team attended all the meetings in the past year so we can provide the best gearbox products now and in the future.

PTE: **What are some of your long-term goals at I-MAK?**

Haffar: The goal is to continue to get closer and closer to our customers. We'd like to be able to provide immediate installation, maintenance, and product support in the field. We're also hoping to provide more energy efficient products in the future with an emphasis on sustainability. It's harder and harder to find the right people to maintain, update and support gearbox technology. Our goal is to provide products and technologies that are easier to use.

PTE: **Why is collaboration so important in our market in 2023?**

Haffar: It's important to not just be a part of the power transmission manufacturing community. We must contribute to all key aspects moving forward whether its digitalization, sustainability, technical resources, or education/training. We're one big family in global power transmission. The exchange of ideas and collaboration with similar organizations will play a huge role in our future success within these markets.

euro-trans.org
imakreduktor.com

NKE Austria

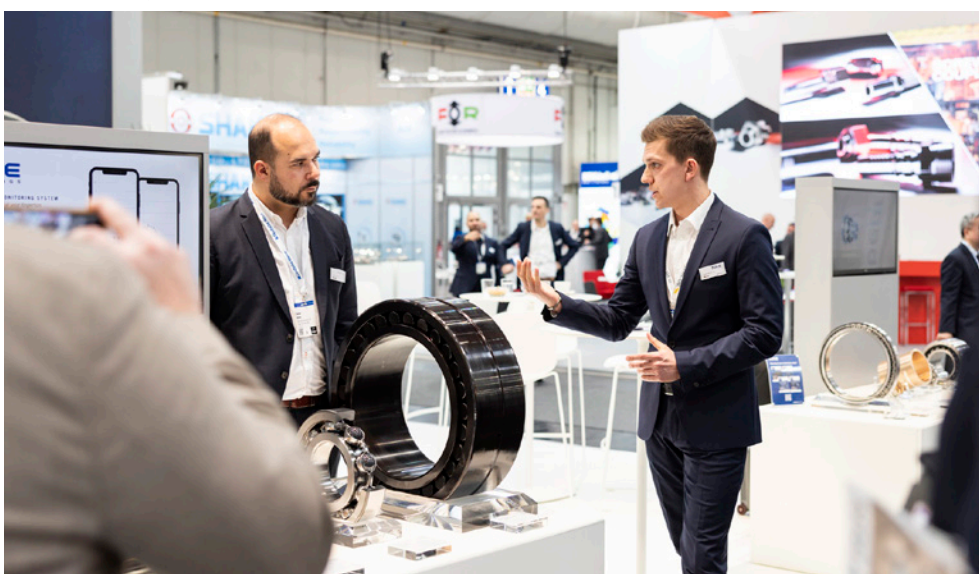
ANNOUNCES PARTNERSHIP WITH KUGLER BIMETAL

Bearing manufacturer NKE Austria GmbH is entering into a strategic partnership with Kugler Bimetal SA, a Swiss producer of bimetallic components and tribological surface finishes. The cooperation was announced at the Hannover Messe in April 2023.

"In the context of this strategic partnership, NKE and Kugler will cooperate in the development and manufacture of solutions for the wind energy market," says Matthias Ortner, managing dof NKE in Steyr. "Our objective is to work together to provide the best possible offering to meet the increasingly demanding standards for bearing solutions in this segment. This can also be rolled out to other industrial applications. At the same time, NKE and the Fersa Group will ensure the essential global framework conditions for accelerating the growth of Kugler and its innovative solutions."

Headquartered in Le Lignon, Geneva, Kugler Bimetal specializes in solving friction problems. The well-established

Heitor Sarro, Kugler, (left) discusses the partnership with Matthias Ortner, NKE.



Swiss company has built its business on meeting the extreme demands that apply not only for components in wind energy, but also in aerospace, the transport sector or for hydraulic equipment. In a special process developed in-house by Kugler, for example, steel parts are coated with the Kugler Tokat lead and lead-free bronze, enabling them to withstand the harshest conditions.

"For NKE, the partnership means rounding out its product portfolio based on complementary technology in the form of friction bearing," says Ortner. "Because in the wind market we are seeing a clear trend towards ever larger wind turbines, and consequently higher performance classes, which means that the use of friction bearings is attracting more and more attention." Together with rail transport, wind power is one of the most important sectors for the Steyr-based bearing expert, which shifted its strategic emphasis to these applications about three years ago.

Ortner explains that the cultural aspect was also a factor in the decision to enter the partnership: "Both companies are premium manufacturers in their respective segments, and both are headquartered in the heart of Europe. We are a technology-driven company, keenly aware of cutting-edge advances, and together with Kugler we will be working on the new product innovations of tomorrow. In this way, NKE is creating another feature that sets it apart from conventional bearing manufacturers and takes another stride towards offering the best bearing solutions in sustainable industries. Through our cooperation with Kugler in the centre of Europe, we intend to further consolidate our powerful European presence."

Besides bearings for wind power and rail vehicles, NKE produces standard and special bearings for all industrial applications. Engineering, product development, production and final processing of components, assembly, quality assurance, logistics, and sales and marketing are centralized at its Steyr headquarters. In addition to product development and application engineering, NKE provides a full range of technical services, consulting, documentation, and training.

nke.at

Croix Gear & Machining

INSTALLS GLEASON PHOENIX II 600HC BEVEL GEAR CUTTING MACHINE

Croix Gear & Machining, recognized as a leader in the custom manufacturing of loose gears, is excited to announce the installation of a Gleason Phoenix II 600HC Bevel Gear Cutting Machine. This new equipment, combined with software upgrades on existing Gleason Phoenix 280c bevel gear cutting machines, will expand capacity and precision capabilities for spiral, straight, hypoid, and Zerol bevel gears.

These combined investments will:

- Increase capacity and reduce lead times.
- Improve part quality and repeatability.
- Expand capabilities up to 24" OD for all bevel gears.

"As a job shop, we are in a unique position to offer this breadth of bevel gear manufacturing capabilities. We are excited about the positive impact this addition will have for our customers who rely on us for bevel gears," stated Ruthie Johnston, CEO/owner.

croixgear.com

Doosan Industrial Vehicle

PARTNERS WITH KOLLMORGEN FOR AUTOMATION SOLUTION

Doosan Industrial Vehicle (DIV), a global South Korean forklift manufacturer, partners with Kollmorgen to secure their leading position in the material handling industry. The objective is to innovate and build efficient, sustainable, and reliable custom made AGVs that exceeds their customers' future requirements.

Present in over 90 countries, DIV is known for their award-winning vehicles that focus on powerful performance, comfort, and ease-of-use. Their product line of over 179 vehicles ranges from cushion, electric and pneumatic forklifts, to reach trucks, stackers, and various other warehouse vehicles.

"Our vehicles are a preferred choice among many of the world's blue-chip companies. That requires us to always be at the forefront of technology and deliver reliable products to the highest of standards. We selected Kollmorgen for that exact reason – being a partner that invests heavily in R&D with a proven track record of solid automation solutions," says Chankyo Chung, vice president, Doosan Industrial Vehicle.

"Doosan Industrial Vehicle has a solid reputation in the market for dependable performance and intelligent design. Their philosophy is to build efficient products with a high longevity, which aligns closely to our own way of business. Coincidentally, we both share a history of over 50 years of experience in the material handling industry—a combined knowhow of over 100 years that offers tremendous value to our joint customers," says Tobias Byfeldt, vice president, Kollmorgen Automation.

doosan-iv.com
kollmorgen.com/agv

June 24–27—EASA Annual Convention 2023

The Electrical Apparatus Service Association (EASA) will hold its Annual Convention and Exposition from June 24—27 in National Harbor, Maryland. EASA is an international trade organization of more than 1,700 electromechanical sales and service firms in nearly 70 countries. EASA supports companies involved in the service and sale of electric motors, pumps, drives, controls, gearboxes, and other rotating machinery. Highlights include synchronous motors, machine reliability, leadership, sustainability, EASA's 90th birthday bash, motor maintenance, pump repair, supply chain issues and more.

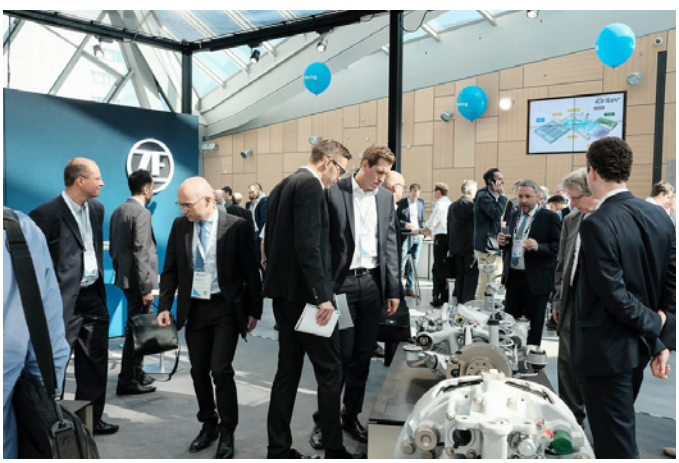
powertransmission.com/events/945-easa-2023-annual-convention

June 27–30—Automatica 2023

Automatica (Munich) is a trade fair for intelligent automation and robotics covers the entire value-added chain: from components to systems; from services to applications—for all manufacturing sectors. It offers an overview of current developments and innovations and thus provides the necessary orientation and investment security. Whether autonomous production, climate protection, supply chain resilience or a shortage of skilled workers: Automatica addresses the major global challenges of our time. To this end, it explores the potential of the key technologies of robotics and automation and offers the greatest possible practical relevance as well as concrete solutions.

powertransmission.com/events/946-automatica-2023

July 5–6—Dritev 2023



The International VDI Congress "Dritev" is one of the world's largest automobile congresses (Baden Baden, Germany). Hundreds of experts with an R&D background meet every year to exchange thoughts on current developments in the field of drivetrain and transmission. It's the ideal place to reach out to long-known fellow experts, find new project partners and pave the way to establish new business ties. This is the one place where you can listen to more than 60 expert presentations and learn about current matters prevailing in series development of powertrains and transmissions.

powertransmission.com/events/953-dritev-2023

July 31–August 3—Reliable Plant 2023

This three-day event (Orlando) offers attendees learning sessions and case studies on the latest industrial lubrication and oil analysis technologies. The comprehensive conference schedule covers every facet of the machinery lubrication industry and includes workshops on topics such as employee performance, lubrication fundamentals, condition-based maintenance, and maintenance planning. Reliable Plant is focused on both entry level and management positions within the lubrication industry including engineers, plant managers, maintenance professionals, safety personnel, planners, quality managers and more.

powertransmission.com/events/955-reliable-plant-2023

August 8–10—ABMA Essential Concepts of Bearing Technology

This ABMA course (Rosemont, IL) will give you an overview of the bearing industry as well as basic bearing types and applications. Knowledge of the key players, bearing types and terminology will ensure that everyone has a basic knowledge of the industry upon arrival. This course is specially designed for engineers and others with technical backgrounds that have limited exposure to bearings and need to adapt their technical training to bearings or seek an upgrade to their technical knowledge. The Essentials Course focuses on understanding basic tribology, bearing attributes and applications and explores the basic concepts around manufacturing methods, loads, lubrication, and failure.

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Bearings 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.

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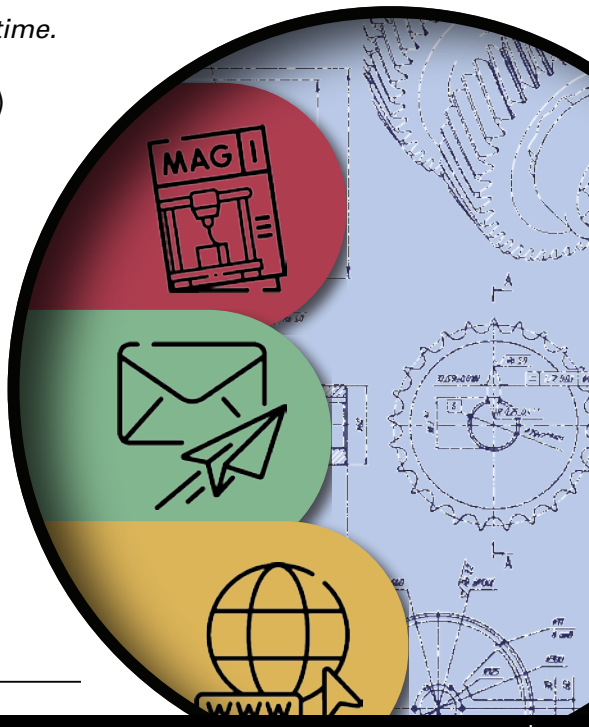

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Industry 5.0

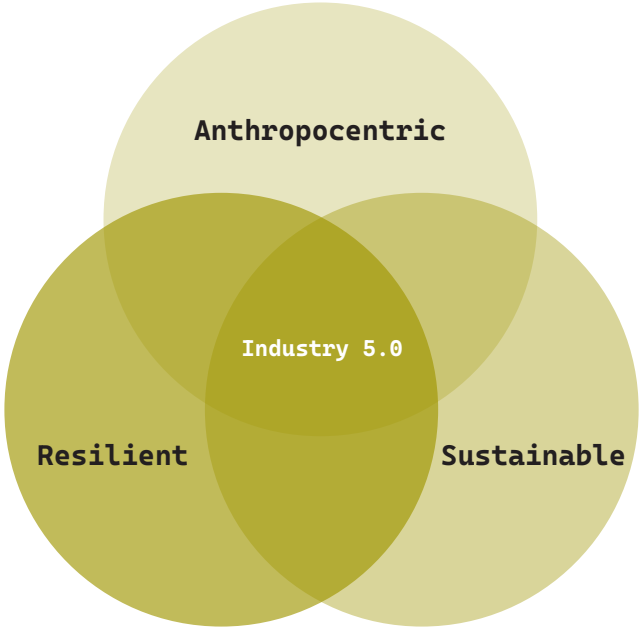
From economic welfare to societal wellbeing

Aaron Fagan, Senior Editor

According to the European Union's Research and Innovation Commission, Industry 5.0 "provides a vision of industry that aims beyond efficiency and productivity as the sole goals and reinforces the role and the contribution of industry to society.... It places the wellbeing of the worker at the centre of the production process and uses new technologies to provide prosperity beyond jobs and growth while respecting the production limits of the planet." Cast another way, Industry 5.0 represents an about-face from the value of economic welfare to the value of societal wellbeing.

Industry 5.0 departs from Industry 4.0 by "specifically putting research and innovation at the service of the transition to a sustainable, human-centric, and resilient European industry." As the European Commission argues, the strategy is "agile and resilient with flexible and adaptable technologies." After COVID-19, global shortages of supplies, and the war in Ukraine, it is clear resilience is key to any strategy moving forward—today and in the future.

While agility and flexibility figure prominently on most company agendas, these in themselves do not necessarily translate to resilience. Most business strategies today are driven by efficiency and optimizing profits, not resilience. This focus on efficiency drives many initiatives to make companies more agile and flexible, but leanness leads to less rather than greater resilience.



According to the European Union, the three pillars of Industry 5.0 are anthropocentric, sustainable, and resilient.

Where the three pillars of Industry 5.0 are concerned, resilience means the primary focus will no longer be on growth, profit, and efficiency, but on creating organizations that are antifragile, meaning they are able to anticipate, react, and learn—timely and systematically—from all manner of crisis and thereby ensure stable and sustainable performance.

There is no widely accepted definition of Industry 5.0, but the general objective is to decrease the emphasis (not reliance) on technology and reorient the potential for progress based on collaboration among humans and machines utilizing big data analytics, IIoT, collaborative robots, blockchain, digital twins, and future 6G systems to get there.

AI, blockchain, and decentralization in particular are expected to enable new forms of collaboration and innovation in Industry 5.0, as well as improved efficiency, transparency, and security in manufacturing and supply chains.

- AI enables machines to learn from experience and make decisions based on data and feedback from human workers, optimizes manufacturing processes, improves quality control, and offers more personalized and responsive manufacturing.
- Blockchain improves the transparency and security of supply chains, enabling more efficient and secure transactions between different stakeholders. It could also enable the creation of decentralized marketplaces for raw materials, components, and finished products.
- Decentralization is a key feature of Industry 5.0, with a focus on distributed manufacturing, decision-making, and innovation. Decentralized systems could enable more flexible and adaptable production processes, with greater resilience and responsiveness to changing market conditions.

The revolution of Industry 5.0 means human workers and universal robots are boosting the productivity of the manufacturing industry. Each of the executive teams of the manufacturing company is required to define the production line, then follow the key performance indicators and ensure that the processes are working—in a manner akin to what we have come to expect from our personal technological devices and services—frictionlessly.

An anthropocentric strategy is one that prioritizes the talents, diversity, and empowerment of people. The most important shift this suggests is one from seeing human resources as ends rather than means. Or, in other words, a shift in perspective from people serving organizations to organizations serving people, which aligns with current developments in the job market. In many industries and countries, finding, serving, and keeping talent has become a much greater challenge than finding, serving, and keeping customers.

Whether one finds this vision appealing or daunting will differ vastly between companies and between people. And the extent to which it will be embraced or rejected rests in the extent to which we embrace or reject the premise of becoming more anthropocentric, resilient, and sustainable.

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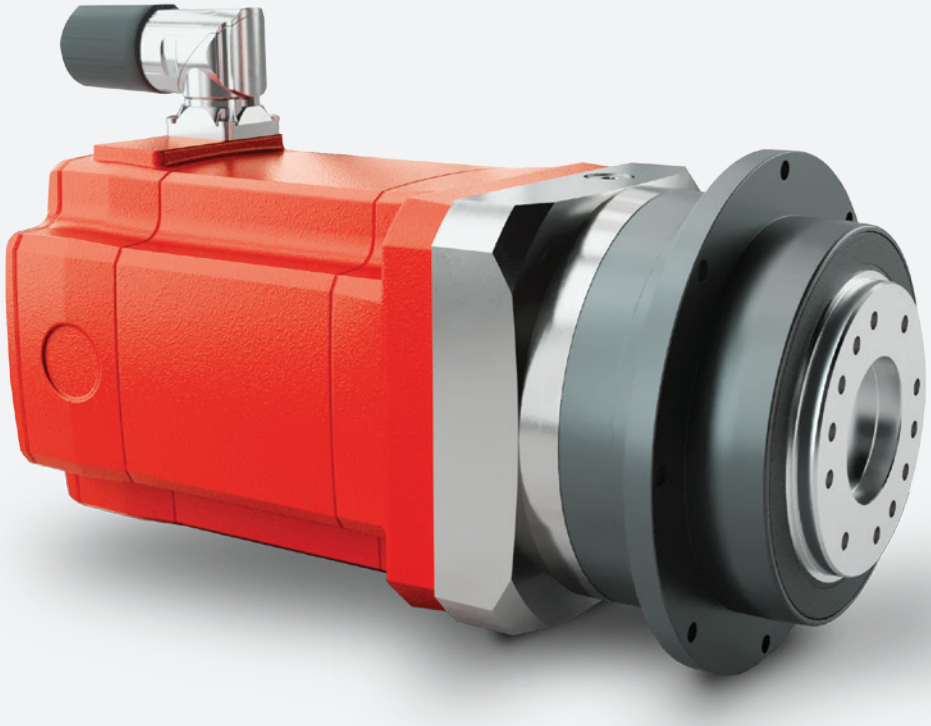

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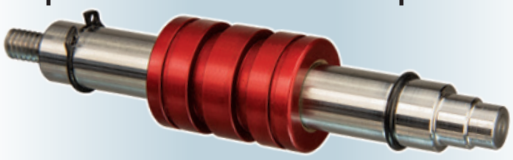

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