# PTE

## POWER TRANSMISSION ENGINEERING™

SEPTEMBER 2025

## GEARMOTORS

## WHAT'S NEW IN ROBOTICS?

## UNLOCKING EFFICIENCY IN PNEUMATIC SYSTEMS

## MPT EXPO 2025

## TECHNICAL

Genetic Optimization of Planetary Gearboxes

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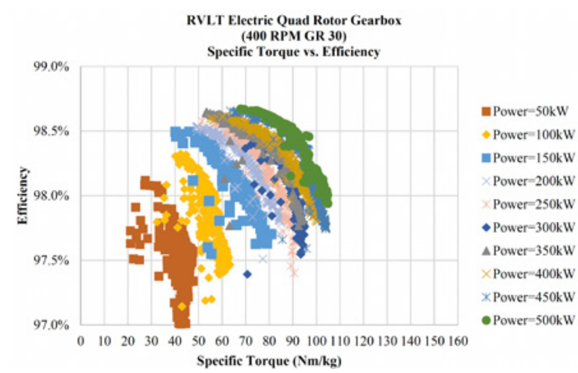
# FEATURE ARTICLES

18



# TECHNICAL ARTICLES

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American Gear Manufacturers Association®

ABMA® American Bearing Manufacturers Association

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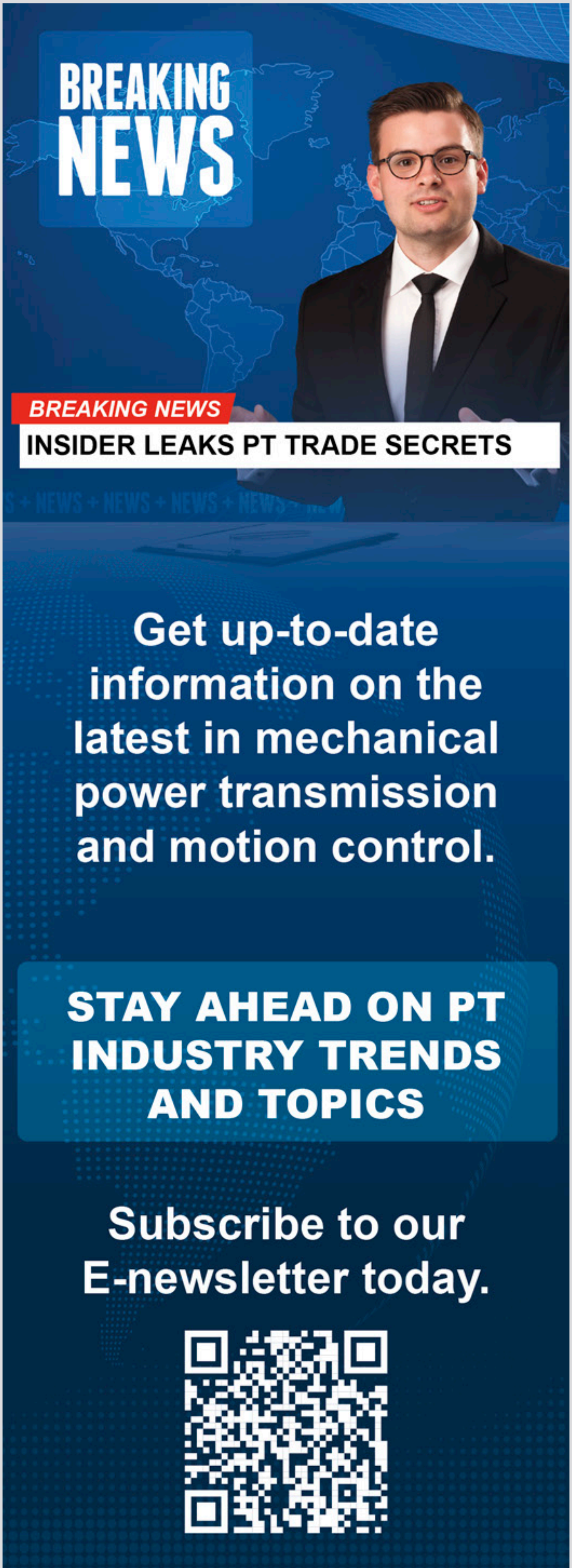
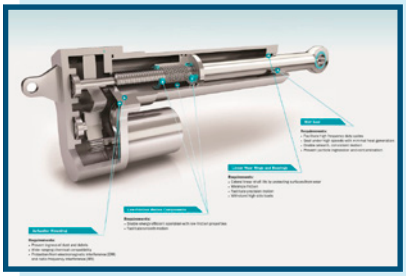



PTE™
VOL. 19, NO. 6

# PTE REVOLUTIONS

## Increasing Speed in Linear Actuators Through Sealing Material and Design



Electromechanical actuators are used in a variety of applications for their ability to convert electrical energy into mechanical motion where precision, flexibility and compactness are required. Linear actuators are a type of electromechanical actuator used where straight-line movement is needed in certain industrial automation, automotive and aerospace applications.

powertransmission.com/increasing-speed-in-linear-actuators-through-sealing-material-and-design

# PTE VIDEOS

## Expertly Designed Complete Actuation System for Aerospace with AMTEK PDS

Elevate the aerospace program with AMETEK PDS. See how their complete actuation systems, designed by a team of experienced


engineers, can meet your specific needs—from a single actuator for a cargo door to a full flap actuation system with motors, actuators, and system-level controllers.

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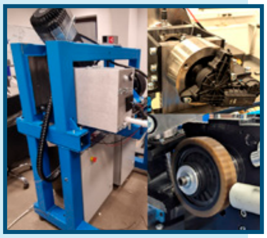
# AS SEEN IN *GEAR TECHNOLOGY*

## Experimental Study on the Performance of Plastic Worm Gears



Plastic worm and crossed helical gears are increasingly utilized in various applications due to their distinct advantages over traditional metal worm gear drives. These advantages include lower weight, reduced noise, and corrosion resistance, making them ideal for automotive, consumer electronics, and medical devices. However, plastic gears also come with limitations such as lower load-bearing capacity and higher susceptibility to temperature variations and wear.

geartechnology.com/experimental-study-on-the-performance-of-plastic-worm-gears

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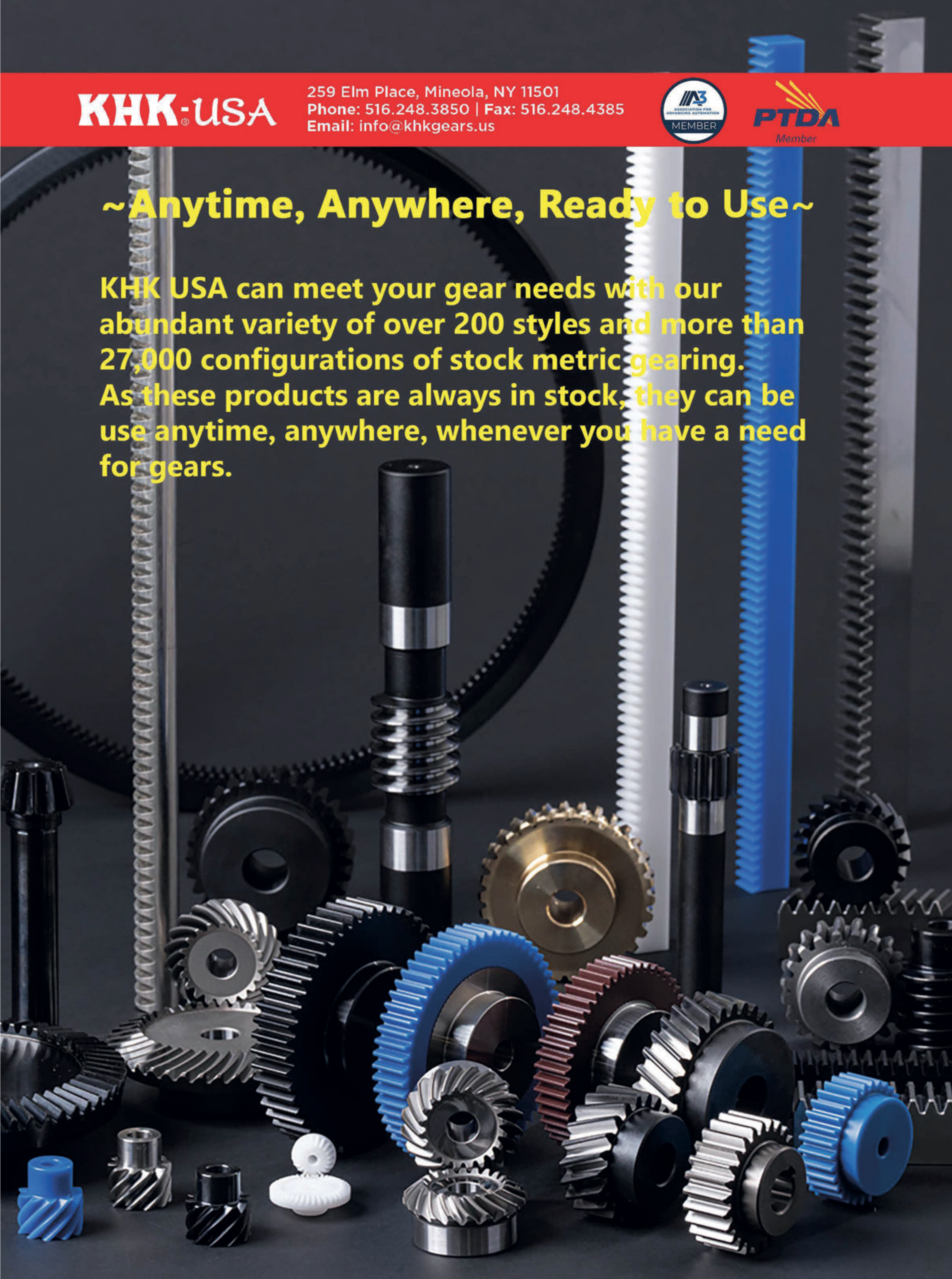
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~Anytime, Anywhere, Ready to Use~
KHK USA can meet your gear needs with our abundant variety of over 200 styles and more than 27,000 configurations of stock metric gearing. As these products are always in stock, they can be use anytime, anywhere, whenever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


# Is MPT Expo for You?

If your work touches mechanical power transmission components, the answer is an overwhelming YES! For example, if you design machinery with gears or bearings, MPT Expo is for you. If you maintain plant equipment that requires replacement of mechanical components, MPT Expo is for you.

The Motion + Power Technology Expo takes place October 21–23 in Detroit (*motionpowerexpo.com*). It's the biennial trade show of the Motion + Power Manufacturers Alliance (which includes both the American Gear Manufacturers Association and the American Bearing Manufacturers Association). It's your one-stop shop covering the complete supply chain of mechanical power transmission.

Here's just a sampling of what you can expect to see when you come to MPT Expo:

- ***Gear and gearbox manufacturers and suppliers.*** Whether you need large industrial gearboxes, plastic gears, custom gear manufacturing or precision drives, MPT Expo has you covered with suppliers like these: Ancon Gear & Instrument, B&D Industrial, Bevel Gears India, Brelie Gear, Capstan Atlantic, **CGI Inc.** (ad on p. 27), Chongqing Landai Precision Components, Chun Yeh Gear Co., Circle Gear and Machine, Columbia Gear, Croix Gear, Delta Gear, Didimo Zanetti, Doppler Gear, Flender, Forest City Gear, Gear Motions, GKN Automotive, Gleason Plastic Gears, Great Taiwan Gears, IPM Inc., **KHK USA** (ad on p. 5), Nanjing High Speed & Accurate Gear Group, Nichiei Co. Ltd., **Nordex** (ad on p. 35), Omni Gear & Machine, PAI Manufacturing, Patodia Forgings & Gears, Penn Machine Company, Perfect Gears, Philadelphia Gear, Power Transmission Group, Pragati Transmission, Quality Gears, RD Motion, Reliance Gear Corp., RENK Group (formerly Cincinnati Gearing Systems), Riley Gear, Rupkala Engineers, Schafer Industries, Triumph Geared Systems, United Gear & Assembly, Usinatech, Vector Companies, and more!
- ***Software for systems design.*** Not only can you find the right tools to help you design and build motion systems, you can also talk to the experts who truly understand gears, bearings, couplings and related components at companies like Dontyne Systems, **FVA GmbH** (ad on p. 35), Gleason/KISSsoft, GWJ Technology, MESYS AG and SMT.
- ***Bearings suppliers and experts.*** Learn from experts at companies like Elgeti Engineering, The Estell Group, **Napoleon Engineering Services** (ad on p. 21) and WD Bearings.
- Plus much, much more. MPT Expo is also home to all of the major suppliers of lubricants, materials and gear manufacturing machinery, tooling and equipment, giving you the full smorgasbord of suppliers whether you want to buy the components or make them yourself.

So make your plans now to attend MPT Expo. It's definitely for you.

PTE

Randy Stott
Publisher & Editor-in-Chief

# ZERO–MAX

## Introduces CD Power-Series Couplings

Zero-Max announces its all-new CD Power-Series of Servo-Rated Composite Disc Flexible Shaft Couplings. These unique couplings feature a higher power-density, providing higher torque capacity in a smaller, more compact solution. Featuring the field-proven Composite Disc technology that has earned the trust of engineers for the most demanding motion control applications, the CD Power-Series Shaft Couplings provide precise high-torque operation in a smaller space envelope. The CD Power-Series Couplings are ideal for use in applications with aggressive motion profiles that include repetitive speed changes, acceleration/deceleration, start/stop, indexing and reversing.

Leveraging the benefits of the field-proven Zero-Max Composite Disc technology, this innovative new design targets the fast-growing and changing needs of automated manufacturing industries. It is especially suited for applications requiring high speed and higher torque where space limitations exist. The ultimate performance of the CD Power-Series Couplings is the result of customer feedback for a coupling design that provides higher torque density. Application examples include packaging machines, pick-and-place operations, test stands, indexing applications, specialty machines, automated assembly equipment, off-highway equipment, and more.

The CD Power-Series Couplings feature torque ratings up to 130,000 in-lbs. / 14,689 Nm peak torque. Standard bore sizes range up to 5.1875 inch / 130 mm. Adaptor Mounts are available for ISO 9409-1 mounting bolt circles from 31.5 mm to 160 mm. Flange Hubs for specialized and compact installations are also offered. As with all Zero-Max products, customized solutions are also available to meet specific application requirements for performance, materials, or dimensional needs.

The new CD Power-Series complements the Traditional CD Couplings by featuring Higher Torque and Higher Torsional Stiffness, while offering a moderate misalignment capacity and reducing the coupling's outside diameter. Zero-Max continues to offer the Traditional CD Couplings that provide High Torque, High Torsional Stiffness, and the Highest Misalignment Capacity.

Extremely important, the CD Power-Series' Composite Disc withstands a wide range of challenging operating environments by offering vibration damping, electrical isolation, fatigue resistance for long life, and alleviating fretting corrosion issues often seen in metal disc couplings. It withstands temperature extremes from -70° to +250° F / -57˚ to 121˚ C, as well as resists the effects of moisture and a wide range of chemicals. The robust composite disc and overall coupling design maximizes the lifespan of the shaft coupling while also helping to increase performance and throughput for the machines and equipment where the coupling is used.

The CD Power-Series is available with: (1) Split-Clamping Hubs to allow for larger bore sizes and higher transmittable torque, with or without keyways, (2) Integral Clamp-Style Hubs, keyed or keyless, (3) Shrink Disc Hubs for high transmittable torque on keyless shaft connections, (4) Adaptor Mounts to fit an ISO 9409-1 Flange Pattern for precision gear reducers, motors, actuators, robotic equipment and more, and (5) Flange Hubs for direct connection to machine flanges, offering a high torsional stiffness connection and the most compact solution possible.

"The CD Power-Series Flexible Shaft Couplings are specifically engineered to withstand the extreme stress and demands of high-performance applications, including those with flanged output gearboxes," reports Brian Mishuk, vice president, sales and marketing at Zero-Max. "The CD Power-Series offer a variety of Clamp-Style, Shrink Disc, Adaptor Mount, and Flanged Hub Options to accommodate a range of possible shaft connections on customer's machines, while maintaining the high performance needed for challenging servo-driven applications."

Also important, CD Power-Series Couplings are available in custom designs to accommodate unique dimensional fit requirements, or extra performance for demanding applications. Examples of Customization can include shortened or extended hubs, special disc packs to boost torque and/or torsional stiffness, alternative plating, coatings, or materials for corrosion protection, modified coupling inertia, custom flange dimensions, and more.

*zero-max.com*

# WINSMITH

## Launches New Line of Aluminum Round and Square Speed Reducers

Winsmith has launched a new line of Aluminum Speed Reducers available in round and square worm gear housing. Winsmith Aluminum Round Speed Reducers (ALRN) and Aluminum Square Speed Reducers (ALSQ, pictured above) are dimensionally interchangeable with global manufacturers of right-angle worm gearboxes. These new single-piece aluminum housing gearboxes are built to order and can be assembled with various accessory options.

Winsmith can ship these new products within one to three days from our Asheville, NC, gearing facility.

"The modular design of our Winsmith Aluminum Speed Reducers allows for precise assembly and quick delivery," explained Crad Winkelvoss, Winsmith vice president/general manager. "These gearboxes are designed for machine builders who need optimized drives with regard to space, noise, torque and weight considerations."

Available gearbox accessories include mounting feet, output flanges, single (solid) output shafts and reaction (torque) arms.

Winsmith high-efficiency, right-angle gearing benefits include:

- Gearing that reduces energy losses due to optimized gearing geometry along with a precision ground and casehardened worm.
- Our robust, compact, lightweight design minimizes space and weight along with increasing life expectancy of supporting elements compared to cast iron products.
- Aluminum housing provides corrosion resistance and eliminates the risk of paint chips breaking off.

*winsmith.com*

# APPLIED MOTION PRODUCTS

## Launches MLA and MEA Series Linear Actuators for Advanced Precision Control

Applied Motion Products introduces its latest innovation: the MLA and MEA Series Linear Actuators. These new actuator families are designed to deliver exceptional precision, force, and reliability across a wide range of industrial and automation environments.

The MLA (Motorized Linear Actuator) and MEA (Motorized Electric Actuator) series represent a new generation of compact linear motion solutions. Each actuator combines a high-performance stepper or StepSERVOs motor with a precision ball screw or lead screw mechanism in a fully integrated, ready-to-install package. Engineered to simplify system integration and enhance motion performance, the MLA and MEA series offer flexible configurations ideal for OEMs, machine builders, and automation professionals.

"Our new MLA and MEA linear actuators were developed in direct response to the growing demand for compact, high-force linear motion systems with easy integration and robust control options," said Don Macleod, CEO of Applied Motion Products. "These products reflect our commitment to providing innovative, high-quality solutions that enhance the performance and efficiency of our customers' machines."

Key Features and Benefits:

- **Integrated Motor and Screw Assembly**—Space-saving design that reduces installation complexity and footprint.
- **High Precision and Repeatability**—Ideal for demanding applications such as lab automation, medical devices, semiconductor manufacturing, and industrial machinery.
- **Flexible Motor Options**—Choose from stepper or servo motors with encoder feedback, integrated drives, and a variety of communication protocols including EtherNet/IP, CANopen, Modbus, and more.
- **Robust Construction**—Engineered with durable materials for reliable operation in challenging environments.
- **Customizable Strokes and Mounting Options**—Tailored configurations available to fit unique application needs.

Applications include precision positioning systems, automated inspection equipment, 3D printing and additive manufacturing, semiconductor equipment and medical and laboratory instrumentation

The MLA and MEA Series Linear Actuators are available now through Applied Motion Products' sales network and authorized distributors. Custom options and technical support are available to help users select the ideal configuration for their motion control needs.

*applied-motion.com*

# RULAND

## Offers Rigid Couplings and Shaft Collars for Food Equipment Applications

Food and beverage manufacturers face unique challenges in ensuring precision, hygiene, and reliability in their equipment. Ruland's shaft collars and rigid couplings are engineered and manufactured to meet the demanding needs of food processing, packaging, and handling systems, offering solutions that enhance efficiency and reduce downtime.

Rigid couplings from Ruland are available in a wide variety of sizes and styles to suit the needs of food packaging applications such as case erectors, cartoners, and form, fill, seal equipment. These couplings are ideal for shaft-to-shaft connections and precise servo driven applications as they do not introduce misalignment, vibration, or bearing noise into the system. They have precision honed bores, anti-vibration hardware, and opposing hardware on two-piece styles to ensure superior fit, alignment and holding power. Ruland offers 303 stainless steel couplings with hardware of like material as standard stock items. Proprietary Nypatch anti-vibration hardware is used to prevent galling, provide event seating of the screw, and allow for repeated screw installations. Rigid couplings are offered in one- and two-piece clamp styles with or without keyways in bore sizes ranging from 3 mm to 50 mm. Custom dimensions, inch to metric step bore combinations, and 316 stainless steel are available by request.

Clamp style shaft collars in food processing, packaging, and handling equipment are commonly used for guiding, spacing, stopping, mounting and component alignment. Food equipment manufacturers benefit from the tightly controlled face to bore perpendicularity of Ruland shaft collars (TIR of $\leq$ 0.05 mm) which is critical when they are used as a load bearing face or for aligning components such as bearings or gears. All Ruland shaft collars are machined to a fine burr free finish that reduces the likelihood of metallic system contamination and complements or enhances the appearance of food processing equipment. Shaft collars made from 303 and 316 stainless steel utilize hardware of like material for consistent corrosion resistance and to meet regulatory standards. Plastic shaft collars can be used as a cost-effective alternative to stainless steel at the expense of performance. They are supplied with stainless steel hardware for corrosion resistance. Ruland also offers anodized aluminum shaft collars with stainless steel hardware for areas of the system where stainless steel or plastic is not required. Shaft collars are manufactured in bore sizes from 3 mm to 150 mm.

Ruland shaft collars and rigid couplings are RoHS3, REACH, and Conflict Minerals compliant. They are made from North American bar stock sourced from select mills and carefully manufactured in Ruland's advanced manufacturing facility in Marlborough, Massachusetts, under strict controls using proprietary processes.

*ruland.com/shaft-collars.html*

# FORCE CONTROL

## MagnaShear Motor Brakes Enhance Conveyor Safety

The MagnaShear motor brake from Force Control Industries employ oil shear technology which transmits torque between lubricated surfaces—thereby eliminating the heat build-up of dry brakes which is a major source of conveyor fires. A patented fluid recirculation system dissipates the heat and keeps these proven brakes running cool. Totally enclosed MagnaShear brakes are impervious to moisture,dirt, and dust—further enhancing their safety. In addition to being safer, oil shear technology eliminates wear on friction surfaces, significantly increasing service life and virtually eliminating adjustment and maintenance—thereby saving time and money. MagnaShear motor brakes are ideal for conveyor applications in all types of industries—including indexing conveyors, holding brakes for bulk materials handling, and more.

The oil shear technology also provides a smooth "cushioned" stop which reduces shock to the drive system, further extending service life of downstream components. In addition to conveyors, they are ideal for applications where the motor is reversed each cycle such as loader/unloader conveyors, as well as cranes, winches, and hoists, rail car spotters and dumpers, rotary samplers, trippers, and pallet return conveyors.

### Suitable for a Wide Range of Motor Sizes

These proven motor brakes are available to accommodate a wide range of applications. Spring set torque ratings from 3 to 1,250 foot-pounds are available. MagnaShear motor brakes can be sized to the correct torque independent of the motor frame size or horsepower.

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

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

*forcecontrol.com*

# MITSUBISHI ELECTRIC

## Unveils Next-Generation FR-D800 Series Inverters for Enhanced Efficiency and Simplicity


Mitsubishi Electric has launched its latest FR-D800 series inverters, designed to deliver better performance, easy operation, and improved energy efficiency for a wide range of industrial applications. Compact and intuitive, the new series delivers powerful performance alongside features designed to make selection, installation, and operation simpler.

With a focus on user-friendliness, the FR-D800 inverters feature a door-style surface cover and integrated wiring to make installation faster and easier. The FR-D800 is up to 37 percent smaller than its equivalent predecessor, reducing enclosure size requirements, allowing for more flexible mounting, and reduced installation costs. A new USB Type-C interface lets users set parameters directly from a PC without powering up the inverter, streamlining both setup and maintenance.

The inverters can help save energy with advanced synchronous motor control, which reduces power consumption and cuts operating costs. Its high-efficiency motor drive and lower standby power consumption also contribute to a reduced carbon footprint, supporting more sustainable production practices.

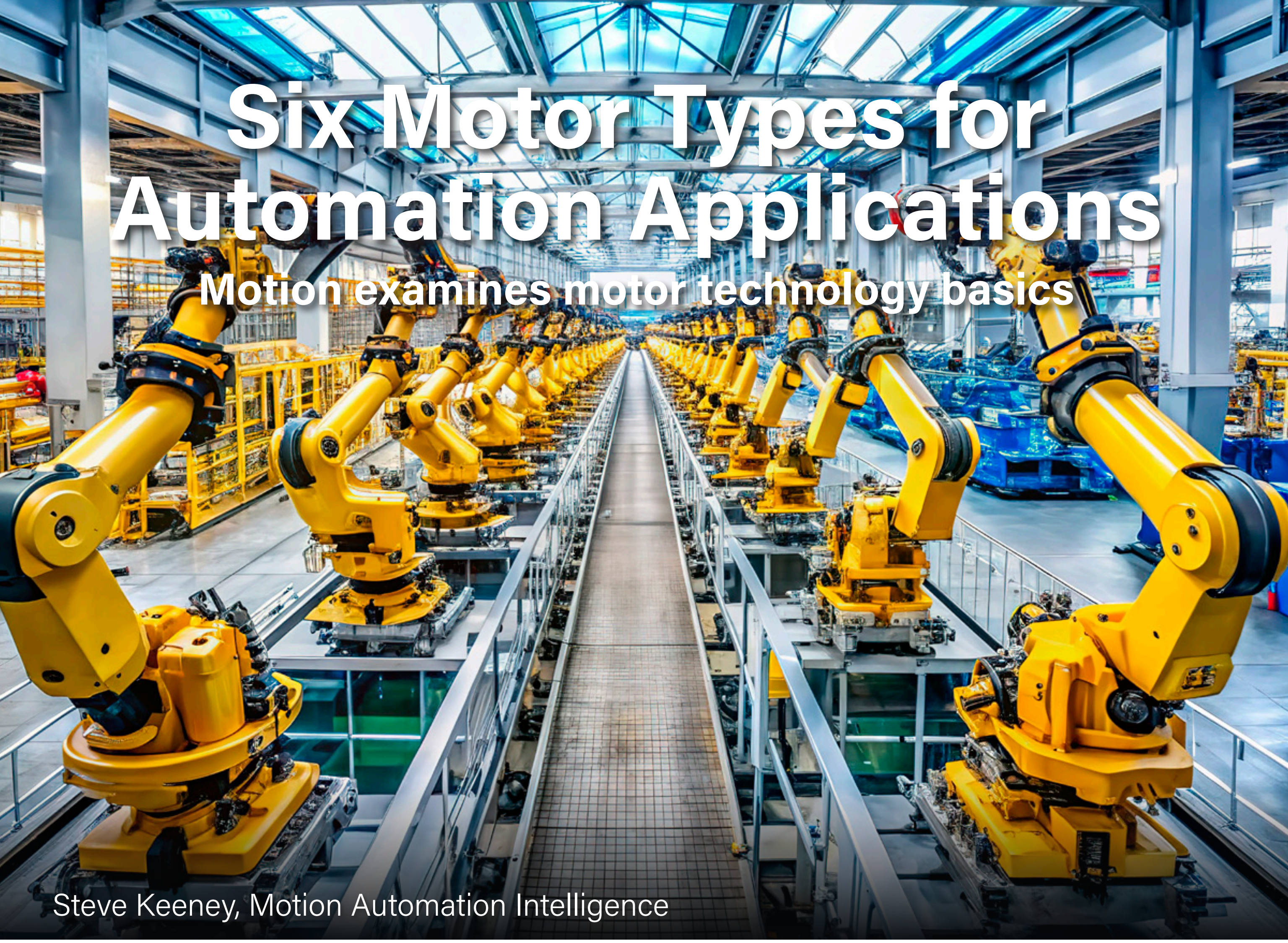
"With the FR-D800 series, we wanted to create an inverter that both new and experienced users can use with confidence," said Shotaro Marumoto, inverter development section leader at Mitsubishi Electric. "We've made it straightforward while delivering the advanced performance businesses need to improve productivity, save energy, and meet their sustainability goals."

The FR-D800 series is suitable for a wide range of applications, from conveyors and pumps to food processing equipment and textile machinery. Selected models are also suitable for harsh, corrosive environments, thanks to circuit board protection meeting IEC 60721-3-3:19943C2/3S2 standards. Furthermore, FR-D800 inverters can control both induction and permanent magnet (PM) motors, eliminating the need for multiple inverters for different motor types. Built-in support for popular Ethernet protocols including CC-Link IE TSN, Modbus/TCP, and Ether-Net/IP ensures seamless integration into existing industrial networks, enabling users to quickly integrate it into their digital manufacturing and smart production environments.

The series also makes maintenance simpler. Its preventive maintenance functions include lifetime diagnostics for key components like capacitors and fans, helping operators spot potential issues early, especially when using the FR Configurator2 support software. Anomaly detection based on current patterns helps reduce the risk of unexpected downtime, and when a fault does occur, analysis functions solve the problem quickly.

"Energy efficiency, simplicity, and reliability are essential for modern automation applications and industry in general," added Marumoto. "The FR-D800 series shows Mitsubishi Electric's commitment to providing solutions that meet these needs while contributing to a greener future."

*us.mitsubishielectric.com/fa/en*



# Six Motor Types for Automation Applications

## Motion examines motor technology basics

Steve Keeney, Motion Automation Intelligence

Motor solutions are the lifeblood of many applications, powering the precise movements and operations that keep automated systems running smoothly. While each system presents unique demands, the wide variety of motor types available ensures there is an option suitable for each specific need. It is vital to understand the pitfalls of choosing an inappropriate motor, given the countless motor types, brands and sizes.

To make informed decisions, it helps to become familiar with the six most common motor types and their key characteristics relevant to automation applications.

### AC Motors

AC motors convert electrical energy into mechanical energy, distributing an alternating current over long ranges. They are flexible, efficient and tend to operate quietly, making them ideal for use in applications such as pumps, fans, blowers and other systems that need constant, variable or adjustable speed control.

AC motors work by using alternating current (AC) to create a rotating magnetic field in the stator, which induces a current in the rotor, causing it to rotate and generate mechanical power. This process is based on electromagnetic induction and the interaction between the magnetic fields of the stator and rotor.

Manufacturers use AC motors for multiple reasons, including:

- **Efficiency:** AC motors have high speed to torque, allowing them to operate without overheating or braking.
- **Brushless Design:** Brushless motors do not create friction, which reduces heat output and increases the motor's lifespan.
- **Quiet Operation:** AC motors run with a very low humming sound.
- **Simplicity and Accessibility:** With only one moving part (the rotor), AC motors are available in various shapes and sizes with different power outputs—suiting them to many applications.
- **Speed Control:** The frequency can be changed to control the motor’s speed.

### Brushed DC Motors

Brushed DC motors are used in applications that need high peak torques and use simple speed controllers. They are cost-efficient, easily controlled and have a linear torque-speed relationship.

A brushed DC motor has four components: a stator, rotor, brushes and a commutator. Basically, the permanent magnets mounted on the motor's outside create an electromagnetic field. Their operation allows them to produce high torque during acceleration and deceleration, making them ideal for industrial applications that involve dispensing, packaging and some robotic applications.

One drawback of brushed DC motors is the mechanical wear and tear on the brushes and the commutator, shortening their lifespan. However, their low initial cost can compensate for their frequent replacement needs.

## Brushless DC Motors

Brushless DC motors are similar in function to brushed DC motors, except that they operate without brushes. While a brushed DC motor has magnets on the outside (the stator), brushless DC motors have magnets on the internal rotor. They do not use brushes to generate an electromagnetic field.

This design makes brushless DC motors quieter, more efficient, and longer lasting than brushed DC motors. They can also run cooler during continuous operation. While these benefits come with a slightly higher initial cost, brushless DC motors are ideal for hazardous environments with dust, grease, oil, and other contaminants.

## Geared DC Motors

Geared DC motors, or gearmotors, have an attached gear assembly that allows the motor to increase the torque and reduce speed as needed—a process called gear reduction.

Gearmotors are rarely (if ever) used with external gearboxes, as the primary need for any reduction is usually addressed by gearmotor selection itself. They are small with a high torque-to-size ratio, creating a smaller motor footprint.

## Stepper Motors

Stepper motors are brushless electric motors that move in precise, fixed increments, making them ideal for applications requiring repeatable positioning. Their unique design allows them to turn at a specific angle with each electrical pulse. Electrically, they operate by energizing multiple coils arranged in phases. When pulses are sent to these coils in a controlled sequence, they create a rotating magnetic field that moves the rotor step by step.

Stepper motors offer several advantages. In lower torque ranges, they are among the most cost-effective motors to produce. They provide precise, repeatable positioning without the need for feedback, making them suitable for open-loop positioning applications. They also deliver high torque at low speeds and are relatively easy to control with digital controllers.

However, stepper motors have limitations. As they typically lack feedback sensors, any missed steps go undetected, resulting in inaccurate positioning. Their torque and efficiency decrease at higher speeds, and they can experience resonance or vibration, which may require digital or mechanical damping techniques. And, unless a more expensive digital controller is used, a stepper motor will consume power continuously, even when not in motion.

Common applications for stepper motors include medical equipment, 2D and 3D printers, camera and optics control, and small gantry systems.

## Servomotors

Servomotors often convert rotary motion into linear motion with their position and velocity feedback. They work in mechanical systems with a feedback device such as an encoder or resolver. These motors provide detailed feedback but require a controller to manage commutation and position/velocity control. This continuously informs the user of the motor's position, speed and torque, making servo motors useful in precise or demanding applications requiring coordinated motion or robotics in industrial production.

Most servomotors today are brushless, offering accuracy, reliability, and efficiency, even in harsh environments. These motors also feature high acceleration, run quietly and operate on closed-loop control, with a high torque-to-inertia ratio comparable to AC motors. Their downside is their higher upfront cost.

Common applications for servomotors include robotics, conveyor belts, metal cutting and forming machines, printing presses, CNC and machine tooling, and food and beverage packaging.

## Starter's Guide

Choosing the right motor for your automation application is a critical decision that can significantly impact performance, efficiency and overall success. No single motor fits every scenario, but understanding the unique features, benefits and drawbacks of each motor type will better equip decision makers to match the technology to the application. While this article's information provides a good start, partnering with a third-party expert can yield the best possible outcome with specialized knowledge and unbiased guidance tailored to your unique requirements.

*motion.com*

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**Steve Keeney** is Strategic Product & Marketing Director for the Motion Automation Intelligence (Motion Ai) business group. Previously a Regional Manager for Rockwell Automation, he was a partner and owner of Applied Machine and Motion Control, Inc. (AMMC) when the company joined the Motion team in 2020. Throughout his 34-year career, Steve has focused on conceptualizing and applying automation, machine and motion control solutions.

# Communication Without Restrictions

## Bodine Electric Company gearmotors deliver precise motion for satellite antennas

Matthew Jaster, Senior Editor

***Bodine Electric Company has provided components for Fly-Away and Drive-Away systems for C-COM.***

C-COM Satellite Systems, a manufacturer of mobile satellite antennas, has integrated several models of Bodine Electric motors across a variety of platforms. These motors are primarily used to drive the Azimuth and Elevation axes on their Fly-Away (portable) and Drive-Away (vehicle-mounted) systems. At the push of a button, these antennas automatically deploy and begin scanning the sky to acquire a satellite signal. Within minutes, users can establish a strong, stable connection, a process made seamless and reliable thanks in large part to the performance and precision of Bodine's motors.

"C-COM needed a small and lightweight gearmotor from us in order to accommodate a highly portable, easily assembled Fly-Away satellite antennas," said Terry Auchstetter, director of marketing and product development at Bodine. "Our DC planetary gearmotor is the ideal combination of a small permanent magnet DC motor—which is capable of a momentary peak torque much greater than its continuous rating and a small planetary gearbox—which is also capable of a very high momentary peak torque by virtue of the load distribution of the multiple planet gears."

The Bodine type 24A4BEPM-60P2 measures only 2.4 inches in diameter, 7.7 inches long and weighs only five pounds, but it is capable of a peak torque of 245 lb.-in.

"C-COM's Fly-1202 antennas are deployed in some of the world's most challenging environments, from the subzero temperatures of the Arctic, to the hot and humid regions of South America, to the dry, dusty terrain of Australia," said Warren Rawlings, purchasing and production manager at C-COM. "We required a motor that could perform reliably in all these conditions. It also needed to deliver enough torque to rotate the antenna while remaining compact enough to fit within our transportable systems. Bodine Electric's gearmotors met all these demands and more. Their motors offer high precision and minimal backlash, which is essential for acquiring and maintaining a stable satellite connection. As our antennas evolved, so did our collaboration with Bodine, now many of the motors we use today are custom-built to meet C-COM's exact specifications."



*The 24A-60P planetary PMDC gearmotor provides high starting torque, adjustable speed and predictable performance.*

## Telecommunication Experts

Established in 1997, C-COM Satellite Systems Inc., Ottawa, Canada, is involved in the design, development and manufacture of commercial grade, fully motorized, auto-pointing mobile antennas for the delivery of broadband Internet to remote locations.

The company has been a pioneer in the one-button, auto-deploy VSAT market – with over 11,000 units in the field, in over 100 countries.

C-COM has developed Comms-on-the-Pause (COTP) antennas that operate in all major satellite bands (Ka, Ku, C, and X-band), in sizes (from 74cm to 2.4M) and in various formats (Drive-Away, Fly-Away, Manpack and Fixed Motorized).

## Precise Positioning

For each system, C-COM required two gearmotors to position the antenna to connect to orbiting telecommunications satellites. The gearmotors deliver precise motion during the initial search of the satellite and then remain idle until the antenna is moved to a new location. These mobile antennas are often used in remote locations to broadcast news or sports events, or for emergency and military communications, therefore the gearmotors needed to be able to operate in harsh outdoors environments and run from a 24 VDC power source.

"Our design team recommended a 24A-60P planetary PMDC gearmotor with custom wiring, shaft, mounting and encoder. The gearmotors provide high torque and precise motion, are small enough to fit the portable application. This proved to be a more cost competitive solution," Auchstetter said.

This design included:

- A totally enclosed type 24A-60P, 24V planetary PMDC gearmotor with needle bearings for high peak torque and long life.
- Sealed gearbox, high-performance lubricant for outdoor applications
- Built-in encoder, 1,000 PPR, quadrature signal is fed into 2-axis motion controller for precise elevation, azimuth, and polarization angle adjustments
- Watertight wiring harness
- Modified mounting and shaft

The 24A4-60P gearmotor combines the high-performance 24A PMDC motor with the type-60P planetary (60 mm) gearhead. The gearmotor's small diameter and predictable variable speed performance make it an ideal drive for industrial automation, pumps, packaging equipment and many other industrial applications. This gearmotor is suitable for applications that require higher torque than conventional helical/spur gearheads can provide, especially for intermittent duty.

Bodine DC speed controls are designed to deliver optimal performance from the company's 12, 24, 90, or 130 Volt PMDC motors and gearmotors. Stock controls are available with either filtered or unfiltered DC output. Current limit, torque limit, maximum/minimum speed, and acceleration/deceleration time can all be adjusted to fit each application.

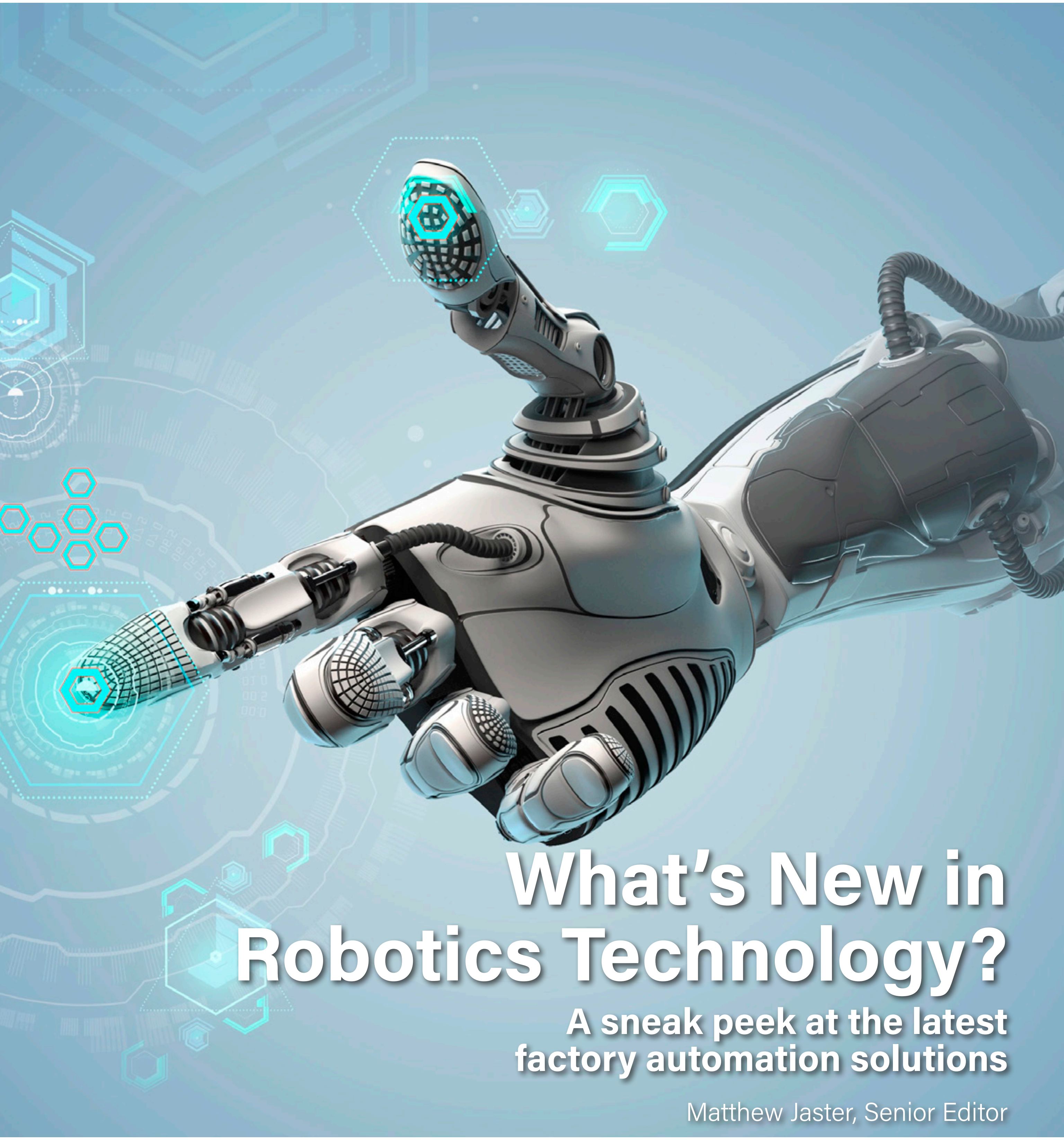
## Application Advantages

Fly-Away antennas are tripod based with transportable cases. They can be deployed and disassembled without tools within a few minutes. They can also be easily transported. These antennas need agile, lightweight and powerful components in order to meet the remote operational requirements for today's telecommunication needs.

"At C-COM, we prioritize reliability, cost-effectiveness, and product availability when selecting component suppliers," Rawlings said. "Bodine Electric consistently delivers on all three. Just as important to us is the quality of the working relationship. We value suppliers who are responsive, knowledgeable, and committed to collaboration. Our representative at Bodine exemplifies this approach, taking the time to understand our requirements and ensuring we always get the right motor for the application."

bodine-electric.com
c-comsat.com

**PTE**



# What's New in Robotics Technology?

## A sneak peek at the latest factory automation solutions

Matthew Jaster, Senior Editor

Manufacturers continue to see the value of automation and robotic technologies as industrial sectors *outside* of automotive look towards these solutions in 2025 and 2026 to bolster efficiency and fill much needed workforce gaps. AMRs, cobots and next-gen vision systems highlight the latest robotic and automation solutions.

## Kuka Showcases Latest Robotic Technology at CMTS 2025

Canadian Manufacturers will experience the future of automated manufacturing as Kuka Robotics brings the latest robotic solutions for automated machine tool tending, AMR-based intralogistics, and robotic additive manufacturing to the Canadian Manufacturing Technology Show (CMTS) from September 29–October 2 at the Toronto Congress Centre in Toronto, Ontario, Canada.

In Booth #729, Kuka will illustrate how robots drive productivity in today's machine shops by automating the feeding of machine tools and the flow of materials between machines. The mini factory in the booth consists of two lathes, each fed by a different Kuka robot in System Partner Waybo's pre-engineered cells. A KMP 600P AMR (Autonomous Mobile Robot) moves materials and tools between the cells as required by the production schedule. In addition to the mini factory, a Kuka robot in System Partner Dyze Design's additive manufacturing cell leverages its high precision and reach to 3D print plastic parts.

Visitors to Kuka's booth will see Waybo's turnkey CyberDrawer automated drawer feeding system that uses a KR Cybertech industrial robot to load and unload a Nakamura-Tome CNC lathe from Elliott Matsuura Canada in a pre-engineered cell. The CyberDrawer is compatible with most machine tools, is quick to install, and allows shops to easily move it from machine to machine, providing more than eight hours of autonomous operation for lights-out production. The KR Cybertech series offers high-performance industrial robots designed for handling, assembly and machining applications with exceptional speed, precision and flexibility. Featuring compact designs and high payload capacities, these robots are optimized for space-saving operation in various manufacturing environments.

The other Waybo pre-engineered cell is the compact PartNR that uses a KR Agilus industrial robot to feed a Siemens-controlled lathe. The uniqueness of this cell is that the Siemens 828D controller controls both the lathe and the robot via Kuka's mxAutomation and Siemens' Run MyRobot/Handling, providing factory personnel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with a single and familiar interface, not just for operation, but also for programming and diagnostics.

The third component of the mini factory is the KMP 600P mobile platform for autonomous material handling that transports parts and tooling between the CyberDrawer and the PartNR cells. The KMP 600P is Kuka's most compact high-performance AMR, is ideal for confined production spaces and offers a 600-kg payload for efficient material transport, process linking and reliable point-to-point delivery. This autonomous mobile robot provides an excellent performance-to-price ratio and is capable of 24/7 operation with extended battery life.

Kuka System Partner Dyze Design's additive manufacturing cell will feature a KR Cybertech-2 robot in live plastic part printing demonstrations. The partner's advanced Typhoon high-flow filament extruder integrated with the KR Cybertech-2 ensures precise, fast and consistent material deposition results. The six-axis KR Cybertech models are rated for payloads ranging from 8 to 22 kg with reaches of 1,612 to 2,013 mm while providing repeatability of ±0.04 mm. They are a compact, multifunction robot with optimized controller structures that make for smooth and sensitive motion characteristics on the path and in positioning. With the ability to be mounted in virtually any position—floor, ceiling, wall or angle—and its streamlined design, the KR Cybertech is ideally suited to space-saving cell designs.

*kuka.com*

## Kassow Robots Introduces Sensitive Arm Technology for Enhanced Collaborative Robotics

Kassow Robots, a manufacturer of 7-axis collaborative robots, recently announced its Sensitive Arm technology across its complete range of 7-axis collaborative robots. Introduced at Automate 2025 in Detroit, MI, this advanced force control system integrates high-resolution torque sensors into all seven joints of each robot, enabling manufacturers to automate delicate and contact-sensitive tasks with greater precision, safety and flexibility.


The Sensitive Arm system provides real-time, low-latency force feedback while utilizing integrated torque sensors across all joints. With a sensor resolution of up to 0.024 Nm/bit and a control frequency of 30 kHz, the system enables compliant and nuanced motions essential for complex tasks such as assembly, surface finishing, inspection and delicate handling.

"The Sensitive Arm is transforming how manufacturers approach automation of complex assembly and finishing operations," said Dieter Pletscher, global sales manager at Kassow Robots. "Our customers are seeing immediate benefits in applications requiring controlled contact forces from precision assembly to surface finishing while maintaining the industrial strength and flexibility that Kassow Robots' 7-axis design is known for."

Operators can fine-tune how the robot responds to external forces using a dedicated interface that makes it easy to adjust parameters such as stiffness, damping and end-effector compliance. The system also enables one of the smoothest and most responsive hand-guiding experiences on the market, with minimal resistance and high sensitivity, enabling fast and intuitive programming by demonstration. This significantly reduces the time and complexity involved in deploying new applications.

By eliminating the need for external force and torque sensors, the Sensitive Arm simplifies system integration while improving feedback accuracy. It also improves collaborative safety by enabling faster, more reliable detection of impacts or unexpected contact, creating safer conditions for human-robot interaction on the factory floor.

The Sensitive Arm is available across Kassow Robots' entire 7-axis collaborative robot portfolio, including new high-payload models, expanding automation possibilities for complex and sensitive tasks. Kassow Robots' expanded lineup now offers significantly greater payload capacities while maintaining precision and safety.

*kassowrobots.com*

## Boston Dynamics and LG Innotek Collaborate on Next-Gen Vision System

Boston Dynamics recently announced a new partnership with LG Innotek, the South Korean materials and electronic components manufacturing company. This strategic alignment will enable Boston Dynamics to install LG Innotek's new vision sensing components into Atlas, Boston Dynamics' humanoid robot.

The collaboration brings together Boston Dynamics' and LG Innotek's research teams to develop new vision sensing systems to address some of robotics hardest to solve problems. The new vision sensing solution will integrate various sensing components and allow robots to detect and perceive their surroundings, including during times of low visibility or poor weather conditions, and in dark environments.

"We're excited to partner with LG Innotek to drive innovation and redefine the development of robot eyes," said Robert Playter, CEO of Boston Dynamics. "Robots should be able to see, process and perceive the world as well as humans. It is my hope that by working together, we will develop groundbreaking vision systems that are as advanced as the cameras in our mobile phones."

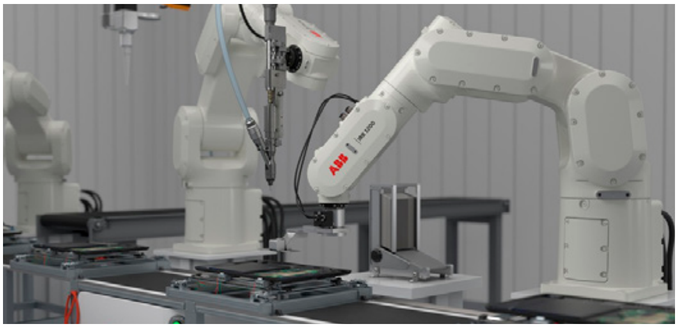

CEO Moon Hyuksoo of LG Innotek said, "By collaborating with Boston Dynamics, a world leader in robotics, LG Innotek will gain an advantage in the robotics components market." He added, "We will continue to introduce core components for robots that will set the standard in the era of robotics and secure a leading position for us in the market."

The new partnership with LG Innotek comes on the heels of other research collaborations with organizations including Toyota Research Institute, Google Deepmind, NVIDIA and Boston Dynamics' sister organization, RAI, all to move the robotics industry forward and to develop the world's most advanced robots.

**bostondynamics.com**

## ABB Offers Next Generation IRB 1200

ABB Robotics' IRB 1200 high performance small robot family is evolving into a new generation that is faster and more precise, improving productivity and efficiency for a wide range of applications.



"With rising demand from SMEs, the need for adaptable and efficient small automation solutions has never been greater," said Marc Segura, president ABB Robotics. "The new IRB 1200 takes efficiency and productivity even further in the most precise automation tasks."

The new generation IRB 1200 family comes in four variants—5, 7, 8 and 9 kg—the latter offering best-in-class payload, making it ideal for handling larger or heavier parts.

Powered by ABB's OmniCore controller, the new robots achieve class-leading motion control, with path accuracy to just 0.6 mm and pose repeatability down to 0.011 mm, even for multiple robots at high speeds of up to 1,600 mm/s.

A five percent faster cycle time ensures that the new IRB 1200 family delivers this precision with even greater productivity, making it ideal for high throughput, complex applications such as surface finishing, assembly, and dispensing, designed for electronics, general industries, automotive electronics, and consumer industries.

Through its leaner design, the new IRB 1200 enables more compact and efficient installation, boosting throughput and efficiency without increasing production footprint. At the same time, it is 20 percent lighter than the previous generation, reducing pedestal mounting and energy consumption.

Thanks to OmniCore, the new generation IRB 1200 family also offers ease of use, through full access to ABB's expanding suite of AI-powered software, such as *RobotStudio*, *RobotStudio AI Assistant*, and *AppStudio*.

**go.abb/robotics**

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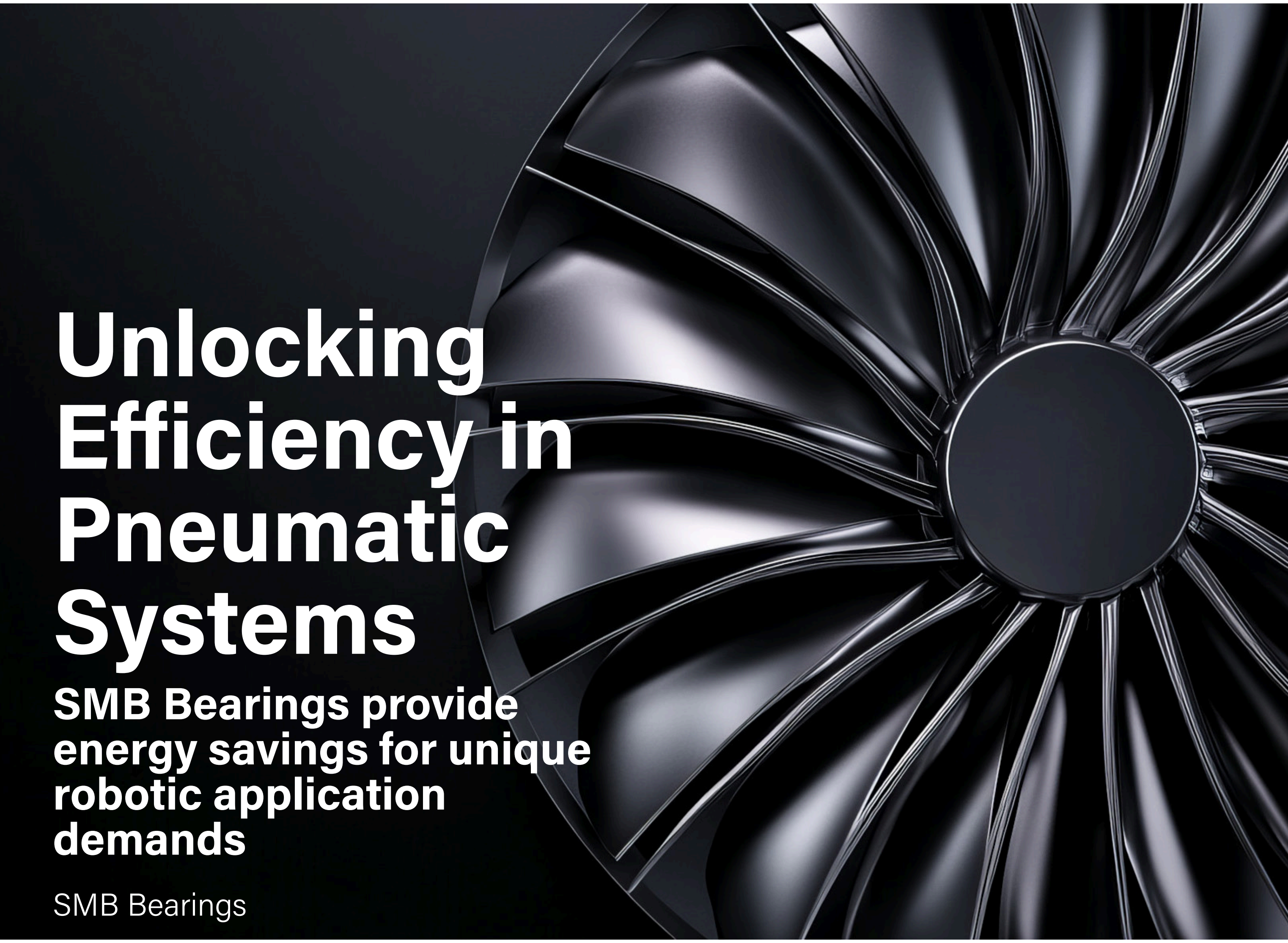

# Unlocking Efficiency in Pneumatic Systems

## SMB Bearings provide energy savings for unique robotic application demands

SMB Bearings

As industries adopt more automation, the demand for reliable and efficient pneumatic systems, which power everything from robotic arms to air-powered tools, continues to rise. However, despite their widespread use, these systems often suffer from hidden inefficiencies. Here, Chris Johnson, managing director at SMB Bearings—Oxfordshire, U.K.) explores how an overlooked component, industrial bearings, can improve the efficiency of pneumatic technologies.

SMB Bearings originally concentrated on miniature bearings, thin-section bearings and stainless-steel bearings. In response to customer demand, the company expanded the range to include other corrosion resistant bearings such as plastic bearings, 316 stainless bearings and ceramic bearings.

Bearings are essential components in pneumatic systems, responsible for reducing friction between moving parts and ensuring smooth operation. Over time, however, bearings can degrade, leading to increased resistance, higher energy consumption and ultimately, system inefficiency.

In pneumatic applications, even slight increases in friction can result in significant energy losses. For instance, air turbines and expanders used in compressed air energy storage systems rely on bearings to maintain smooth operation. If these bearings become worn or inefficient, the performance of the entire system can suffer.

As industries increasingly rely on automated systems, the demands on pneumatic equipment are becoming more stringent. Bearings that were once considered secondary components are now critical to ensuring efficiency, longevity and cost-effectiveness. Yet, too many companies continue to use bearings that are not suited to pneumatic systems.

## Determining the Right Bearing Fit

In this excerpt from the SMB Bearings blog, Chris Johnson, explores why precision fits demand greater attention from engineers and manufacturers:

Determining the most suitable fit begins with evaluating key operational factors. Load and speed are crucial considerations. High-speed applications often require tighter tolerances to minimize vibration and prevent slippage, whereas heavy-load machinery relies on interference fits to secure components and withstand significant forces.

Engineers also need to consider the operating environment. Harsh conditions, such as exposure to extreme temperatures or contaminants, may necessitate precise adjustments to maintain sealing integrity and protect against wear.

Thermal expansion is another critical factor. Material expansion rates must align to avoid performance issues caused by mismatched thermal changes. For example, in applications involving steel bearings housed in aluminum, the higher expansion rate of aluminum must be accounted for to prevent loosening during operation. Similarly, the operating temperature range of the machinery should guide the decision about fits to ensure consistent performance over time.

Maintenance considerations also play a role in fit selection. Bearings that require frequent removal for servicing or replacement benefit from transition fits, which facilitate disassembly without sacrificing operational stability. By factoring in these maintenance needs during the design phase, engineers can achieve a balance between ease of access and reliable performance.

Despite its importance, fit selection often takes a backseat to other design considerations. This oversight may stem from a lack of awareness about the impact of fits or an overreliance on standard configurations that fail to meet the unique needs of specific applications.

Industry standards and guidelines, such as those from The International Organization for Standardization (ISO), offer valuable frameworks but must be applied judiciously to account for application-specific requirements.

Addressing this issue requires a proactive approach. By consulting a bearing specialist early in the design phase, engineers can achieve optimal fits that prolong bearing life, reduce maintenance costs and enhance equipment performance.

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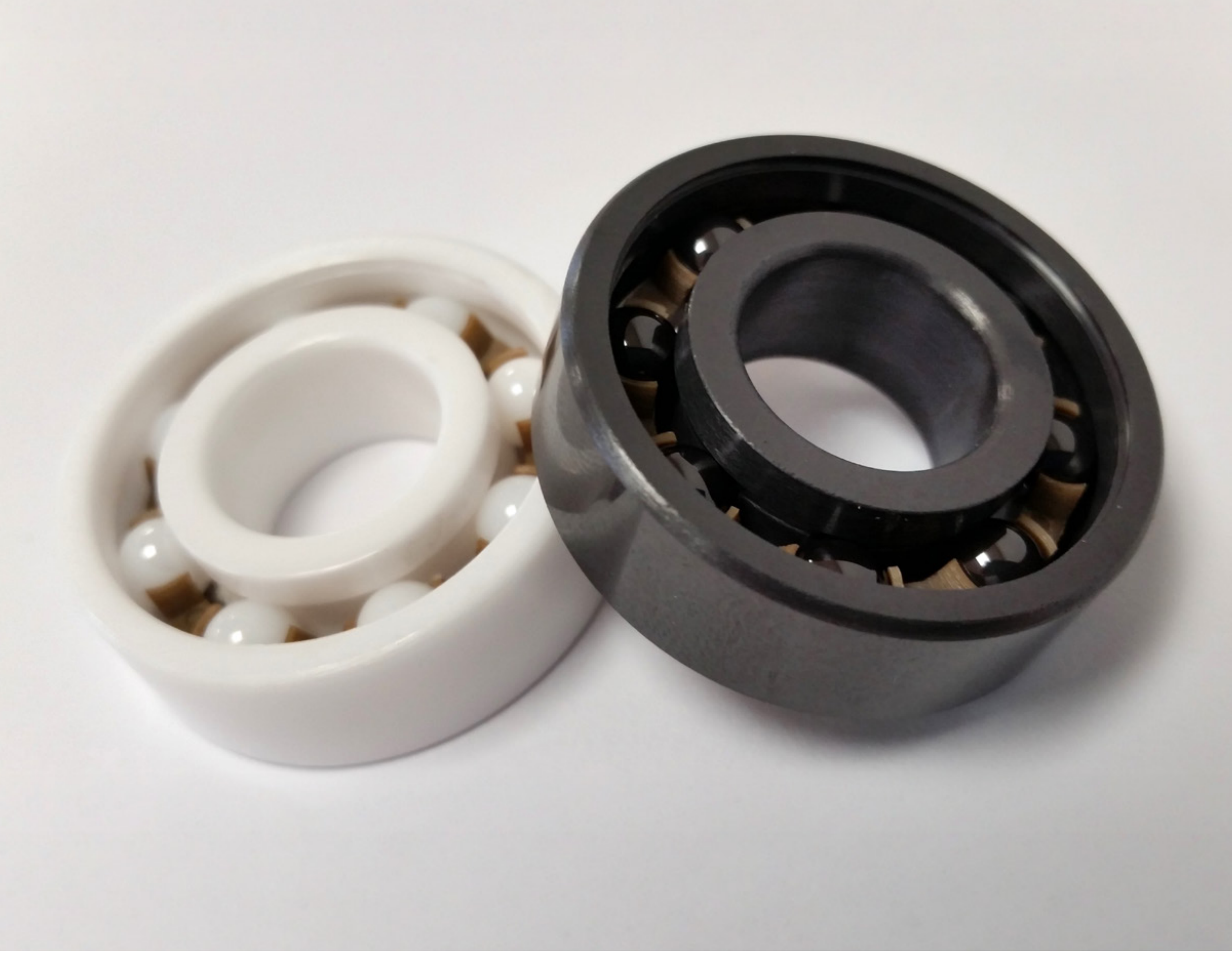
### Optimizing bearings for maximum efficiency

To tackle inefficiencies, many industries are turning to more advanced bearing technologies. Traditional metal bearings may not provide the performance needed for modern, high-performance pneumatic systems. The solution? Advanced materials such as ceramic or hybrid bearings, which offer lower friction, better wear resistance and longer lifespans.

Ceramic and hybrid bearings are designed to reduce friction in pneumatic systems, which directly



*SMB's EZO thin-type precision bearings are highly accurate due to quality control and advanced manufacturing techniques.*

translates to lower energy consumption and improved system performance. These bearings not only reduce the strain on pneumatic systems but also extend the life of equipment, leading to fewer repairs and less downtime.

SMB Bearings, for example, offers a range of miniature, ceramic and stainless-steel bearings tailored to the specific demands of pneumatic systems. These bearings provide reduced friction and enhanced durability, which can help manufacturers cut energy costs and improve overall system efficiency.

## The benefits of smart monitoring

In addition to upgrading mechanical components like bearings, manufacturers are increasingly incorporating smart technologies into their pneumatic systems. The Internet of Things (IoT) has allowed for real-time monitoring of energy consumption, enabling more precise control over system operation. Through IoT-enabled sensors and automated adjustments, manufacturers can optimize parameters such as air pressure and compressor operation to reduce energy use.

These smart systems not only improve energy efficiency but also help prevent unexpected failures by providing early warnings of potential issues. By integrating advanced monitoring technologies with high-performance bearings, companies can ensure that their pneumatic systems are operating at peak efficiency, leading to reduced energy costs and improved sustainability.

## EZO bearings in robotics and automation

SMB Bearings is already supporting robotic applications. In one case, it collaborated with Shadow Robot Company to supply precision EZO thin-type bearings for its Smart Grasping System. Standard industrial grippers are designed for repetitive tasks, often limited to handling a single object type. However, modern manufacturing demands greater flexibility. Manufacturers now require adaptable tooling capable of handling various object types, making single-use grippers obsolete.

Built by a founder with no tech background and a bunch of hobbyists meeting in an attic, Shadow Robot Company—headquartered in London—was formed in response to receiving its first order and has flourished over the last two decades. The talented engineers continue to be motivated by the challenge of building next-generation robot systems with advanced dexterity to solve problems and enable innovation. The company is courageous enough to pursue world firsts and never relies on off-the-shelf solutions. Each order is custom built to customer specifications

Shadow Robot Company leveraged its expertise in dexterous robotic hands to create a robust and intelligent Smart Grasping System. This system is designed to recognize different objects and select the appropriate grasp for each.

During development, Shadow Robot Company needed bearings with extremely tight dimensional tolerances to ensure precise movements and easy installation. SMB Bearings, known for its high-quality non-standard bearings, supplied EZO thin-type precision bearings tailored to the project's unique requirements.

The EZO thin-type precision bearings are highly accurate due to EZO's advanced manufacturing techniques and rigorous quality control. In particular, the consistency in bearing shape and size is crucial for maintaining precise robot joint positioning and overall system accuracy.

Shadow Robot Company's research and development team tested different grease levels to find the optimal fill percentage, balancing the need for smooth movement with controlled friction. Once the ideal coefficient of friction was determined, SMB Bearings supplied the required bearings to the exact specifications.

The customer reported that the bearings were very easy to install, with consistent quality and tight tolerances that are essential for repeated assembly and high precision across multiple robots. Shadow Robot also expected the bearings to outlast most other components in the system.

Unlocking the full potential of pneumatic systems requires a holistic approach that goes beyond merely upgrading compressors and air lines. By focusing on the performance of critical components like bearings, manufacturers can achieve substantial energy savings, improve system reliability and reduce operational costs. As industries continue to embrace more sustainable practices, the role of high-performance bearings in pneumatic systems will only become more important.

*smbbearings.com*
*shadowrobot.com*

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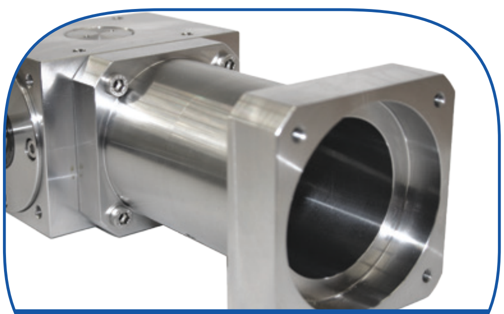
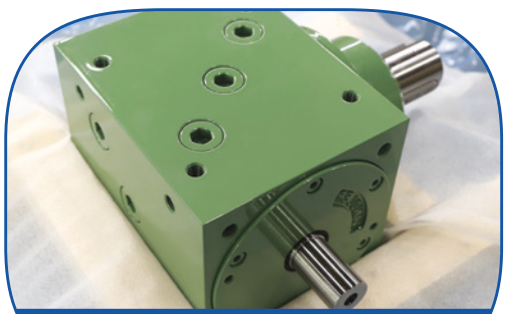
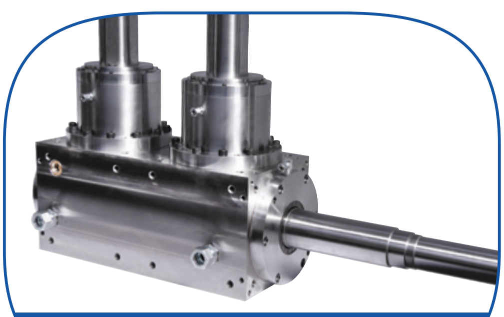


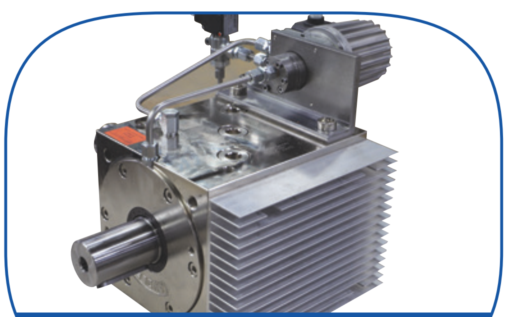
Custom Flanges



Custom Paint



Complete Redesigns



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## Motion Control and Power Transmission Drive Components


# MPT Expo 2025 Accelerates Innovation

## Detroit show offers latest advancements in power transmission and gearing technologies

Matt Jaster, Senior Editor, and Aaron Fagan, Senior Editor

The Motion + Power Technology Expo (MPT Expo) returns to Detroit from October 21–23, 2025, bringing together a comprehensive cross-section of the mechanical, fluid, and electrical power transmission sectors. Hosted in one of North America's manufacturing hubs, the event serves as a convergence point for engineers, technologists, researchers and decision-makers involved in the design, production and integration of power transmission systems.

### The 2025 Show

The MPT Expo provides a technical showcase of state-of-the-art solutions spanning gear design and manufacturing, electric drive systems, hydraulic and pneumatic components, motion control, and system-level integration. Over 300 exhibiting companies will present hardware, software, and process innovations relevant to the evolving demands of high-performance mechanical systems, particularly those targeting greater efficiency, durability, miniaturization, and system interoperability.

### Event Highlights

#### Industry Podcast Returns to MPT Expo with New Host, Bigger Platform

The Motion + Power Technology Expo (MPT Expo) is bringing back its live podcast experience, this time with an exciting new twist. Building on the success of its 2023 debut, the American Gear Manufacturers Association (AGMA) has named Tony Gunn as the exclusive host of this engaging on-site feature. A respected industry podcaster, influencer, and CEO of TGM, as well as director of global operations at MTDCNC, Gunn brings energy and insight into every conversation.

In 2023, thousands of attendees and exhibitors had the chance to witness podcast interviews happening live on the Expo floor, capturing insights from subject matter experts, and global industry leaders. Topics ranged from innovation and workforce development to real-world power transmission solutions. For 2025, the format is being refined with Gunn at the helm, delivering focused, high-impact interviews with thought leaders, AGMA members and experts from around the world.

"Our goal is to build on the progress from the last show and potentially connect with the hundreds of thousands of viewers and followers that Tony and his team inspire every day," said Rebecca Brinkley, senior director, member engagement, AGMA. "We know our exhibitors, attendees, experts, and AGMA team members have important stories to tell. The modern world, as we know it, only exists because of the technology that power transmission, gearing and bearing manufacturers and suppliers produce."

"I'm genuinely pumped to be back in Detroit this fall for the Motion + Power Technology Expo," said Gunn. "This is where the gearheads, the innovators and the heroes of power transmission all collide in one place to solve real-world problems."

As manufacturers across sectors continue to navigate workforce issues, increasing global competition, and supply chain and tariff challenges, visibility has never been more important. The podcast will help amplify exhibitor voices and provide attendees with another reason to visit and engage on-site.

"MPT Expo brings the entire gearing ecosystem under one roof, and that's rare," Gunn added. "Hosting the podcast here means we're turning up the volume on visibility, giving every company, big or small, a chance to be seen, heard, and celebrated on a global scale."

## Networking Events

### Women in Manufacturing and Engineering Breakfast October 21 (7:00 am–9:00 am)

AGMA and ASM are pleased to invite all women at MPT Expo to a networking breakfast where there will be a panel of industry experts sharing experiences and advice about how to become leaders in your field and how to avoid complacency in the workforce to advocate for your own career. Join others from all sectors of manufacturing and engineering, from new employees to high-level executives, to build new relationships, grow your network, and innovate for the future. All women exhibiting or attending Motion + Power Technology Expo, the Heat Treat Conference & Exposition, or IMAT events who want to network and be inspired!

### The Materials Fusion Experience October 22 (6:00 pm–9:00 pm)

Join us for The Materials Fusion Experience, an exclusive social networking event, offering a dynamic and immersive environment for professionals to connect, collaborate, and explore the city's vibrant history and industry. This event seamlessly blends the city's cultural roots with modern innovation, creating a multifaceted experience designed to inspire, engage, and foster meaningful connections.

### Fall Technical Meeting (FTM) Networking Reception October 23 (6:30 pm–8:30 pm)

Join us for an evening of networking, entertainment, and connection at Corktown Taphouse. This high-energy reception brings together professionals from across the gear industry in a relaxed setting, offering a chance to meet new attendees, reconnect with colleagues, and set the stage for a week of innovation and collaboration. Enjoy interactive games like augmented reality darts and duckpin bowling, designed to spark conversation and fun. With over 70 self-pour beverage options, including craft beers, ciders, wines, and non-alcoholic choices, there's something for everyone. Whether you're looking to grow your network or simply enjoy a lively evening with colleagues, this event is the perfect way to start the 2025 Fall Technical Meeting. This reception is included in FTM Full Pass registrations. Tickets are available for Single Session Passholders and MPT Expo attendees.

## Technology Preview

### CGI, Inc. Booth #311

CGI continues in its commitment to providing the latest technology with innovative new products while consistently investing in state-of-the-art manufacturing, inspection and assembly equipment. CGI is a supply chain partner from prototype to product launch and life cycle support. CGI's engineering, manufacturing and quality departments employ the latest systems available, such as *Solidworks* with FE analysis, *AutoCad*, *CAD/CAM*, and Infor Visual Enterprise with ERP System. CGI implements *KISSsoft* gear and bearing software in every design application. The company strives to improve standard products as well as minimize the time from preliminary design to final design approval ready for production.

CGI serves a wide array of industries including medical, robotics, aerospace, defense, semi-conductor, industrial automation, motion control and many others. CGI is certified to ISO9001 and ISO13485 quality management systems. In addition, they are FDA and AS9100 compliant.

`cgimotion.com`

### Croix Gear—Booth 613

Croix Gear has recently achieved AS9100D certification, aligning its quality management system with aerospace and defense industry standards. The certification applies to the company's full range of manufacturing processes and reflects implementation of documented traceability, process control, and continuous improvement protocols.

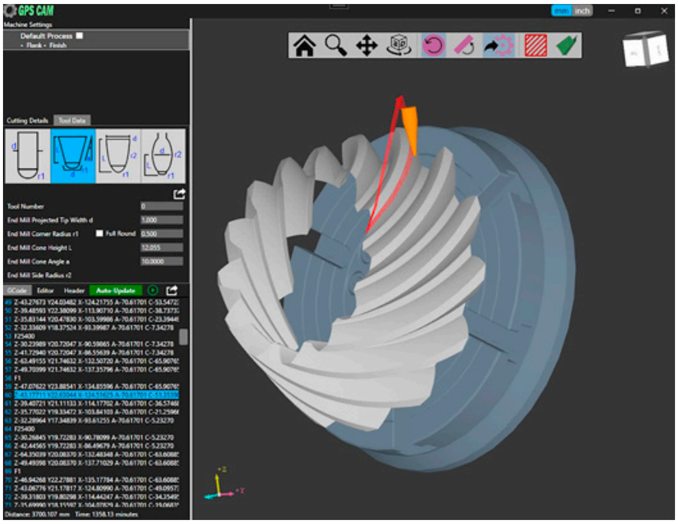
Best known for its specialization in bevel gears—including spiral bevel, straight bevel, hypoid bevel, and Zerol configurations—Croix Gear serves a range of industries requiring application-specific gear geometries and high dimensional stability. The company also produces spur, helical, internal, and worm gears and maintains capabilities for high-accuracy gear inspection and quality documentation to customer specifications.

With AS9100D now in place, Croix Gear is positioned to support more complex requirements in aerospace and defense applications, where performance tolerances, material conformance, and process traceability are critical. The company's bevel gear expertise includes precision matching, optimized tooth contact patterns, and consistent profile control across batches.

Croix Gear is exhibiting at Booth 613 at this year's Motion + Power Technology Expo. Technical representatives will be available to provide details on gear manufacturing capabilities, inspection protocols, and aerospace-related production workflows.

*croixgear.com*

## Dontyne Systems—Booth 213




Dontyne Systems has released a second update to the *Gear Production Suite (GPS)* in 2025 to reflect the volume of recent technical additions. Originally developed in 2008, GPS integrates gear design, machining simulation, and inspection data into a single environment to identify and mitigate manufacturing issues at the design stage.

The software's Loaded Tooth Contact Analysis functionality has been extended to hypoid gear geometry. Additional design and analysis features have been introduced to support non-standard gear forms requested by users in specific application domains.

Manufacturing simulation capabilities have continued to expand. Modules for plunge shaving and internal profile grinding have been added alongside existing processes such as hobbing, shaping, external shaving, and form grinding. The skiving simulation supports both internal and external cylindrical gears and is used to optimize tool design, machine settings, and cutting conditions over the life of the tool, including post-sharpening states. The module has been adapted for non-involute profiles and is compatible with both dedicated machines and 5-axis CNC platforms.

The honing simulation now includes analysis of contact line distribution to evaluate force balance during generation. It can also incorporate data from upstream roughing processes—such as hobbing or skiving—to improve calculation of stock allowance and breakout location at the tooth root.

The *GPS CAM* module has been extended to simulate the production of straight and spiral bevel gears using fixed tools on 5-axis CNC machines. This workflow is suited to batch production where machine utilization and toolpath control are critical. Dontyne continues to support prototyping and gear testing, providing output in the form of *CAD* models, *GPS* project files, and inspection reports.

The *Inspection Centre Module* interfaces with coordinate measuring machines (CMM) and dedicated gear inspection systems, maintaining consistent surface definitions between design and measurement. Measurement data may be imported into *GPS* for closed-loop feedback in load distribution analysis or for compensating deviations from machining processes.

A standalone inspection package, the *Dontyne On Machine Measuring System (DOMMS)*, has been introduced to perform gear geometry evaluation directly on machine platforms. *DOMMS* is compatible with multiple hardware configurations and produces measurement data that integrates with *GPS* analysis modules.

*dontynesystems.com*

## Forest City Gear—Booth 419

Forest City Gear specializes in fine- and medium-pitch custom gears for critical applications in aerospace, defense, robotics, medical instrumentation, and other high-reliability sectors. The company operates two facilities: its primary gear cutting and inspection plant and a dedicated turning facility known as Roscoe Works.

The company's manufacturing capabilities include the production of spur and helical gears, involute splines, worms, worm gears, sprockets, and other cylindrical gear types. These components are produced in a wide range of materials and geometries, including small-scale parts


held to tight tolerances for use in environments with extreme thermal, mechanical, or vacuum conditions. Their gears have been deployed in terrestrial and aerospace systems, including the International Space Station and various NASA rover platforms.

Forest City Gear supports both complete part manufacturing and contract gear cutting. Under its "Make Complete" workflow, parts are manufactured from raw stock through final inspection, including material sourcing, turning, heat treatment coordination, and finish grinding. Design-for-manufacturability input is offered at the early stages of project development. The "Cut Teeth Only" workflow applies to customer-supplied blanks and includes gear cutting, measurement, and final inspection. The company maintains a tooling inventory of over 7,000 hobs and 5,000 shaper cutters, enabling short lead times on a wide range of standard and custom profiles.

Forest City Gear holds ITAR registration and maintains certifications to AS9100D / ISO 9001:2015 and ISO 13485:2016, with Nadcap accreditation for magnetic particle inspection (MPI). The company is an active member of the American Gear Manufacturers Association (AGMA).

Representatives will be available at Booth 419 to provide technical information on current capabilities, tolerances, materials, and lead time estimates.

*forestcitygear.com*

## Gleason Corporation—Booth 529

The latest release of *KISSsoft*, now integrated with the *System Module*, enables simulation of complete drivetrains at the concept stage. This system-level engineering tool supports component optimization and design validation early in development.

For molded parts, Gleason Plastic Gears combines *KISSsoft*-driven optimization with moldability analysis, custom materials, multi-cavity tooling, and advanced molding strategies such as weld-line elimination and over-molding.

Gleason Global Services rounds out its offerings with on-site demonstrations of digital maintenance platforms, lifecycle support tools, and modernization programs to maximize machine availability and long-term process capabilities.

*gleason.com/mpt2025*

## PAI Industries Booth #713

PAI takes a complete product approach that encompasses engineering, manufacturing, quality control, testing and assembly. They offer customers scalable production solutions. PAI's recent investments in new technology, new equipment and state-of-the-art in-house heat treating now provides open production capacity and the opportunity to take on new customers.

With the implementation of lean concepts like 5S, Kaizen, SMED, WPO, PAI continues to make improvements and new methodologies to processes. "In the rapidly evolving gear manufacturing business, innovation is our driving force," said Navid Yavari, PAI vice president.

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# Genetic Optimization of Planetary Gearboxes Based on Analytical Gearing Equations

Thomas Tallerico

Future electric and hybrid electric vertical takeoff and landing vehicles will require high efficiency and lightweight electric motor driven propulsion systems. One key to designing an optimum electric motor driven propulsions system, is to have a method for estimating the mass and efficiency of a gearbox for different power levels, motor speeds, and propellor speeds. Understanding the trade space for gearbox mass and efficiency allows the overall optimization of the propulsion system.

A number of past papers have detailed gearing theory, sizing, and efficiency calculations (Ref. 1). Past work at NASA has explored the optimum sizing of gearsets (Ref. 2). More recently, genetic optimization tools have been used to optimize gearboxes for terrestrial traction applications (Refs. 3–6). Genetic optimization algorithms are ideal for gearbox design due to the number of optimization variables that create discontinuities in the design space (Ref. 5). In this paper, a preliminary analytical gearbox optimization tool for electric vertical takeoff and landing vehicles is presented. Example gearbox sizing studies are carried out with the tool for electric multirotor type vehicles based on the NASA Revolutionary Vertical Lift Technology (RVLT) project 6-passenger quadrotor vehicle (Ref. 7).

The section "Gearbox Genetic Optimization" discusses the details of the optimization tool. Example tool results are presented in the section "Example Design Optimization Results" for multirotor-type vehicles based on the RVLT quadrotor concept vehicle. The "Conclusion" section outlines future tool improvement and development plans.

## Gearbox Genetic Optimization Tool

A flow diagram for the design tool is given in Figure 1. The following sections discuss each of the boxes in the flow diagram in order. The tool is presented in the context of a single or two-stage planetary gearbox.

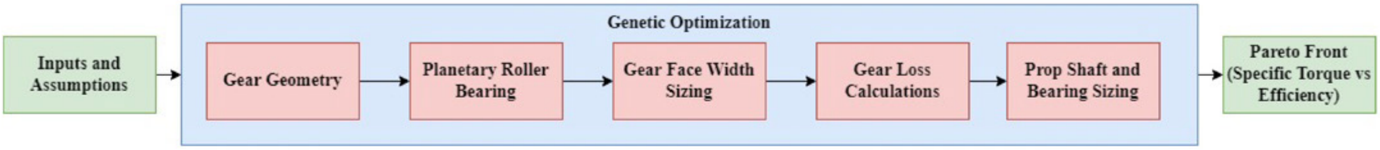


*Figure 1—Flow diagram for gearbox genetic optimization tool.*

| | | | |
|---|---|---|---|
| Target life | 5000 h | Propellor thrust | 0.006*Power |
| Target reliability | 99.9 percent | Prop drag coefficient | 0.015 |
| Gear Material | Steel | Prop tip speed | 167 m/s |
| Gear steel modulus | 200 GPa | Prop hub moment | Estimated |
| Gear steel Poisson's ratio | 0.3 | Vehicle cruise velocity | 31.5 m/s |
| Gear steel hardness | 627 HB | Propellor material | Carbon fiber |
| Gear steel fatigue bending strength | 517 MPa | Oil viscosity | 100 cSt |
| Gear steel fatigue contact strength | 1.90 GPa | Air viscosity | 0.02 |
| Housing material | Aluminum | Shaft material | Steel |
| Gear pressure angle | 20 degrees | Gear type | Spur gears |

*Table 1—Assumptions and inputs used in this paper.*

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## Input, Constants, and Assumptions

Table 1 provides the inputs and assumptions used in this paper. Along with basic output speed, power, and gear ratio, the tool requires a target life and reliability to size the gears and bearings. Gear, oil and other material information must be provided to estimate the life and power loss of the gearbox. Propeller loading information can optionally be provided for a given application. In this paper, the bulk of the propeller loading properties are based on the RVLT quad rotor concept vehicle. Hub moments in cruise are estimated based on the rotor disk loading, rotational speed, radius, and cruise velocity. These values are used as an example case. Ideally, actual values would be applied for a given target propeller design specification.

The code uses 3 genetic optimization variables for single-stage planetaries and 7 variables for two-stage planetaries. For each stage, sun gear tooth count, ring gear diameter, and number of planets are used as optimization variables. The seventh variable for the two-stage planetary is the gear ratio of the first stage. Other parameters like gear tooth pressure angle, listed as an assumption in Table 1, can also be used as genetic optimization variables if desired.

## Gear Geometry Calculations

The 2D geometry of each gear set is generated based on the inputs provided to the fitness function by the genetic optimizer. For a single-stage planetary, first the ring and planet gear tooth counts are calculated based on the target gear ratio and the input sun gear tooth count.

$$Z_2 = round\left(GR_t * \frac{Z_1}{2} - Z_1\right) \quad (1)$$

$$Z_3 = Z_1 + 2 * Z_2 \quad (2)$$

where $Z_1$ is the sun gear tooth count, $Z_2$ is the planet gears tooth count and $Z_3$ is the ring gear tooth count. Because $Z_2$ must be rounded to an integer value number of gear teeth in Equation 1, actual gear ratio is calculated for the gear stage as,

$$GR = \frac{Z_3}{Z_1} + 1 \quad (3)$$

The code verifies that the actual gear ratio, rounded to the nearest whole number, is equal to the target gear ratio. Input parameter sets that do not meet this target are discarded in genetic optimization.

The gear ratio of the planets relative to the sun gear is defined as

$$GR_p = \frac{Z_2}{Z_1} \quad (4)$$

The rotational speed of the sun gear is defined as

$$\mathrm{RPM}_1 = GR * \mathrm{RPM}_{out} \quad (5)$$

The rotational speed of the planets is defined as

$$\mathrm{RPM}_P = \frac{\mathrm{RPM}_1}{GR_p} + \mathrm{RPM}_{out} * \left(1 + \frac{1}{GR_p}\right) \quad (6)$$

Whether the planetary stage can be assembled is verified by checking if

$$\frac{Z_1 + Z_3}{N_p} \quad (7)$$

is equal to a whole number (Ref. 1). $N_p$ is the number of planet gears. Input parameter sets that result in a planetary stage that is not possible to assemble are discarded in the genetic optimization.

The diametral pitch of the planetary stage is calculated using the ring gear tooth count and input diameter.

$$P = \frac{Z_3}{D_{p,3}} \quad (8)$$

where $P$ is the gear pitch. The pitch radius of all the gears in the set is then calculated as

$$R_p = \frac{Z}{2 * P} \quad (9)$$

where $R_p$ is the pitch radius. The tooth tip radius of the sun and planet gears is calculated as

$$R_a = R_p + \frac{add}{P} \quad (10)$$

where $R_a$ is the tip radius and *add* is the gear addendum ratio. Ring gear tip radius is calculated as

$$R_{a,3} = R_{p,3} - \frac{add}{P} \quad (11)$$

Gear tooth base radius for the sun and planet gears is calculated as

$$R_c = R_p - \frac{ded}{P} \quad (12)$$

where $R_c$ is the gear tooth base radius and ded is the gear dedendum ratio. Ring gear tooth base radius is calculated as

$$R_{c,3} = R_{p,3} + \frac{ded}{P} \quad (13)$$

Gear base radii are calculated as

$$R_b = R_p * \cos(\theta) \tag{14}$$

where $R_b$ is the gear base circle radius and $\theta$ is the gearset pressure angle. The base pitch of the gears is calculated as

$$P_b = \frac{2\pi R_b}{Z} \tag{15}$$

Gear center distance between the sun and planet gears is calculated as

$$C_{12} = P_{r,1} + P_{r,2} \tag{16}$$

Gear center distance between the ring and planet gear is calculated as

$$C_{23} = P_{r,3} - P_{r,2} \tag{17}$$

The length of a sun-planet gear tooth contact along the line of action is calculated as

$$X_{12} = \sqrt{R_{a,1}^2 - R_{b,1}^2} + \sqrt{R_{a,2}^2 - R_{b,2}^2} - C_{12}\sin(\theta) \tag{18}$$

where $X_{12}$ is the length of a sun-planet gear tooth contact (Ref. 1). The length of a planet-ring gear tooth contact along the line of action is calculated as

$$X_{23} = \sqrt{R_{a,2}^2 - R_{b,2}^2} - \sqrt{R_{b,3}^2 - R_{b,3}^2} - C_{23}\sin(\theta) \tag{19}$$

where $X_{23}$ is the length of a planet-ring gear tooth contact (Ref. 1). Contact ratios are calculated as

$$CR = \frac{X}{P_b} \tag{20}$$

where $CR$ is the contact ratio of each mesh (planet-ring and sun planet). Contact ratios for both meshes are required to be between 1.2 and 2 in this paper (Ref. 1).

Gear tooth thickness calculations are carried out for the sun gear only. First an initial estimate of gear tooth thickness at the pitch circle is made as

$$t_{R_p} = \frac{\pi}{2 * P} \tag{21}$$

Tooth thicknesses at the gear tooth inner radius and outer radius are calculated by calculating the corresponding roll angle:

$$\alpha_R = \sqrt{\left(\frac{R}{R_b}\right)^2 - 1} \tag{22}$$

where $\alpha_R$ is roll angle at radius $R$. The angular position of a gear tooth at a given radius is defined as

$$\beta_R = \operatorname{atan}\left(\frac{\sin(\alpha_R) - \alpha_R * \cos(\alpha_R)}{\cos(\alpha_R) + \alpha_R * \sin(\alpha_R)}\right) \tag{23}$$

where $\beta_R$ is the angular position of the face of the gear tooth at radius $R$. The span angle of the gear tooth at the pitch radius $R_p$ is calculated as

$$\gamma_{R_p} = \operatorname{atan}\left(\frac{t_{R_p}}{R_p}\right) \tag{24}$$

where $\gamma_{R_p}$ is the span angle of the gear tooth at radius $R_p$. The tooth span angle at any other radius, $R$, can then be calculated as

$$\gamma_R = \gamma_{R_p} - 2 * (\beta_R - \beta_{R_p}) \tag{25}$$

Gear tooth thickness at any radius $R$, can then be calculated as

$$t_R = 2 * R * \tan\left(\frac{\gamma_R}{2}\right) \tag{26}$$

The radius of the fillet at the base of the gear tooth, $hob_R$, is calculated from the difference between the available space at the tooth base and the size of the tooth at the base. A max size for $hob_R$ is set to the 0.25/P. A min size is set to 0.25 mm.

Gear tooth thickness at the pitch radius size is iteratively decreased until at least 0.2 mm of clearance exists between the gear teeth in mesh. If the tooth thickness at the pitch radius drops below 3 mm, the gear design is discarded in the genetic optimization. 3 mm is used as a rough estimate of the limits of manufacturing size for a planetary gearset of appropriate size for eVTOL applications.

The radius of the center of the gear tooth base fillet is calculated as

$$R_f = R_c + hob_R \tag{27}$$

where $R_f$ is the radius of the center of the gear tooth. The tooth thicknesses for bending stress calculations $t_{R_f}$ and $t_0$ are calculated at this radius.

## Planetary Bearing Calculation

In the tool it is assumed that spherical roller bearings are used to transmit torque from the planet gears to the planet carrier due to their high load capacity and ability to react moments and axial forces. The force on each roller bearing is estimated as

$$F_{roller} = \frac{\tau}{C_{12} * \cos(\theta) * NP} \quad (28)$$

where $\tau$ is the output torque of the planetary stage. The bearing life equations from (Ref. 8) are used to evaluate all the bearings in a spherical roller bearing database composed from (Ref. 9). Max speed limitations for each bearing are also checked relative to the planet gear rotational speed. The lowest mass bearing that is able to meet the target life, speed requirements, and fit dimensionally within the planet gear is selected. If no bearing meets the requirements, the input parameter set is discarded in the genetic optimization.

Roller bearing losses are calculated using the equations found in Ref. 10 and are included in the efficiency estimate for the planetary stage.

## Gear Face Width Sizing

The face width of a given gear tooth set is calculated by first calculating the min required tooth width for bending stress, contact stress, and pitting life respectively. Gear tooth width for all the gears in the planetary gear train is set to the maximum of the three calculated minimum required thicknesses. Gear mass and losses are calculated using that face width. The following sections describe each of the gear tooth face width calculations.

### Gear Tooth Bending Stress

The max allowable bending stress in a gear tooth is defined as

$$S_{b,max} = S_{t,fatigue} * \left(\frac{k_L}{SF_t k_t k_r}\right) \quad (29)$$

where $S_{b,max}$ is the max allowable bending stress, $S_{t,fatigue}$ is the fatigue strength of the steel, $k_L$ is the life factor, $SF_t$ is the bending fatigue safety factor, $k_t$ is the temperature factor, and $k_r$ is the reliability factor (Ref. 1). Assuming an AGMA grade 3 case carburized gear tooth, $S_{t,fatigue}$ is estimated as 517 MPa (Ref. 11). $SF_t$ is set to 1.25 in this paper. $k_t$ is taken to be unity, assuming the gear oil temperature is in the range of 60–80 °C, and correspondingly, the gear tooth temperature is less than 177 °C (Ref. 1). $k_r$ in this paper is taken to be 1.5 for 99.99 percent reliability (Ref. 1). $k_L$ is defined based on Figure 18 in (Ref. 11) as

$$k_L = 1.6831 * N^{-0.323} \quad (30)$$

where $N$ is the number of stress cycles the gear tooth experiences.

The bending stress is calculated on the pinion for each gear set. The method described on page 33 of Ref. 1 is used. The calculation is carried out at the highest point of single tooth contact. To define the highest point of single tooth contact, first the corresponding roll angle is calculated as defined in Ref. 2

$$\alpha_{R_{HS}} = \frac{\sqrt{R_a^2 - R_b^2} - (X_{12} - P_b)}{R_b} \quad (31)$$

The pressure angle at $R_{HS}$ is calculated as

$$\theta_{R_{HS}} = \operatorname{atan}(\alpha_{R_{HS}}) \quad (32)$$

$R_{HS}$ is calculated as

$$R_{HS} = \frac{R_b}{\cos(\theta_{R_{HS}})} \quad (33)$$

Tooth thickness at $R_{HS}$, $t_{RHS}$, is calculated using Equations 21–26.

An iterative solver is then used to define the angle, $\delta$, which defines the location on the gear tooth fillet for gear stress calculations (Ref. 1). An initial guess of $\pi/4$ is used for $\delta_0$. A next approximation of $\delta$ is then estimated as

$$\delta_{i+1} = \frac{(1 + 0.16 * A_i^{0.7}) * A_i}{B_i(4 + 0.416A_i^{0.7}) - \left(\frac{1}{3} + 0.016A_i^{0.7}\right)A_i \tan(\theta_{HS})} \quad (34)$$

where $B_i$ is defined as

$$B_i = \frac{l_0}{hob_r} + \sin(\delta_i) \quad (35)$$

and $A_i$ is defined as

$$A_i = \frac{t_0}{hob_r} + 2(1 - \cos(\delta_i)) \quad (36)$$

where

- $t_0$ is the distance between centers of the gear tooth fillets

$$t_0 = t_{R_f} + 2 * hob_r \quad (37)$$

- $l_0$ is the distance from the radius of intersection of the line of action with the center of the gear tooth and the radius of the center of the fillet $R_f$,

$$l_0 = R_{HS} - \tan(\theta_{HS}) * \frac{t_{R_{HS}}}{2} - R_f \quad (38)$$

Three iterations of the iterative solver are used to refine the angle $\delta$. The required face width of the gear to keep bending stress below $S_{b,max}$ is then calculated as

$$F_b = \frac{W_N \cos(\theta_{HS})}{S_{b,max}}\left(1 + 0.26\left(\frac{t_s}{2hob_r}\right)^{0.7}\right)\left(\frac{6l_s'}{t_s^2} + \sqrt{\frac{0.72}{t_s l_s}} * \left(1 + \frac{t_{R_{HS}}}{t_s} v * \tan(\theta_{HS})\right) - \frac{\tan(\theta_{HS})}{t_s}\right) \tag{39}$$

where

- $F_b$ is the estimated minimum required face width of the gear set needed to keep bending stress below the max allowable
- $W_N$ is the force applied at the highest point of single tooth contact.
- $t_s$ is the thickness of the gear tooth at the location gear stress is calculated

$$t_s = t_0 - 2 * hob_r * \cos(\delta) \tag{40}$$

- $l_s'$ is the distance from the radius of intersection of the line of action with the center of the gear tooth to the radius of the point of max stress

$$l_s' = l_0 + hob_r * \sin(\delta) \tag{41}$$

- $l_s$ is the radial distance from the highest point of single tooth contact to the radius of the point of max stress

$$l_s = R_{HS} - R_f + hob_r * \sin(\delta) \tag{42}$$

- $v$ is Poisson's ratio for the gear steel.

## Gear Tooth Contact Stress Calculations

The max allowable contact stress in a gear set is defined as

$$S_{c,max} = S_{c,fatigue} * \left(\frac{k_{L,c}}{SF_c k_t k_r}\right) \tag{43}$$

where $S_{c,max}$ is the max allowable contact stress, $S_{c,fatigue}$ is the contact fatigue strength of the steel, $k_L$ is the life factor, $SF_{t,c}$ is the contact fatigue safety factor, $k_t$ is the temperature factor, and $k_r$ is the reliability factor (Ref. 1). Assuming an AGMA grade 3 case carburized gear tooth, $S_{c,fatigue}$ is estimated as 1,896 MPa (Ref. 11). $SF_c$ is set to 1.25 in this paper. $k_t$ and $k_r$ are the same as those used for bending stress calculations. $k_L$ is defined based on Figure 17 in Reference 11 as

$$k_{L,c} = 2.466 * N^{-0.056} \tag{44}$$

where $N$ is the number of stress cycles the gear tooth experiences.

Gear tooth contact stress and life calculations are carried out at the lowest point of single tooth contact on the gear set's pinion. The roll angle of the lowest point of single tooth contact is calculated as

$$\alpha_{R_{LS}} = \frac{\sqrt{R_a^2 - R_b^2} - P_b}{R_b} \tag{45}$$

Pressure angle at the point of lowest single tooth contact is calculated as

$$\theta_{LS} = \operatorname{atan}(\alpha_{R_{LS}}) \tag{46}$$

The required face width needed to maintain contact stress below $S_{c,max}$ is calculated as

$$F_c = \frac{W_n * E}{S_{c,max}^2} * \frac{C_{12}\sin(\theta)}{2(1 - v^2)\pi\cos(\theta_{LS})\alpha_{R_{LS}} R_{b1} C_{12}\sin(\theta_{LS} + \alpha_{R_{LS}} R_{b1})} \tag{47}$$

where $E$ is the elastic modules of the material (Ref. 2).

## Gear Tooth Pitting Life Calculation

A third required face width calculation is also used based on the method described in Section 5.2 of Ref. 1.

$$F_d = 0.001 * \left( \frac{L_1}{K_1 K_{10} W_n^{-4.3} l^{-0.4} \left( \frac{\left( \frac{0.001}{P_{R1}} + \frac{0.001}{P_{R2}} \right)}{\sin(\theta)} \right)} \right)^{\frac{1}{3.9}}$$

(48)

where

- $L_1$ is a constant defined

$$L_1 = \left( \frac{\log\left(\frac{1}{0.99}\right)}{\log\left(\frac{1}{0.9}\right)} \right)^{\frac{1}{2.5}} \frac{Life * \text{RPM}}{0.405E6} * \frac{60}{2 * Z_1 * N_p} \blacksquare^{-\frac{1}{2.5}}$$

(49)

- $K_1$ is set to 1.6, assuming the gears are shot peened AISI 9310 per Table 7 of Ref. 1
- $K_{10}$ is a constant equal to 6.44E9 per Ref. 1
- $l$ is the length of the contact
- $l$ is calculated as

$$l = 10^3 * R_{b1} \varepsilon_H \left( \varepsilon_c + \varepsilon_L + \frac{\varepsilon_H}{2} \right)$$

(50)

where

- $\varepsilon_H$ is the pinion roll angle increment for single tooth contact, Ref. 1

$$\varepsilon_H = \frac{2P_b - x_1}{R_{b1}}$$

(51)

- $\varepsilon_c$ is the pinion roll angle from the base of the involute to the start of double tooth contact Ref. 1

$$\varepsilon_c = \frac{(R_{p1} + R_{p2})\sin(\theta) - \sqrt{(R_{a2}^2 - R_{b2}^2)}}{R_{b1}}$$

(52)

- $\varepsilon_L$ is the pinion roll angle increment for double tooth contact, Ref. 1

$$\varepsilon_H = \frac{X_1 - P_b}{R_{b1}}$$

(53)

## Gear Face Width and Mass

Gear face width, $F$, is defined as the max of $F_b$, $F_c$, and $F_d$. If the largest of these face width values is less than 5 mm, face width is set to 5 mm. 5 mm is selected as the minimum allowable face width so that the gear maintains out of plane stiffness and has reasonable face area to account for misalignment and 3D gear tooth features like tooth crowning.

The mass of an external gear is estimated as

$$Mass = D_{steel} * F * \pi * (R_p^2 - (R_c - Rim_t)^2)$$

(54)

where $Rim_t$ is an input estimate of the required gear rim thickness to avoid distortion of the gears an $D_{steel}$ is the density of the steel used to make the drivetrain. 5 mm is used in this paper so that the gear rims have reasonable stiffness and can support centripetal loads. Integrating more detailed and physics-based gear rim design is the target of future work.

The mass of an internal gear is defined as

$$Mass = D_{steel} * F * \pi * ((R_c + Rim_t)^2 - R_p^2)$$

(55)

For a planetary gear member, the mass of the roller bearings and an estimate of the carrier mass are included. Roller bearing mass is taken to be 66 percent of the mass listed in Ref. 9, assuming some portion of the inner and outer races of the bearings are integrated into the rim of the gear and the gear's shaft. An estimate of planet carrier mass is also included

$$Mass_{carier} = D_{steel} * NP * C_{12} * 0.02 * Rim_t \tag{56}$$

This planet carrier mass estimate only serves as a rough mass estimate that scales with the size of the gear set and number of planets. Adding a higher fidelity methodology for carrier mass estimate is a potential area of improvement for the code.

## Gear Efficiency Calculations

With the gearset face width defined, windage, sliding, and rolling loss for each gear mesh are calculated using the method described in Ref. 12.

### Windage Loss Calculation

For the sun gear windage power loss is calculated as

$$P_{w1} = 2.82 * 10^{-7} * \left(1 + 2.3 * \frac{F}{R_{a1}}\right)\mathrm{RPM}_1^{2.8} * R_{a1}^{4.6} * (0.028 * \mu + 0.019)^{0.2} \tag{57}$$

where $P_{w1}$ is the windage loss of the pinion gear and $\mu$ is the viscosity of the oil.

The windage power loss of the planet gears is estimated as

$$P_{w2} = NP * 2.82 * 10^{-7} * \left(1 + 2.3 * \frac{F}{R_{a2}}\right)\mathrm{RPM}_2^{2.8} * R_{a2}^{4.6} * (0.028 * \mu + 0.019)^{0.2} \tag{58}$$

### Sliding Loss

Sliding loss is defined as

$$Loss_s = \frac{(PS_{L1} + PS_{L2}) * L_3 + PS_{L4} * \frac{L_5}{2}}{L_6} \tag{59}$$

where $PS_L$ is the instantaneous sliding loss along the length $L$ of the gear tooth contact. The lengths $L$ are defined below in Table 2 for a pair of external gears and Table 3 for an external gear mating with an internal gear.

| | |
|---|---|
| Length between interference points | $X_A = (R_{P1} + R_{P2})\sin(\theta)$ |
| Start of double tooth contact | $X_1 = X_A - \sqrt{R_{a1}^2 - R_{b1}^2}$ |
| End of single tooth contact | $X_3 = X_1 + P_{b1}$ |
| End of mesh cycle | $X_4 = \sqrt{(R_{a2}^2 - R_{b2}^2)}$ |
| End of double tooth contact | $X_2 = X_4 - P_{b1}$ |
| Pitch point | $X_2 = X_1 + \sqrt{\frac{2 + Z_1^2}{2P} - \left(\frac{Z_1\cos(\theta)}{2P}\right)^2} - \frac{Z_1\sin(\theta)}{2P}$ |
| Midpoint between $X_1$ and $X_2$ | $L_1 = \frac{X_1 + X_2}{2}$ |
| Midpoint between $X_3$ and $X_4$ | $L_2 + L_1 - X_1 + X_3$ |
| Length of single tooth contact | $L_3 = X_4 - X_3 + X_2 - X_1$ |
| Start of double tooth contact | $L_4 = X_2 + 3E - 5$ |
| Length of double tooth contact | $L_5 = X_3 - X_2$ |
| Total length of contact | $L_6 = X_4 - X_1$ |

***Table 2—Mesh lengths and positions for two external gears meshing.***

| | |
|---|---|
| Length between interference points | $X_A = (R_{P2} + R_{P1})\sin(\theta)$ |
| Start of double tooth contact | $X_1 = X_A - \sqrt{R_{c2}^2 - R_{b2}^2}$ |
| End of single tooth contact | $X_3 = X_2 + P_{b2}$ |
| End of mesh cycle | $X_4 = \sqrt{(R_{a1}^2 - R_{b1}^2)}$ |
| End of double tooth contact | $X_2 = X_4 - P_{b2}$ |
| Pitch point | $X_2 = X_1 + \sqrt{\frac{2 + Z_2^2}{2P} - \left(\frac{Z_2\cos(\theta)}{2P}\right)^2} - \frac{Z_2\sin(\theta)}{2P}$ |
| Midpoint between $X_1$ and $X_2$ | $L_1 = \frac{X_1 + X_2}{2}$ |
| Midpoint between $X_3$ and $X_4$ | $L_2 + L_1 - X_1 + X_3$ |
| Length of single tooth contact | $L_3 = X_4 - X_3 + X_2 - X_1$ |
| Start of double tooth contact | $L_4 = X_2 + 3E - 5$ |
| Length of double tooth contact | $L_5 = X_3 - X_2$ |
| Total length of contact | $L_6 = X_4 - X_1$ |

***Table 3—Mesh lengths and positions for an external and an internal gear meshing.***

$$PS_L = 10^{-3} * VS_L * f_L * W_N \tag{60}$$

$f_L$ is the friction coefficient defined as

$$f_L = 0.0127 * \log\left(29.66 * \frac{W_N}{F * \mu * VS_L * VT_L^2}\right) \tag{61}$$

$VS_L$ is the average sliding velocity over length $L$

$$VS_L = 0.147 * (\mathrm{RPM}_1 + \mathrm{RPM}_2) * \mathrm{abs}(L - X_p) \tag{62}$$

$VT_L$ is the average rolling velocity over length $L$

$$VT_L = 0.104 * RPM_2 * 2 * P_{R2}(-(GR - 1)) * \frac{\mathrm{abs}(L - X_p)}{2 * PR_1} \tag{63}$$

The friction coefficient, $f_L$, from Equation 61 is based on a curve fit to an experimental data set (Ref. 1).

The use of a logarithmic function as a fitting function leads to the $f_L$ calculated by the equation at high surface velocities going negative. To avoid these negative predicted values, a min value for $f_L$ is set to 0.01 in this paper per the recommendations of Ref. 1.

## Rolling Loss

Gear tooth rolling loss is calculated as

$$Loss_R = \frac{(PR_{L1} + PR_{L2}) * L_3 + PR_{XP} * L_5}{L_6} \tag{64}$$

where $PR_L$ is the instantaneous power loss along the length $L$ of the gear tooth contact

$$PR_L = 9 * 10^4 * VT_L * h_L * F \tag{65}$$

where $h_L$ is the hydraulic film thickness at point $L$

$$h_L = 2.051 * 10^{-7}(VT_L * \mu)^{0.67} * W_N^{-0.067} * Req_L^{0.464} \tag{66}$$

where $Req_L$ is the equivalent contact radius

$$Req_L = \frac{Rog_L * Rop_L}{Rop_L + Rog_L} \tag{67}$$

The equivalent radius of the gear, $Rog_L$, is defined as

$$Rog_L = R_{P2}\sin(\theta) + \text{abs}(L - X_P) \tag{68}$$

for an internal gear and as

$$Rog_L = R_{P2}\sin(\theta) - \text{abs}(L - X_P) \tag{69}$$

for an external gear.

The equivalent radius of the pinion, $Rop_L$, is

$$Rop_L = R_{p1}\sin(\theta) + \text{abs}(L - X_P) \tag{70}$$

### Total Losses

For a planetary gear set, total loss is calculated as the sum of the windage losses as well as the rolling and sliding losses from each gear tooth mesh.

$$Loss = P_{w1} + NP * P_{w2} + NP * (Loss_{s(1-2)} + Loss_{r(1-2)} + Loss_{s(2-3)} + Loss_{r(2-3)}) \tag{71}$$

## Shaft and Bearing Mass Estimate Calculations

In the code, it is assumed that the gearbox is responsible for handling the vehicle propellor loads. Vehicle hub moments, propellor lift and drag force, and the mass and moment of inertia of the propellor assembly are required inputs. Peak vehicle accelerations and pitch/roll/yaw rates are also required. The assumed layout of bearings in the drivetrain of a single planetary gearbox is shown in Figure 2. Note that the input to the sun gear shaft and how it is integrated with the gearbox is neglected for all gearboxes in this paper unless it is another gearing stage.

An iterative solver is used to create a rough bearing and shaft mass estimate. A bearing data based composed of super precision angular contact ball bearings based on Reference 13 is used as a reference bearing data set in the design tool. From the database, for each run, all bearings that do not fit within the ID of the smallest sun gear are eliminated from consideration. Shaft length, see Figure 2, is initially set to 2 m and then iterated down in 0.25 m increments until a minimum mass bearing and shaft set is found. At each shaft length loads are calculated at both the aft and forward bearing position using balance of forces and moments and assuming the shaft behaves as a rigid body. All the bearings in the bearing database are evaluated for their ability to provide the target life at both the forward and aft bearing locations. For simplicity, it is assumed that the same bearing is used for the forward, aft, and all gear bearings which sit on the propellor shaft. Using the same bearing in all locations and only angular contact bearings for a propellor shaft likely is not optimum, but for a preliminary mass estimate assuming that all the bearings are the same is a reasonable approximation.

| Load case | Max | Nominal |
|---|---|---|
| Gx | 2 | 0.1 |
| Gy | 0.2 | 0.1 |
| Gz | 2 | 1.1 |
| Pitch rate | 0.5 | 0.05 |
| Roll rate | 0.25 | 0 |
| Percent of life | 0.05 | 0.95 |

***Table 4—Nominal and max load case used for propeller shaft and bearing sizing.***

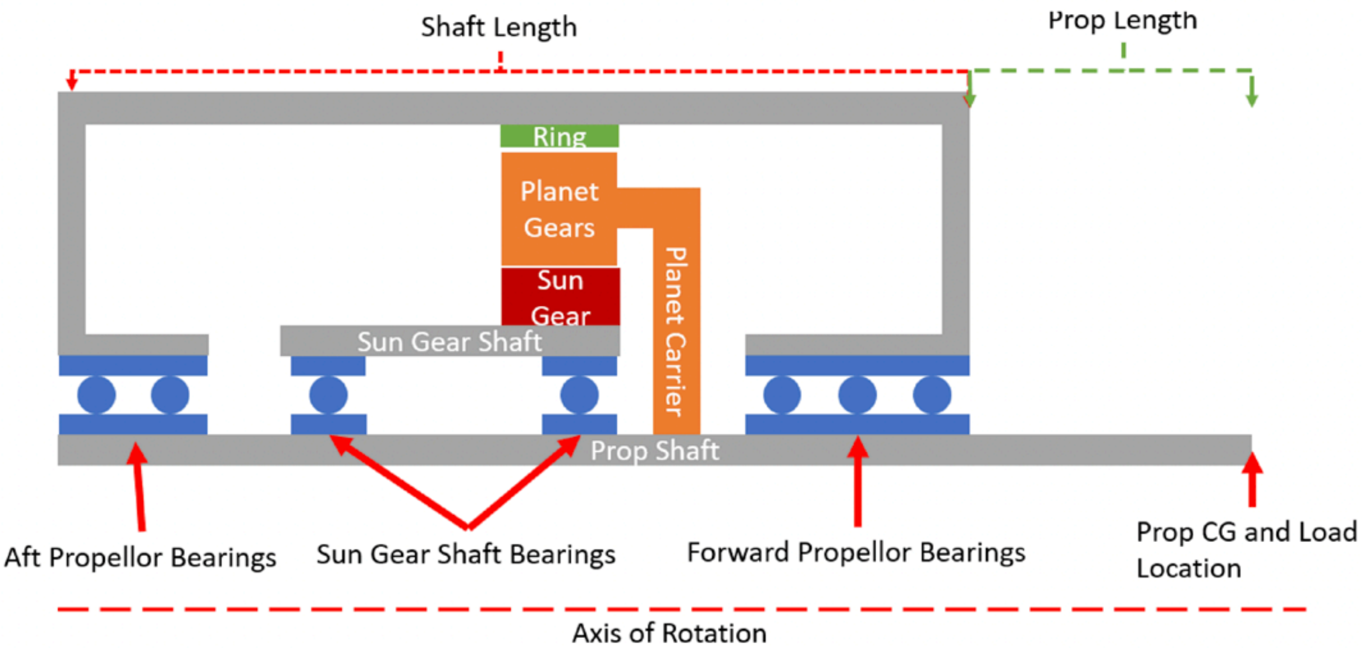


***Figure 2—Assumed layout of gears and bearings for bearing load calculations.***

Each bearing is evaluated for whether it can meet the target life with 99 percent reliability at the forward and aft bearing locations per the bearing lifing method described in Reference 8. Two different load cases are included per Table 4. For the forward bearing, if for a given bearing in the database, a single bearing is not sufficient, an iterative solver is used to find the number of bearings of that type needed in parallel to achieve the target bearing life. The number of bearings used is limited to 4. A knock down on the bearings' dynamic load carrying capacity of 20 percent is applied if more than one bearing is used. Bearings for which no solution is found to meet the target life are eliminated from consideration.

A shaft is sized for each bearing set that meets the target life and reliability. The outer diameter (OD) of the shaft is set to the inner diameter (ID) of the bearing and an iterative solution method is used to size the ID of the shaft. At each shaft internal diameter, Bernoulli beam bending equations and shaft tensile and shear equations are combined to calculate the Von Mises stress in the shaft at the location of the forward bearing. Stress is required to be below the fatigue limit of the selected shaft material. In this paper, a limit of 300 MPa is used. Shafts that are not able meet the target stress requirement with even a solid shaft, are eliminated from consideration.

A total mass estimate for the shaft, aft bearing, forward bearing, and a housing is created for each shaft/bearing set that meets the requirements. Housing mass is estimated as

$$M_{housing} = D_{al} * (L_{shaft} * 2 * \pi * R_{p3} + 2 * \pi * R_{p3}^2) \quad (72)$$

After iterating to solve for shaft length, the shaft/bearing set with the lowest mass is selected. Loss analysis is carried out for that bearing set per the method described in Reference 10 and included in the total drive efficiency estimate.

## Example Design Optimization Results

Six studies were completed for the multirotor type vehicles main propulsion gearboxes. Table 5 summarizes the studies. The first three studies target the effects of gearbox input and output speed explicitly for the RVLT 6 passenger all electric concept vehicle. The other three studies target power scaling effects at constant output speed and relevant gear ratios for electric motors.

For the studies, estimated propellor properties change with rotational speed power. Table 6 lists a few relevant example cases for propellor properties. It should be noted that these are just estimates based on extrapolating data from the RVLT concept vehicles. In an ideal scenario, the propellor loading would be taken from a higher fidelity analysis.

Results for the first three studies (rotor and motor rotational speed sweeps) are given in Figure 3 to Figure 5.

| Study no. | Propellor speed, RPM | Power, kW | Gear ratio |
|---|---|---|---|
| 1 | 400 | 140 | 3,5,8,10,15,20,30 |
| 2 | 550 | 140 | 3,5,8,10,15,20,30 |
| 3 | 700 | 140 | 3,5,8,10,15,20,30 |
| 4 | 400 | 50:50:500 | 10 |
| 5 | 400 | 50:50:500 | 20 |
| 6 | 400 | 50:50:500 | 30 |

***Table 5—Details of six studies completed for this study.***

| Power, kW | Speed, RPM | Prop weight, kg | Prop radius, m | Prop drag, N | Prop thrust, N | Aero hub moment, Nm |
|---|---|---|---|---|---|---|
| 140 | 700 | 177 | 2.28 | 121 | 8,232 | 849 |
| 140 | 550 | 177 | 2.9 | 196 | 8,232 | 1,059 |
| 140 | 400 | 177 | 3.99 | 371.6 | 8,232 | 1,466 |
| 50 | 400 | 63 | 3.99 | 371.6 | 2,940 | 524 |
| 300 | 400 | 379 | 3.99 | 371.6 | 17,640 | 3,141 |
| 450 | 400 | 569 | 3.99 | 371.6 | 26,460 | 4,712 |

***Table 6—Estimated propeller loads for example cases.***

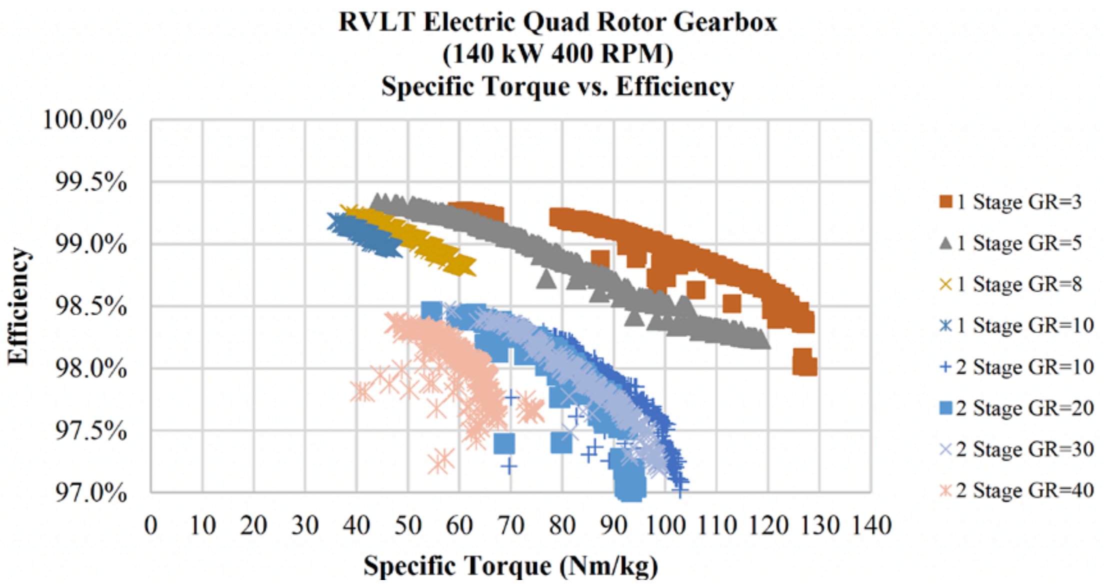


***Figure 3—Results of Study 1—Gear ratio sweep at 140 kW and 400 RPM propeller speed. Specific torque vs. efficiency.***

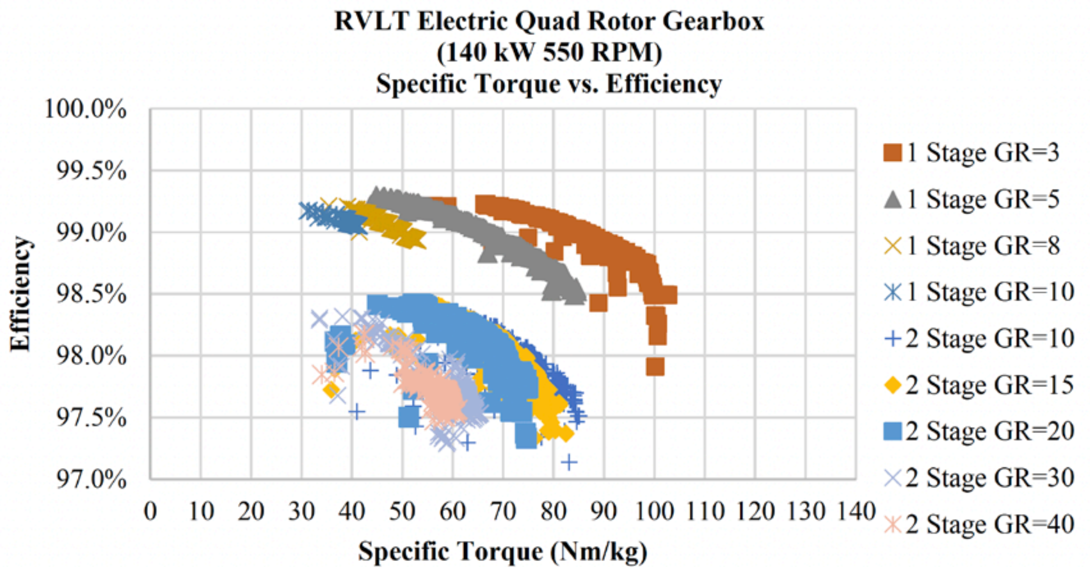


***Figure 4—Results of Study 2—Gear ratio sweep at 140 kW and 550 RPM propeller speed. Specific torque vs. efficiency.***

In Figure 3 to Figure 5, a clear trend of specific torque decreasing with increased gear ratio (increased motor speed) can be seen. Efficiency does not exhibit a significant trend with gear ratio except for the difference between single and two stage gear boxes. A drop off in efficiency occurs at gear ratio values around 40 for the 700 RPM case due to the very high RPM of the sun gear (28,000 RPM) in this case as well as the relatively high overall ratio. Between the three plots at a given gear ratio a reduction in gear specific torque with increased propellor speed can be seen. This reduction corresponds to gearbox specific torque decreasing with decreased torque, because despite the reduction in gear mass the weight of the housing, shafts, and bearings does not reduce as significantly with reduced torque. This trend is illustrated more clearly for the results below from studies 4 to 6 with constant rotor speed and increasing power.

Figure 6–Figure 8 show the results of Studies 4–6 per Table 5. All of the results in these three studies were for two-stage planetary gearboxes. Gear ratios of 10, 20 and 30 were used, targeting a range of motor rotation speed from 4,000 to 12,000 RPM.

Figures 6–8 show clear trends for increasing gearbox-specific torque and efficiency with increased power/torque. As with Studies 1–3, comparing across plots, specific torque and efficiency are shown to drop with increased gear ratio.

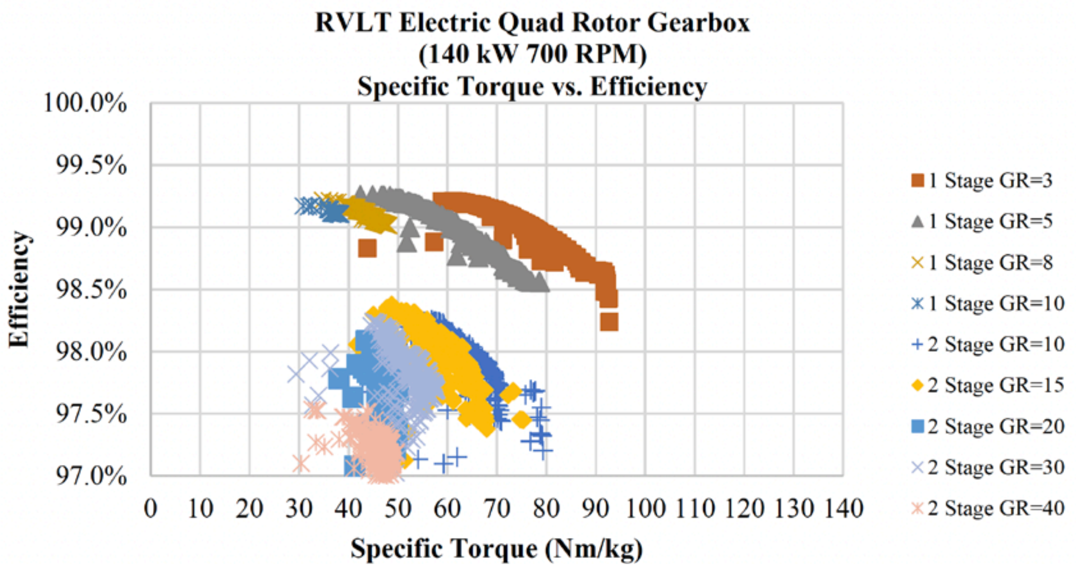


*Figure 5—Results of Study 3—Gear ratio sweep at 140 kW and 700 RPM propeller speed. Specific torque vs. efficiency.*

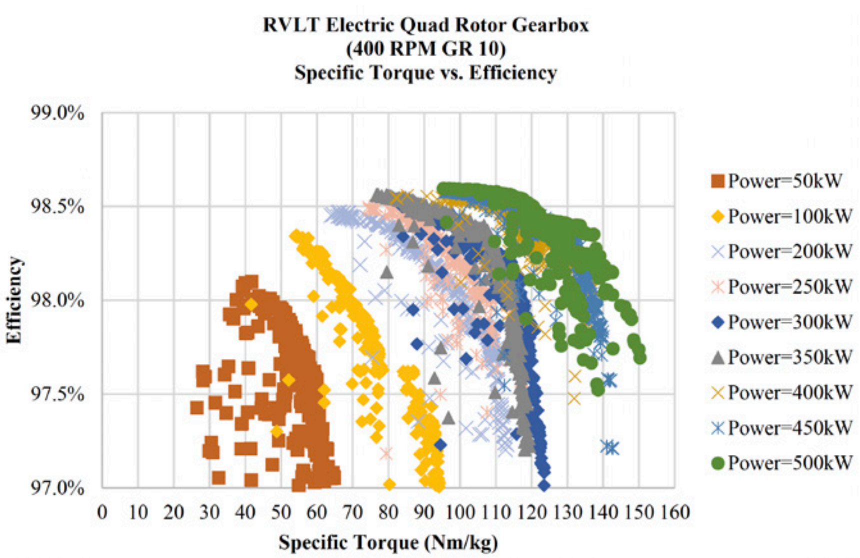


*Figure 6—Results of Study 4—Power sweep at GR 10 and 400 RPM propeller speed. Specific torque vs. efficiency.*

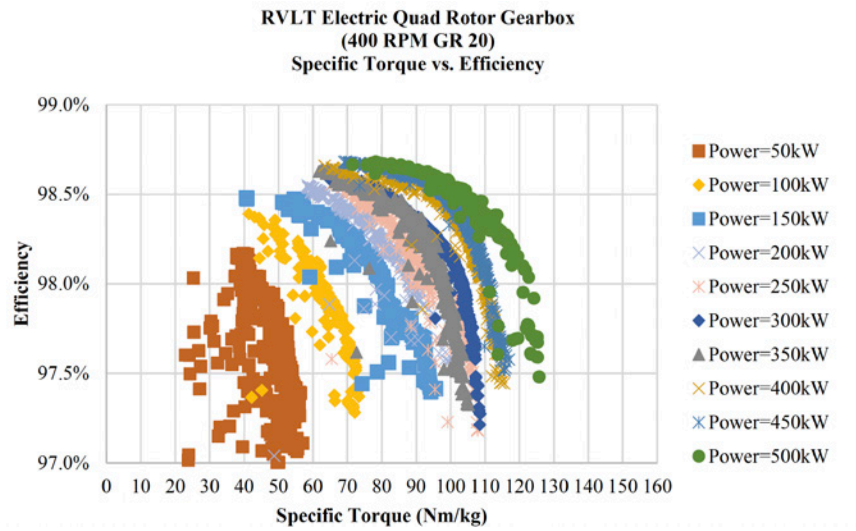


*Figure 7—Results of Study 5—Power sweep at GR 20 and 400 RPM propeller speed. Specific torque vs. efficiency.*

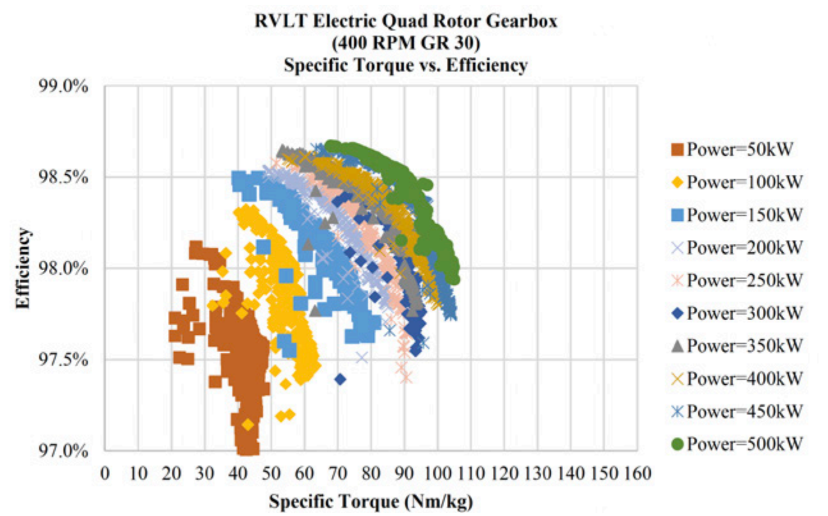


*Figure 8—Results of Study 6—Power sweep at GR 30 and 400 RPM propeller speed. Specific torque vs. efficiency.*

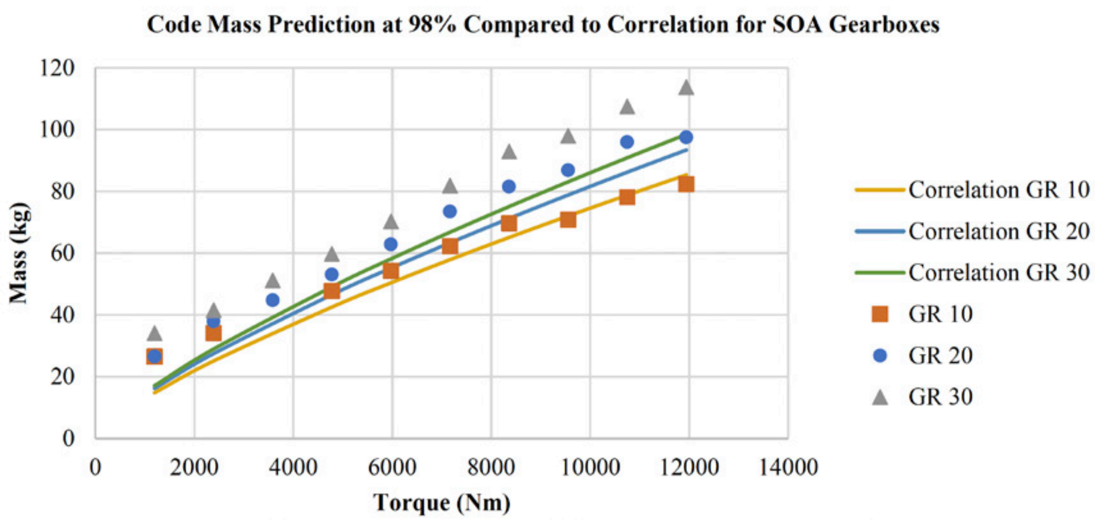


*Figure 9—Comparison of code results for Studies 4-6 at 98 percent efficiency to the curve fit to real gearbox data from Reference 14.*

Figure 9 shows the trend of torque versus mass at a constant 98 percent efficiency from studies 4 to 6. Along with the data from the studies, the trendlines from Reference 14 for state-of-the-art gearbox mass versus torque, gear ratio, and output speed are shown. The trendlines are based on curve fits to actual aerospace gearboxes. The curve fit defines mass in pounds as

$$Mass\ in\ lb = 94 * \mathrm{HP}^{0.76} * \frac{\mathrm{RPM}_{\mathrm{In}}^{0.13}}{\mathrm{RPM}_{\mathrm{out}}^{0.89}} \tag{73}$$

where HP is the power of the gearbox in horsepower.

In Figure 9, the masses predicted by the code presented in this report and the trendline from Reference 14 have reasonable agreement, suggesting that the code provides good estimates of gearbox mass. The greater mass predicted by the code is likely driven by the relatively low fidelity design of the housing in the code. The discrepancy growing with higher gear ratio likely results from using constant efficiency data from the code. It is unlikely that one would not trade some efficiency for lower mass in the design of an actual aerospace gearbox.

## Conclusions

This paper presents a preliminary version of a gearbox genetic optimization tool. The goal of the developed tool is to enable preliminary sizing of gearboxes for concept electric aircraft applications so that coupled optimization of electric motor-driven propulsion systems can be completed. Further development of the tool will look to add more capability to address different gear stage types and increase the fidelity of the gearbox design. The addition of a way to predict coolant requirements is also a needed improvement to enable optimization of electric aircraft drivetrain thermal management systems. At the cost of processing and solution speed, the analytical methodology presented here could be replaced with greater fidelity finite element models. Based on matching past correlations for gearbox mass, the method detailed in the paper appears to be reasonable for the preliminary design of electric motor drivetrains.

**PTE**

**Thomas Tallerico** is a Research Mechanical Engineer at NASA Glenn Research Center, Cleveland Ohio. He conducts fundamental research on advanced drivetrains for aerospace applications including research on mechanical gears, magnetic gears, and electric motors.

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# BELL
## Awarded Funding for X-plane Build Phase of SPRINT Program


Bell Textron Inc. has been down-selected for Phase 2 of Defense Advanced Research Projects Agency (DARPA) Speed and Runway Independent Technologies (SPRINT) X-Plane program with the objective to complete design, construction, ground testing and certification of an X-plane demonstrator.

"Bell is honored to have been selected for the next phase of DARPA's SPRINT program and is excited to demonstrate a brand-new aircraft with the first-ever stop/fold technology," said Jason Hurst, senior vice president, engineering. "This is an achievement we've been working towards for over 10 years, as we've leveraged our nearly 90-year history of X-plane development to bring new technology to our warfighters."

The goal of the program is to provide these aircraft with the ability to cruise at speeds from 400 to 450 knots at relevant altitudes and hover in austere environments from unprepared surfaces. In Phase 1A and 1B, Bell completed conceptual and preliminary design efforts for the SPRINT X-plane. Phase 2 includes detailed design and build culminating in flight test during Phase 3.

In preparation for X-plane development, Bell has completed significant risk reduction activities including demonstrating folding rotor, integrated propulsion, and flight control technologies at Holloman Air Force Base as well as wind tunnel testing at the National Institute for Aviation Research (NIAR) at Wichita State University. Bell has a rich history of breaking barriers and high-speed vertical lift technology development, pioneering innovative VTOL configurations like the X-14, X-22, XV-3 and XV-15 for NASA, the U.S. Army and U.S. Air Force, and continues to build on the legacy of the Bell X-1.

*bellflight.com*

# SIEMENS
## Expands Train Factory and Service Center in Munich


Siemens recently celebrated the opening of its expanded train factory in Munich-Allach, one of the most modern train production facilities in Europe and a key location in Siemens Mobility's European service network. Around €250 million has been invested in new buildings, state-of-the-art production facilities, and the expansion of AI-based software solutions since 2023. This development underscores the technology company's commitment to Germany as a viable location for manufacturing and innovation.

The location's expansion will create over 500 new jobs and increase the workforce to approximately 2,500 employees. On the factory's doubled workspace, Vectouro passenger cars will also be produced along with the market-leading models of the Vectron locomotive platform. This marks the first time that Siemens will manufacture all products based on Vectron technology under one roof. The location will also triple its capacity for modern services. In addition, Munich-Allach will become the new headquarters of Siemens Mobility, and the location will bring together key business areas such as research and development, production, service, and management. By bundling competencies for integrated innovations and rapid implementation for its customers, Siemens is implementing a core element of its ONE Tech Company program.

"In Allach, Siemens is demonstrating how competitive manufacturing is possible in Germany today: with superior products, maximum automation, digitalization, and the use of artificial intelligence. With the software and digital services offered to customers through our open business platform Siemens Xcelerator, we are showing the way to networked mobility of the future," said Roland Busch, CEO of Siemens AG.

"The expansion of our location in Munich-Allach into a global competence center and home of the new company headquarters combines efficiency and innovation. With an investment of around €250 million in modern production facilities, service capacities, and digital solutions, we are securing our competitiveness and further boosting our innovative strength. By combining AI-based applications and innovative production technologies such as laser-guided installation, robotics, and digital twins, we are transforming 'heavy metal' into 'heavy AI' and taking the rail industry in Germany to a new level," commented Michael Peter, CEO of Siemens Mobility.

"Munich-Allach is a beacon of our innovation strategy and a prime example of German engineering. With over 1.2 billion kilometers in service, our Vectron locomotives clearly prove that premium products can be successfully manufactured in Germany. We are proud to be creating more than 500 additional jobs in the 'Home of Vectron' and to be consolidating central functions such as management, development, production, and service in one location. This move will secure our role as industry leader and strengthen the economic power of Munich and Germany," said Karl Blaim, CFO of Siemens Mobility.

The Rail Service Center is being substantially expanded to enable it to handle up to 80 locomotive overhauls and accident repairs annually, up from 25 currently. When completed, the competence center for heavy maintenance work will have tripled its capacity to meet the rapidly growing market for high-quality service and fast response times. In addition to its four new service tracks, the new building includes specialized workshops for bogies and wheelsets. These investments are decisive for continuing to offer customers high-performance services and the shortest possible turnaround times. Completion of the new building is planned for 2026.

Along with the Rail Service Center, the service portfolio at Munich-Allach will be complemented by around 70 data and software specialists on site who will support international customers with their digital transformations by providing modular services and the Railigent X application suite. This unique bundling of expertise from production and service enhances and strengthens the role of the Munich-Allach plant as a holistic competence center and "Home of Vectron".

*siemens.com*

# FOREST CITY GEAR

## Celebrates Josh Gates's 10th Anniversary

Forest City Gear has recognized Josh Gates on his 10th anniversary and thanked him for his long-term dedication to the company.

Gates is Forest City Gear's Turning Lead. He started at Forest City Gear in the high-volume department working second shift, then soon transitioned to the turning department, which later combined with milling to create the CNC machining department located in the Roscoe Works building. Gates is the sole programmer for this department. He has a vast knowledge of tooling, turning, and milling, and had contributed greatly to the success of Roscoe Works over the years.

*Josh Gates*

Gates completed and graduated from the Rock River Valley Tooling & Machining Association CNC Precision Machinist apprenticeship program, sponsored by Forest City Gear. And for the past three years, he has been an adjunct professor at Rock Valley College teaching Mastercam and CNC setup classes for the apprenticeship students.

Forest City Gear thanked Gates for his above-and-beyond commitment and years of dedication to Excellence Without Exception.

*forestcitygear.com*

# NTN AMERICA'S

## Cheryl Loew-Resch Honored Among 2025 Women at the Wheel Trailblazers

NTN is proud to announce that Cheryl Loew-Resch, marketing events and promotions manager, has been named a 2025 Women at the Wheel honoree by *aftermarketNews*.

Announced in the May 2025 issue of *aftermarketNews*, Women at the Wheel celebrates women who are making a significant impact in the automotive aftermarket. The program honors those who are leading, innovating, and thriving in an industry that has traditionally been male-dominated.

Loew-Resch's Women at the Wheel feature highlights her passion for brand storytelling, her support for fostering growth in others, and her ability to elevate brand presence through strategic marketing. With over two decades of experience in the automotive aftermarket, she has consistently demonstrated leadership, creativity, and a deep understanding of the industry's evolving landscape.

*Cheryl Loew-Resch*

"Cheryl's dedication to excellence and her ability to connect with people through authentic, impactful communication make her an invaluable asset to our team and the industry," said Georgianne Dickey, director of marketing at NTN. "Her recognition as a Women at the Wheel honoree is a testament to her hard work, vision, and the respect she's earned from colleagues and peers alike. We couldn't be prouder."

Loew-Resch has been with NTN for 21 years, supporting multiple business units including the automotive and industrial aftermarkets. She also serves on the executive team of the MEMA AAPEX Exhibitor Committee, where she helps shape event content, contributes innovative ideas, and provides feedback to enhance the AAPEX experience.

*ntnamerica.com*

September 27–October 1

## Weftec 2025

*More than 20,000 water professionals come to Weftec each year to share ideas, spark innovation and move the industry forward. At Weftec 2025 (Chicago), you'll find exhibits, hands-on learning experiences and a global network of water professionals. The show features 1,000+ exhibitors showcasing the latest water and wastewater technologies, solutions and services. More than 130 technical sessions examine topics such as energy management, maintenance, operations, treatment technologies, global insights, research and development and more.*

powertransmission.com/events/weftec-2025

September 29–October 1

## Pack Expo Las Vegas 2025

*Pack Expo Las Vegas features targeted pavilions or "shows within a show" featuring solutions that address many industry challenges. All of the pavilions have expanded, reflecting the tremendous market growth in packaging and processing. The Logistics Pavilion: With the rapid expansion of e-commerce, this pavilion will feature cutting-edge supply chain solutions, including warehousing, fulfillment, distribution logistics, and transportation providers. The Processing Zone: This area showcases the latest processing innovations, including homogenizing, heat treating, forming/sizing, and coating solutions. The Healthcare Packaging Pavilion: Focused on life sciences, this pavilion will showcase packaging innovations for pharmaceuticals, biopharmaceuticals, nutraceuticals, and medical devices. The Showcase of Packaging Innovations: Sponsored by Smurfit Westrock, this attendee favorite will display award-nominated packaging solutions.*

powertransmission.com/events/pack-expo-las-vegas-2025

October 21–23

## Motion + Power Technology Expo 2025

*Produced by AGMA, Motion + Power Technology Expo (Detroit) is a three-day show that connects professionals looking for motion power solutions with manufacturers, suppliers, and buyers. Attendees will find new power transmission parts, materials, and manufacturing processes. Buy, sell, and get business done with organizations in aerospace, automotive, agricultural, energy, construction and more. Forge partnerships at one of the largest gatherings of CEOs, owners, engineers, sales managers, and other professionals in the electric, fluid, mechanical and gear industries. End-users can shop the latest technology, gear products, and services from leading manufacturers.*

powertransmission.com/events/motion-power-technology-expo-2025

October 21–23

## Southtec 2025

*Southtec 2025 (Greenville, SC) draws manufacturing suppliers, distributors, and equipment builders from across North America and around the world. With hundreds of exhibiting companies, attendees can find all the latest technologies and services – plus the experts who build them—ready to demonstrate solutions that can help them grow their business. Visitors can make side-by-side comparisons, discover integrated equipment, hear about industry trends and forecasts and leverage their purchasing power. Explore more than 300 exhibits featuring areas such as automation, robotics, smart manufacturing, precision machining, software solutions, and industrial IoT.*

powertransmission.com/events/southtec-2025

October 29–30

## Advanced Engineering UK 2025

*Advanced Engineering (Birmingham, UK) showcases how manufacturing products and solutions meet capability challenges, enhance manufacturing processes and help companies stay at the forefront of industry trends. In 2025, buyers and procurement teams, decision-makers, R&D and directors from leading OEMs, Tier 1 & Tier 2 companies will be eager to engage with the latest technologies and manufacturing solutions. The show also raises awareness and fosters collaboration among businesses, educational institutions, associations and the government to develop a skilled workforce capable of driving the UK's manufacturing and engineering sector.*

powertransmission.com/events/advanced-engineering

# AD INDEX



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☐ WE **DESIGN** products with power transmission components in them

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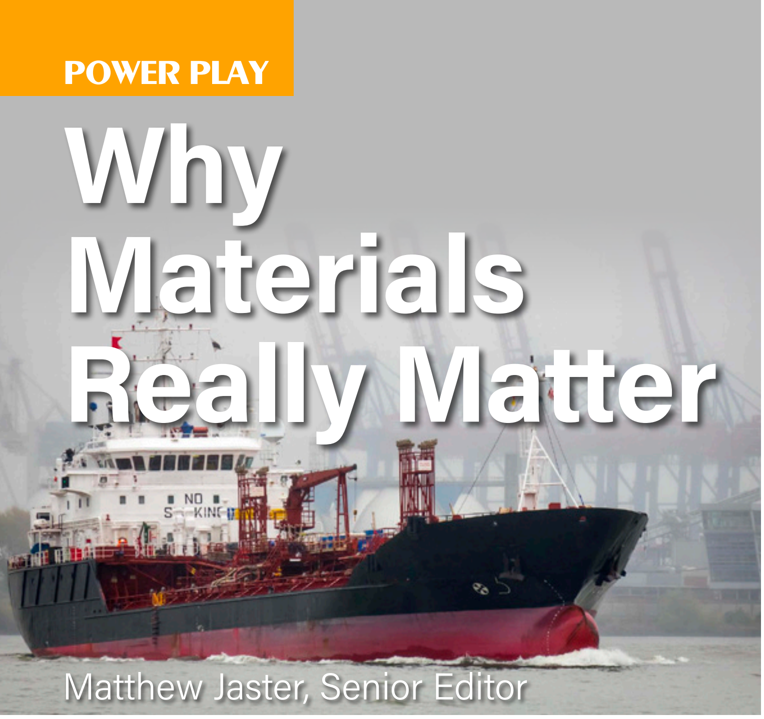
# Why Materials Really Matter



Matthew Jaster, Senior Editor

Material plays a crucial role in manufacturing. Vesconite Bearings is a perfect example of this as the company provides bearings and bushings for a versatile application range where the components must survive in the most extreme environments.

The company's flagship bearing material—Hilube—is designed for difficult operating environments where regular maintenance is impractical. Hitemp 160 has also received key industry certifications that attest to its safety and compliance in sensitive applications, presenting a robust alternative to traditional bearing materials. Some recent examples:

## Marine Application

Vesconite Bearings has supplied one of its largest stern tube bushings to date for installation on a Singapore-flagged oil and chemical tanker. The order adds to a legacy of over one thousand stern tube and rudder bearings supplied by Vesconite Bearings for Southeast Asian cargo vessels over the past 28 years.

The bearings, manufactured from Vesconite Hilube, a long-life, no-swell bearing material, were supplied as stock material and machined to final dimensions at a shipyard in Shanghai, China, when the 149-metre-long vessel entered dry dock in March 2025.

"This delivery continues our longstanding commitment to the Southeast Asian marine sector, where Vesconite Bearings has been supplying bushings and bearings for tankers, container vessels, and bulk carriers for over 36 years," says Wian Venter, managing director of Vesconite Bearings SEA, a newly created regional branch of Vesconite Bearings.

## Hydroelectric Application

Vesconite Bearings installed its Vesconite Hilube hydroelectric components at the Lake Creek Hydroelectric Plant, which was officially commissioned in Troy, MT.

According to Canyon Hydro, which performed the plant's retrofit for owner and operator Northern Lights, the plant's startup was smooth, and everything worked well. The project marks an important collaboration for Vesconite Bearings, as the installation involved a range of advanced, no-swell, self-lubricating bearings designed for hydroelectric applications.

Lake Creek Dam is small relative to other hydroelectric dams in the region, but it remains important since it provides about 10 percent of Northern Lights' power. The Vesconite Hilube high-performance parts are integral to the plant's operation and efficiency, helping to ensure smooth and reliable generation of power. The grease-free Vesconite Hilube components provide an environmentally friendly solution that ensures there are no oil or grease spills in this run-of-river application.

"Our self-lubricating, no-swell Vesconite Hilube components are designed to enhance the longevity and reliability of equipment, and the Lake Creek installation demonstrates their effectiveness in real-world applications," said Vesconite Bearings Application Engineer Louis Gouws.

## Food and Beverage Application

Hitemp 160 line shaft bearings have demonstrated reliability in a high-temperature vegetable oil pump application.

This is according to a European pump manufacturer, which used these bearings in centrifugal vertical pumps that transport vegetable oil at 110°C. These pumps, installed in food production facilities in Belgium and the Netherlands, are critical to the manufacturing process of frying potato chips.

The client tested the pump for over a year and reported no complaints, further validating the material's durability and reliability in real-world conditions. The long-term successful operation of the bearings in this demanding environment reinforces their suitability for applications requiring high performance under extreme conditions.

"Our customers' real-world experiences continue to demonstrate the exceptional resilience of Hitemp 160 in high-temperature environments," says Vesconite Bearings application engineer Tristen Wintershoven. "Its ability to maintain its structural integrity at high temperatures makes it an excellent choice for challenging industrial applications."

Beyond its high-temperature performance, Hitemp 160 has also received key industry certifications that attest to its safety and compliance in sensitive applications. The Water Regulations Advisory Scheme (WRAS) has approved it for use in drinking water systems up to 65°C. Additionally, the French National Metrology and Testing Laboratory (LNE) has certified the material for food contact applications.

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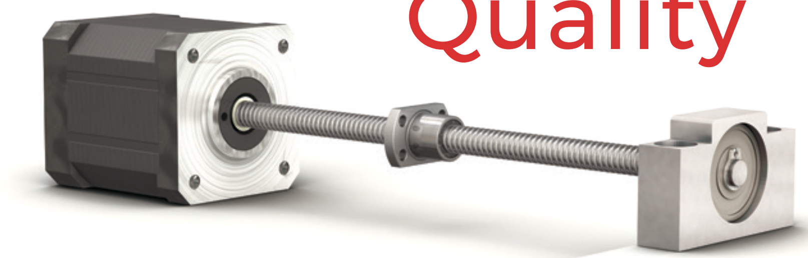

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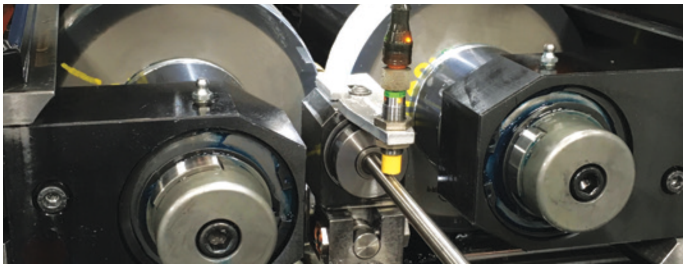

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