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DECEMBER 2022

2022 Buyer's Guide

Linear Motion: Jack Screw vs. Ball Screws
Bearings for Food & Beverage Applications
Turbomachinery & Pump Symposium

TECHNICAL

Sizing Gearboxes
Load Distribution of Planetary Stages

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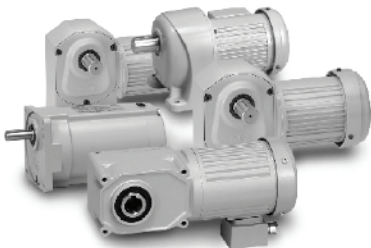
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FEATURE

[16] Comparing Machine Screw Jacks and Ball Screw Jacks for Heavy Lifting Capabilities

Factors engineers should consider during the design phase.

[22] Bearing Design Considerations for the Food and Processing Industries

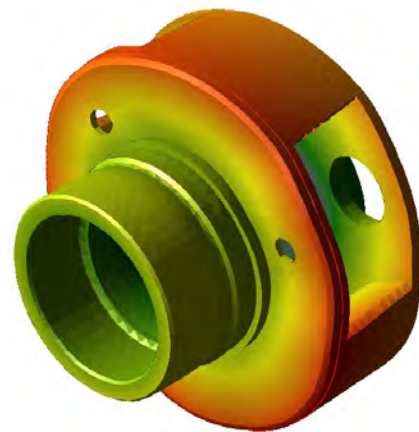
Materials, enclosures, and lubrication options must be properly selected to ensure the optimal performance of bearings used in this machinery.

[28] Highlights of Turbomachinery & Pump Symposium 2022

A strong post-pandemic turnout brings the turbo and pump industry up to speed.

[34] Annual Buyer's Guide

Find suppliers of power transmission components in this comprehensive directory.



TECHNICAL ARTICLES

[66] More Than Just Motor Size

Use application information to size your gearbox correctly.

[70] Determination of the Longitudinal Load Distribution of Planetary Stages

A planetary cylindrical gear unit from the FVA Nacelle Research Project is used in this case study to consider all relevant design factors.

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Power Transmission Engineering

VOL. 16, NO. 8

- [04] **PTEExtras**
 Video from **SICK and Thomson Linear**; Revolutions blogs on components and automation technologies presented during Pack Expo 2022.
- [06] **Publisher's Page**
 Looking Back, Looking Forward.
- [08] **Product News**
 Technologies from **Eaton, NUM, ABB, Renewable Lubricants, Bonfiglioli, Zero-Max, KISSsoft, and SKF.**
- [64] **Engineering sMart**
 Products and services marketplace.
- [74] **Industry News**
Kurt Hydraulics, Universal Robots, Solve, and the LEGO Group.
- [77] **Calendar**
 Upcoming events in the power transmission industry.
- [78] **Advertiser Index**
 Contact information for every advertiser in this issue.
- [79] **Subscriptions**
 Renew your free subscription today.
- [80] **Power Play**
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PTE Videos

SICK Solution Hackathon

The SICK Solution Hackathon gives young talents from universities and startups a chance to bring in their way of thinking and creating new ideas. Together with hack coaches from well-known industry leaders such as Bosch Rexroth, SAP or Trumpf, the hack participants recently competed in a three-day contest at SICK's Sensor Intelligence Academy near Freiburg in Southern Germany.



[powertransmission.com/media/videos/play/227](https://www.powertransmission.com/media/videos/play/227)

Thomson Screw Jacks

Delivering high reliability and life expectancy under varying operating conditions, Thomson and Nook ball splines are optimal for applications that require high speed, vibration, shock loading, precise positioning requirements and high torsional loads. In this video, learn what goes into making our high-quality screw jacks and how they can be your next linear motion solution.



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PTE Revolutions Pack Expo Recap

Take a quick look at some of the technology you may have missed during Pack Expo 2022 which took place in October in Chicago.



[powertransmission.com/blogs/1-revolutions/post/8878-automation-robotics-and-mechatronics-at-pack-expo-2022](https://www.powertransmission.com/blogs/1-revolutions/post/8878-automation-robotics-and-mechatronics-at-pack-expo-2022)

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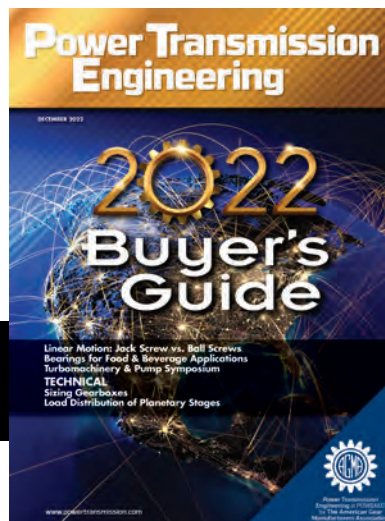
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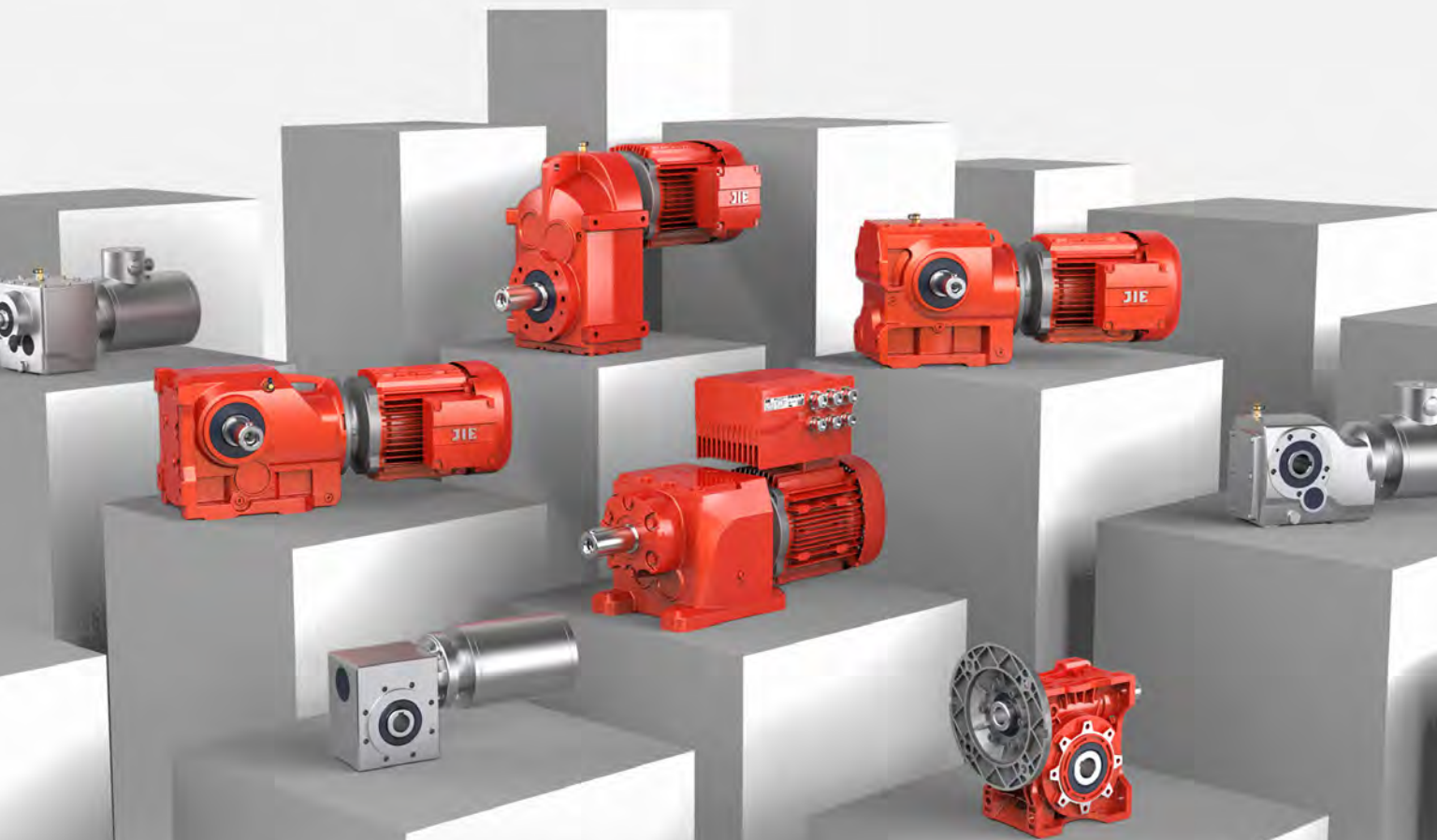
Michael Goldstein founded *Gear Technology* in 1984 and *Power Transmission Engineering* in 2007, and he served as Publisher and Editor-in-Chief from 1984 through 2019. Michael continues working with both magazines in a consulting role and can be reached via e-mail at michael@geartechnology.com.

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Looking Back, Looking Forward

2023 Loading...



Is it just me, or did the rest of you also blink and find that 2022 had whooshed by before you knew it? Here we are, on the cusp of 2023.

As always, we find ourselves reflecting on the year past and looking forward to the one coming up.

In many ways, 2022 has been a return to normalcy—at least as far as COVID is concerned. What seemed to dominate the headlines since early 2020 has become almost an afterthought for many. Masks wearing has become the exception rather than the rule, and crowded gatherings have become normal again.

Trade shows have become normal again, and although most are not yet back to pre-2020 levels, they're at least considered part of the marketing mix again for a lot of companies, whereas over the last two years, many companies just dismissed them out of hand. Travel was restricted. The fear seems to be mostly gone.

But what 2022 also reminds us is that there really is no normal. One crisis is often replaced by another. COVID may no longer be front and center, but its aftereffects are still with us, at least as far as the supply chain goes. Add to that the effects of the war in Europe and the disruptions in the food supply and the oil and gas industry, and it looks like it's going to be a rough winter for much of Europe.

And then there's inflation.

So there's a lot of uncertainty out there, and we're by no means ready to celebrate the good times just yet.

That being said, most of the manufacturers I've talked to recently have said they're still going strong. Many are still working to fill the backlog of orders they've had over the past couple of years. I've heard no indication that anyone is looking to cut staff. Where they're reducing head count at all, it's through attrition and strategic investment in automation to fill the gap.

I have heard recently, though, that orders are beginning to soften. Over the past several months, for example, the

ISM's Manufacturing Purchasing Managers Index was at 50.2% in October. Technically this still indicates manufacturing growth (for the 29th consecutive month), but that growth has definitely slowed, as the number has crept steadily toward 50%, which marks the delineation between growth and contraction. I won't be at all surprised if we see the PMI drop below 50% before the end of 2022.

So there's a lot of uncertainty in the air. Manufacturers are preparing for the slowdown, and they're trying to figure out if their backlogs will carry them through the downturn. They're hoping they don't see order cancellations and that the markets will correct themselves sooner rather than later.

Compared to COVID, these seem like normal problems. But they're still problems, and not small ones, either.

Here at *Power Transmission Engineering*, we're taking a positive outlook on 2023. Demand will continue to be high, and manufacturers will continue to produce. Like many of you, we expect challenges ahead, but we're looking forward to meeting them.

P.S. With all the turmoil over the last couple of years, many of you have changed positions, moved to new locations or simply been busy. As a result, you've let your subscriptions lapse. If you have a QR code attached to the front of your magazine this issue, or if you've received a renewal message in your e-mail, it means it's time to renew. Please take a few minutes to visit powertransmission.com/subscribe2022 and make sure your information is up to date. Thank you!

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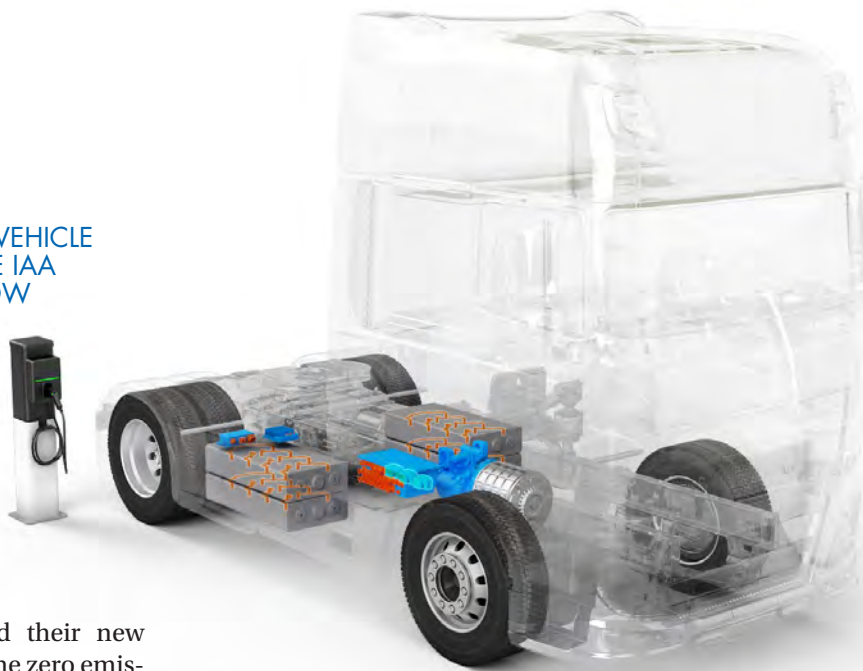


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Eaton

OFFERS COMMERCIAL VEHICLE TECHNOLOGIES AT THE IAA TRANSPORTATION SHOW



Eaton recently displayed their new technologies to support the zero emissions journey in the commercial vehicle market at the IAA Transportation show in Hannover, Germany.

“We are helping our customers around the globe with technologies that solve some of the toughest challenges throughout the electrified vehicle (EV) ecosystem,” said Scott Adams, president, Eaton’s eMobility business. “Eaton provides a vast portfolio of EV technologies for full battery electric, fuel cell and hybrid commercial vehicles, as well as EV charging infrastructure solutions.”

Eaton’s eMobility business offers a new Flex Power Distribution Unit (PDU) for high voltage electrified commercial vehicles that is uniquely designed to handle multiple load requirements.

The Flex PDU integrates Eaton’s Breaktor circuit protection technology, which improves vehicle safety and protects components from any level of overcurrent condition more effectively than traditional circuit protection methods. The Breaktor circuit protection solution is resettable like a circuit breaker, enabling reactivation of the device following a functionality check and reducing cost for both the OEM and consumer.

The Flex PDU also leverages sealed and corrosion-resistant terminals and connectors from Royal Power Solutions, a power distribution and

transmission solutions provider that Eaton acquired earlier this year. Eaton’s Bussmann series fuses are also integrated to meet the requirements for use in the latest high-powered electrified vehicles with ratings up to 1,000 volts of direct current (VDC) and 600 amps.

Eaton’s Flex PDU protects vital components and occupants and is also an intelligent unit that provides the OEM diagnostic information, including where the most power is being consumed, to maximize performance and efficiency. Its integrated and optimized design reduces the number of components, lessening complexity.

Eaton’s new 4-speed transmissions provide superior performance on grades and acceleration for electrified commercial vehicles while offering more flexible gear ratios compared to competitive technologies. The compact 4-speed transmissions for medium- and heavy-duty electrified commercial vehicles also improve system efficiency, enabling longer vehicle range and battery life.

“We supply transmissions for multiple global commercial vehicle manufacturers, and many more are interested,” Adams said. “With decades of experience, we continue to build on

our heritage as a top supplier of commercial vehicle transmissions.”

Eaton recently introduced a 48-volt DC-DC converter to power accessories such as antilock brakes and lighting for commercial vehicles with 48-volt electrical systems. Unlike competitive offerings, Eaton’s DC-DC converters are operational in ambient temperatures up to 85°C and boast 97 percent design efficiency.

Eaton’s DC-DC converter portfolio covers a spectrum of power requirements, ranging from low- to high-voltage systems, depending on customer specifications. The converters can be tuned for duty cycles via their advanced digital control architecture, enabling flexible control modes through firmware adaptation.

In March 2021, Eaton acquired Switzerland-based Green Motion SA, a designer and manufacturer of electric vehicle charging hardware and related software. Eaton’s efficient electric vehicle charging infrastructure expertise includes the production and operation of charging stations, designing management software for charging networks, and serving as an electric mobility service provider.

Many workplaces host vehicle fleets, such as cars for the salesforce and vans

for deliveries. Fleet managers switching to EVs, either now or in the future, will want to electrify their fleet while ensuring business continuity. Eaton's "Buildings as a Grid" approach helps fleet managers devise an EV charging strategy that is fast to implement, cybersecure and scalable so that they can add more EV charging capacity when needed.

The strategy may include EV charging infrastructure at their site or depot, on-site renewables like solar panels on buildings, and options for fleet drivers to charge at home and when they are traveling. Eaton's digital and physical infrastructure transforms a workplace or depot into an energy hub, and because it is a gateway to electrifying the entire functionality of the site, it is also a strategic investment in the energy transition.

eaton.com

NUM

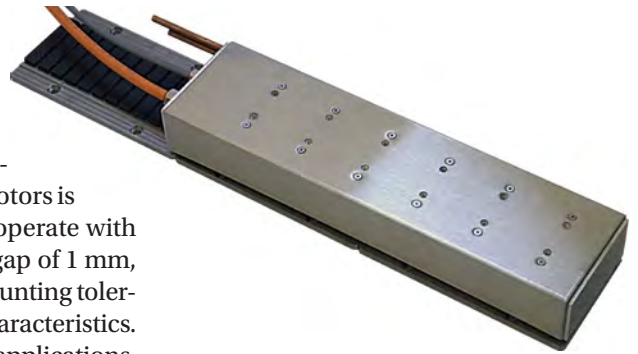
LAUNCHES LINEAR ELECTRIC MOTORS SERIES DESIGNED FOR MACHINE TOOLS

NUM has launched a series of brushless linear servomotors designed specifically for continuous duty cycle applications in machine tools.

Until now, most linear motors on the market have been designed for general-purpose automation involving fast A-B positioning capabilities but relatively low duty cycles. NUM has taken a more conservative design approach, waiting until the market matured before creating a linear motor expressly intended for continuous operation in the harsh environment of modern machine tools.

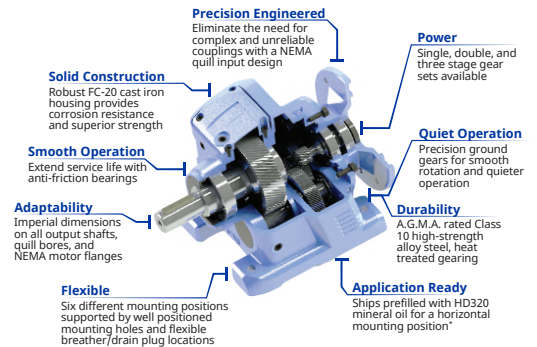
NUM's new LMX series linear motors incorporate a number of features to help mitigate the effect of arduous operating conditions. Their moving coil primary section is fully encapsulated in a robust stainless-steel housing, with an integrated cooling circuit designed to maximize the flow rate, which also allows the use of low specific heat capacity cooling liquids. The motors have a short pole pitch to increase force density, minimize cogging forces and reduce thermal losses.

LMX linear motors comprise a metal track with multiple embedded rare earth magnets, and a coil assembly supported by a customer-supplied guide-way. A key feature of the motors is that they are designed to operate with a comparatively large air gap of 1 mm, to reduce the impact of mounting tolerances on performance characteristics. For most machine tool applications,



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the track is held stationary, and the coil assembly is free to move—but converse mounting arrangements are also practicable, with similar performance attributes.

Suitable for use with standard 3-phase sinusoidal brushless servo drives, NUM's LMX series linear motors are especially cost-effective when teamed with the company's NUMDrive X or new NUM DrivePro drives. Both these families of high-performance drives feature a high degree of functional integration, making them some of the smallest on the market, and offer extensive safe motion monitoring and control options to help simplify design-in.

The new NUM DrivePro drives are likely to be of particular interest to OEMs seeking maximum performance from NUM's new LMX series linear motors. Implemented using advanced system-on-chip (SoC) technology and based on a multi-core ARM processor, the drives employ bare metal programming to eliminate operating system latency.

NUM produces a wide range of electric motors, including spindle, servo, torque, synchronous and asynchronous, and now linear. According to Massimiliano Menegotto, managing director and CTO of NUM Group, "Choosing the best kinematic solution for any machine often involves a tradeoff between various technical factors. NUM can support machine designers, during the machine's development phase, with the selection of the most appropriate solution."

num.com

ABB

EXPANDS SMART SENSOR TO GENERAL MACHINERY

ABB is now enabling customers to remotely monitor the health and performance of general machinery with the ABB Ability Smart Sensor, a key element of the ABB Ability Digital Powertrain.

The ABB Ability Smart Sensor turns rotating equipment including drives, motors, and applications such as



pumps, into smart, wireless connected assets. This new innovative solution is designed to detect potential asset disturbances and planned maintenance before the reliability, productivity and safety of machinery are impacted. The smart sensor fits to the asset's surfaces, collecting and transmitting data via smartphone or gateway to a secure cloud service. Advanced algorithms analyze the data to provide real-time insights into the condition and performance of monitored assets. The asset to be monitored is chosen during commissioning. All components of a powertrain can be monitored via one portal; either individually or as part of the complete powertrain.

The ABB Ability Smart Sensor is ideal for application in hazardous areas and harsh environments. The sensor's enclosure is designed to withstand high vibration levels and protects from total dust ingress (IP66/67). The sensor is certified for ATEX, IECEx and NEC 500.

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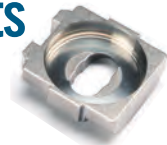
INTRODUCES THE WINCH DRIVE SERIES 800

Bonfiglioli presents the new high performant 800 series which comes in five sizes from 25,000 to 160,000 Nm in marine-resistant paint, suitable for blast cleaning. Easy and fast assembly of the 800 series gearboxes into the winch drum is a key feature of their design. Maintenance requirements are made as simple as possible, e.g., with an easy access to the brake, ready-made brake replacement kits as well as easy access to oil filling, draining plugs, and oil level pipe/indicator.

Thanks to a certified modular architecture the new 800 winch drive series is extremely flexible. Additional standard stages widen the available range of torque and speed. A broad spectrum of motor flanges allows the combination with preferred electric as well as hydraulic motors and right-angle stages allow space saving winch designs. Therefore, the new winch drive series 800 widens the freedom of all people involved: from the design phase to life-long maintenance.

All Bonfiglioli drives are designed to meet high performance requirements under the special conditions at sea with a torque range from 1.000 to 3.000.000 Nm. The drives have been approved in accordance with the standards set by the American Bureau of Shipping (ABS). Certificates from Det Norske Veritas and Germanischer Lloyd (DNV GL) and the China Classification Society (CCS) are also available.

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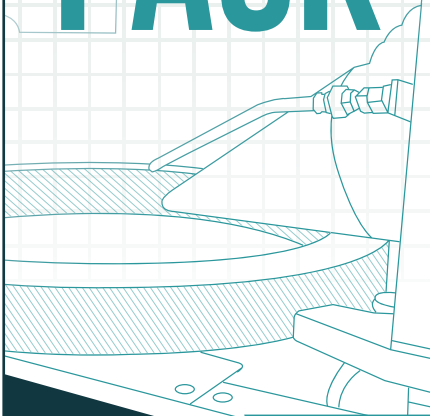
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bonfiglioli.com

Zero-Max INTRODUCES NEW OHLA MODELS

Zero-Max did it again—three entirely new extra-duty Overhung Load Adaptor (OHLA) models. Based on decades of experience solving overhung load issues in the most demanding applications, the new designs feature a number of carefully chosen upgrades including spherical bearings, enhanced sealing technology, stronger shafts and a longer profile delivering increased operating life, heavy load capacities, and higher speed ratings.

While the standard OHLA product line is designed to handle high loads at high operating speeds, these new extra-duty models are designed to maximize performance in the most demanding applications. They provide a solid, permanent mounting surface eliminating premature motor or pump

failure due to axial and radial overhung loads on a motor or pump shaft. They feature these important design enhancements:

Extended Housing Length for improved load distribution on the bearings, increasing load capacity and operating lifetime.

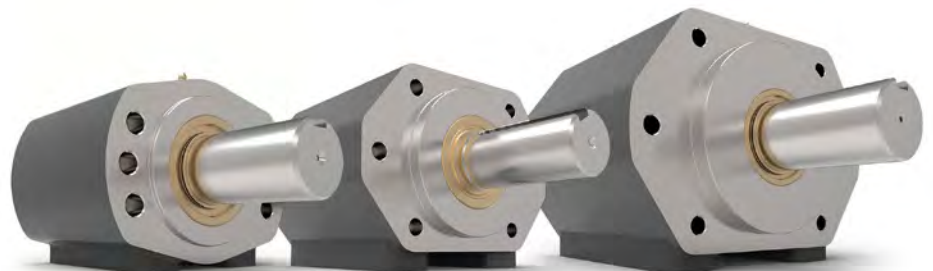
Spherical Roller Bearings as standard for the best combination of high load and high-speed capacity.

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Heat Treated Shafts with splined input bores as standard for handling higher torque and higher shock load applications.

O-Ring Seal at input that provides a consistent, positive seal between the hydraulic pump/motor and the OHLA.

Special Bi-Directional Dual-Lip Seal at the output shaft with two primary seal lips to keep lubricant in the OHLA bearings and dirt and debris outside of the OHLA. NOTE: Typical dual lip seals have a primary lip seal for fluid separation on one side with a secondary lip for excluding contaminants on the other side. This new specially designed extra-duty seal has two opposing primary lip sealing surfaces to provide fluid separation and contaminant exclusion from both directions—inside and outside of the OHLA. Additionally, this newly designed seal is rubber coated with stainless steel garter springs for added corrosion protection from the external environment



with enhanced protection from debris and other contaminants.

The three new extra-duty models are:

- 350 Series (SAE A mount, accepts 2-bolt and 4-bolt Magneto mounting patterns)
- 650 Series (SAE B mount, accepts 2-bolt and 4-bolt mounting patterns)
- 950 Series (SAE C mount, accepts 2-bolt and 4-bolt mounting patterns)

Special extra-duty OHLA designs are also available for applications with challenging performance, material, and dimensional specifications including vertical shaft mounting orientations. Zero-Max offers a free analysis of any overhung load application to assure proper selection including estimated bearing life, confirming strength of the input shaft connection and making lubrication recommendations. There is no engineering charge for custom designs, and they are available in any quantity from one to hundreds or thousands of units.

zero-max.com

KISSsoft

INTEGRATES SCHAEFFLER CATALOG BEARINGS

Manufacturer-independent engineering tools, such as *KISSsoft*, basically offer users the opportunity to offer more flexibility in selecting suppliers and procuring components. On the other hand, in some cases there is no access to exclusive product data from the manufacturer in order to be able to perform the calculation with the greatest possible accuracy and reliability.

In the meantime, hybrid software solutions have also

become established on the market, in which the original manufacturer data—not visible to the customer—is integrated into the software: *KISSsoft* is one of these.

For rolling bearing calculations, catalog bearings from Schaeffler can now be selected in *KISSsoft* with the manufacturer data stored invisibly. These standard bearings are calculated using the manufacturer's real internal geometrical data. One of the many advantages: In addition to the calculated rating life, for example, the load distribution in the bearing and the pressure curves for each individual rolling contact can be determined very precisely and displayed graphically.

Users thus benefit from greater accuracy and reliability of the calculation. It is now also possible to make comparisons very easily with rolling bearings from other manufacturers with regard to the effects of the internal design.

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SKF entered a unique collaborative partnership with Heat and Control, Inc., an equipment solution manufacturer, to assist in engineering a new horizontal motion conveying technology, FastBack 4.0.

The partnership evolved when Heat and Control asked SKF to

contribute to the design of the company's latest revolution in horizontal motion conveying equipment. In response, SKF assembled a team including application engineering, R&D, and product development, plus support from factories across the globe. As a leading bearing manufacturer that also manufactures seals, SKF has a unique perspective on the interplay of the elements in rotating equipment. Drawing on SKF's years of experience in a wide range of industries, the team the



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Partnering with QualityReducer to provide Gearbox repair, rebuilding and reverse-engineering.

team was able to refine and improve the customer's design for FastBack 4.0, bringing tremendous benefits to horizontal motion conveying in the food processing markets.

"We are fully committed to the relationships and collaboration we've built with our customers; leading to an understanding of their technical, and commercial needs," said Marshall Ahrens, SKF applications engineer. "Heat and Control challenged us with the collaborative development of the FastBack system, targeting improvements in every category for their horizontal motion conveying systems. The result of our combined effort between the teams at SKF and Heat and Control is Fastback 4.0: a new, innovative design that pushes the performance boundaries of horizontal motion further into the future."



SKF engineers relied on vast industry knowledge, experience, and simulation tools to translate Heat and Control's requirements into an application-specific design for speedy development. The team analyzed the concept to determine the life predictions for the bearings and lubrication used on FastBack 4.0.

"This new generation is a transformative technology, and our design process focused on simplifying and improving conveying. We wanted FastBack4.0 to set a new standard making it easy to use, operate and own," said Blake Svejkovsky, Heat and Control, Inc., general manager, product handling systems. "In addition to our collaboration from a design standpoint, SKF is also able to meet growth targets thanks to an its extensive global footprint."

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Comparing Machine Screw Jacks and Ball Screw Jacks for Heavy Lifting Capabilities

Engineers should consider the following factors during the design phase

Mitch Katona, Thomson Industries
Ilan Miller, Motion

When motion system designers want the application flexibility of an electric linear actuator and a hydraulic cylinder's heavy lifting, lowering and tilting capability, they often turn to screw jacks. Where electric actuators might handle up to two tons, screw jacks can handle more than 100. Their high load capacities come from a worm gear configuration that converts energy from motor or manual input. The two main types of screw jacks are machine screw jacks and ball screw jacks (Figure 1).

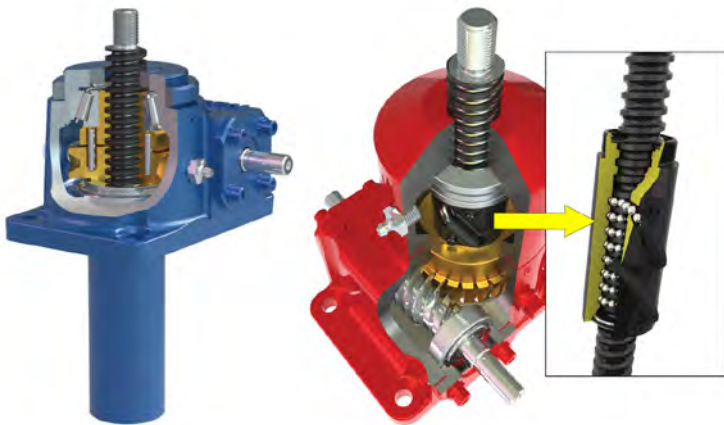


Figure 1—Machine screw jacks (left) use a threaded metal shaft and nut, which is very economical but provides high friction and low efficiency. Ball screw jacks (right) are more expensive, but their use of rolling balls reduces friction and improves efficiency. (Images courtesy of Thomson Industries.)

Machine screw jacks can be provided with a threaded alloy lift shaft attached to a load driven by a bronze nut or ball bearing nut, or the lift shaft can be attached to the drive gear and drive a travel nut that attaches to the load. The relatively simple metal-on-bronze design makes machine screws less expensive but produces more heat-generating friction, making them less desirable for many applications. A ball screw jack also uses a threaded metal lift shaft, but the nut is outfitted with rolling balls that can reduce friction

between the screw and nut by nearly 95 percent, offering significant advantages for many applications.

To determine whether a machine screw jack or ball screw jack is the right fit for your application, consider the following application parameters early in the design phase:

- Required load
- Expected duty cycle
- Ambient temperature during operation
- Presence of particulates or corrosive substances
- Tolerance for backdrive
- Travel length
- Oscillation
- Speed

Other design factors that may come into play are the needs for energy efficiency, predictable lifecycle, precision, and position control.

Load handling requirements

Motion application developers typically consider screw jacks for loads between $\frac{1}{4}$ and 100 tons. When machine screw jacks are linked together, even higher loads can be achieved. For example, if the loads are static, machine screw jacks would most effectively support bridges for extended periods as friction would not be a problem. However, for dynamic loads with frequent load cycles, such as moving a conveyor segment between two lines in a production facility, a ball screw configuration would be better. This type of application would produce high friction on a machine screw jack.

The potential for shock loading should also be considered. Although vendors seldom recommend machine screw jacks or ball screw jacks for high-shock environments, both can temporarily exceed their rated capacity by about 10 percent for dynamic loads and 30 percent for static loads.

Duty cycle

After load conditions, the most important variable to consider is duty cycle, the percentage of time the screw jack will be working. The machine screw jack's limited ability to dis-

sipate heat constrains the duty cycle. If the jack operated less than 25 percent of the time, which may be necessary to adjust the position of a heavy press, the machine screw jack

would be adequate. In many applications where high cyclical load movement demands high-duty cycles, often ball screw jacks can be the preferred solution (Figure 2).



Figure 2—Due to their higher duty cycle, ball screw jacks are ideal for designers looking to produce a fast-paced automated conveyor system.



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Temperature operating range

Ambient temperature impacts the operating temperature as well. Neither machine screws nor ball screws should operate when the housing temperatures near the worm gear exceed 200°F (93.3°C), and ambient temperature will contribute to this reading. Screw jack manufacturers typically recommend operating at ambient temperatures of around 176°F (80°C) for 25 percent duty cycles and below 122°F (50°C) for more continuous duty.

The hotter the ambient temperature, the greater the need for the low-friction operation of ball screw jacks. Factors contributing to heat and thus favoring ball screw usage include travel length, oscillatory motion, and speed. Designers would not, however, typically use screw jacks in high-speed operations.

Energy consumption

Efficient energy usage also gives ball screw jacks an advantage in reducing costs. Because of their efficiency, ball screw jacks require less horsepower to operate and thus consume less energy. This feature enables designers to specify a smaller motor to meet sustainability objectives. However, this choice does depend on other application variables, including the duty cycle, environment, and speed.

A simple horsepower calculation can determine the proper size of screw jack to use in each application. In addition, measuring the housing temperature can ensure the jack's usage is not exceeded. Suppose the temperature exceeds the screw

jack's limitations. In that case, the designer might still benefit from a more cost-effective machine screw jack but would need to use a larger jack, reduce the motor input speed, or use a right-angle reducer. Otherwise, they can use a ball screw jack to take advantage of their higher efficiencies.

The high-friction operation of the machine screw within a jack requires about twice as much input torque, so a larger motor would also be required. In applications in which either multiple machine or ball screw jacks are configured in a system, a single motor could drive all jacks, further improving energy efficiency. A scissor lift, for example, might deploy jacks driving its left and right sides with a connecting shaft in between. One motor can drive both jacks (Figure 3).

Tolerance for backdrive

Axial pressure on the lift shaft or travel nut can push it backward, especially if a brake or other holding mechanism in a vertical orientation fails or the system loses power. In such cases, the relative inefficiency and high friction potential of machine screws give them an advantage over ball screws. Depending on the gear ratio and efficiency of the lift shaft, machine screw jacks can be considered self-locking.

The high efficiency of ball screws used in vertical configurations can cause them to slide backward easily if power goes down. For that reason, ball screw jacks must be outfitted with a brake or other holding mechanism, adding cost and complexity.

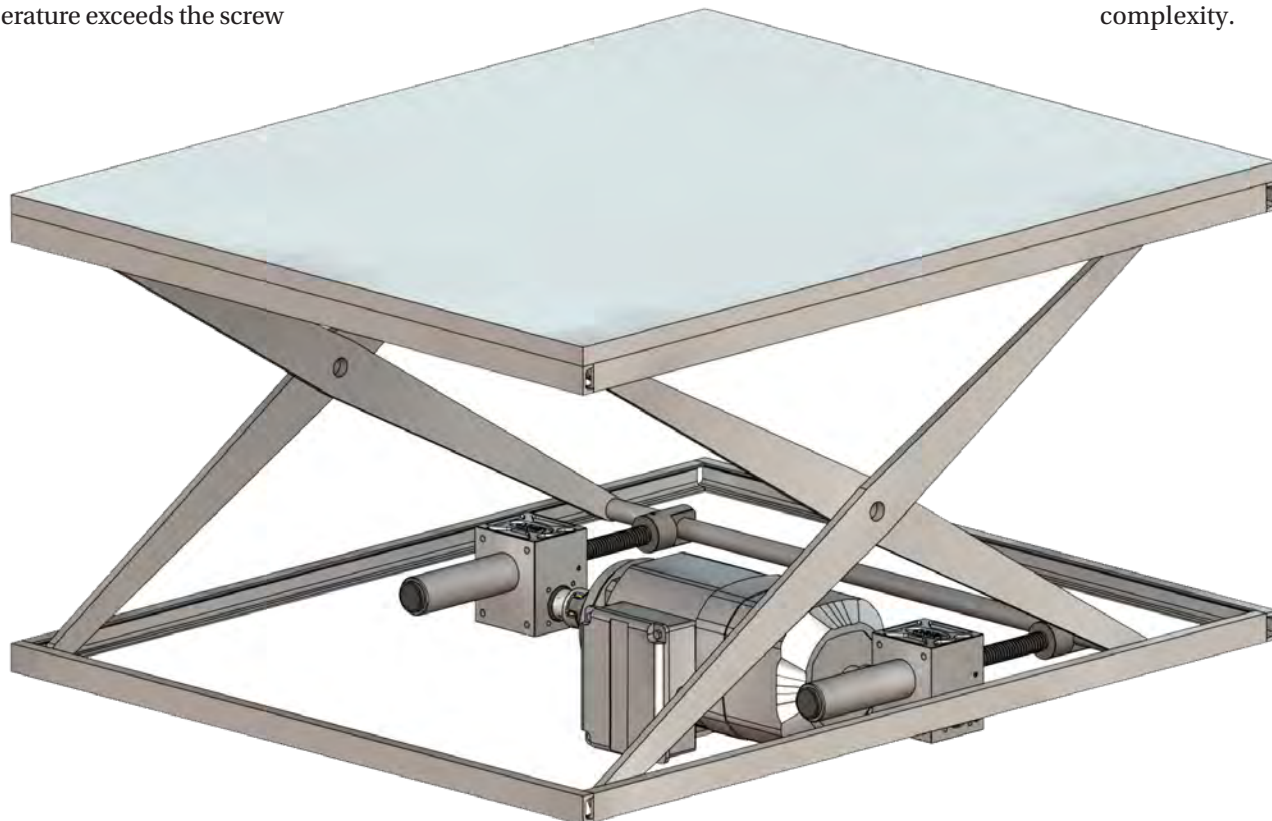


Figure 3. The two screw jacks on this scissor lift can work with a single motor. If the duty cycle was less than 25 percent, they could operate with a machine screw jack, which might counter the higher energy consumption.

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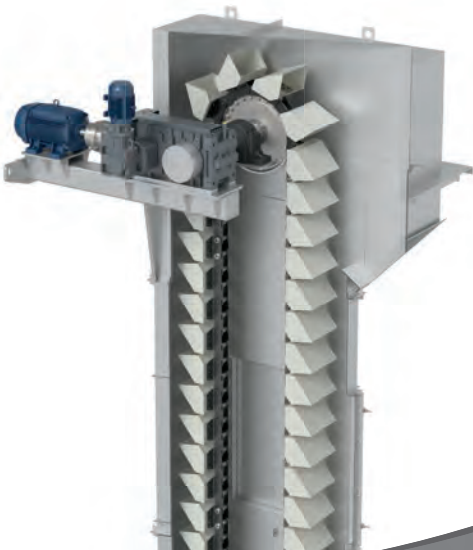
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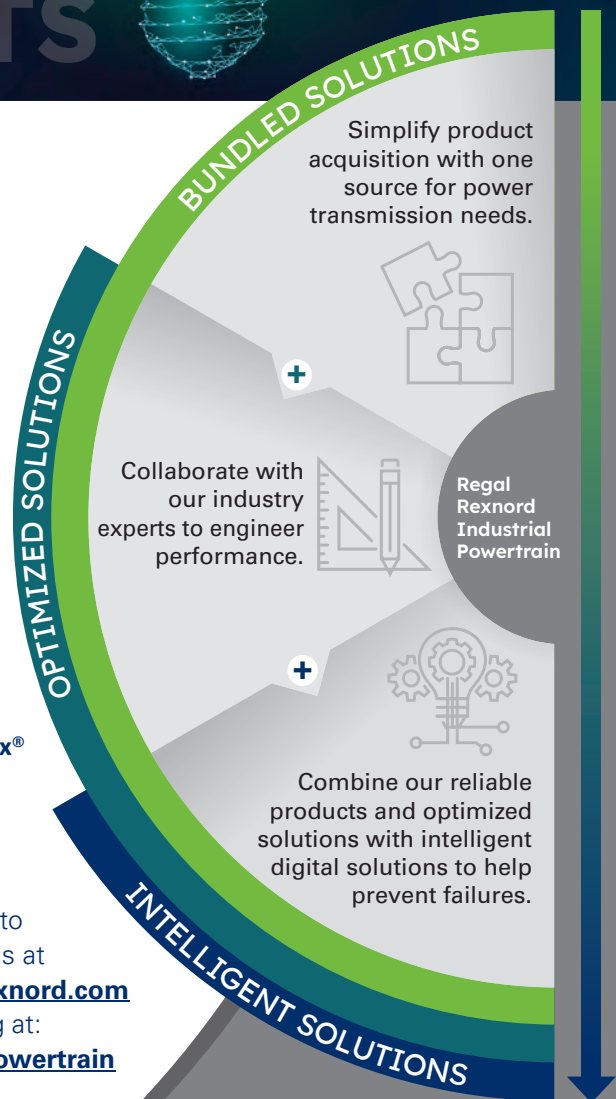
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Presence of particulates, corrosive chemicals, vibration, and noise

While ball screws have an advantage in high-duty-cycle applications, machine screws have advantages where particulates, toxic chemicals and vibration are present, or excess noise can be an issue.

Machine screws are less sensitive to contamination, making them better for areas in mills or woodworking where particulates might fill the air. Machine screw jacks can be supplied with stainless steel to prevent corrosion in high-moisture environments. Ball screw jacks can utilize various plating techniques to achieve similar benefits.

Machine screw jacks are less sensitive to vibration and quieter because no balls are recirculating. This makes them preferable in noise-sensitive environments such as residential or healthcare settings.

Need to predict life cycle

The engaged frictional thread of the machine screw jack makes it difficult to predict its life cycle. Ball screw life cycle, however, can be calculated based on measurable inefficiencies that contribute to fatigue of the ball bearings under a dynamic load. Known as the L10 standard, this calculation estimates the number of revolutions or hours at a given constant speed that 90 percent of a screw system's group of bearings will complete or exceed before failure. It is impossible to predict the life of machine screws, so if end users need to predict the life of their screw jacks, the ball type is the only option.

Need for precision

Both machine screw jacks and ball screw jacks are highly repeatable. Depending on size, they will have an associated lash between 0.003 and 0.020 in. This can be reduced using a clearance ball nut or a split drive nut for the machine screw jacks.

Need for position control

Both machine screw jacks and ball screw jacks can be motor driven and provide position control options. However, the higher the precision required and the higher the duty cycle, the more the application would gain from using a ball screw jack.

For example, a tilt station platform supporting a team working on a large airplane wing might use multiple ball screw jacks synchronized in communication via a CAN bus network. However, if the platform needed adjustment only two or three times per week, a machine screw jack would be adequate. In that latter case, even a machine screw jack equipped with a single general-purpose motor—using shafting to mechanically link each jack—might be sufficient.

Logical choices

In many applications involving loads of up to 100 tons, screw jacks can provide a desirable alternative to hydraulic cylinders. Still, it is important to specify the correct type of screw jack. For static loads with duty cycles below 25 percent, a machine screw jack will usually be the most cost-effective. For dynamic loads with higher-duty cycles, a ball screw jack is necessary.

However, within those broad parameters, many other factors could affect the decision. Machine screw jacks are more resistant to airborne particulates and corrosive chemicals, are quieter and have minimal backlash. Ball screw jacks, on the other hand, have more predictable life cycles.

Of course, whether the machine screw jack or ball screw jack is right for you will depend on your application parameters. No matter which screw jack you choose, their increased control, tremendous power, easier installation, and environmental friendliness will instill confidence in your motion system design.

	MACHINE SCREW JACKS	BALL SCREW JACKS
Load	Up to 100 tons, static	
Duty cycle	Up to 25%	Up to 35%
Operating temperature	Housing temperature maintained below 200°F	
Environmental resistance	Less sensitive to particulates, corrosion, vibration and noise	Particulates may interfere with ball function; ball alloys subject to corrosion; but low friction makes them more tolerant of oscillation
Energy consumption	Lower efficiency consumes more energy	Faster acceleration, better overall energy utilization
Backdrive	Depending on gear ratio and efficiency of lift shaft, can be considered self locking	Requires brake or other holding mechanism
Durability Life	Not predictable	Predictable
Precision	0.007" to 0.020" of lash, depending on screw size	0.003" to 0.015" of lash, depending on screw size
Position control	Highly repeatable	
Travel length	Up to 240"	
Speed	Typical recommended maximum of 1,800 rpm provided that the recommended horsepower and temperature are not exceeded	Typical recommended maximum of 3,000 rpm provided that recommended horsepower and temperature are not exceeded



Mitch Katona is a product line specialist—screw jacks, for Thomson Industries, Inc. He is responsible for supporting and developing the Thomson screw jack product line. He earned his B.S. in Applied Engineering from Kent State University and has worked at Thomson for five years.



Based out of Calgary, **Ian Miller, P.Eng.** is national services business development manager for Motion. He has over a decade of hydraulic and electrical experience in the field, including system design, troubleshooting, on-site installations, and technical training/support.

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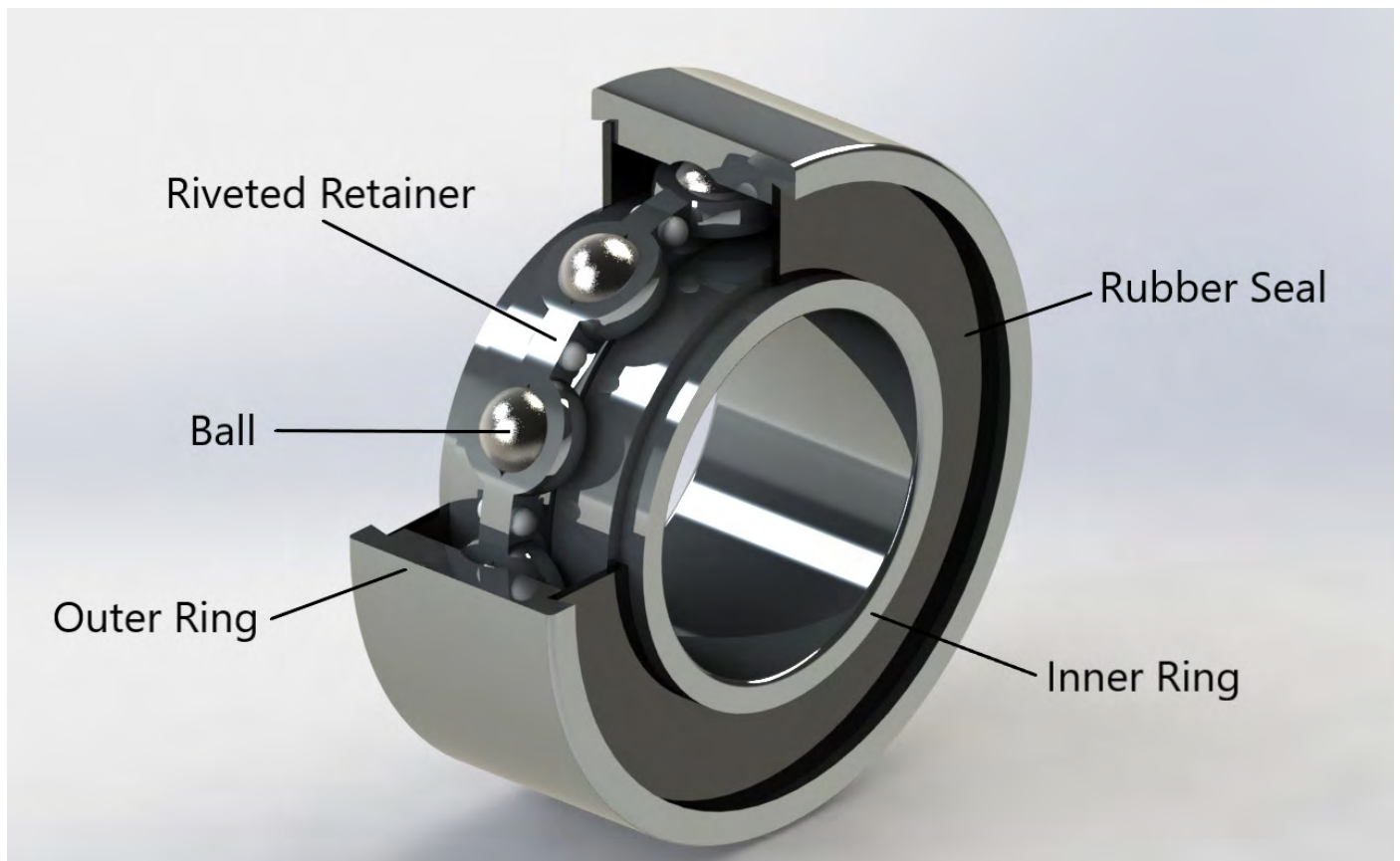
MASTA¹²

The collage features several technical visualizations: a CAD software interface showing a 3D model of a transmission component; a mesh model of a circular component; a contour plot showing stress or temperature distribution on a transmission housing; and a QR code for more information.

Bearing Design Considerations for the Food Processing Industry

Materials, closures and lubrication options must be properly selected to ensure the optimal performance of bearings used in this machinery.

John Wallace, Vice President of Operations, AST Bearings and Mark Manegold, Technical Marketing Manager, AST Bearings



Basic components of a sealed ball bearing (lubrication not shown).

Food production is an essential, but often overlooked, component of our food chain. Reliable, efficient machinery plays a key role in the food processing industry—and ball bearings are essential to the performance of this equipment. Designers and engineers are faced with important decisions when specifying bearings used in food processing equipment, which must withstand challenging operating environments while meeting stringent safety requirements.

Regulatory Compliance

The U.S. food processing industry is heavily regulated by government agencies. Two federal agencies dominate this regulatory oversight: The Food Safety Inspection Service of the U.S. Department of Agriculture (USDA-FSIS) and the Food and Drug Administration (FDA). USDA-FSIS is responsible for meat, poultry and egg processing while the FDA oversees all other food processing businesses. State agencies also play an active role in oversight. All materials, including

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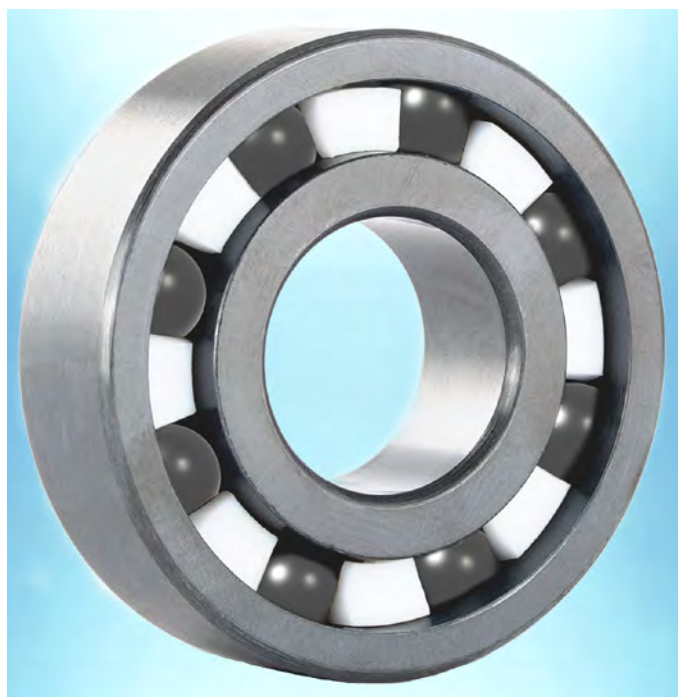
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lubricants, must comply with applicable state and federal food processing requirements. Depending on the application, components used in machinery (such as a complete bearing) may require regulatory approval as well.

Materials



Hybrid ball bearing, made from stainless steel rings, ceramic silicon nitride balls, and a fluororesin cage (lubrication and enclosure not shown).

Bearings used in food production equipment must be manufactured from high-purity materials. While bearing rings are commonly produced from SAE 52100 chrome steel, food processing applications generally require rings made from martensitic stainless steel (such as AISI 440C). This stainless steel offers the best combination of corrosion resistance and fatigue life. For additional corrosion resistance, nitrogen-enhanced martensitic stainless steel can be used. This steel is more expensive than 440C but offers five times the corrosion resistance. It also exhibits extended fatigue life and very low noise levels due to its fine crystalline structure, which contains small chromium nitrides (as opposed to larger chromium carbides).

Bearing components such as shields, slingers and cages should be manufactured from AISI 302 or 304 austenitic stainless steel. Bearing rings can also be manufactured from AISI 300 series stainless steel (which has outstanding corrosion resistance compared to 400 series stainless steel) but is typically not used in food processing applications due to a compromise in fatigue strength. Load ratings for ball bearings with 300 series stainless steel rings are approximately 20 percent of the load ratings for bearings with 400 series stainless steel rings. However, if the application loads are very light and corrosion is a concern, 300 series stainless steel can be considered an acceptable option.

In applications where bearings are required to operate

immersed in water or be resistant to chemical attack, hybrid ball bearings should be used. These bearings are constructed with rings made from martensitic stainless steel and balls produced from ceramic silicon nitride. The bearing cage is made from a fluororesin such as Teflon, which is water-resistant, inert to most chemicals, and reduces friction. Hybrid bearings are maintenance-free and extend service life in these severe operating conditions.

Mounted bearing units are used extensively in food processing conveyors and similar equipment. This type of component often consists of a radial ball bearing, known as an insert, mounted within a housing. Various housing styles allow for different mounting arrangements. Pillow blocks, one of the more common types of housings, are used for low torque, light load applications. In the meat and poultry sectors, high strength housings called plummer blocks are often required to transfer ample power and support heavy loads.

Insert bearings should be produced from 440C stainless steel. AISI 52100 chrome steel bearings, either plated with zinc chromate or coated with black oxide, are another good option to consider. Several choices are available for corrosion resistant, food-safe housings. Cast or ductile iron housings with electroless nickel plating are a cost-effective solution that offers high strength and can withstand the effects of most washdowns. Cast 300 series stainless steel, however, is the best option when facing high concentrations of chlorine or other chemicals in cleaning solutions. Thermoplastic housings are an effective alternative for use in high moisture and caustic environments. While not as strong as iron or steel, these housings are lightweight and will not chip or flake as will a plated housing. Regardless of housing material, all surfaces should be smooth with flat mounting bases and be free from recessed areas. This type of design allows for effective washdowns and eliminates the possibility of food by-products or debris getting caught in the housing, which can lead to bacterial growth.

Seals

Bearings are continuously exposed to liquids and various types of particulate debris in food processing plants. Sealed or shielded bearings should always be used. Seals are the



Mounted Bearing Units (counterclockwise, from rear): Two Bolt Pillow Block, Flangette, Two Bolt Flange.



Flange mounted bearing units supporting conveyor belt shafts in an egg processing facility.

best option for preventing the ingress of foreign debris and retaining lubricant in the bearing.

The most common bearing seal material is nitrile rubber, also known as NBR or Buna-N. This type of seal is comprised of a rubber profile bonded to a steel insert and has a maximum operating temperature of 240°F. Seals are typically fixed into a groove in the outer ring of the bearing and contact the inner ring, providing better protection than a metal shield in contaminated environments. However, this seal contact results in an increase in rotational torque and reduces the maximum speed capability of the bearing. Still, this limitation is usually seen as a design trade-off made to improve bearing life. Nitrile rubber reacts negatively with certain chemicals and lubricants and is unsuitable for high temperature applications. Alternative materials include fluoroelastomers, such as Viton, which has good chemical resistance and a maximum operating temperature of 400°F. FDA-approved food-grade silicone rubber, which has an operating temperature range from -80°F to 450°F, is another option for extreme temperature applications. Teflon and glass-reinforced PTFE seals are also excellent material choices for food processing applications. They have outstanding chemical resistance, can withstand high and low temperatures, and exhibit less torque than rubber seals. However, these seals are not as robust as those made from other materials—and depending on the bearing type and construction—can be easily dislodged if hit directly with a high velocity stream of fluid.

Construction of a seal can greatly improve its ability to function in extreme environments. The outer surface of the seal rubber can be shrouded in metal, such as stainless or galvanized steel. This metal shroud protects the rubber material from abrasion. On insert bearings found in mounted units, these shrouds are often referred to as slingers. The portion of the seal that contacts the inner ring of a bearing is known as the seal lip. Seal lips can be designed with a single, double, or triple lip configuration. The seal lip flares outward where it contacts the inner ring, providing very effective protection against the ingress of wet or particulate contaminants. Triple lip seals provide the most protection, but also increase rotational torque substantially when

compared to single lip designs. When low torque is an application requirement, a noncontact rubber seal with a labyrinth design can be used. This type of seal configuration creates a labyrinth path which is difficult for fluid or debris to navigate. The seals found on most types of bearings are not designed for fluid immersion. If subjected to this environment, fluid penetration will eventually take place. In general, seals offer excellent protection from particulate contamination, fluid splash and wipe down operations.

Lubrication

Lubricant selection is critical to bearing performance and life, yet it is often overlooked by designers and engineers. Bearing life in harsh environments such as those found in food processing depends on “proper lubrication”—meaning both type and amount. Operating temperature is the primary consideration when selecting a lubricant. Temperature directly affects the viscosity of the lubricant base oil, which in turn impacts the lubricant’s ability to support application loads.

Lubricant selection not only depends on the operating conditions the bearing will encounter; it may also be subject to regulatory requirements. Manufacturers of food processing machinery are often required to use a special class of lubricants, referred to as food-grade lubricants. These lubricants are classified into three categories, based on the probability of contact with food products. The USDA created the original food-grade lubricant designations H1, H2 and H3. In 1999, the National Sanitation Federation (NSF) evolved globally and took over the regulatory oversight of food-grade lubrication, while retaining the original H-system designation. The designations are defined as follows:

H1 lubricants are those used in food processing equipment and on machine parts where there is a possibility of incidental food contact.

H2 lubricants are those used in food processing equipment and on machine parts where there is no possibility of food contact.



Bearings used in produce processing facilities must be resistant to very wet environments.

H3 lubricants, also known as soluble or edible oil, are those used to clean and prevent rust on hooks, trolleys and similar equipment. They are generally regarded as safe and FDA-compliant mineral oil. The equipment surfaces that contact edible products must be clean and free of the oil before reuse.

H1 lubricants typically have synthetic, hydrocarbon base oils with urea, polyurea, or aluminum complex thickeners. H2 lubricants typically have mineral or PFPE base oils with calcium soap or PTFE thickeners. Solid lubricants can be used in very demanding applications. These are oil-filled polymers, or grease and polymer mixtures, that solidify once heated and cooled. Solid lubricants can eliminate problems with grease leakage and emulsification, especially when water is present.

Lubricants need to provide good wear and corrosion resistance. Those used in high temperature applications such as meat, poultry and beverage processing should have high temperature oxidation stability. Machinery used in beef, pork and poultry processing is typically exposed to wash-down procedures, which use high pressure water and antibacterial solutions that can displace the grease. To avoid this displacement, greases with high resistance to water wash-out are used, with fill amounts in the range of 70–100 percent (as opposed to a typical fill amount of 30 percent.) While the large fill amount limits rotational speed, it significantly improves bearing life.

Thousands of greases and oils are readily available, designed for a wide variety of operating conditions. Features, benefits and price are all important factors to consider when making a choice. Both a lubrication specialist and the bearing manufacturer should be consulted before making a final lubricant selection.



Bearings used in meat processing facilities, which require frequent washdowns, must be able to withstand harsh cleaning procedures such as high-pressure sprays of water or chemicals.

Summary

Bearing life plays a key role in optimizing uptime, efficiency and reliability of equipment used in the food processing industry. Bearings are exposed to extremely harsh condi-

tions in these applications, and designers must consider protection from corrosion and contamination while maximizing lubricant life. Materials, sealing solutions and lubrication—along with operational loading—should be carefully evaluated in the bearing selection process to achieve desired bearing life.

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John Wallace is a degreed mechanical engineer with over 35 years of industry experience in engineering, manufacturing, and quality assurance. He recently retired after serving as vice president of operations at AST Bearings from 2003 to 2022.



Mark Manegold is a degreed mechanical engineer with over 25 years of industry experience in applications analysis, design, and project management. He currently is the technical marketing manager at AST Bearings. Mark can be reached at mark.manegold@astbearings.com.

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Highlights of Turbomachinery & Pump Symposia 2022

A strong post-pandemic turnout brings the turbo and pump industry up to speed

Aaron Fagan, Senior Editor

TPS is an industry event that offers an integral forum for the exchange of ideas between rotating equipment engineers and technicians worldwide. TPS is known for its spirited engagement with turbomachinery, pump, oil and gas, petrochemical, power, aerospace, chemical, and water industries through its peer-reviewed technical program and world-class exhibition.

Overall, the conference saw 3,815 attendees, hosted 94 technical sessions, and had 274 exhibiting companies. Many attendees commented on the value of networking conversation at the show. From 2021 to 2022, TPS saw an increase in international delegates, with just 19 countries represented in 2021, to 44 countries represented in 2022. Below is a taste of the booths we had the chance to visit.



Dr. Eric Petersen, pictured here delivering the TPS welcome address, is the Director of the Turbomachinery Laboratory at Texas A&M which hosts the annual event in Houston.

Sundyne

At the recent Turbomachinery and Pump Symposia in Houston, Sundyne showcased a wide range of Pumps & Centrifugal Compressors that are used in gas processing applications such as: amine treating, molecular sieve dehydration, cryogenic processing & distillation, and fractionation applications, which remove carbon atoms and separate heavier hydrocarbons (such as Ethane, Propane and Butane) from gas streams.

Sundyne's LMV 311 pumps were on display at TPS, because they are widely used within the hydrocarbon, petrochemical and power generation markets. Sundyne's LMV (Line Mounted Vertical) pumps are specifically engineered for high-head, low-flow, heavy-duty services. They're commonly deployed as booster pumps, bottoms pumps, reflux pumps and condensate pumps in reformer, hydrotreater, hydrocracker and isomerization process units.



Sundyne's LMV (Line Mounted Vertical) 311 pumps are engineered for high-head, low-flow, heavy-duty services.

Sundyne's centrifugal integrally geared compressors, such as the LMC/BMC/LF-2000 series are widely used in refineries and petrochemical plants to compress hydrogen and other critical gasses, for various applications such as: injection, scrubbing, dehydration, regeneration and H₂S removal. Each Sundyne compressor is custom-built to provide pulsation- and vibration-free operation and to deliver oil-free process gas with zero emissions.



In addition to the traditional refinery/EPI applications, Sundyne also showcased its diaphragm compressors, which are widely used for Hydrogen processing applications.

As every industry seeks to lower its carbon footprint, the interest in using Hydrogen for power generation, transportation and other applications continues to increase. Hydrogen is a versatile energy carrier, and it can be stored for extended periods of time, which makes it a valuable complement to other renewable sources in the electricity system.



Sundyne's PPI compressors play a key role in the production, transportation, and distribution of Hydrogen (and CCS).

PPI diaphragm compressors are specifically designed to compress H₂ from low-pressure levels (such as electrolyzer outlet pressure) up to the 700 bar levels that are required

by today's vehicles that run on Hydrogen. The reason diaphragm compressors are popular for Hydrogen applications is that they address the following requirements:

- High-Compression Ratios
- Product Purity
- Reliability
- Environmental Safety
- Lower Energy Costs
- Industry Standards compliance

In addition to the API-compliant pumps & compressors on display at the show, Sundyne also showcased its range of sealless magnetic-drive pumps, which are commonly deployed outside of the battery limit in wastewater facilities.



Sundyne's sealless magnetic-drive pumps include the ANSIMAG (left) and the HMD Kontro CSA.

The HMD Kontro CSA and ANSIMAG Sealless Pumps are popular due to their cost effectiveness, reliability, ease of maintenance, and the safety that comes from sealless pumps that never leak.

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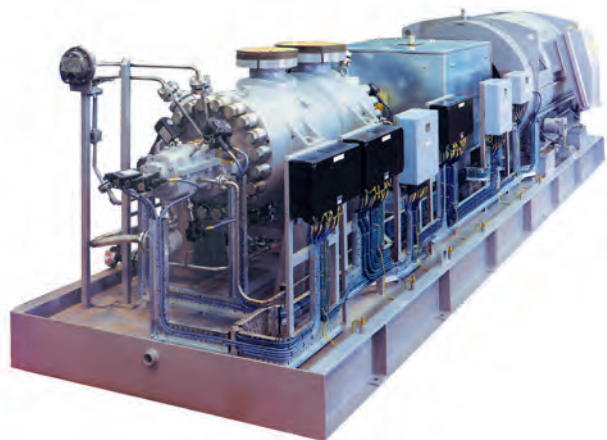
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CUP BB5V volute pump from Celeros Flow Technology offers high reliability in demanding applications. CUP BB5 multistage pumps from Celeros Flow Technology are among the most robust in the industry. They are engineered to order by the company's ClydeUnion Pumps brand and offer superior design features providing long and trouble-free operation in demanding applications, both onshore and offshore.



CUP-BB5V multistage pump.

The range includes the CUP-BB5V, which is available in two heavy-duty designs: multi-stage diffuser or double case volute type. Both versions are designed and engineered to order to the latest edition of API610 and API682. Typical applications include sea-water injection, produced water injection, main oil line, and condensate export.

The CUP-BB5V is designed to offer the lowest cost of life ownership. It has the inherent ability to withstand thermal shock and offers a wealth of features to optimize uptime, including full cartridge withdrawal. All the pump internals can be withdrawn quickly without disturbing pump alignment or pipework, minimizing the time required to maintain the equipment.

Anti-vibration mounts (AVMs) and advanced sealing arrangements coupled with a robust forged or cast barrel casing construction ensure that the CUP-BB5V will perform reliably at capacities up to 2,350 USgpm (2,800m³/hr) and at temperatures up to 350°F (180°C).

Various types of drive equipment can be specified to suit the application, including fixed or variable-speed electric motors, combustion engines, or gas/steam turbines. These can be complemented with API 677 or API 613 gearbox units or fluid couplings to achieve the optimal running speed.

These pumps can be supplied with a range of monitoring equipment to enable measurement and analysis of performance data to support preventative maintenance regimes and increase availability.

Celeros Flow Technology is committed to supporting its installed base throughout its operational life. Customers benefit from original or upgraded specification spare parts, and access to experienced and fully qualified service engineers who can perform upgrades & re-rates, service & overhaul, installation & commissioning, and inventory management.

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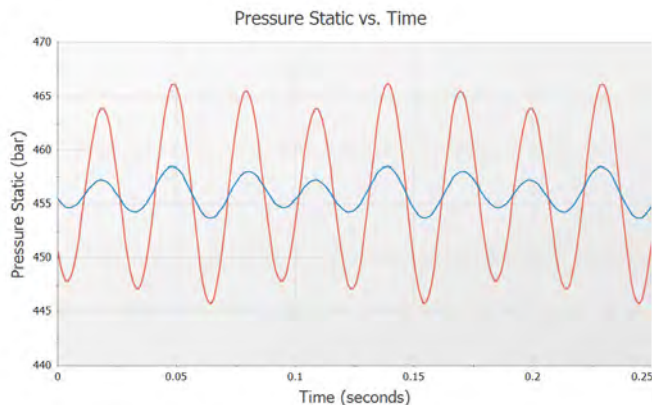
AFT—Applied Flow Technology

Reciprocating compressors and pumps are mainly used to produce a high discharge pressure that is difficult, or uneconomical, for the centrifugal machineries to achieve. However, a major problem in reciprocating compressors and pumps is the pulsation of the flow. The pulsating flow causes vibration in the piping and the resulting issues and risks can be complicated. Once piping starts shaking due to pulsation, it could be a serious situation and cause an immediate shutdown of the plant. Pulsation and vibration, and their associated concerns, are not only issues due to reciprocating equipment, however.

Applied Flow Technology (AFT) has long been established as an authority in modeling pressure and flow distribution in pipe and duct systems. AFT's pipe flow analysis software gives engineers the capability to efficiently identify major reliability issues in their systems: such as understanding the cause and effect of vibration and pulsation on their piping system. The modeling software allows them to simulate multiple operating conditions and gives them the results they need to mitigate these issues quickly and efficiently.

How to Identify and Avoid Resonant Frequencies in Pumps Systems

In liquid systems, cavitation through pumps or flashing at high points in a system could introduce vibration into a system. This vapor formation and collapse would be indicated by the steady-state solver AFT Fathom or modeled in the transient solver AFT Impulse during a transient event. AFT Impulse will similarly model other transient events like pump starts, pump trips, and valve closures and their resulting pressure surges within a piping system. These pressure waves create imbalanced forces and vibration throughout the system. Reciprocating equipment, like positive displacement pumps, will introduce pulsation into a piping system. If this pulsation aligns with the acoustical resonant frequencies of the system, the system can rapidly fail. The Pulsation Frequency Analysis (PFA) module for AFT Impulse enables engineers to identify these resonant frequencies to avoid during operation. Engineers can similarly test modifications to the system to minimize the risk of failure from pulsation and conform to API 674 standards.



Impulse PFA: Pressure response at a problematic pump speed.

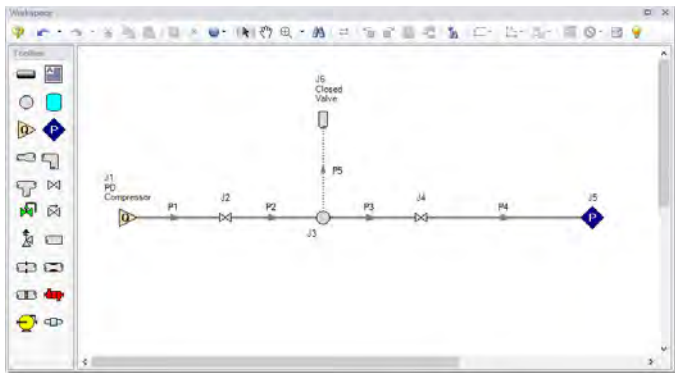


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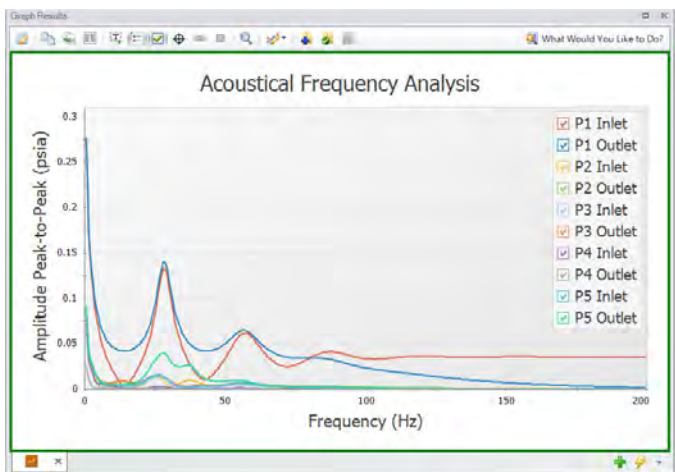
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[motion.com](https://www.motion.com)



xStream PFA: Simplified model of reciprocating compressor for pulsation analysis.



xStream Alt: Problematic frequencies identified by the Pulsation Frequency Analysis module.

Proactively Address Vibration and Pulsation from Turbomachinery

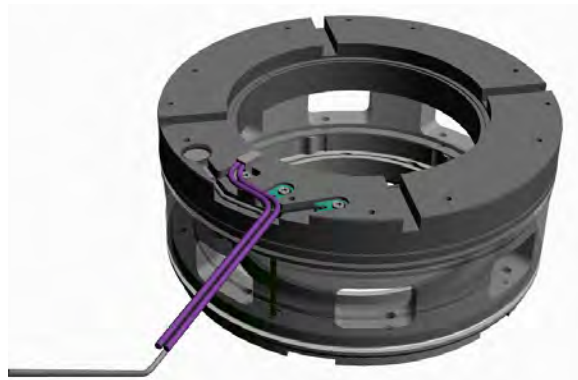
Like positive displacement pumps, reciprocating compressors similarly introduce pulsation risk to a gaseous system. AFT xStream, the compressible equivalent of AFT Impulse, can model this pulsation to identify resonant frequencies in gas and steam systems. Pulsation can also be induced by steady gas flow across a dead-end branch, which can be considered from the steady-state compressible solver AFT Arrow and applicable Energy Institute standards. High-frequency acoustic induced vibration can occur in gas systems with high velocity, and again can be considered with AFT Arrow and applicable Energy Institute standards. These high-frequency responses result in a short time to failure, potentially in seconds or minutes if not addressed.

aft.com

John Crane

John Crane specializes in rotating equipment solutions, supplying engineered technologies and services to process industries. The company designs and manufactures a variety of products, including mechanical seals and systems, couplings, filtration systems and digital diagnostics technologies. They featured a variety of new products and technologies at TPS 2022 including a first-to-market, sensor-enabled dry gas seal digital diagnostics solution and new and improved sealing technologies

The John Crane Sense Turbo uses a unique set of sensors embedded directly into a compressor’s dry gas seal to deliver continuous, real-time insight to identify potential issues and ensure corrective actions are taken to extend the useful life of the seal. By getting insights into the remaining useful life of a mechanical seal, you can improve your asset’s performance, extend the mean time between repair, eliminate unplanned downtime, optimize your maintenance schedule and reduce the costs of repair.



Sense Turbo provides visibility into the health of the dry gas seal so you can have confidence in your compressor reliability.



Type 2874HTC is a noncontact, metal bellows, outward pumping dual pressurized gas lubricated seal.

The Type 2874HTC is a cost-effective alternative to conventional wet contacting seals supported by various piping plans that provide liquid barriers or quenches to the primary seal interface. Instead of using a wet support system, the advantages of non-contacting gas-lubricated technology can be used for reliable operation with either nitrogen, argon, or steam barrier significantly reducing your lifecycle costs.

Reliably sealing high and low-temperature process fluids up to 425°C (800°F), the Type 2874HTC incorporates unique HTC (high-temperature, corrosion-resistant) metal bellows technology with non-contacting gas-lubricated technologies.

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2022 PTE Buyers Guide

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The 2022 *Power Transmission Engineering Buyers Guide* was compiled to provide you with a handy resource containing the contact information for significant suppliers of power transmission components.

ACCESSORIES	34
ACTUATORS	36
ADJUSTABLE SPEED DRIVES	38
BEARINGS	39
BELTING & BELT DRIVES	41
BRAKES	42
CHAIN & CHAIN DRIVES	43
CLUTCHES	46
CONTROLS	47
COUPLINGS & U-JOINTS	49
FLUID POWER	51
GEAR DRIVES	51
GEAR MANUFACTURING SERVICES	54
GEARS	56
INDUSTRIAL HARDWARE AND MACHINE PARTS	59
LINEAR MOTION DEVICES	59
LUBRICATION	60
MOTORS	61
RESOURCES	63
SEALS	63
SENSORS	63
SOFTWARE	64

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Although every effort has been made to ensure that this Buyers Guide is as comprehensive, complete and accurate as possible, some companies may have been inadvertently omitted. If you'd like to add your company to the directory, we welcome you. Please visit powertransmission.com/getlisted.php to fill out a short form with your company information and Buyers Guide categories. These listings will appear online at powertransmission.com, and those listed online will automatically appear in next year's printed Buyers Guide.

Handy Online Resources

The *Power Transmission Engineering Buyers Guide*—The listings printed here are just the basics. Visit our online buyers guide for the most comprehensive directory of suppliers of gears, bearings, motors, clutches, couplings, gear drives and other mechanical power transmission components, broken down into sub-category by type of product manufactured:

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Page 31

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TSS Rotterdam B.V.
www.tssr.nl

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www.tsubaki.ca

Turbo Hydraulic Coupling Co.
www.turbokaplin.com.tr

TVT America, Inc.
www.tvtamerica.com

Twin Spring Coupling LLC
www.twinspringcoupling.com



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www.ustsubaki.com

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Page 7, 36

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unitedgearworks.com

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www.USABorescopes.com

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www.visionqci.com

VL Motion Systems Inc.
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Voith Turbo Inc
voith.com/usa/en

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www.wimberg.com

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www.wajax.com

Warner Linear
www.warnerlinear.com

WD Bearing America
www.wd-bearings.com

 Whitmore
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SEE OUR AD ON
Page 9

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Althen Sensors & Controls
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Page 27

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Page 3

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www.drives.nidec-shimpo.com

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SEE OUR AD ON
Page 5

SEE OUR AD ON
Page 15

SEE OUR AD ON
Inside Back
Cover

SEE OUR AD ON
Page 9

SEE OUR AD ON
Page 33

SEE OUR AD ON
Page 3

SEE OUR AD ON
Page 13

SEE OUR AD ON
Page 27

SEE OUR AD ON
Page 31

SEE OUR AD ON
Page 64

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SEE OUR AD ON
Page 17, 40

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Page 19

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SEE OUR AD ON
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SEE OUR AD ON
Page 13

SEE OUR AD ON
Page 31

SEE OUR AD ON
Page 64

SEE OUR AD ON
Back Cover

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SEE OUR AD ON
Page 7, 36

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SEE OUR AD ON
Page 64

SEE OUR AD ON
Page 15

SEE OUR AD ON
Page 27

SEE OUR AD ON
Page 13

SEE OUR AD ON
Page 31

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SEE OUR AD ON
Page 64

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www.performance-gear.com

 PIC Design
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Plastock - Putnam Precision Molding, Inc.
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Phone: (608) 364-8800
Fax: (608) 364-8816
www.regalrexnord.com

SEE OUR AD ON
Page 19

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www.renebaerag.ch

 Renold Jeffrey
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Ringball Corporation
www.ringball.com

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Rowland Co., The
www.rowlandcompany.com

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www.chssb.com

Sichuan Mighty Machinery Co. Ltd.
www.sc-mighty.com

Silcoms Ltd.
www.silcoms.com/conveyor-chain-division

 SKF USA Inc.
www.skf.com

Snow Nabstedt Power Transmissions Inc
www.snpt.biz

Special Ingranaggi
www.specialinranaggi.com/en

Sprockets Australia Pty. Ltd.
sprocketsoz.com.au

ST Gear & Machine LLC
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SEE OUR AD ON
Page 27

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Torque Transmission
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Transmission Developments Co (GB) Ltd
www.transdev.co.uk

SEE OUR AD ON
Page 31

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Trojon Gear Inc.
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mtimotion.com

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Rolling Motion Industries
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SEE OUR AD ON
Page 7, 36

SEE OUR AD ON
Page 65

SEE OUR AD ON
Page 13

SEE OUR AD ON
Page 31

SEE OUR AD ON
Page 64

SEE OUR AD ON
Page 19

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SBT Gearing Solutions
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Snow Nabstedt Power Transmissions Inc
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SEE OUR AD ON
Page 27



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Page 3

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SEE OUR AD ON
Page 29, 65

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SEE OUR AD ON
Page 5

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Northwest Electric Motor Company
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Ormec
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Parker Hannifin Electronic Motion and Control
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ROSCOE, IL 61073
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peacosupport.com

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 Precipart
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SEE OUR AD ON
Page 31

SEE OUR AD ON
Page 65

SEE OUR AD ON
Back Cover

SEE OUR AD ON
Page 7, 36

SEE OUR AD ON
Page 64

SEE OUR AD ON
Page 9

SEE OUR AD ON
Inside Back
Cover



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SEE OUR AD ON
Page 29, 65

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Page 19

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Page 27

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Page 7, 36

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SEE OUR AD ON
Page 33

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Page 31

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SEE OUR AD ON
Page 19

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SEE OUR AD ON
Page 64

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SEE OUR AD ON
Page 29, 65

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SEE OUR AD ON
Page 15

SEE OUR AD ON
Page 13

SEE OUR AD ON
Page 31

SEE OUR AD ON
Page 5

SEE OUR AD ON
Page 2

SEE OUR AD ON
Page 64

SEE OUR AD ON
Page 19

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 **Triumph Gear Systems**
www.triumphgroup.com

Trojon Gear Inc.
www.trojon-gear.com

Turner Uni-Drive
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TVT America, Inc.
www.tvtamerica.com

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301 E. MARQUARDT DR.
WHEELING, IL 60090
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Fax: (847) 459-9515
www.ustsubaki.com

United Gear Works
unitedgearworks.com

Unlaub
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SEE OUR AD ON
Page 27

SEE OUR AD ON
Page 23, 52

SEE OUR AD ON
Page 65

SEE OUR AD ON
Page 7, 36

Var-Spe Variatori Oleodinamici
www.varspe.com

Varitron Engineering (Taiwan) Co., Ltd
www.c-var.com

Venture Mfg. Co.
www.venturemfgco.com

VL Motion Systems Inc.
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Voith Turbo Inc
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W.M. Berg
www.wmberg.com

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WEG
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WEG Cestari Redutores
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Wittenstein
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WMH Transmissions Ltd
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Phone: 800-808-2131
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 **WPT Power Corporation**
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SEE OUR AD ON
Page 9

SEE OUR AD ON
Page 33

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SEE OUR AD ON
Page 14

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SEE OUR AD ON
Page 69

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SEE OUR AD ON
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SEE OUR AD ON
Page 64

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SEE OUR AD ON
Page 19

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Page 3

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SEE OUR AD ON
Page 10

SEE OUR AD ON
Page 27

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SEE OUR AD ON
Page 64

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SEE OUR AD ON
Page 14

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SEE OUR AD ON
Page 69

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SEE OUR AD ON
Page 5

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Neugart USA Corp
14325 SOUTH LAKES DRIVE
CHARLOTTE, NC 28273
Phone: 980-299-9800
Fax: 980-299-9799
www.neugart.com/en-us

New Allenberry Works (Deepak Industries Ltd.)
www.allenberrygears.com

Nichiei Company, Ltd.
www.nichiei-ind.com/english/index.html

Nidec-Shimpo Corporation
www.drives.nidec-shimpo.com

Niebuhr Gears
www.niebuhr.dk

Nordex, Inc.
426 FEDERAL ROAD
BROOKFIELD, CT 06804
Phone: (203) 775-4877
Fax: (203) 775-6552
www.nordex.com

Northwest Electric Motor Company
northwestmotor.com

Nu-Teck Couplings Pvt. Ltd
www.nuteckcouplings.com

Nuttall Gear (div. of Altra Industrial Motion)
www.nuttallgear.com

Om Engineering Works
www.omengineeringworks.in

Ondrives US Corp.
www.ondrivesus.com

Ontario Gear and Spline
www.ontariogearandspline.com

P. G. DRIVE
www.pgdrive.com

P.T. International Corp. (PTI)
www.ptintl.com

Performance Gear Systems, Inc.
www.performance-gear.com

Perry Technology Corporation
www.perrygear.com

PETOL Gearch
petol.com

PIC Design
www.pic-design.com

Plastock—Putnam Precision Molding, Inc.
www.plastockonline.com

SEE OUR AD ON
Page 12

Portescap
www.portescap.com

Power Electric
www.powerelectric.com

Pragati Transmission Pvt. Ltd.
www.pragatigears.com

Precipart
www.precipart.com

Precision Arrow Gear Co.
www.pagllc.com

Precision Technologies Group (PTG) Ltd.
www.holroyd.com

Prozamet
prozamet.pl

PST Group (Precision Screw Thread)
mtimotion.com

Pulley Manufacturers International Inc.
www.pulleys.com

Pulsgetriebe GmbH & Co. KG
www.pulsgetriebe.com

Qingdao Vanhon Machinery Technology Co. Ltd.
www.vanhmt.com

QTC Metric Gears
www.qtcgears.com

Quality Bearings & Components
www.qbcbearings.com

Radicon Drive Systems, Inc.
us.radicon.com

Rave Gears LLC
www.ravegears.com

RBI Bearing Inc.
www.rbibearing.com

Regal Rexnord
200 STATE STREET
BELOIT, WI 53511
Phone: (608) 364-8800
Fax: (608) 364-8816
www.regalrexnord.com

Reh fuss Drive Solutions GmbH
www.rehfuss.com/en

Reliance Gear Corporation
www.reliancegear.com

Renold
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Ricardo UK Ltd
www.ricardo.com

Riley Gear Corporation
www.rileygear.com

Ringball Corporation
www.ringball.com

Ritbearing Corp.
www.ritbearing.com

Riverside Spline and Gear
www.splineandgear.com

Rj Link International, Inc.
www.rjlink.com

Ronson Gears Pty. Ltd.
www.ronsongears.com.au

Rush Gears Inc.
www.rushgears.com

SBT Gearing Solutions
sbt-gears.co.uk

Schaeffler Group USA Inc.
www.schaeffler.us

Schafer Industries
www.schafergear.com

Shanghai Shine Transmission Machinery Co. Ltd.
www.syptworld.com

Shijiazhuang CAPT Power Transmission Co., Ltd
www.chssb.com

Shivam Autotech Ltd.
www.shivamautotech.com

Shreecon Gear
shreecongear.com

Sichuan Mighty Machinery Co. Ltd.
www.sc-mighty.com

SEE OUR AD ON
Page 31SEE OUR AD ON
Page 2SEE OUR AD ON
Page 19SEE OUR AD ON
Page 64

Sinotech
www.sinotech.com

 SIPCO
www.sipco-mls.com

Siti Spa Riduttori
www.sitiriduttori.it

Six Star
www.sixstar.com.tw

 SKF USA Inc.
www.skf.com

Snow Nabstedt Power Transmissions Inc
www.snpt.biz

Sokhi Heli-Wom Gears Pvt. Ltd.
www.gearboxindia.com

Source Engineering Inc.
www.sei-automation.com

 Southern Gear & Machine
www.southerngear.com

Special Ingranaggi
www.specialingranaggi.com/en

 Spencer Pettus
www.spgear.com

Spiroid Gearing
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ALEXANDRIA, MN 56308
Phone: (320) 762-7133
www.spiroidgearing.com

SEE OUR AD ON
Page 10

SPN Schwaben Praezision
www.spn-hopf.de

Sprockets Australia Pty. Ltd.
sprocketsoz.com.au

ST Gear & Machine LLC
www.stgearandmachine.com

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Page 27

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Suzhou Asia Pacific Metal Co., Ltd.
www.szapmc.com

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Team Industries
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Thyssenkrupp Rothe Erde USA Inc.
www.thyssenkrupp-rotheerde.com

 Tien Yi Gear Works Co., Ltd
www.tienyigear.com.tw

Toledo Gearmotor
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Torque Transmission
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Transply Inc.
www.transply.com

 Triumph Gear Systems
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Trojon Gear Inc.
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Tsubaki of Canada Limited
www.tsubaki.ca

Turner Uni-Drive
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United Gear Works
unitedgearworks.com

Unlaub
www.unlaub.com

VCST LP
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Victrex Gear Solutions
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VW Broaching Service Inc.
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Bearing Engineering Company
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Bearing Headquarters
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Page 64

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Stanley Spring & Stamping Corporation
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Page 27

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AST Bearings
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bearingengineering.com

Bearing Headquarters
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Bearings and Industrial Supply Company, Inc.
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Bosch Rexroth
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Page 29, 65

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Drive Lines Technologies Ltd.
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Duff Norton Australia
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Duff-Norton
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Dunkermotoren USA Inc.
www.dunkermotoren.com

Durabond Slide
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Dynamic Structures and Materials, LLC
www.dynamic-structures.com

Dynatect Manufacturing Inc.
www.dynatect.com

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www.dynexhydraulics.com

Elliott Manufacturing
www.elliottmfg.com

Emerson Industrial Automation - Drives & Motor
www.emerson.com/en-us/automation-solutions

Exlar Actuation Solutions (Curtiss-Wright)
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Festo Corporation
www.festo.com/usa

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Framo Morat Inc.
www.framo-morat.com

H2W Technologies
www.h2wtech.com

Hallmark Industries Inc.
www.hallmarkind.com

Helix Linear Technologies
www.helixlinear.com

Houston Pump and Gear
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HPB Motion Control Co. Ltd.
www.hpb-industry.com

HVH Industrial Solutions
hvhindustrial.com

IAI America, Inc.
www.intelligentactuator.com

IBT Industrial Solutions
www.ibtinc.com

IDA Motion Inc.
www.idamotion.com

IKO International Inc.
www.ikont.com

IMS LLC
www.intermotionsupply.com

Intellidrives, Inc
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ISC Companies
isccompanies.com

K+S Services
www.k-and-s.com

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www.kollmorgen.com

Leeson Electric (div. of Regal Rexnord)
www.leeson.com

 Machinists Inc.
machinistsinc.com

Mavilor Motors, S.a.
www.mavilor.es

Melfast
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Midwest Motion Products, Inc.
www.midwestmotion.com

Mitsubishi Electric Automation, Inc.
us.mitsubishielectric.com/fa/en

Modern Linear Inc.
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Molon Motor and Coil
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MOONS' Industries
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1605 ALTON RD.
BIRMINGHAM, AL 35210
Phone: (800) 526-9328
Fax: (205) 957-5290
www.motionindustries.com

Nichiei Company, Ltd.
www.nichiei-ind.com/english/index.html



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SEE OUR AD ON
Page 64

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northwestmotor.com

Novotec Argentina SRL
www.novotecargentina.com

NSK Corporation
www.nskamericas.com/en/industries/industrial/power-transmission.html

Ormec
www.ormec.com

Orttech
www.orttech.com

Parker Hannifin Electronic Motion and Control
www.parker.com/ssdusa

PBC Linear
6402 E. ROCKTON ROAD
ROSCOE, IL 61073
Phone: (815) 389-5600
www.pbclinear.com

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peacosupport.com



Performance Gear Systems, Inc.
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www.pi-usa.us



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Portescap
www.portescap.com

Power Electric
www.powerelectric.com



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Precision Technologies Group (PTG) Ltd.
www.holroyd.com

PST Group (Precision Screw Thread)
mtimotion.com

Rex Engineering Corp.
www.rex-engineering.com

RGW Sales Canada
www.rgwsalescanada.com

Ringball Corporation
www.ringball.com

Rockwell Automation
www.rockwellautomation.com

Roton Products
www.rotom.com

Rowland Co., The
www.rowlandcompany.com

Schaeffler Group USA Inc.
www.schaeffler.us

Sensata Technologies
www.sensata.com

Serapid Inc.
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Sesame Motor Corp.
www.sesamemotor.com.tw



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Inside Back
Cover

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www.siemens.com/us/en.html



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Page 31

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www.sdp-si.com

SEE OUR AD ON
Page 27

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www.stoffelpolygon.com

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www.tawinc.com

TDK InvenSense
www.invensense.com

Technico
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Tecnotion BV
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TelcoMotion
9812 WHITHORN DR.
HOUSTON, TX 77095
Phone: (281) 855-2218
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www.telcointercon.com/brand/telcogear

SEE OUR AD ON
Page 65

Therm-X
www.therm-x.com

Thomson Industries Inc.
www.thomsonlinear.com

Tolomatic, Inc.
www.tolomatic.com

Transmission Developments Co (GB) Ltd
www.transdev.co.uk

TVT America, Inc.
www.tvtamerica.com

Venture Mfg. Co.
www.venturermfgco.com

VL Motion Systems Inc.
www.vlmotion.com

W.M. Berg
www.wmberg.com

Wajax
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Warner Linear
www.warnerlinear.com

WEG
www.weg.net

Whittet-Higgins Company
whittet-higgins.com

Wittenstein
www.wittenstein-us.com

WMH Transmissions Ltd
www.wmh-trans.co.uk

Yaskawa America, Inc.
www.yaskawa.com

LUBRICATION

Acorn Industrial Services Ltd.
www.acorn-ind.co.uk

Affiliated Distributors
www.adhq.com

AIMS Industrial Supplies
www.aimsindustrial.com.au

American Chemical Technologies, Inc.
www.americanchemtech.com

Atlanta Drive Systems Inc.
www.atlantadrives.com

Avalon International Corp.
www.avalongateway.com

BDI - Bearing Distributors Inc.
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Bearing Service Company
www.bearing-service.com

Bearings and Industrial Supply Company, Inc.
www.bearingsnow.com

Bibby Turboflex
www.bibbyturboflex.com

BK Power Systems - An Integrated Corrosion Co.
www.bkpowersystems.com

Checkfluid
www.checkfluid.com

Chesterton
chestertonlubricants.chesterton.com/en-us

Cortec Corporation
www.cortecvci.com

Dalton Bearing Service, Inc.
www.daltonbearing.com

Daubert Cromwell LLC
www.daubertcromwell.com

Elkem Silicones
www.silicones.elkem.com

 Evolvent Design
evolventdesign.com

Extreme Industrial Lubricants
www.extremelubricants.com

Filter Pumper/Hydraulic Problems, Inc.
www.filterpumper.com

G.L. Huyett
www.huyett.com

 GearTec
www.geartec.com

 Gleason Plastic Gears
www.gleason.com

Helix Linear Technologies
www.helixlinear.com

HVH Industrial Solutions
hvhindustrial.com

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Integrated Components Inc.
www.integratedcomponentsinc.com

ISC Companies
isccompanies.com

IseI Inc.
iselinc.com

Kluber Lubrication North America L.P.
www.kluber.com

Kyodo Yushi USA Inc.
www.kyodoyushi.co.jp/english/

 Lovejoy, Inc. (A Timken Brand)
www.lovejoy-inc.com

Lubricant Store
thelubricantstore.com

Lubriplate Lubricants Co.
www.lubriplate.com

Malloy Electric
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Microsurface Corporation
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 SKF USA Inc.
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SEE OUR AD ON
Page 3

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abm-drives.us

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Inside Front
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Page 29, 65

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Page 5SEE OUR AD ON
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Page 31

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When a right angle gearbox is subjected to a higher torque or horsepower load than its rating, the overload situation will eventually shorten its lifetime. If the overload is mild in severity, the gearbox may operate normally for some period before the increased wear makes replacement necessary.

When your equipment calls for a right angle gearbox, proper sizing makes a difference. A wide range of application factors must be considered, or you will face problems down the road. Possible problems can include increased maintenance, worn teeth and reduced mean time between failure (MTBF). Additionally, an oversized gearbox will cost more money than necessary. This article will provide an overview of how to apply application information to accurately size an Andantex Anglgear right angle gearbox for your installation.

Determine Your Target Speed and Output Torque

To begin sizing, determine the horsepower or torque that must be transmitted in the application. Next, you must consider how fast the output shaft will turn to meet your

requirements. Additionally, we must consider both the axial and radial loads applied to the gearbox shafts.

As power and torque requirements increase, the gear set diameter will also increase to transmit the larger forces. As the gearset grows in diameter, the gearbox housing must grow to accommodate the larger gears. Knowing the power and speed, you can always calculate the torque. Or, by knowing the torque and speed, you can calculate the power. The formulae for determining torque and horsepower are shown in Table 1. The axial and radial load ratings can be found in Table 2.

When a right angle gearbox is subjected to a higher torque or horsepower load than its rating, the overload situation will eventually shorten its lifetime. If the overload is mild in severity, the gearbox may operate normally for

some period before the increased wear makes replacement necessary. Severe overloading can result in damaged bearings, broken gear teeth or both. When the axial or radial load ratings are exceeded, it will shorten the life of the bearing thus reducing the between-gearbox replacement. Therefore, some gearbox specifiers may be tempted to size the gearbox to the drive motor, resulting in an oversized gearbox.

For example, if the application requires ¾ hp, a motor manufacturer may recommend a 1 hp motor. When it's time to select the gearbox, the customer may in turn be inclined to select the appropriate gearbox for 1 hp, which may be a unit rated for 1½ hp. The gearbox will be capable of transmitting much greater torque than required, but it will come with a higher price tag, size and weight. That's why it's important to determine your gearbox's service factor requirements.

Understand Service Factor

Gearbox manufacturers typically publish charts that account for the working conditions the gearbox is expected to withstand such as hours of service per day and the type of load—uniform and moderate shock. Service factors for Anglgear right angle gearboxes are shown in Table 1. Note that high-shock or impact loads can prematurely damage gear teeth and bearings. If you expect the application to impose non-uniform loads on a gearbox, be sure to consult the manufacturer to determine the appropriate service factor that will account for those loads.

SERVICE FACTORS

OPERATION CONDITIONS	UNIFORM LOAD	MODERATE SHOCK	
SERVICE (hours/day)	3	0.7	0.9
	8	0.9	1
	12	1	1.3
	24	1.3	1.8

$$T \text{ (in.lb)} = 63,000 \times \text{HP} / \text{RPM}$$

$$\text{HP} = T \times \text{RPM} / 63,000$$

Table 1—Service factors for Anglgear right angle gearboxes.

Step by Step: How to Size an Anglgear Right Angle Gearbox

1. Determine the output speed and torque required for your application. The maximum recommended output speed for Anglgear right angle gearboxes is 3,000 rpm for 1:1 units and 1,500 rpm for 2:1 units. Note: 2:1 units are *not* recommended for use as speed increasers.

2. Select an application service factor from Table 1. Multiply your torque by the selected service factor.
3. Using Table 2, find your output speed in the left column. If you do not see your output speed, use the next highest speed. Depending on the ratio you require—1:1 or 2:1—follow the chart across until you find a torque value that is larger than your corrected torque value.
4. The unit size for your application will be at the top of that column. Anglgear comes in five sizes, and the bottom of the column lists the various models available for the selected size. Select the model number based on the gear ratio and the number of shafts you need—two or three. When ordering, use the model number you selected along with the desired ratio.

OUTPUT SPEED (RPM)	SIZE 1		SIZE 2		SIZE 3		SIZE 4		SIZE 5	
	1:1	2:1	1:1	2:1	1:1	2:1	1:1	2:1	1:1	2:1
RATINGS*	in.lb	HP	in.lb	HP	in.lb	HP	in.lb	HP	in.lb	HP
50	17	0.01	10	0.01	51	0.04	32	0.03	229	0.18
100	16	0.03	10	0.02	49	0.08	30	0.05	215	0.34
200	15	0.05	9	0.03	46	0.15	28	0.09	207	0.66
300	15	0.07	9	0.04	47	0.23	27	0.13	205	0.98
400	14	0.09	8	0.05	47	0.30	26	0.17	203	1.29
500	14	0.11	8	0.06	46	0.37	25	0.20	200	1.59
750	13	0.15	8	0.09	46	0.54	24	0.29	196	2.34
1000	13	0.20	8	0.12	45	0.71	23	0.37	193	3.06
1250	13	0.25	7	0.14	44	0.88	23	0.45	190	3.77
1500	13	0.30	7	0.17	44	1.05	23	0.54	187	4.45
1750	12	0.34			43	1.21			185	5.14
2000	12	0.39			43	1.37			183	5.80
2500	12	0.48			42	1.68			179	7.11
3000	12	0.57			42	1.99			176	8.39
2-WAY	R3000	R3000-2	R3200	R3200-2	R3300	R3300-2	R3400	R3400-2	R3570	R3590
3-WAY	R3100	R3100-2	R3300	R3300-2	R3500	R3500-2	R3600	R3600-2	R3750	R3900
2-WAY	R3003	R3003-2	R3203	R3203-2	R3303	R3303-2				
3-WAY	R3103	R3103-2	R3303	R3303-2						
MODEL DATA (lbs)	R3000	R3100	R3200	R3300	R3330	R3350	R3400	R3500	R3570	R3590
1:1	2.1	1.1	2.1	1.1	2.1	1.1	2.1	1.1	2.1	1.1
2:1	2.1	1.1	2.1	1.1	2.1	1.1	2.1	1.1	2.1	1.1
RADIAL LOAD	25	25	25	25	50	50	50	100	100	100
THRUST LOAD	50	50	50	50	100	100	100	200	200	200
WEIGHT	0.5	0.5	0.5	0.5	2.2	2.2	2.4	2.4	8.7	8.7
	9.0	9.0	9.0	9.0	14.5	14.5	15	15	17.5	18

Table 2—Andantex Anglgear selection chart: Note the unit ratings output torque (in.lb) and outpower power (hp).

5. Check the applied radial and thrust loads on the unit compared with the loads in Table 2. If the applied loads are larger than the chart values, select a larger unit.

Andantex Anglgear right angle gearboxes are available in both imperial and metric versions, and each appear in separate sections of our catalog. When ordering, keep in mind that the versions are not interchangeable. Shaft diameters are available in either imperial or metric measurements, and the housings are also measured to each system.

When to Size Up

Although it's important to avoid oversizing a gearbox, there are times that specifiers may have to go up in size.

Overhung loads

Failure to address an overhung load could result in reduced bearing life and possibly misaligned gears that may cause the gear teeth to deteriorate. If you anticipate an overhung

load, manufacturers publish an acceptable overhung load value for a specific gearbox size. If your overhung load exceeds that value, the manufacturer typically recommends the next size up.

Shafts

Anglgear gearboxes are available with output shafts. If the size is smaller than the application's size requirements, consider a larger size or work with your manufacturer to create a custom gearbox. Andantex specializes in creating custom gearboxes, and we can design or modify units with special shaft lengths and configurations.

Applied loads

As mentioned previously, if applied load values are larger than those in the manufacturer's chart, move up to a size that can accommodate them. Be sure to consider how the gearbox will be coupled to the application. Whether coupled directly or via a belt or chain drive, your coupling method is critical to calculate the radial loads your gearbox will handle.

Environment, Construction and Other Considerations

In addition to applying power, torque, and load factors to determine the size of your gearbox during selection, you must also consider aspects pertaining to the unit's operating environment and construction. For example, aluminum housings are standard for Anglgear gearboxes. However, aluminum is not always optimal under certain conditions, such as when corrosive chemicals are present.

Food and beverage environments can also be tough on gearbox housings. They will be subjected to frequent wash-downs and harsh chemicals. For these environments, Andantex offers Anglgear "specials"—units customized with hard anodized coatings, nickel-plated aluminum housings and epoxy-painted housings with the appropriate shaft seals. Larger versions of Anglgear come with carbon steel shafts, so be sure to consult with us for units subject to wet or corrosive conditions.

Other considerations include:

- High temperature: Be sure to bring high-temperature environments to the manufacturer's attention.
- Backlash: For reversing and positioning applications, consider a modified gearbox or one that is configured to ensure zero backlash.
- Special greases and coatings for applications in vacuum, high heat, and food environments: Your gearbox manufacturer can provide sizing assistance for these applications.
- Hand operation: Sometimes engineers specify a smaller gearbox for hand-operated systems, without considering that a human can apply more force than the gearbox can tolerate without protection.

Consider A Special Design

Although sizing a right angle gearbox is a straightforward process when applying your power and torque requirements, there may be times when you will need help from your gearbox manufacturer. Andantex works closely with customers, and if a standard unit doesn't fit the requirements, we have the technical means to modify a gearbox or create "special" designs. Examples include:

- Non-standard sizes including various shaft lengths and configurations.
- Changing the relative rotation of input-to-output shafts (BO).
- Three-way units with counter-rotating output shafts.
- Shafts with flats, splines, holes and hexagonal outputs.
- Modifications to the mounting flanges and housing.
- Special materials, bearings, seals, greases and coatings.

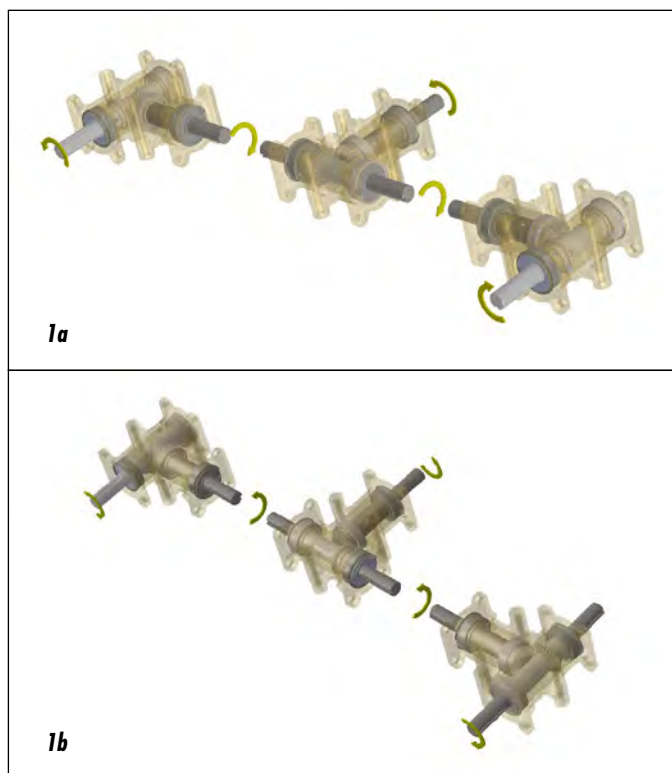


Figure 1a and 1b—Anglgear gearboxes can be outfitted with opposite-rotation input-to-output shafts (a) or the same rotation of input-to-output shafts (b).

Remember All Your Application Factors

When sizing a right angle gearbox, it can be tempting to specify a size according to the drive motor size. However, many factors must be considered to deliver optimal performance and reliability without costly oversizing. Be sure to bring as much application information into the selection process as possible and carefully consider all the factors presented above. By doing so, you'll correctly size a gearbox to match your needs.

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Determination of the Longitudinal Load Distribution of Planetary Stages

Benjamin Abert, FVA GmbH

The goal of increasing the power density of a gear unit demands that extraneous material reserves can be detected and reduced to the necessary level. In this context, it is important to know the influences acting on the gear unit and the resulting loads. Precise knowledge of the longitudinal load distribution in the gear meshes during operation, and specification of suitable microgeometries for its optimization, play a decisive role.

In the following, the example of a planetary cylindrical gear unit from the FVA Nacelle Research Project (Ref. 1), as typically used in wind turbines with an output up to 1.5 MW, will be used to demonstrate the realistic determination of the longitudinal load distribution in the planetary stages and calculation of the required face modifications with the *FVA-Workbench*. In doing so, the influence of the stiffness of the planet carrier will be quantified and taken into consideration.

Calculation of the longitudinal load distribution of planetary stages

The longitudinal load distribution of a planetary stage is primarily determined by the following influencing factors: torsional deformation of the sun gear, deflection of the planet pins, twisting of the planet webs (for dual-plate planet carriers), and deflections and clearances of the planetary bearings (especially with helical gears).

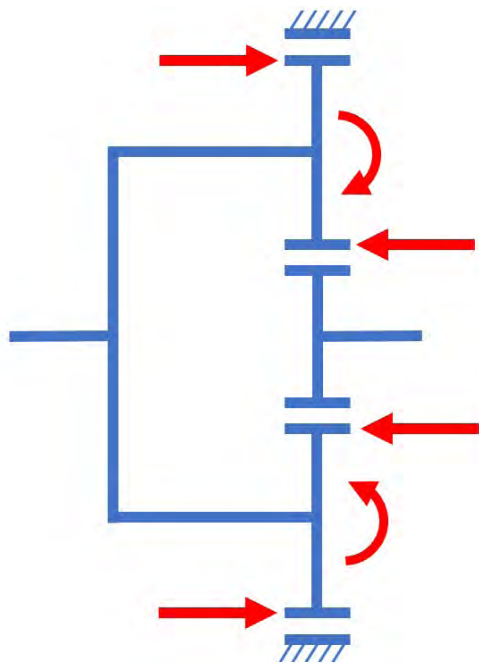


Figure 1 — Tilting of the planet gear.

The torsional deformation can be effectively calculated with the formulas specified in the standards. Likewise, the bending deformation of the planet pin can also be effectively estimated. These two deformation types make up the primary influences on the longitudinal load distribution in simplified calculation processes, which are largely based on the methods described in the load capacity standards.

However, the deformation behavior of the planet carrier cannot be described with sufficient accuracy using these simplified formulas. The Finite Element Method must be applied to obtain realistic results.

Furthermore, with helical planetary gears, the opposing axial forces in the sun-planet and planet-ring gear meshes lead to tilting of the planets within the elastic bearing deflections and the radial clearances of the planetary bearings. Once again, there are no formulas in the standards for detailed estimation of these amounts based on the bearing geometry and the load distribution in the bearing.

Consideration of planet carrier deformation in the FVA-Workbench

There are four different options in the *FVA-Workbench* for considering the planet carrier deformation:

Option 1: The webs of the planet carrier are simplified as torsionally stiff solid discs. For dual-plate planet carriers, the torque is transferred between the two webs via the bolts. An additional torsional stiffness between the webs can also be specified if it is available from measurements or external calculations.

Option 2: The planet carrier is modeled in the *FVA-Workbench* by approximating the webs and bolts as solid discs and shafts, respectively. For dual-plate planet carriers, different strut shapes between the two webs can also be defined. This geometry is automatically meshed within the *FVA-Workbench*, and the planet carrier deformation is then calculated with the Finite Element Solver (Ref. 2).

Option 3: If a fully designed planet carrier is available as a CAD file, it can be loaded in the *FVA-Workbench*. Here, too, the meshing is automated with subsequent calculation of the deformation using the FE method. Figure 2 shows an example of a deformed planet carrier and the resulting deflection of the planet pins.

Option 4: If the planet carrier deformation has already been calculated externally, the determined deformation behavior can be considered in the *FVA-Workbench* by importing a reduced stiffness matrix in Harwell-Boeing format.

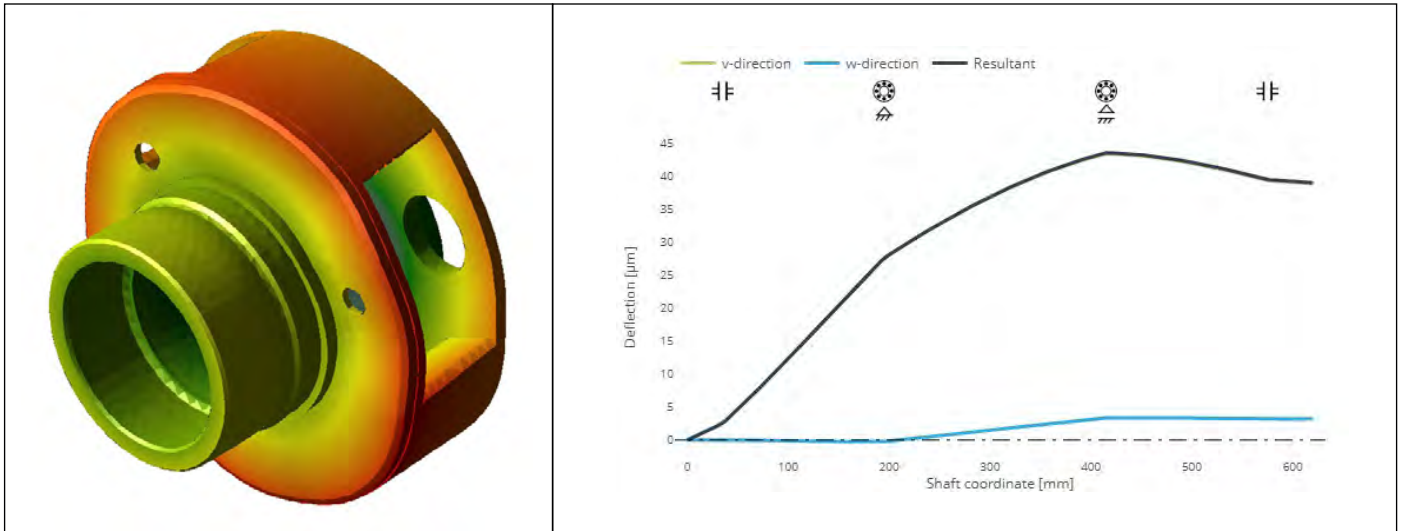


Figure 2—Deformed planet carrier (left) and planet pin deflection (right).

The accuracy of the results of the component calculations using the FE method greatly depends on the selection of suitable boundary conditions and the meshing. In the *FVA-Workbench*, the meshing of the component and definition of the coupling points is largely automated (one-click FEM method) and is adapted to the specific gearbox components to be calculated. Components are loaded and positioned in the 3D Model, with the system providing user guidance for support. This method ensures that reliable and reproducible results can be achieved, even without special FE knowledge.

Calculation of rolling bearing stiffness and operating clearance in the FVA-Workbench

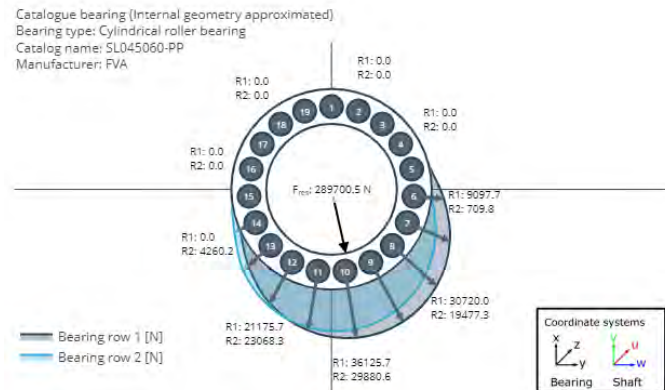


Figure 3—Load distribution in a planetary bearing.

In the *FVA-Workbench*, the stiffness and operating clearance of rolling bearings are calculated using methods developed in FVA research projects (Refs. 3, 4). These are based on detailed analysis of the contact between the rolling elements and the bearing rings. As part of these research projects, the methods were validated by test stand experiments and by comparing the results to those of the bearing manufacturers.

Calculation example

Below, the gearbox model from the FVA Nacelle Research Project (Ref. 1) is used to demonstrate the importance of a detailed deformation analysis for calculation of the longitudinal load distribution and the design of face modifications for planetary gears.

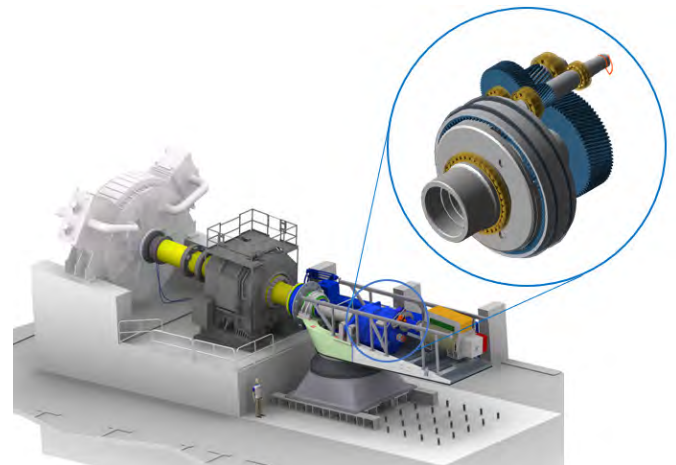
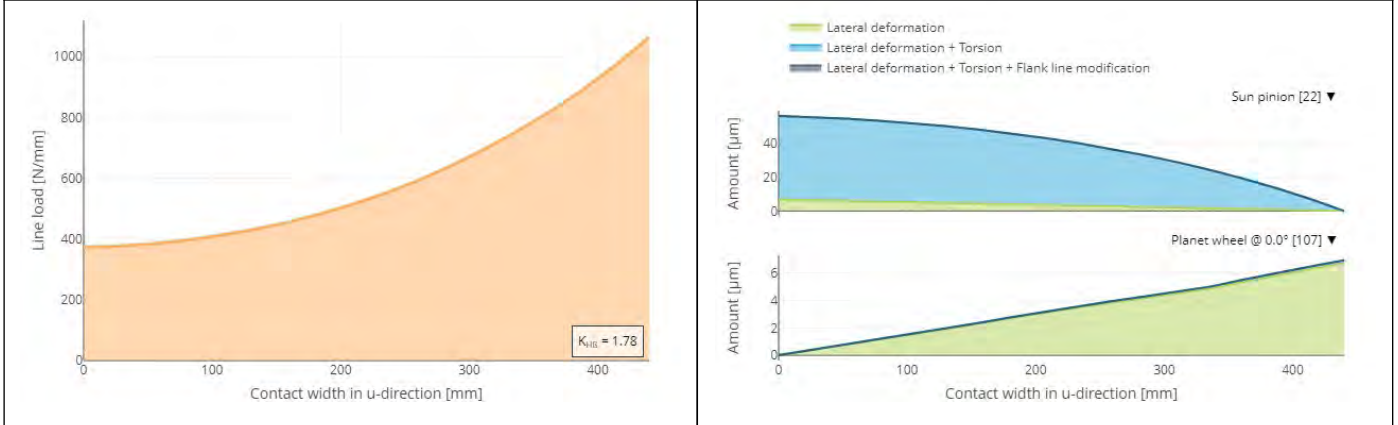


Figure 4—FVA Nacelle Research Project (Ref. 1) test stand setup and FVA-Workbench gear model.

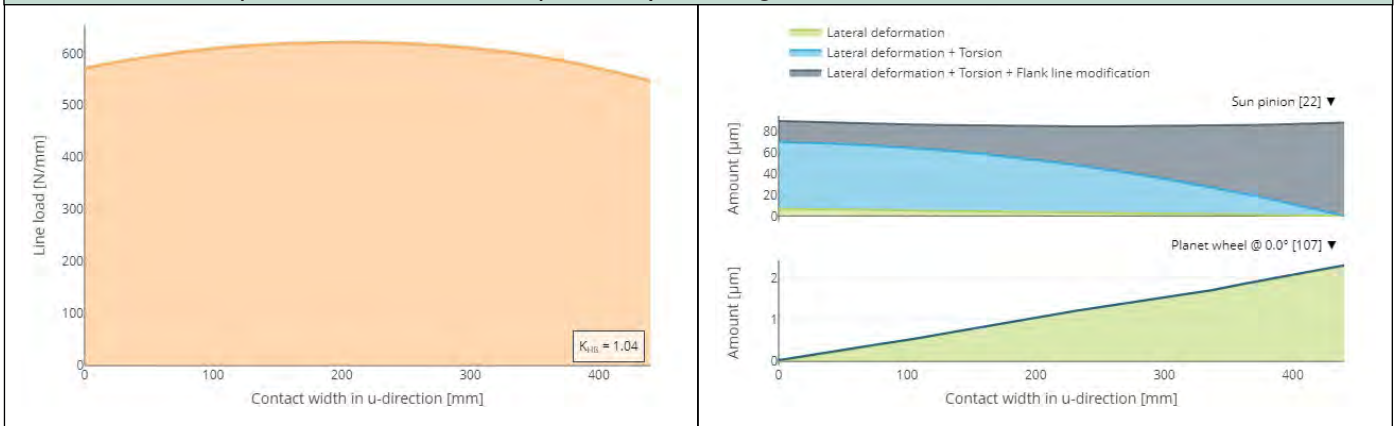
Figure 5 compares the longitudinal load distribution of the planetary stage in the sun-planet mesh for three different calculation variants:

Variante 1: Here, the longitudinal load distribution is shown based on a simplified calculation, without consideration of the deformation of the planet carrier and deflection of the planetary bearings, as is still often used in simplified methods. In the *FVA-Workbench*, the torsional stiffness of the planet carrier and the radial stiffness of the planetary bearings can be set to a very high value. The torsional deformation of the sun gear (blue area) is dominant compared to the tilting of the planets (green area). This method produces a calculated overload at the generator-side end of the gear.

Variant 1 – stiff planet carrier and stiff planetary bearings



Variant 2 – stiff planet carrier and stiff planetary bearings with flank modification



Variant 3 – elastic planet carrier and planetary bearings with flank modification from Variant 2

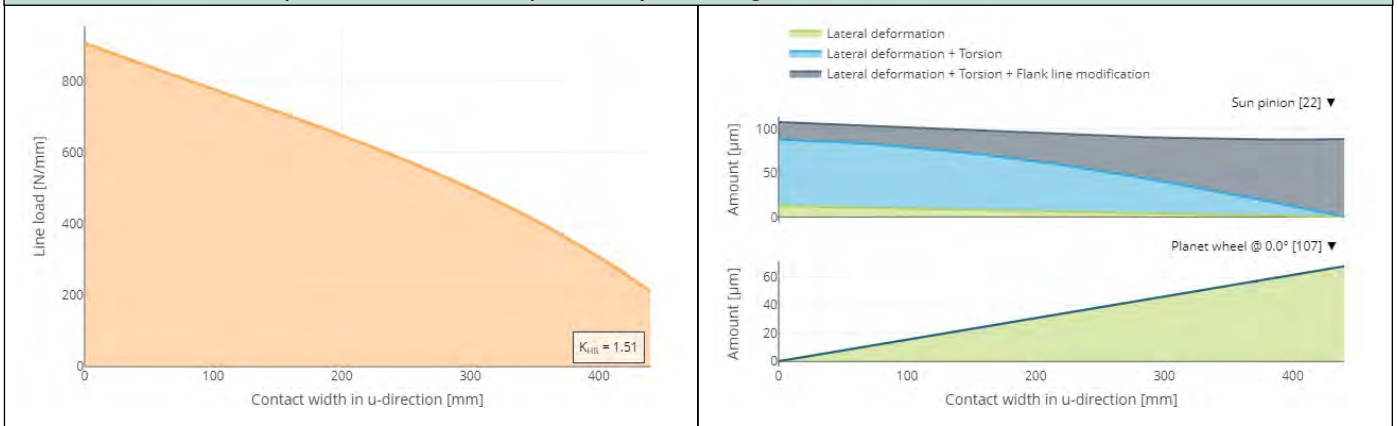


Figure 5—Sun-planet mesh load distribution (left) and deformation amounts along the face width (right).

Variante 2: An additional face modification in the form of a helix angle modification with symmetrical crowning is considered in this calculation. This face modification is designed to produce a uniform load distribution when combined with the deformations from the simplified calculation in Variant 1.

Variante 3: This longitudinal load distribution is the result of the detailed calculation of the deformations of the planet carrier and the planetary bearings, which are to be compensated by the flank modifications determined from the simplified calculation. In this case, the greater tilting of the

planet gear leads to a local overload on the rotor-side end of the gear.

For planetary stages in which a gear modification that was designed using simplified methods is combined with low material reserves, damage patterns may occur with large pitting areas on the rotor-side end of the sun gear. Figure 6 shows an example of such a damage pattern, which can be attributed to a local overload, on a sun gear shaft from the main gearbox of a wind turbine in the 1.5 MW class, like the calculation model used.

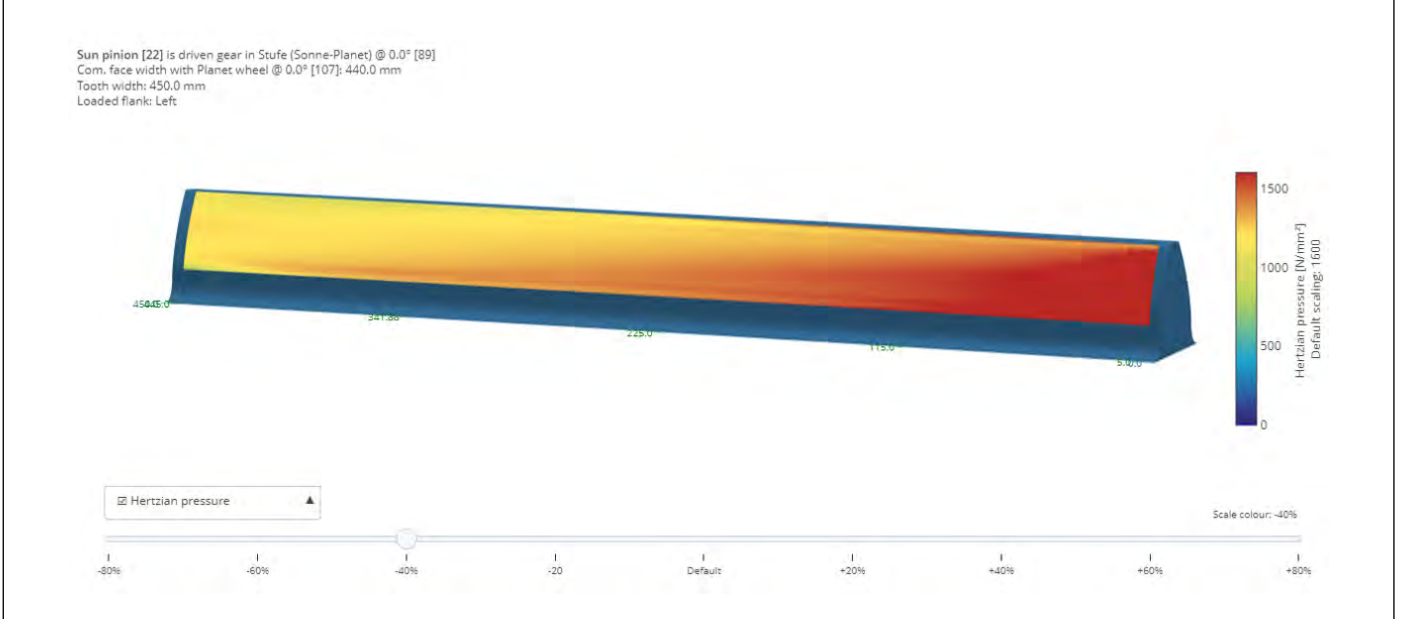


Figure 6 — Practical example of a damaged sun gear (top); 3D pressure distribution, Variant 3 (bottom).

Conclusion

The *FVA-Workbench* makes it easy to consider all relevant influencing factors in the design of gear modifications for planetary stages. This allows for weight- and cost-efficient design while also ensuring high operational stability. **PTE**

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4. FVA Research Project 909—Rolling Bearing Calculation Transfer.



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Kurt Hydraulics and Dayco

REACH AGREEMENT ON HYDRAULIC HOSES AND COUPLING INVENTORY



Kurt Hydraulics and Dayco have reached an agreement for all Dayco-branded hydraulic hose and coupling inventory to be transferred to Kurt Hydraulics. Dayco North America will be exiting the hydraulics category and Kurt will take over manufacture and supply directly to all Dayco distributors.

Scott Czupryna, national sales manager for Kurt Hydraulics, announced the agreement with Dayco. "As a long-time partner to Dayco's hydraulic coupling business our hose and couplings are interchangeable with Dayco's product line and have a part match in the Kurt catalog and website. Kurt Hydraulics has been manufacturing hydraulic fittings for Dayco for over 20 years, and has its own distribution network, so the transition is a natural one for us."

Kurt Hydraulics will be able to provide a greatly expanded product offering for previous Dayco distributors with a complete line of hose, fittings, and crimpers. Kurt has over 3,000 available items, including braided, spiral, marine, thermoplastic, and specialty hoses. Kurt Hydraulic fittings are manufactured in the USA with more than 2,500 styles and sizes that include bite the wire, compression, reusable and ultra-high pressure hydraulic fittings. All Kurt Hydraulic fittings and hose are tested beyond SAE specifications and our fittings are ROHS compliant.

Kurt Hydraulics is in the process of creating individual accounts for Dayco customers and providing notice to those customers. Additionally, Kurt is setting up a warehouse in Canada to better service Canadian distributors. Kurt's dedicated customer service team and engineering support are on call Monday through Friday.

kurthydraulics.com

Universal Robots

OFFERS SHORT LEAD TIMES TO MEET TAX DEDUCTION DEADLINES



Facing unprecedented low unemployment figures, manufacturers of all sizes are struggling to fill repetitive and undesirable manufacturing jobs. With the help of the Section 179 tax deduction, US businesses may be able to significantly stretch their use-it-or-lose-it 2022 budgets and purchase collaborative robots to take on the repetitive manufacturing tasks that workers don't want. Section 179 requires that qualified equipment and off-the-shelf software is purchased and placed into service by December 31, 2022, but with its unique two-week ship program, Universal Robots (UR) can make that happen.

"Manufacturers simply can't staff positions to meet their production demands, and many can't turn to traditional automation, which is too expensive and complex, especially for small and mid-sized businesses," says Joe Campbell, senior manager of applications development and strategic marketing at Universal Robots. "UR cobots are cost-effective and easy to implement, and with the Section 179 tax deduction they can be even more affordable. Businesses should consult their tax

expert right away to see if they can take advantage of this opportunity, and we'll do our part to help them meet eligibility requirements."

Universal Robots successfully navigating supply chain landscape

The strain placed on global supply chains this year continues to make headlines, from semiconductor shortages to labor and equipment availability, all exacerbated by geopolitical uncertainty. Despite these headwinds, Universal Robots has seen significant growth in production while fulfilling its production plan; One cobot is typically comprised of around 600 different parts, sourced from more than 100 separate suppliers.

The 150-person production team at Universal Robots are all involved in getting a cobot made on time, many specifically tasked with overcoming supply chain issues; dual or even triple sourcing parts, including team members travelling to component suppliers to oversee the finalizing and shipping of crucial components. "Collaboration and communication have been key, with the team speaking to primary suppliers on at least a daily basis," said Vice President for Operations and Supply Chain, Anders Lassen, adding "The emphasis is on keeping everyone aligned to the shared goal—namely, the timely delivery of cobots to our customers."

universal-robots.com

Solve

SELECTS CHARLOTTE FOR NEW DISTRIBUTION CENTER



Solve Industrial Motion Group (Solve) has officially signed a lease for a 282,134-square-foot, state-of-the-art distribution center in Charlotte.



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The AGMA Gear Industry News contains curated news items from around the Internet on topics affecting the power transmission industry, including electric vehicles, alternative energy, robotics, emerging technologies—and the companies influencing the gear industry of tomorrow.

powertransmission.com/getnews

Located on Westinghouse Boulevard, the new facility is roughly two miles west of the company's current warehouse with easy access to I-77, I-85, the Charlotte Inland Port, and the Port of Charleston. Solve is collaborating with Beacon Partners for site development. Construction is slated to begin in 2022 with the complete build-out scheduled for 2023.

The new space has more than 200,000 additional square feet than Solve's current facility, where it's been since the early 1990s. In addition to supporting the company's growth, the new space will allow for expanded engineering and quality control capabilities, flexible shipping and receiving areas, and designated product customization stations.

After an extensive evaluation of multiple potential locations in North and South Carolina, Charlotte was selected for the company's anchor facility. The project was a coordinated effort between Solve, the City of Charlotte, Mecklenburg County, and Beacon Partners. Charlotte was chosen for its central location and capability of providing next day service to all the southeast.

"Charlotte represents a strategic expansion of our network while reinforcing our position as the most trusted and knowledgeable source for bearings and power transmission products," said Lisa Mitchell, CEO of Solve. "The search was challenging, but it accommodates our future growth and our commitment to having the right inventory in the right location to best serve our customers."

solve-industrial.com

LEGO Group

ANNOUNCES ONLINE CAMPAIGN TO NURTURE STEAM ACTIVITIES FOR GIRLS

The LEGO Group marked International Day of the Girl on October 11th with a new campaign to encourage girls to stay curious about STEAM subjects and careers. New and sobering statistics from the Geena Davis Institute on Gender in Media and the LEGO Group show girls are

still discouraged from STEAM fields from a young age when play is often gender stereotyped.

For example, one statistic in the "Geena Davis Institute LEGO Creativity Study" shows 80 percent of boys are encouraged to code at a young age, compared with only 20 percent of girls. Furthermore, when asked, children as young as six think girls don't like science. These misconceptions extend into the teen years and adulthood and contribute to the gender gap within STEAM related careers.

To help combat these misconceptions, the LEGO Group is launching an online campaign called 'Let's Keep them Curious!' that includes five STEAM play activities which aim to inspire parents to continue to nurture girls' interests in STEAM by exploring fun LEGO brick challenges.

"We know that girls and women excel in STEAM when they set their minds to it. Today half of the participants of the FIRST LEGO League robotics competition are girls. But they are still under-represented in STEAM careers because from a young age they can be encouraged to explore other interests. We want to change that mindset for future generations—so the world can benefit from having more girls in STEAM." said Carolina Teixeira, global brand marketing director, purpose and inclusion, the LEGO Group.

The LEGO Play Well Study 2022 found that most parents believe their child, regardless of gender, can do any job they

want (88 percent), but that there is a self-perpetuating cycle within STEAM play. Because mothers are less likely to have been encouraged to follow a career in STEM than fathers (54 vs 69 percent) they consequently become less likely to encourage their own children to work in STEM (69 vs 78 percent).

"Closing the gender gap within STEAM careers starts with closing the gender gap within STEAM play. The LEGO Foundation believes that all children have the right to learn and play—as a vehicle to unleash creative potential and build vital skills—essential for the future workforce." outlines Ida Thyregod, Team Leader for Strategic Partnerships at the LEGO Foundation.

Beyond STEAM activities, the LEGO Group is also committed to unlocking girls' access to education opportunities by donating \$120,000 to the Girls Opportunity Alliance, a program of the Obama Foundation, in support of their efforts to help adolescent girls and the grassroots leaders working to educate them.

"We are thrilled that the LEGO Group has joined our alliance of partners who are united in our efforts to ensure all girls are empowered with the resources they need to achieve their dreams," said Tiffany Drake, vice president and executive director of the Girls Opportunity Alliance. "We know that when you educate girls, our entire world benefits."

lego.com/da-dk/categories/stem/girls-in-stem



January 24-26—TIPE 2023

For its third edition, the virtual trade fair TIPE 2023 (Technology, Industry, People, Economics) curates, once again, an inspirational all-women agenda of speakers and panelists. The first of its kind, the TIPE conference addresses all facets of additive manufacturing including the latest innovations, industry applications, and the economics behind the technology. This is made possible through the lens, expertise, and experience of underrepresented genders. The conference is a Women in 3D Printing event, co-produced with SME, and welcomes all genders to attend. powertransmission.com/events/928-tipe-2023

January 24-26—IPPE 2023

The International Production & Processing Expo (Atlanta) is the world's largest annual poultry, meat, and feed industry event of its kind. A wide range of international decision-makers attend this annual event to network and become informed on the latest technological developments and issues facing the industry. Previous shows featured more than 8,018 international visitors from over 129 countries. Mexico and Latin American/Caribbean countries represent the largest region of international visitors, but there has been continued growth in numbers coming from Europe. Canada represents the largest single country outside the United States with regards to number of attendees. powertransmission.com/events/923-ippe-2023

February 21-23—PowerGen International 2023



PowerGen is the largest network and business hub for electricity generators and solution providers engaged in power generation. Power producers, utilities, EPCs, consultants, OEMs, and large-scale energy users gather at PowerGen International (Orlando, Florida) to discover new solutions as large, centralized power generation business models evolve into cleaner and more sustainable energy sources. This year-round platform of digital education, current and breaking industry news, thought leadership articles, quality matched meetings, and industry-leading live events provide a hub for power generation professionals to learn and network.

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

February 21-23—Houstex 2023

SME's Manufacturing Technology Series in Houston, Texas brings together key decision makers, major tool and tech-



nology suppliers and thought leaders from across a broad spectrum of manufacturing disciplines. Hands-on equipment demonstrations, keynotes and panel discussions, emerging manufacturing technology showcases and networking activities offer attendees an opportunity to learn about the latest manufacturing trends. Regional industries include oil and gas, aerospace, automotive, transportation, energy, military, plastics, research and development and more. Houstex is an interactive experience, dedicated to showcasing advanced technologies and processes that help manufacturers innovate and create industry transformation. Houstex features hundreds of exhibits highlighting the latest products and services designed to help manufacturers develop their pathway to success. powertransmission.com/events/927-houstex-2023

March 14-18—IFPE 2023



IFPE, the International Fluid Power Exposition, is the leading North American exhibition bringing together the fluid power, power transmission and motion control industries. IFPE is colocated with CONEXPO-CON/AGG, held at the Las Vegas Convention Center. IFPE is where fluid power professionals meet to discover highly engineered solutions for improving mobile and industrial equipment's efficiency, performance, and sustainability. Attendees will also learn about the latest technology available to the industry and network to discuss and combat the most pressing industrial challenges. From sensor technology and data analytics to robotics, custom software development, and industrial automation, attendees will experience the latest innovations in fluid power. powertransmission.com/events/906-ifpe-2023



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Wind of Change

The “electrify everything” movement continues to drive innovation

Aaron Fagan, Senior Editor

The phrase “electrify everything” refers to the movement to replace our fossil-fuel economy with wind, solar, hydro, electric vehicles, heat pumps, and a robust electric grid that allows a two-way transfer of energy. Where wind energy is concerned, the drivetrain is the powerhouse of a turbine containing the generator and gearbox which converts torque into electricity. The design of a wind turbine gearbox is challenging due to the loading and environmental conditions in which the gearbox must operate. Torque from the rotor generates power, but the turbine rotor also applies large moments and forces to the wind-turbine drivetrain. It is important to ensure that the drivetrain effectively isolates the gearbox, or ensures the gearbox is designed to support these loads, otherwise internal gearbox components can become severely misaligned. This can lead to stress concentrations and failures.

Most wind turbine drivetrains currently use generators that are connected to gearboxes, which speed up the rotation from the relatively slow speed of the turbine’s blades (typically 5–15 rpm for a modern machine) to the high speeds (1,000–1,800 rpm) needed to generate electricity using a high-speed induction generator. Having all of those moving parts makes the gearbox one of the highest-maintenance parts of a wind turbine.

Wind-turbine drivetrains undergo severe transient loading during start-ups, shut-downs, emergency stops, and during grid connections. Load cases that result in torque reversals may be particularly damaging to bearings, as rollers may be skidding during the sudden relocation of the loaded zone. Seals and lubrication systems must work reliably over a wide temperature variation to prevent the ingress of dirt and moisture and perform effectively at all rotational speeds in the gearbox. Many wind-turbine gearboxes have also suffered from fundamental design issues such as ineffective interference fits that result in unintended motion and wear, ineffectiveness of internal lubrication paths and problems with sealing. Improving the resistance of future gearbox designs to all these issues is a key to the future cost of energy generated by wind turbines.

Purdue University engineers—Jun Chen, a professor in the School of Mechanical Engineering, and Lizhi Shang, an assistant professor in the Department of Agricultural and Biological Engineering and School of Mechanical Engineering—have developed a transmission system that

uses an adaptive transmission ratio, allowing for the optimization of the speed and torque going into the generator. This approach improves system efficiency, while also allowing for individual control of turbines and generators across an array, leading to the potential for networks of systems that work cohesively for maximum efficiency.

Additionally, this powertrain allows for the detachment of the generator from the turbine, which reduces the weight of the turbine nacelle and allows the transmission to be placed in an area that is more convenient for maintenance. This technology is also capable of using water as a working fluid, which minimizes the environmental impact of leakages.

“There have been some attempts to use hydrostatic transmissions in wind-turbine applications,” Shang said. “The main obstacles are maintenance and environmental concerns. They demonstrate low efficiency, frequently required maintenance, and oil leakage.” Chen and Shang’s powertrain design transmits the power from the low-speed, high-torque turbine to the high-speed, low-torque generator while maintaining constant generator speed. Chen said the design allows for the detachment of the generator from the turbine. “The generator can be placed at the ground level of wind turbines or the water surface level for marine hydrokinetic turbines,” he said. “This reduces the nacelle weight of the turbine and simplifies maintenance.” Shang said the design also allows for smart, collective energy harvesting using an array of individual turbines and one or more centralized generators.

“The energy losses for regulating electric power frequency can be eliminated,” Chen said. “Compared to an existing hydrostatic wind-turbine powertrain, our technology is more efficient, up to 90 percent. Water is a better working fluid for long-distance hydraulic power transmission, which enables collective energy harvesting. It is easy to refill, and leakage causes less environmental damage than conventional mineral-based hydraulic oil.”

The next step in developing the new powertrain is to test the prototype in a towing tank at Purdue. Data will be collected, measured, and analyzed, which will lead to further improvements in the design.

Chen and Shang disclosed the powertrain design to the Purdue Research Foundation Office of Technology Commercialization (OTC) which applied for a patent to protect the intellectual property earlier this year. **PTE**



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