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MARCH 2020



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Manufacturers Association

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Power Transmission Engineering

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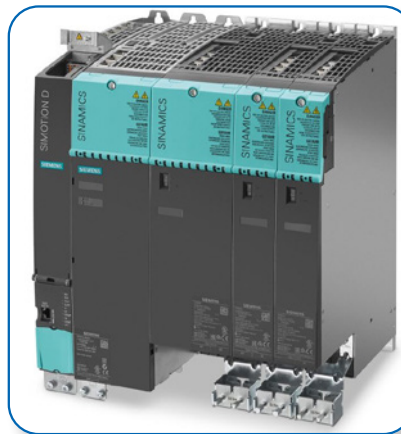
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PTE Videos

Rockwell Automation Smart Sensors

Increase throughput by 5–10% and minimize downtime with smart sensor solutions that enable quick product changeover. In this scenario, four smart sensors on a bottling line collect a range of data points. Multiple sensor profiles are stored in the Logix controller with an extensive range of sensor parameters available. Learn more here:

www.powertransmission.com/videos/Smart-Sensors-from-Rockwell-Automation-/



Siemens High-End Motion Control System

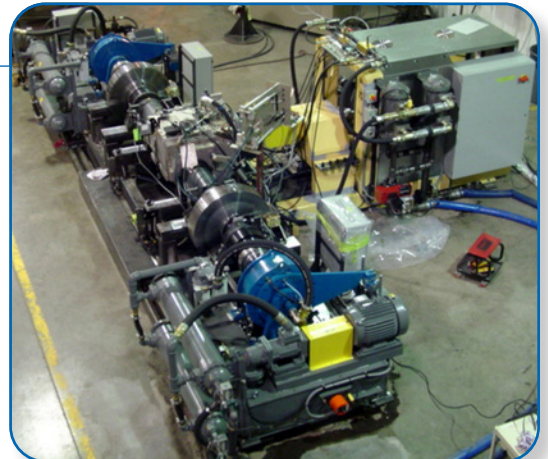
Simotion, the proven high-end motion control system, features optimal performance for all machine concepts as well as maximum modularity. Learn more here:

www.powertransmission.com/videos/Siemens-High-End-Motion-Control-System/

Editor's Choice: Force Control Dynamometers Suitable for High- Torque, Low-Speed Testing

High torque, low-speed testing is often a challenge for dynamometers equipped with traditional load brakes. Testing which requires the brake to absorb significant horsepower and torque but at low to very low speed can result in cogging, chatter, or stick slip, producing inaccurate data if any data is captured at all. Learn more here:

www.powertransmission.com/blog/force-control-dynamometers-suitable-for-high-torque-low-speed-testing/



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Disinfecting the News Cycle



Staying sane is tough when the world seems so crazy, and having your brain plugged directly into the news cycle doesn't help. I know it's not healthy to keep refreshing my news feed. But the coronavirus has everyone scared, myself included.

So I keep scrolling. I keep checking my phone. I keep listening to the news. I can't help it. I need to know if my children will be safe at school, if my loved ones overseas are in danger, if I should cancel my family vacation or my upcoming business trip. The whole world is in a panic, and I need to know if I've stockpiled enough toilet paper and canned beans to make it through the apocalypse.

Okay, that last part is an exaggeration, but you get the point. It was bad enough when we were just dealing with impeachment and the presidential primaries. Add in a global pandemic and its associated travel bans, stock market volatility and disruption of daily life, and you have all the fuel you need to feed our smart-phone driven anxiety.

The experts at the World Health Organization and the Centers for Disease Control and Prevention are telling us that we should avoid large gatherings. We should consider working from home and cancel all nonessential travel. As the disease ramped up here in the United States, people began—slowly—to take heed. SXSW was cancelled. Various trade shows, conferences and business events have been postponed. The NBA, NHL and Major League Soccer suspended their seasons.

Now that the disease is everywhere, the best thing we can do is help prevent or slow its spread. Wash your hands. Don't touch your face. Stay away from crowds as much as possible. Social distancing is how we limit the spread of the disease.

Maybe the social distancing principle should also be applied to our news feeds.

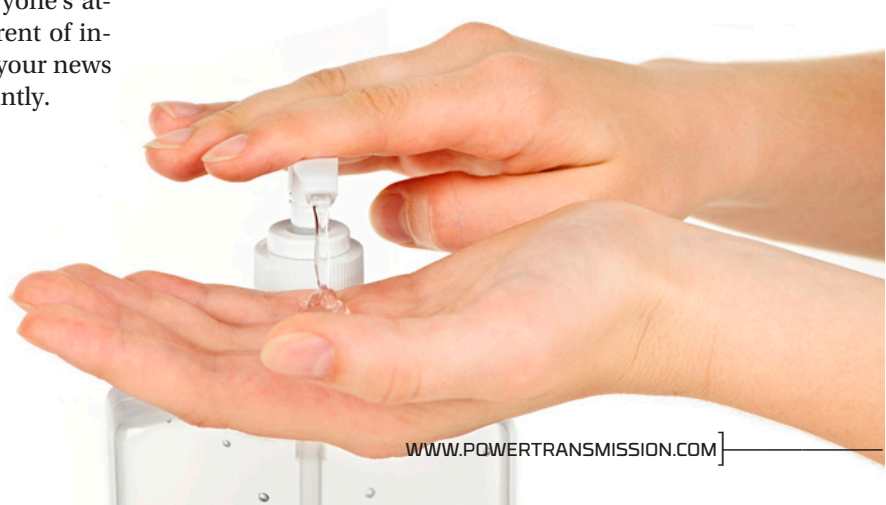
I'm not saying you should bury your head in the sand. Clearly this is a serious issue that requires everyone's attention. But a little bit of distance from the torrent of information might be a good thing. Maybe check your news feeds a couple of times per day instead of constantly.

The CDC is also recommending judicious disinfecting to help prevent the spread of the disease. And this, too, should be applied to our news feeds. Although cleaning your phone is probably a good idea, no amount of Purell or Clorox wipes will protect you from all the fake news, highly politicized commentary, deliberate misinformation and ignorance you have to wade through to get anything useful. No, some mental filtering is probably what you need in order to find whatever small kernels of truth are out there.

Taking these steps won't solve any problems. But they'll go a long way toward alleviating your anxiety and allowing you to focus on the things you can actually control. You can't solve the coronavirus crisis by yourself. But you can still meet your deadlines at work. You can still be a good parent, spouse, friend and co-worker. You can still serve your customers.

So stay focused on the things you can control, and keep your business running. Yes, you'll have to deal with disruptions, but don't let everything grind to a halt. The more you can keep things moving now, the better off you'll be. When the COVID-19 outbreak dies down, I have a feeling we're all going to have a lot of ground to make up.

Randy Stott



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OFFER FALK WRAPFLEX ELASTOMERIC COUPLINGS

The Falk Wrapflex elastomeric coupling from Rexnord offers an innovative “replace-in-place” element that allows quick, easy installation and replacement—eliminating the need to move or realign equipment. The compact design eliminates the need for coupling guard redesign on existing machinery. Maximum bore capacity is 7¼": (186 mm), and finished bores are available in popular sizes ranging from .625" to 4.125".

Available in close-coupled (Type R10) and spacer designs (R31 and R35), the Wrapflex coupling's 9 sizes range from 5R through 80R, and accommodates torque loads up to 133,000 lb-in (15,000 Nm). The nonlubricated design features a tough polyurethane element resistant to wear and chemicals, with an operating temperature of -40°C (-40°F) to 95°C (200°F). The vibration dampening capability and high-misalignment capacity provide extended life to connected equipment.

The optional high torque 70D black element can increase standard catalog

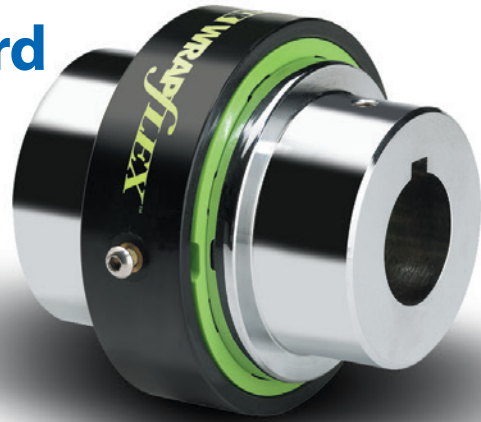
torque ratings by 25%. Standard covers are nylon for sizes 5R-50R and black epoxy-coated steel for sizes 60R-80R. Optional black epoxy-coated steel covers and stainless-steel hubs are available for highly corrosive, severe-duty and food industry applications. Electroless nickel plated carbon steel hubs are also optional for moderately corrosive applications. Hubs are available in rough bore, custom bore and bushed designs.

Safety was a top consideration when the Wrapflex couplings were engineered, designed with two stainless steel button head cap screws—positioned

180° apart—that prevent relative motion between cover and element, and provide a positive means of retaining the cover to the element. The flexible element is retained after failure, helping minimize the potential for damage or personal injury.

The Wrapflex R10 couplings are perfect for many applications including gearboxes, conveyors, lube oil pumps, centrifugal pumps, vertical pumps, compressors, blowers, mixers, winders for paper rolls, and runout tables.

For more information:
 Motion Industries
 Phone: (800) 526-9328
Motionindustries.com/PTE



Eaton

ANNOUNCES BEZARES PTO FOR ENDURANT AND DETROIT AUTOMATED TRANSMISSIONS

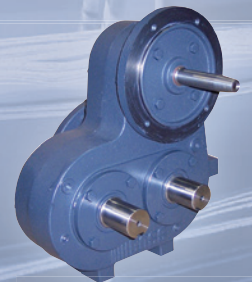
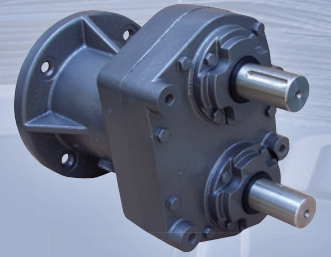
Power management company Eaton recently announced it will expand its mobile power take-off (PTO) portfolio to include two new Bezares PTO units. These new offerings complement the all-makes portfolio already available for a variety of vehicles and transmissions in operation in North America.

Eaton will distribute the Bezares 95X series four-bolt, rear-mounted PTO for the Eaton Cummins Automated Transmission Technologies Endurant 12-speed automated transmission and the new Bezares PTO for the Detroit DT12 automated transmission.

Eaton announced in early 2019 its Vehicle Group's Aftermarket division had reached a distribution agreement with Bezares SA to become the North American master distributor for its mobile power hydraulic portfolio.

“Since introducing our relationship with Bezares a year ago, we worked to quickly ramp up availability of Bezares products and achieved a fully stocked warehouse,” said Tim Bauer, vice president, Aftermarket, Eaton's Vehicle Group North America. “We also have secured a strong distribution footprint across North America and will continue to build on the momentum throughout 2020. These new offerings show our continued commitment to supporting mobile power hydraulic customers in North America.”





What **if...**

your application
needs something not
found in a catalog?

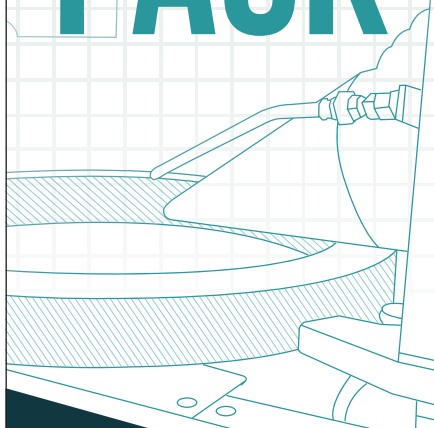
Accustomed to customs – one size does not fit all, and sometimes your application requires an engineered-to-order speed reducer and gear drive. Our engineering and technical support teams are proficient in working closely with our customers to design and develop speed reducer and gear drives specific to the application requirements, when what's in the catalog won't work!

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The Bezares 95X series, the lightest and most compact rear countershaft PTO for Endurant in the heavy-duty segment, features pneumatic shifting and is available with three different internal ratios and popular output types. The offset design improves the position of an attached pump to avoid possible interference with other vehicle elements.

The heavy-duty, two-gear 120X series PTO is built from an aluminum housing, coupling heavy-duty strength with light weight, and fits models DT12-DA/14.93-1.0 and DT12-OA/14.96-1.0.

Featuring internal ratios from 1:1 to 1:1.8, the 120X PTO series integrates with the auxiliary systems of the DT12

transmission and offers four different output options. The PTO housing is designed to improve clearance and ease of installation, while the DIN output option permits multiple configuration options. A lube pump flange is included with the PTO, simplifying ordering and installation.

Eaton will add the Bezares portfolio to its online Order Center, which includes real-time inventory visibility, quick and easy ordering, and improved order management, with an anticipated launch in Q2 2020.

For more information:

Eaton Corp.
Phone: (248) 226-6462
Eaton.com

Freudenberg Sealing Technologies

INTRODUCES A SEAL WITH INTEGRATED BEARING

Freudenberg Sealing Technologies has introduced a machine component that combines a plastic rotating bearing with a seal in a single, precisely matched unit. The design offers significant weight, cost and friction advantages over separate bearings and seals and improves the properties of the mated bearings and seals. Freudenberg has validated the advantages of this new component through extensive testing performed in a sensor housing unit including the seal-bearing component.

While mostly hidden from view,

seals and bearings are nonetheless important components in automotive and industrial applications. They are key elements in operational safety and performance and their durability must be optimized to prevent system failure. At the same time, these bearings and seals must be small, lightweight and cost efficient in keeping with manufacturers' efforts to remove cost and weight from vehicles without sacrificing performance.

Freudenberg has resolved this challenge with the introduction of its seal





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with integrated bearing (SWIB). The company spent two years developing this engineered solution and has successfully tested it in a sensor housing of an electric power steering (EPS) system installed in an electric powered vehicle.

The sensor records data, like steering angle, which is critical to advanced driver assistance programs like electronic stability control (ESC). The seal inside the housing is responsible for protecting the sensor from the penetration of dust, splash water and other media over the entire service life of the vehicle. Bearings used in the assembly are also important; they must withstand significant mechanical loads—sometimes as much as 3,000 Newton of radial force when a car drives over a curb with its wheels at an extreme angle.

Integrated system can reduce loads and vibration

Freudenberg Sealing Technologies' integrated solution offers significant improvements compared with sepa-

rate bearings and seals. The rigidity of the integrated plastic bearing is higher so that its deflection is reduced by nearly 50 percent when lateral forces are exerted. This reduces the induced vibrations to increase the steering comfort for the driver. The seal, on the other hand, has 35 percent less friction, which reduces resistance during steering—especially important for highly automated driving. The weight of the overall solution is reduced by as much as 80 percent through integration. Freudenberg's patented plastic bearing plays a major role in achieving these component breakthroughs.

Automotive safety applications are subject to many requirements which individual manufacturers define according to their own specifications. Freudenberg Sealing Technologies used common specifications—a temperature resistance of -40 to +125 degrees Celsius under mechanical stress, for example—to test its integrated component during the past year. Extreme cases, such as direct exposure

to high water pressure, which can occur in practice during engine washing, were also tested. The seal that includes an integrated bearing proved itself in all tests. "We can now commence with customer-specific series development at any time," says Freudenberg expert Frank Schönberg.

Product experts at Freudenberg Sealing Technologies are already researching additional industrial applications for the new component. In addition to automotive applications, seals with integrated plastic bearings can likely bring benefits to many industrial operations. Freudenberg is also looking to the manufacturing process for further innovation: If the seal/bearing unit is currently still being assembled, it could be produced using new materials in an integrated two-component injection molding process in the future.

For more information:

Freudenberg Sealing Technologies
Phone: +49 6201 80 5713 (Europe)
(734) 354-5373 (USA)
www.fst.com

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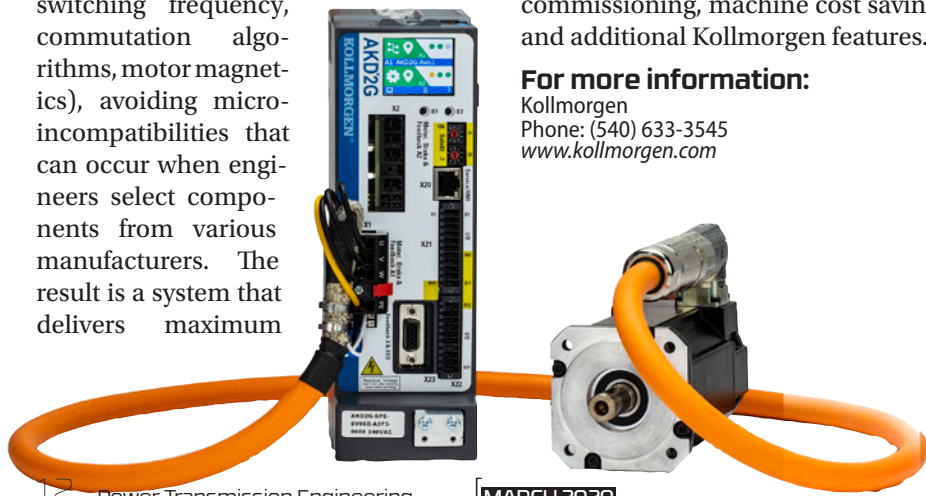
2G MOTION SYSTEM OFFERS SINGLE-SOURCE SOLUTIONS

Kollmorgen announces the 2G Motion System, a servo solution based on the latest thinking about single-source, systems-based design. The 2G Motion System was designed specifically to harness the performance capabilities of Kollmorgen's AKD2G servo drive and AKM2G servo motor. Motor and drive are precisely matched in every element (e.g. drive switching frequency, commutation algorithms, motor magnetics), avoiding micro-incompatibilities that can occur when engineers select components from various manufacturers. The result is a system that delivers maximum

performance, efficiency, and effectiveness in even the most demanding applications, including industrial printing, laser cutting, packaging, robotics, inspection and measurement, machine tools, winding machines, and food processing. Key benefits of the 2G Motion System include a reduced design envelope, increased dynamic performance, faster development and commissioning, machine cost savings, and additional Kollmorgen features.

For more information:

Kollmorgen
Phone: (540) 633-3545
www.kollmorgen.com



Stagnoli

OFFERS PLASTIC GEARING FOR VARIOUS INDUSTRIAL APPLICATIONS

The request for higher performance solutions intensifies metal replacement activity in many fields like automotive, medical, aerospace, electrotechnics. Currently, about the 16 percent of weight in a vehicle is in plastic, and it is expected to reach at least 25 percent within the next five years.

Metal replacement projects requires experience from the material choice to the functionality of the final product. For 30+ years, Stagnoli has been a leader in designing and producing techno-polymer mechanic transmissions for any type of application.

The company offers a wide range of spur gears, bevel gears, timing pulleys, belt tensioner pulleys, sprockets, chain tensioner sprockets, joints, racks and planetary gearboxes in PA6-Stagnoli Fiber Torque. Geometric and dimensional characteristics (UNI 6773 and UNI 4760 standards) makes

them interchangeable with the respective metal products.

Stagnoli has a department dedicated to mechanical machining (CNC) that gives the possibility to customize the standard product as our client needs (bores, keyway etc).

Benefits of techno-polymer gears include lightness, low noise, self-lubrication, chemical inertia, and a cost-savings on machining and lubrication.

S-Torque Gears

PA6-Stagnoli Fiber Torque is a semi-crystalline polyamide. Production of these polymers requires the repeated

joining of an amine group and a terminal carbonyl component of a functional group. These gears are used in applications that require low engine speed and high transmissible torques.

S-Speed Gears

POM-Stagnoli Celeretal is a partially semi-crystalline thermoplastic material that is formed during the formaldehyde polymerization. These gears are used with applications that require high rotation speed and low transmissible torques; they also have a good dimensional stability essentially above all at a low hygroscopicity (low water

absorption) of the techno-polymer, good sliding properties and wear resistance; they are physiologically inert (suitable for contact with food) and have good resistance to a wide range of chemicals.

S-Shock Gears

PK-Stagnoli Keton Shock is chemical compounds in which several ketone groups are present. Precisely the identifying term of synthetic polymers composed of carbonyl groups (C=O) spaced from other related groups (for example, alkyls).

They have a chemical resistance and





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hydrolysis that is usually detectable only on plastic materials with high performances that are positioned in much higher price ranges, as in the case of PEEK or PPS; it has low water absorption which translates into excellent dimensional stability, has a high barrier effect and high toughness and impact resistance.

The S-Shock, compared to the S-Speed series, can be managed at a higher operating temperature, ensure greater chemical resistance and impact and thanks to an excellent surface finish reduces the squeaking that occurs when the resin acetate rotates in contact with another type of techno-polymer.

For more information:

Stagnoli
Phone: +39 030 91 39 511
www.stagnoligears.com



KISSsoft

OFFERS DIRECT ACCESS TO SKF BEARING DATA

Recently, the Swedish rolling bearing manufacturer SKF and the Swiss gearbox design software developer KISSsoft have joined forces: The *KISSsoft Release 2019* offers the possibility to calculate bearing performance by SKF through a cloud calculation service (Module WPK and WB1).

Bearing rating life and other performance parameters are calculated based on direct access to SKF bearing geometry data and SKF formulas which have been validated by extensive testing at SKF facilities. The results are separately displayed in *KISSsoft* and can therefore quickly be compared with ISO results.

The SKF bearing module in *KISSsoft* enables a machine engineer to a seamless experience when working on a new gearbox design. As a result, the prediction of bearing performance becomes more realistic, especially for the SKF Explorer range and hybrid bearings.

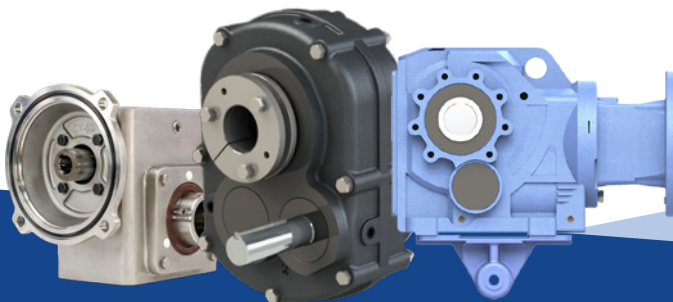
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Applied Motion Products

SOLVES HEAT PROBLEMS WITH INTEGRATED CLOSED-LOOP STEP MOTORS

Applied Motion Products solved heat problems associated with a peristaltic pump system that supplies materials to a bioreactor by replacing open-loop step motors with closed-loop step motors. A peristaltic pump, with internal tubing that separates media from pump components, offers a sanitary method to supply the bioreactor with various fluids to grow cell cultures in the development of new medicines. Step motors are used to drive the pump head, compressing and releasing the pump tubing to move media into the bioreactor chamber.

Initially, excessive heat generated by open-loop step motors elevated the temperature of fluids being pumped into the bioreactor. The

higher temperatures, in turn, adversely affected biological processing times and reduced yields. Integrated closed-loop step motors from Applied Motion Products eliminated the heat problem by operating cooler and consuming less power than open-loop step motors.

Incorporating encoder feedback and servo-control firmware, the closed-loop step motor system's current is controlled to precisely meet torque demands. Drawing only enough current as needed, the closed-loop step motor generates substantially less heat than an open-loop step motor. Closed-loop step motors also run quieter and more smoothly than their open-loop counterparts. Open-loop step motors operate continuously at full current regardless of load requirements, which results in excessive heat generation.

Switching to a closed-loop step motor also enabled the life sciences company to use a single-size NEMA 23 step motor to address all combinations of pump tubing and media instead of stocking different pump and motor sizes. This change to a single motor supported the development of one standard pump head assembly that required only switching tube adapters



to dispense different materials to the bioreactor.

Using an integrated motor design also reduced componentry and decreased space requirements in the control panel. Combining a step motor, encoder, drive, controller and connectors into a single package, the integrated motor eliminated the need for cabling to connect separate motion control components together, which freed space in the very small control panels. Dual-port Ethernet connections enabled daisy-chain connections of Ethernet signals among multiple motors to reduce network cables routed around the equipment and back to the control panel.

For more information:

Applied Motion Products
Phone: (800) 525-1609
www.applied-motion.com

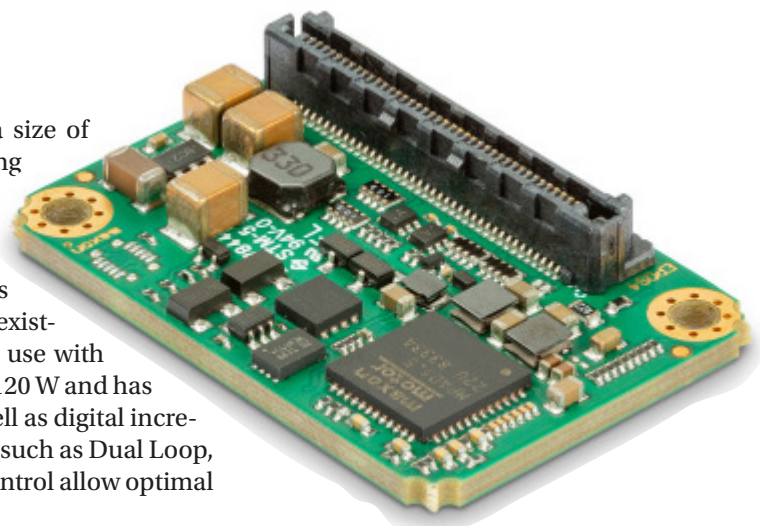


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The first derivative of this new micro design is the CANopen version, which can also be addressed via RS232 or USB, as usual. In spring 2020, the EPOS4 Micro 24/5 EtherCAT will follow as a second product of similarly small size.

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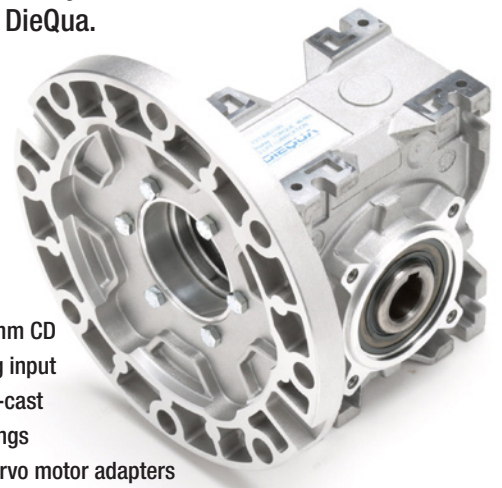


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Regal Beloit

WORM GEAR REDUCER RECEIVES IP69K CERTIFICATION

Regal Beloit Corporation has announced that its Grove Gear Stainless Steel Worm Gear Reducer has achieved third party IP69K certification.

Ingress Protection (IP) Marking rates the degree of protection provided by mechanical casings and electrical enclosures against intrusion, dust, accidental contact and water. It is published by the International Electrotechnical Commission (IEC). The IP69K rating is for high-pressure, high temperature washdown applications. Enclosures conforming to it must not only be dust-tight, but also able to withstand high pressure and steam cleaning.

The Grove Gear Stainless Steel Worm Gear Reducer now joins the Hub City Hera Stainless Steel Gear Drive, Sealmaster PN Gold Mounted Bearings and the Leeson Extreme Duck Ultra Motor as third party IP69K-certified products from Regal. Together, these four products provide a complete washdown solution for food and beverage, pharmaceutical and chemical processing applications.

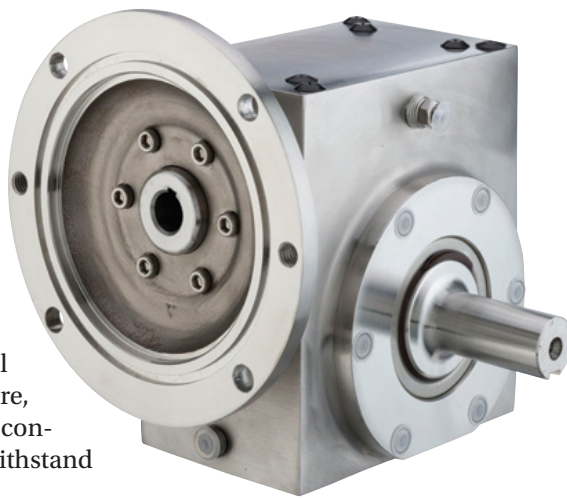
"Traditionally, IP ratings have been used for electrical components, but the industry is starting to recognize the benefit of IP rating for power transmission components," said David Silverman, product manager of worm gearing at Regal. "This allows our customers to have a better understanding of the product capabilities for specification purposes. We are pleased that the Grove Gear Stainless Steel Worm Gear Reducer now carries the formal IP69K certification."

This Grove Gear Stainless Steel Worm Gear Reducer has a 316 stainless steel housing to withstand extreme environments. An O-ring on the face of the motor adapter, poppet-style vent, and v-rings on the output shaft seals provide a system that fights dust and moisture intrusion. A 303 stainless steel output shaft and stainless-steel hardware are also included.

This reducer is also available with Leeson motors pre-assembled for the perfect performance-matched and IP69K-certified solution.

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Value-Driven

New Opportunities and Technologies Allow AC Motors to Enhance Motion Control Applications

Matthew Jaster, Senior Editor

The induction motor was invented and perfected 100 years ago, according to Matt Hanson, general manager, industrial markets at Bison Gear & Engineering. Significant improvements have been made in insulation materials, lamination steels and bearing systems through the years, but in general, the machines operate as they did a century ago.

However, we've seen plenty of significant changes in the motor market in general. We've seen changes in regulations, weight, energy efficiency and the way manufacturers can collect component data. We've seen new opportunities for motors in areas like AGVs, robotics and vehicle electrification. *PTE* recently spoke with representatives from Bison, Bodine, Parker and Lafert North America to examine the challenges, trends and outlook for motors in motion control applications today.

The New Normal in 2020

Viruses, global competition and raw material shortages can disrupt any motor manufacturer, whether based here in the United States or abroad. The key to overcoming the many challenges facing manufacturers in 2020 is the ability to stay one-step ahead.


"As recent events have shown, the global supply chain can be negatively affected by import or export tariffs, raw material shortages,

and even health related crises," said Terry Auchstetter, business development manager at Bodine Electric. "Any of these disruptors can affect manufacturing cost and delivery times to customers. Our purchasing and materials planning teams regularly review these potential disruptors and plan for these contingencies."

Jeff Nazzaro, servo motor product manager at Parker Hannifin, agreed. "The challenges today include global competition for motors, drives and controllers. There are so many manufacturers in the market today. It's also finding the right opportunities in product and service that will add value and differentiate you from your competitors. Adapting quickly (providing custom solutions) for unique opportunities that cannot be satisfied with standard catalog products," he added.

"Customer satisfaction starts with understanding the customers application and proper sizing of components. Our sales team is very good at listening to our customers and trying to help optimize product selection," Hanson said.

Another challenge that U.S.-based manufacturers continue to face is to find and retain skilled employees that are needed for today's more advanced manufacturing environment. "We continue to actively work with local high schools and colleges on skills training, recruitment and career development programs," Auchstetter said.



Advancements made with VFDs and their ability to operate permanent magnet AC motors (PMAC) have created new opportunities for Bison's new motor platform called VFsync.

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Opportunities in Motion Control Applications

Industrial intelligence firms predict strong growth for the motion control market within the Americas region for the next five years. Supporting this consensus positive outlook is the extrapolation of recent and significant year-over-year increases in new projects and sales volume for motion control applications, said Matthew Temple, outside sales, Lafert North America.

The rising tide of a growing market is undeniable as the driver but novel AC motor products from Lafert are well-positioned to serve outperforming motion sectors, namely mobile automation and industrial robotics.

“Increasing market awareness and understanding of the value proposition for permanent magnet AC motors will remain key to continued Lafert growth within the motion control market segment,” Temple said.

At Parker, Nazzaro is seeing expansion in semiconductor, electronics, robotics and vehicle electrification. “For robotics and vehicle electrification we have seen a significant increase in the purchase of frameless motors and custom housed motors which incorporate frameless motors into their design,” he said. “We see the motion control market expanding in general due to continued adoption of automation in factories, particularly with advances in artificial intelligence in the control systems and autonomous operation of the machines.”

Auchstetter at Bodine Electric believes the small AC induction gearmotor is playing more of a “supporting role” to the highly advanced servo-driven machinery. Because AC gearmotors and motors are constrained to a more-less stationary installation by nature of the AC power supply, they are used more often in point-to-point transportation of material, such as a conveyor system between production cells, or in a packaging line. This is in stark contrast to the free movement of battery powered AGVs or service robots.

“Online commerce continues to create a demand for the construction of more distribution centers with robots and cobots

engaged in the transportation of goods from the shelf to the packing station to the shipping dock. The AC-powered gearmotors and motors are found in the stationary cells from which the battery-powered robots or AGVs travel to collect items or pick orders,” Auchstetter said. “We’re seeing new opportunities in packaging, conveyors, greenhouse equipment and bottling equipment today.”

Hanson said that advancements made with variable frequency drives and their ability to operate permanent magnet AC motors (PMAC) have created new opportunities for Bison’s new motor platform called VFs_{ync}. These are variable speed AC motors that run synchronously with the input AC frequency. PMAC motors are a great choice for applications that require velocity control, as they are less expensive than their servo counterparts. The motors rotor contains magnets that precisely follow the rotating magnetic field, without slip, as in general induction motors. All the major motion control platforms offer electronic drives that will run PMAC motors, so capturing the cost savings by switching motor types can happen with minimum engineering investment.



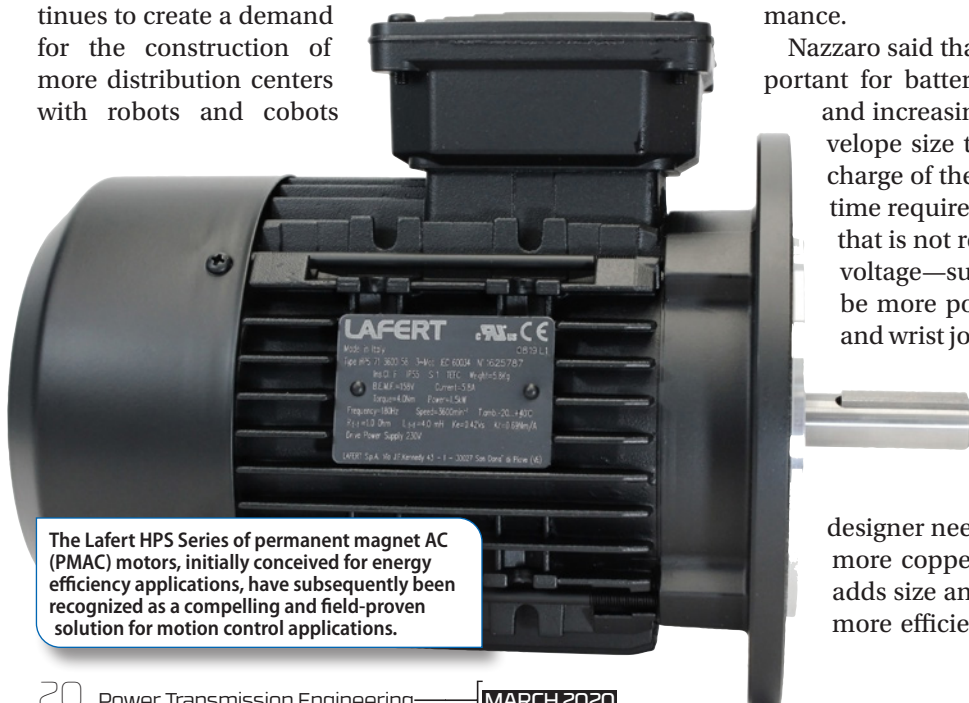
All Lafert HPS Series permanent magnet AC motors reach or exceed the IE4 “Super Premium” efficiency level.

Examining Weight & Motor Efficiency

Our interviewees all believed that weight and motor efficiency remained critical in order to meet energy regulations and improve overall system performance.

Nazzaro said that efficiency and weight are especially important for battery operated vehicles. Minimizing weight and increasing efficiency helps to keep the overall envelope size to a minimum and will allow the battery charge of the vehicle to last longer reducing the down time required to recharge. “Even a robotic application that is not relying on battery but operating under low voltage—such as 48 VDC—benefits as your motor will be more power dense and moment loads for elbow and wrist joints will be kept to a minimum,” he added.

Bison’s customers require motors that have improved efficiency in order to meet DOE regulations on a variety of equipment types. In order to improve efficiency on induction motors a motor designer needs to add additional lamination steel and more copper magnet wire, which reduces losses but adds size and weight. PMAC motors are considerably more efficient as the rotor uses permanent magnets.



The Lafert HPS Series of permanent magnet AC (PMAC) motors, initially conceived for energy efficiency applications, have subsequently been recognized as a compelling and field-proven solution for motion control applications.

PMAC motors are considerably smaller in diameter and lighter in weight than their induction motor counterparts.

“Today’s small three phase induction motors range in efficiency from 60% to 70% efficient. Bison’s new PMAC motors are 80 to 90% efficient. As a result, the size of the motors is reduced by 50% and up to 60% less weight than conventional AC induction motors,” said Hanson.

Auchstetter said that motor efficiency and weight are less critical in stationary applications where AC-powered fractional HP gearmotors are used, versus in mobile applications where battery-powered DC gearmotors are used.

“However, both are critical performance characteristics for many gearmotor applications. Efficiency is related to motor temperature, and many stationary machines in a factory setting have exposed motors that can be a burn hazard to humans. Weight is related to size, and a compact size is generally desirable to keep the gearmotors from sticking out into aisles where humans might bump into them when walking by the machine,” he added.

Temple said that energy costs have not been a traditional performance metric for motion control applications in North America, but the market increasingly recognizes that motor efficiency has real and measurable impacts on the performance and reliability of motors and systems.

“Reduction or elimination of iron or copper motor losses, which convert input electrical energy to waste heat, translate to increased motor energy efficiency and reduced operating temperature. The well-documented inverse relationship between operating temperature and expected motor insulation system lifetime is often raised when discussing the value of increased motor efficiency, but the benefits of cooler operation for motion control applications are multi-dimensional. Increased efficiency motors can enable motion systems to operate continuously at higher ambient temperatures and power output or increase the permissible duty cycle and root mean square (RMS) torque during intermittent operation,” Temple said.

Collecting (and Utilizing) Component Data

Auchstetter said that as controls with higher processing power, artificial intelligence, and machines that operate autonomously become more prevalent, the reliability of the gearmotors in industrial applications becomes far more important than the cost. Reliability can be accomplished in the design through higher quality materials and components, or through simpler or modular designs.

“Sensors are added to the motors to predict when failure is imminent. Depending on the gearmotor size, the appropriate

Parker is seeing expansion in semiconductor, electronics, robotics and vehicle electrification applications.



type of sensor might be for vibration or for temperature monitoring. Or both. The data from encoders, besides being used for position and speed control of the gearmotor, can be used for logging the number of hours of operation of the motor and comparing it to the MTBF of the gearmotor,” he added.

New PMAC motors, when ordered with an optional encoder, provide feedback on the motor that can be used by controls for rotor shaft position. PMAC VFD controls provide online information regarding current draw, input frequency and a variety of other parameters. Depending on the application, IIoT features are available with our standard products to meet the engineer’s requirements, said Hanson.

“On the motor side it is primarily with the addition of sensors and with the gathering of information, let’s say into an encoder, for condition monitoring. This can help in supporting the preventative maintenance of the motor as well as the components that the motor is driving (ie.. linear actuators, gearheads, etc...)” Nazzaro added.

Temple said that the core concept of smart manufacturing is to implement systems which capture, collect, analyze and act upon manufacturing process information to improve and optimize the process. The traditional standalone AC motor, absent the embedded logic to for condition monitoring and communication, does not directly generate input data for smart manufacturing systems.

“This should not be understood to mean that AC motors cannot make meaningful contributions to systematic efforts to continuously improve manufacturing operations, most particularly in reducing energy usage. Strategic Energy Management (SEM) programs, for example, which implement systems to help manufacturers understand, monitor and continuously improve their energy consumption, are very much aligned to and compatible with smart manufacturing methodology and goals,” Temple said.

Considering that electric motors account for approximately half of US manufacturing energy consumption, it is not surprising that leading manufacturers have utilized SEM programs to quantify and consider the energy costs for their



motor-driven equipment.

“The outsized role of motors in manufacturing energy consumption means that AC motor energy savings, such as those achieved through replacement of induction motors with Lafert HPS Series PMAC motors, can translate to significant facility energy savings. Motion control systems for continuous or high duty cycle applications, such as conveyors and sortation, are consequently bound to be identified as opportunities for efficiency improvements through the SEM process,” Temple added.

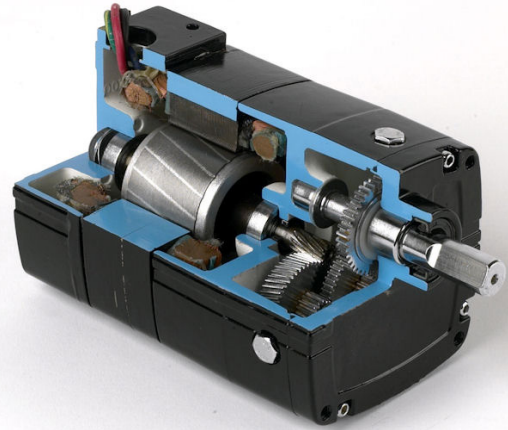
A Change in Technology

While the inside (the guts) of induction and synchronous motors have remained relatively the same, new market opportunities demand new technologies and functions.

For example, in traction applications and high-power work function, active cooling is necessary to deliver the power density.

“When you add minimizing size and weight, and cost, the result is motors that are a combination permanent magnet torque and reluctance torque. This motor type is often referred to as salient-motors or PM assisted synchronous reluctance motors. The control of these motor is more complex as compared to PM only designs. Without the proper controls, full performance cannot be extracted from the motor. New tools and technique will be required to improve the ease of use of salient motors designs. At present, day to week on the dyno is required to map the control parameters at each operating point in order to squeeze the last bit of motor performance,” Nazzaro said.

Finite Element Analysis tools have changed how motors are *designed* over the last 20 years. “These software programs use FEA tools to analyze the magnetic system within the motor being worked on, and then apply decades of motor engineering equations and relationships to predict the performance of the motor,” Hanson said. “Today’s software can predict size, performance and thermal characteristics of a design in minutes, allowing engineers to tune motor performance as the customer requires. Design accuracy continues to improve with additional software developments.” **PTE**



Gearmotor reliability can be accomplished in the design through higher quality materials and components, or through simpler or modular designs. (Courtesy of Bodine)

For more information:

Bison Gear & Engineering
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www.bisongear.com

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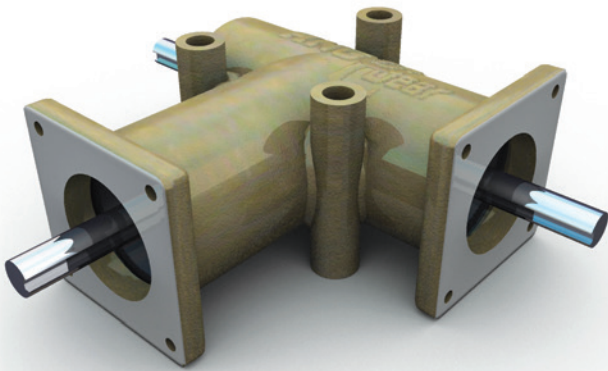


AC gearmotors and motors are often found in conveyor systems, between production cells or in packaging lines. (Courtesy of Bodine)

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Shielding Sensors

Dust, lubricants, extreme weather — no matter what environment your sensors operate in, there are bound to be elements you have to protect them from. Here's how Heidenhain designs their encoders to specifically meet those challenges.

Alex Cannella, Associate Editor

One of the most sensitive components in a machine is likely the sensor. Even more so than with other components, precision is a top requirement for sensors, which also means that of all components, it takes the least amount of interference to disrupt them. Extreme temperatures, dirt, even a few simple motes of dust can interfere with an encoder's operation, meaning one of the most important challenges when designing an encoder is making sure it's as resistant to the elements as possible.

We sat down with Heidenhain to see how they tackle this issue. As it turns out, the answer is one environmental hazard at a time. According to Jonathan Dougherty, business development manager for automation at Heidenhain, most solutions are situational and about combating specific threats on a per-environment basis.

“From a wide view, you want to know environmental conditions, and from there, it's time to sit down and see ok, what kind of contamination is possible in these conditions?” Dougherty said.



No matter the environment, dirt contamination is one of the most frequent disruptions of an encoder's performance. But heavy-duty applications such as mining and oil/gas can easily be the dirtiest.

The easiest way to break down those conditions is with a simple question: is your machinery operating indoors or outdoors? Depending on the answer, you'll be dealing with your own set of challenges.

Out in the great wild, of course, is where the “most extreme” environmental conditions exist. You're subject to weather and local climate conditions, and many of the heaviest duty (aka dirtiest) applications like oil and mining are conducted outdoors.



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Extreme temperatures, however, are one of the greatest stressors on Heidenhain's sensors. Try an offshore oil rig in Siberia, for example. Out there, temperatures can drop well below zero and get so cold that the lubricants in the bearing freeze solid. When that happens, the whole bearing locks up and can't turn properly. And then there's the concern of how the cold will cause the components to contract.

And on the opposite side of the equation is a mining application in Brazil. Small surprise, when in such a hot environment, it's easier than ever for components to overheat. Heat dispersion becomes an absolute priority concern.

"It's just making sure that you have proper heat sinks and dispersion in the encoder itself so that the electronics don't overheat," Dougherty said.

That simple solution, however, is complicated by the extreme amount of contamination (read: dirt) that gets kicked around in a mining application. And that requires its own set of tactics to combat.

Just because these environments are more extreme doesn't mean you can just go without encoders in these applications. Instead, Heidenhain's had to come up with ways to keep their encoders as well-protected from the elements as possible. But every solution needs to be tailored for the specific environment the encoder is going to be working in, because no one solution fits all, and any adjustments designed to tackle a problem are going to come with tradeoffs.

Take the Siberian oil rig. In those extreme colds, a bearing becomes as much a liability as a boon. Heidenhain's first response is to skip the bearing and mount the encoder directly on the shaft, but this leaves the encoder vulnerable to other issues. After all, that bearing is there for a reason: it helps protect against runout, which can produce noise and disrupt the encoder's readings. Removing the bearing isn't fatal, but it does leave the encoder more susceptible to being affected by runout, requiring a more restrictive overall design.

For dealing with contamination, meanwhile, Heidenhain has two solutions. The first line of defense is to sidestep the issue entirely by using inductive scanners like the ones featured on their ECI/EQI 1100 and 1300 series encoders.

The general standard for encoders is to work with optical scanning, which operates by shining an LED light on a disc with graduations on it. The obvious problem is that as contamination find its way onto the disc, it disrupts that light. Inductive scanning sidesteps the issue by instead utilizing measurements between the inductive sensor (encoder head) and measuring scale, which periodically changes the mutual inductance of each coil and generates the signal.

"If you don't have any light, the materials and contamination getting in don't affect it," Dougherty said. "So you're able to still operate even in some more contaminated

environments."

As always, however, there's a tradeoff for these more durable solutions, and the downside in this case is that inductive scanners haven't quite matched the accuracy of their optical cousins yet.

"If your application needs high accuracy, you still want to go with the optical," Dougherty said. "And in that case, you try to minimize the risk of something happening, whereas if the accuracy of the inductive solution is good enough, you go with that and you don't have to worry about the contamination. It's kind of a give and take situation, so we really try to provide options and go with the one that suits the application the best."

And in cases where optical encoders are a must, Heidenhain's next solution is their Advanced Diagnostic System (ADS), software which is specifically designed not



Cold temperatures can be one of the greatest threats to an encoder, and combating them requires tradeoffs.

just to monitor the encoder itself, but also the encoder's environment. It's meant to identify an encoder's most pressing contamination threats and alert operators when a problem is brewing before it becomes so pronounced that it starts affecting a machine's performance.

"The goal of that is to help our customers to move from something like preventative maintenance structures where you replace on error towards more predictive and proactive maintenance," Dougherty said. "So that you can predict 'ok, this is becoming an issue that will be causing an error down the line.'"

Heidenhain most commonly utilizes ADS in oil/gas operations, mining applications, and wind turbines, some of the harshest conditions their encoders can end up operating under.

Looking back at that specific mining application in Brazil, Heidenhain's encoder kept notifying the operators of a critical issue where vibrations were disrupting its ability to work, but

A wireframe funnel, resembling a time machine or a wormhole, is positioned vertically in the center of the page. At the top opening of the funnel, a small Earth is visible. At the bottom opening, a larger Earth is shown. The background is a dark space filled with a vibrant red nebula and numerous white stars. In the upper left and lower right corners, there are smaller, distant Earths.

GREAT SCOTT!

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the encoder itself seemed perfectly fine. It took Heidenhain's ADS system for the operators to locate the real source of the problem: the concrete base the encoder's motor was installed on. The base had a crack in it, and every time the machine turned on, that crack grew just a little bit, and as the crack got worse, so too did the vibrations, in turn, until finally the issue became bad enough to hamper the encoder.

Indoors, things are a bit tamer. Indoor environments can actually be controlled to a degree. The humble dust mote is usually the greatest threat here, but a significant threat, it remains. Even when working with machine tools, dust is a challenge sensors have to contend with, even though you would think machine tools working inside sealed, automated machinery would make for the most controlled and safest environment of all for a sensor.

But on the contrary, that need for a controlled environment instead exacerbates the issue. Many components these days are manufactured with an acceptable deviation of mere microns, and when you're striving for that level of accuracy, suddenly even a little bit of dust can become a credible threat, and even minor contamination of a sensor can lead to errors in a component's surface finish just as surely those extreme contamination conditions in Brazil could. And that's to say nothing of how lubricants can splash around and cause the same issues.

Here again, inductive scanning can be a helpful solution, but it still comes with the same tradeoffs as when used outside. Sometimes, handling this issue is instead as simple as using a bit of foreknowledge. The easiest way to avoid something like lubricants contaminating an encoder is to design

ahead of the issue by ensuring the encoder doesn't have to be installed directly in their path.

That might sound like sense so common as to barely be worth mentioning—gee, who would have thought the easiest way to stop lubricants from contaminating your encoder would be to just put the encoder somewhere away from the lubricants! But actually doing that requires forethought during a machine's design process, which means communication with your component manufacturers. As with numerous other issues that can crop up in manufacturing, a primary way to avoid a problem from occurring in the first place is to just get your suppliers onboard early and communicate with them often about design parameters they have to be aware of.

This holds true for every environment highlighted in this article, even the most stressful ones. After all, a manufacturer like Heidenhain can't plan for environmental factors that their customers don't tell them about. When designing a machine, how your encoders might function in the cold probably isn't the first question at the front of your mind, if indeed it's something being considered at all.

It's just one of a thousand other design questions that need to be incorporated into the design process, but it's an important one to ask that can save you a lot of headache later down the line. Properly identifying those threats is the hard part, and once you figure out what you're up against, you'll be able to find a solution that works for you.

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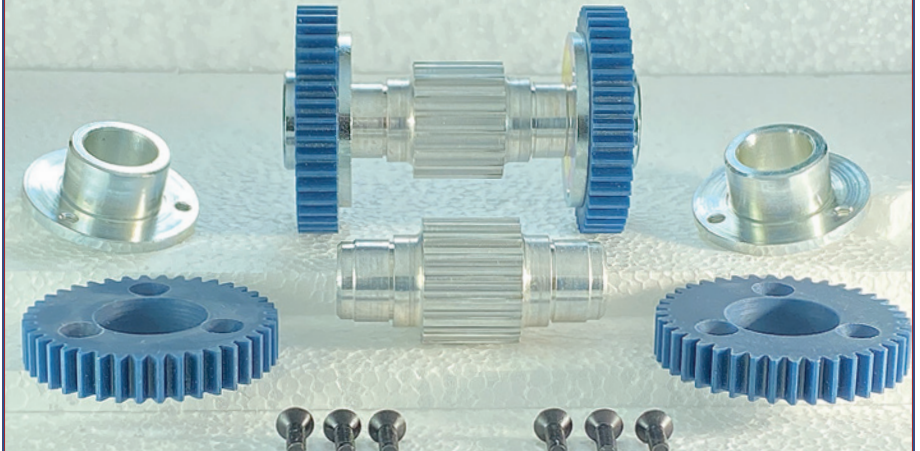


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Smart Couplings Remove Guesswork from Measurements in Machinery Applications

Jack McGuinn, Senior Editor

Quite often, the collection of precise data in drive technology applications can be problematic. Data monitoring in a rotating drivetrain is difficult because a direct networking cable connection is often not an available option. Nothing sends shivers down the spine of for example, a production line manager or a system integrator like uncertainty. That's why achieving precise measurement of things like torque and other parameters in machinery applications is, while daunting, a dearly desired goal, especially if those measurements are only available at the drive and motor. Accordingly, couplings used in machinery and other applications today are being developed with a "smarts" and "intelligence" never seen before in such hardware. Coupling manufacturers are now producing couplings with leading edge measuring capabilities by virtue of adding sensors and software to the equation. These custom coupling are thus creating a new paradigm in manufacturing by enabling the wireless transmission of mechanical data from directly within components like, for example, a rotating drivetrain.

Call it "smart" or "intelligent" coupling (take your pick), this new technology provides a coupling system with measurement capabilities that are taken directly in the drivetrain, providing enhanced data acquisition and enhanced transparency in the drivetrain in a timely manner.

Following in much greater detail is a discussion regarding this latest advance in coupling technology. Our responders include: Andy Lechner (AL), VP-Sales & Marketing of R+W; Todd Lehman (TL), sales manager, Coupling and Drive Technologies, Voith Turbo North America and Christopher Hoeweler (CH), condition monitoring expert, Voith Digital Ventures; Tim Nageli (TN), global sales manager-mill products-Ameridrives and Mark O'Neil (MO), chief principal engineer, Altra Couplings; and Ralf Epple (RE), product manager at Mayr Power Transmission in Mauerstetten.

In drive technology, why is accurate measurement of torque and other parameters in machinery (drivetrain) applications so important?

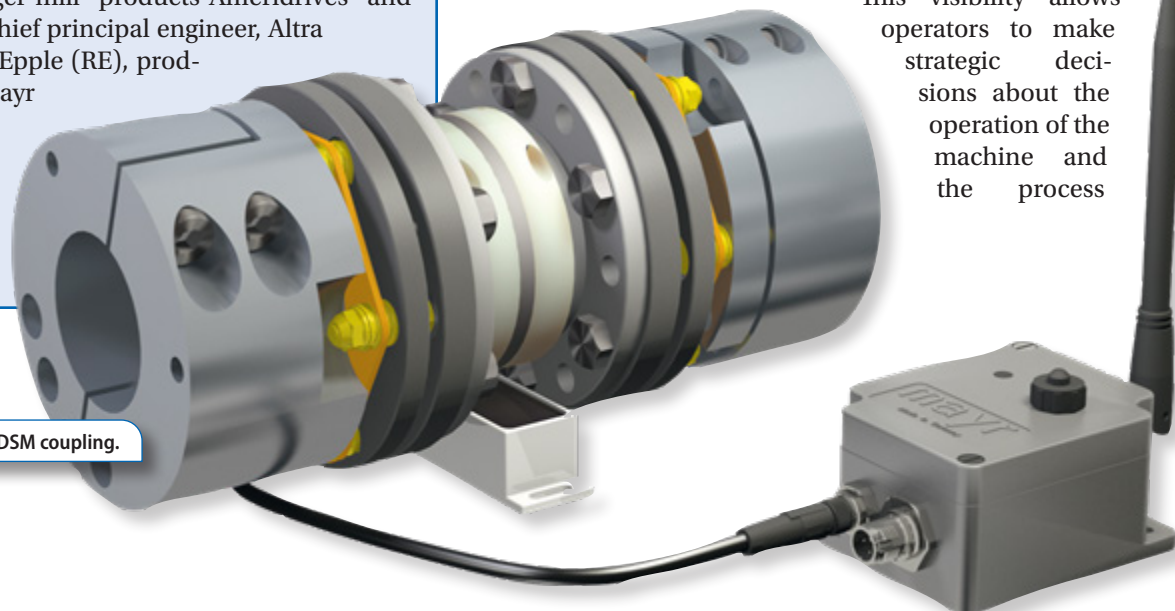
Andy Lechner (AL)/R+W: All components in a mechanical drive line have limits to the amount of torque they can withstand before failure, and as machine designs are continually optimized for size and weight, while running faster, the margin of safety from torque overload is becoming smaller. Conditions detrimental to machine performance such as wear, misalignment, loss of lubrication and binding of workpieces all increase the amount of torque required to make the machine move. So an accurate measurement of the torque being applied at key locations in the drive line can be essential to condition monitoring and predictive maintenance. Similarly, vibration can be caused and exacerbated by these same detrimental conditions, as can the axial force applied to shafting as a result of movement and heat generation. Having the ability to measure changes in these parameters is also useful in monitoring the overall health of rotating equipment.

In other instances, particularly in the process industry, changes in the density and viscosity of materials being mixed, pressed, pumped or extruded can manifest themselves as changes in the torque required to drive the process. Here too, accurate measurement of torque can aid engineers in optimizing quality and throughput.

Todd Lehman/Christopher Hoeweler (TL/CH) Voith: Remote monitoring of equipment provides operators and equipment manufacturers the ability to see what's happening with the drive chain.

This visibility allows operators to make strategic decisions about the operation of the machine and the process

Mayr ROBA-DSM coupling.





Voith Dtect torque limiting coupling expandable monitoring system with HMI (Courtesy Voith).

MO/Altra: Special precautions are often taken in oil refineries, petrochemical plants and other potentially explosive environments, where torque monitors and strain gages are installed. Couplings are often positioned within isolated enclosures that can be gas purged since these monitoring systems require electric current to operate and can potentially emit a spark. Incorporating “intrinsically-safe” ATEX-approved equipment that does not cause sparks is preferred.

Continuous-duty torque monitoring is often a requirement on natural gas pipelines. Compressor stations, typically placed 40 to 70 miles apart along

the pipeline, are required to boost/maintain proper pressure through the pipeline’s entire length. To control costs, usually only every 4th or 5th station is manned. The remaining stations utilize continuous torque and vibration monitoring systems that relay data to a central pipeline control room. In this way, the performance of all turbine/coupling/compressor drivetrains along the pipeline can be viewed in real-time to identify any potential problems as they arise that can lead to a potentially catastrophic system failure.

Ralf Eppel (RE)/MAYR: Only accurate measurement allows us to carry out a realistic analysis of the data. Only in this way, the data can be used for an analysis or wear and maintenance models and provide a meaningful overall picture of the system.

Why are measurements taken at the drive and motor in drive technology often insufficient?

AL/R+W: Monitoring the amperage drawn by the motor is a great starting point for letting the user know approximately how much torque the motor itself is generating. But these measurements become less sensitive the further one travels down the drive line. In many cases a main drive motor is used to power multiple rotating axes in a machine, separated by different types of gearing and belts, making it impossible to use amperage to monitor the torque being applied to a single branch axis. Estimating torque at the motor also fails to consider the flywheel effect of downstream equipment, where a rotating mass that has already been powered by the motor can apply large torques to components further yet down the driveline, with no evidence of this applied torque available at the drive. Depending on the speed of the application, even the inertia of the motor shaft can serve to conceal variations in mechanical torque when measured only by the real time power consumption of the motor.

that it is performing. The accuracy and timeliness of the measurement will provide the operator the ability to maximize machine productivity without exceeding individual drive chain component capacities. In addition, equipment monitoring can provide the ability to produce trend data for each monitored component of the drive chain. This can help operators make decisions about the health of each drive component allowing them to order spare parts in preparation for repair.

A good example is our OnCare.Health ACIDA — Report generator. The measurement is not only dependent on the accuracy but also on the reliability of gathering the data. It is important to trust the data to make decisions on actions improving maintenance or operations.

It is also noted that the torque signal is also carrier of health information of the driveline. Tracking natural frequencies, for instance, allows the ability to pinpoint changes in the system characteristics which may have been caused by rotor cracks.

Tim Nageli/Mark O’Neil (TN/MO) Altra: Measuring torque, vibration and other machinery conditions significantly reduces machine failures, downtime for repairs and stock of spare parts while increasing efficiency, production and component service life.

O’Neil/Altra: On turbomachinery in a petrochemical plant, for example, a single day of an individual out-of-service compressor can shut down the entire process and cost millions of dollars. Monitoring systems can identify performance deterioration. A decrease in torque indicates a problem such as excessive turbine or compressor wear that causes an efficiency loss. Proper monitoring allows users to trend the torque transmission and performance of their equipment. The data collected allows the user to schedule and perform any required preventative maintenance in a more controlled time frame versus the stress associated with a costly, unplanned equipment failure.

TL/CH/Voith: The accuracy of measurements taken at the prime mover and the machine can provide a view to issues that may exist within a driveline. However, the view will not be complete unless all of the components of that driveline are measured. Many times, drivelines are monitored and controlled via the target speed of the engine or current draw of the motor without consideration for monitoring of the reaction of the connecting coupling or the driven machine. Connecting couplings include mechanical rubber, grid, gear, disc and diaphragm couplings as well as universal joint shafts, torque limiting and hydrodynamic fluid couplings. In such cases, the set target speed or monitored current provides limited information about the true load seen by the driven machine. Voith field service technicians have diagnosed issues, such as a failing machine bearing, which will only appear to the operator as additional load seen by the increase in engine fuel consumption or motor amperage demand. The operator could view this as additional production throughput when in reality the added demand is caused by potentially imminent machine failure.

TN/Altra: On metal mill applications, U-Joint and gear spindle measurements taken at the motor are often a motor current reading average over a certain length of time. It has been proven that within that time length, the mill can experience significant torque spikes at the roll end that are averaged out with the current or not read as high as they are. Also, the gearing and equipment through the complete drivetrain dampens the torque spikes.

RE/MAYR: Quite frequently the measurement is carried out at the wrong position and at an insufficient sampling rate.

How sophisticated is the software used in conjunction with the sensors?

AL/R+W: The software is quite simple and can be run on any Android based mobile device. It provides for real time monitoring of multiple couplings simultaneously and offers a data log output in the form of a CSV file. R+W is also in the process of developing a gateway with a USB, RS232 and an analog output, allowing the user to transfer the information to their own data acquisition software or control systems. IO-Link is next.

TL/CH/Voith: The level of software sophistication will normally be determined by the needs of the customer and the application, and it typically relates to the value of the equipment that is to be monitored. The software can be as simple as some added lines of code to the existing plant

PLC for simple alarm or shutdown settings. In contrast, software can be developed for the collection of operating data, or the complete operation, monitoring and control of the machine. Once the scope and requirements of our customer's application is known, Voith will work to define and create the software for the collection and evaluation of the incoming data. The sophistication of the software will be determined first by the components of the drive chain, second by the number of sensors and data points that are to be evaluated and third by the process and how this data is to interface with the overall operating process of the machine.

TN/Altra: Permanent systems that can be measured remotely in real time can be quite elaborate. Temporary systems, installed for troubleshooting certain applications that aren't as sophisticated, collect data that is read and analyzed later.

MO/Altra: Many drivetrains utilize sophisticated VFD/AFD controls. Care must be taken when monitoring equipment in these applications since these types of variable frequency drives can cause a 20% variation in torque in extreme cases. Special software with very high data sampling rates are required to evaluate these types of applications.

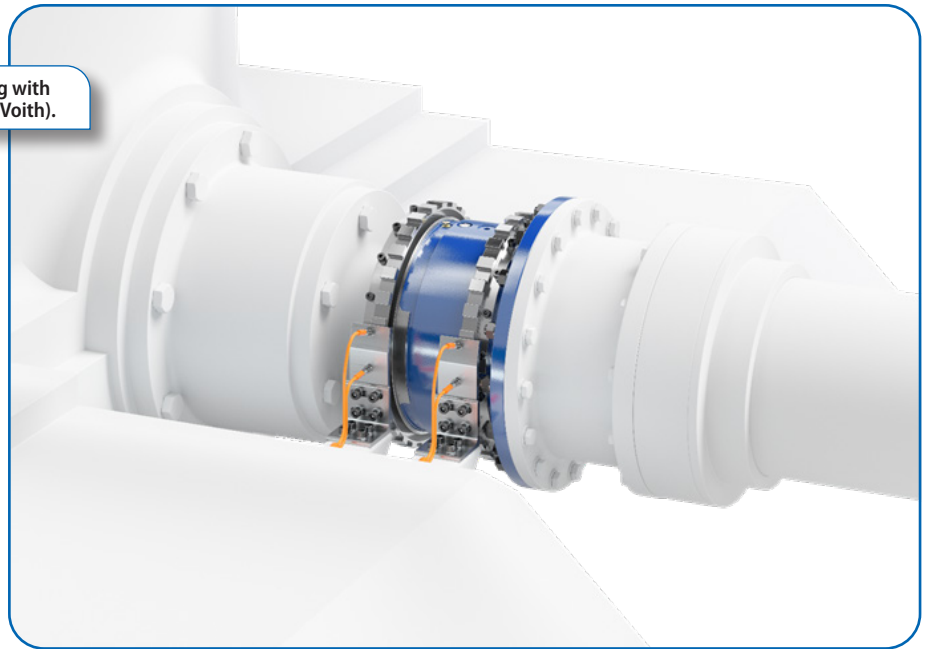
RE/MAYR: In our opinion a reasonable measurement signal (sampling rate/resolution/accuracy) is most important and in a second step suitable software is required. Bad or inaccurate measurements cannot be compensated even by the best software.

How are the sensors incorporated into the couplings?

AL/R+W: The sensor package consists of a steel frame, to which strain gauges are applied for torque and force measurements, an accelerometer (like those used in smart phones) for vibration measurement, and a gyroscope to provide speed measurements. This steel frame is pressed into an intermediate spacer in the center section of the coupling and sealed off with resin.

TL/CH/Voith: Incorporation of sensors onto or into couplings vary. Sensors are typically externally mounted onto the coupling or the corresponding shaft that supports the coupling and remotely monitored since in most cases the coupling is rotating. However there are situations where a sensor may be incorporated within the coupling. Measurements typically include torque, speed and temperature. If the coupling is operated within a stationary housing, sensors will be applied to the housing for the monitoring of data such as vibration, temperature, fluid level and flow, and relative position of essential components. In certain

Voith SmartSet torque limiting coupling with Dtect slip detection sensors (Courtesy Voith).



situations, caused by physical access limitations to the coupling, Voith has incorporated sensors within the flexible element of the coupling to collect operating data for a temporary period since battery life is limited. We have used these types of units to record driveline operation behaviors for analysis and verification of proper coupling selection in situations where published machine data was not matching the actual operational data.

In addition to the direct torque measurement, rapid torque changes can be captured allowing customers to see maximum torque levels in drivelines which may be unseen on calculated motor torque. Also since strain gauges are directly mounted on driveline equipment, dynamic driveline characteristics can be made visible, which may have been isolated in the calculated torque measurement. By measuring torque precisely, operators and engineers are able to make strategic decisions that reduce downtime, increase efficiency, and save money.

TN/Altra: In mill applications, strain gages are added to the spacer section of universal joints or gear spindles along with a protective casing, power, and remote antenna. Strain gages are a good diagnostic tool. There are cost-effective short-term systems and more robust long-term continuous-duty systems available.

Are torque, rotational speed, vibration and axial forces the parameters requiring precise measurement?

TL/CH/Voith: The determination of measurement accuracy requirements will vary among industries, applications, and customers. The precision of all those measurements mentioned can be very important. At Voith, we place importance on not only high resolution in amplitude, but also on frequency of the signal. A lot of information is found in the frequency content of a signal. Measurement of these Eigen frequencies in a drive line might be correlated to a cracking shaft or other issue if there is a change in the monitored frequency. The cause of such a frequency change needs to be identified as soon as possible to safeguard the environment. Other precise measurements, for example, temperature, can also be required to enable to safe and stable operation of a drivechain.

RE/MAYR: The parameters mentioned in the question are certainly not the only parameters that play a role, but

the most important ones. In addition, the temperature and the angular position of the acceleration are also important parameters for us. But what's really crucial are the accuracy and reproducibility of the measurement signals - these factors are more important than the total number of possible recordable parameters.

Is this enhanced measurement regimen IIoT-driven?

AL/R+W: The need for simple and cost-effective measurement of mechanical behaviors in drive lines precedes IIoT, but related technological advancements have facilitated the development of this product, and certainly help drive demand for it.

TL/CH/Voith: Once again, it will depend upon the industries, applications, and customers. It will also depend upon the function and value of the equipment. Generally, IIoT-driven architectures are increasingly being focused upon by companies. Voith, like many companies, is constantly working to develop intelligent equipment technologies so that they can be operated and monitored within unmanned facilities or stations remotely. To Voith, this increases the need for and importance of accurate and reliable instrumentation for measurement of all of the drive chain components.

MO/Altra: Torque monitoring systems have been available and widely used throughout various industries for many years. The growth of the IIoT has raised awareness of these types of remote performance monitoring devices. While most large couplings could benefit from torque monitoring, the reality is that many of the sophisticated torque monitoring systems currently on the market have associated costs that exceed the cost of the actual coupling being monitored. Hopefully, as newer technologies evolve, the cost of these important devices will begin to come down.

RE/MAYR: We have been working on the topic process monitoring for more than 15 years. During all this time, we have continuously further developed our product, the ROBA-DSM coupling. But it is only with the possibility of faster data acquisition and processing and the resulting analysis systems that possibilities have arisen here to make this information widely available. Of course IIO

Are the mechanical properties of “smart couplings” affected by the integrated sensors?

AL/R+W: The sensor package occupies approximately 75mm of length within the coupling, which depending on the individual application, could require that the coupling be slightly longer than it would otherwise be. The focus has been primarily on flexible disc couplings in the capacity range of 350 to 2,500 Nm, though plans to integrate into larger coupling sizes are also being implemented. The larger the coupling is, the less of an impact the sensor package has on its mechanical properties.

TL/CH/Voith: There are many factors that must be considered when evaluating the integration of sensors onto a coupling. Factors include, but are not limited to, the method of attachment, the sensor weight and the impact of the

sensor on the normal function of the coupling. We present all these factors for customer consideration prior to sensor installation to maintain the longevity and reliability of the coupling.

RE/MAYR: In some cases it will not be possible to avoid that rigidity, maximum torques and displacements have to be changed or limited due to the implementation of sensors. But this is exactly where our know-how as a clutch/coupling manufacturer comes into play: We select the type of sensors in such a way that this plays a subordinate role for the application. And this is the reason why we will not focus on a specific measurement system or sensor type. Our applications are too diverse. Not every application requires the same data and the same sensor technology. And the costs should also always be kept in mind here. In the area of process monitoring or analysis, the additional cost is often a decision criterion whether certain processes are monitored or not.

How is the information provided by the sensors processed and applied in real time?

AL/R+W: This depends on the type of process being monitored and how the information is being used. It could be used to trigger warnings in case of torque and vibration increases beyond a certain threshold in manufacturing equipment, or to verify the consistency of media in processing equipment and advise that other mechanical adjustments be made, or simply to confirm that a device is producing or receiving sufficient torque in test and measurement equipment. Ultimately the way the information is processed and applied is up to the user.

TL/CH/Voith: The machine monitoring system or PLC will process the data according to how the machines process lines of code dictates. The data transfer from the sensor to the PLC for evaluation happens within milliseconds. The result of the sensor data causes the PLC to control the machine normally or make adjustments to the machine operation, again within milliseconds.

Can the smart coupling be integrated in existing systems?

TL/CH/Voith: Customer demand is there and we are capable of adding sensors and related supporting equipment to an existing system. However, we have found physical dimensions and layout of the system along with the desired sensor array will ultimately determine what is and what is not possible. In other words, sensor integration into existing systems can be done to varying degrees on a case by case basis.



Voith SVTL variable speed hydrodynamic coupling with housing mounted sensors. (Courtesy Voith)

iLP3: rendering of R+W sensor package installed into the spacer of an LP3 flexible disc coupling. (Courtesy R+W.)

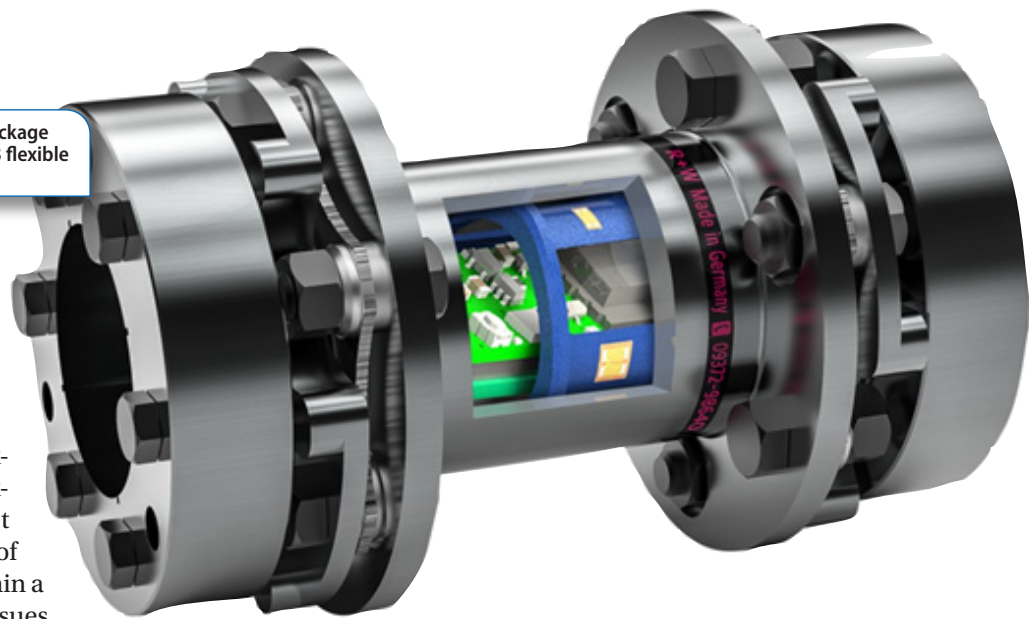
Regarding torques and axial forces, how do the smart couplings-sensors help reduce or prevent failure and/or downtime?

TL/CH/Voith: Drivelines that experience over torques and / or excessive axial forces typically do not last a long time. The integration of strain gauges at various places within a driveline that experiences such issues, at least on a temporary basis, can identify the magnitude of the torque or axial forces and allow the machine owner to make educated decisions. For example, in one case, a universal joint shaft in a scrap metal recycling shredder application experienced over torques that could have led to the premature or catastrophic failure of the universal joint shaft. Sensor feedback in this application showed the machine owner the amplitudes and durations of the torque spikes and indicated the need for the addition of a torque-fuse coupling, such as a hydrodynamic fluid coupling or a torque-limiting safety coupling, to the machine drive chain. Such a torque-fuse coupling would act as the soft element in the drive system with built-in safety and release features. They then also had the ability remotely monitor the system for over-temperature and release conditions.

Torque, axial forces and radial forces are part of the design of machinery and integrated in the game of engineering. However things can be overseen during design phase or machinery is operated out of allowed operating points. In such cases, dynamic forces can rise quickly and damage machinery or civil structures prematurely. Measurement of dynamic forces is therefore a great tool to understand the system characteristics to avoid premature failures and also to identify the root cause of vibration problems.

RE/MAYR: Monitoring in the drive line provides the opportunity to detect errors and wear that are gradually becoming apparent at an early stage and then to act with foresight.

Also, when planning maintenance periods, for example, the parts which are subject to wear can be ordered in advance. This reduces the maintenance time and thus the overall downtime of the system. In particular changing vibration patterns or torques with always the same process sequences are ideal signal generators or indicators. Also load conditions that are recorded by the sensors (torque/temperature/speed) in the drive line enable the system operator to carry out the maintenance interval sooner or later if necessary and to plan it better.



For more information:

Altra Motion
Mark O'Neil, Chief Principal Engineer, Altra Couplings
ameridrives.com

Mayr
Ralf Epple
Phone: 0049 8341/804-0,
info@mayr.com
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R+W America
Andy Lechner
Phone: +1 (630) 521-9911, Ext. 13
Mobile: +1 (630) 624-9911
alechner@rw-america.com
www.rw-america.com

Voith
Todd Lehman, Sales Manager, Coupling and Drive Technologies, Voith Turbo North America
todd.lehman@voith.com
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Power — and Sand — to the People

SPPS Solves Energy Challenges at Sand Mine

Jim Wahl and Ben Morris

Zach Rountree's life would be a lot easier if his job site was closer to town. As the owner and president of Rountree Construction, he oversees an operation that pulls 200 tons of material an hour out of a remote lake in Stockton, Georgia. Big equipment demands three-phase power, but out in the remote timberlands of rural Georgia, only single-phase power was available.

Rountree Construction runs a surface sand mine, processing sand for the ready-mix industry, masonry products and sand for golf courses—everything from the sand for bricks to the sand that swallows your golf ball.

Until recently, their sand mine ran rotary phase converters to generate three-phase power. But the phase converters that couldn't take the extreme weather conditions, particularly in the height of a Georgia summer. The high heat and humidity prompt locals to run their air conditioning, which maxes out the electrical grid. Inconsistent power flow to the rotary phase converters, like the sags that occur when there is a large demand on the grid, would cause them to shut down. Swells in the power supply, like those caused by lightning strikes in the area, a common summertime occurrence, would also cause the rotary phase converters to kick out. So Rountree approached his local utility company, which suggested installing a Single Phase 1-to-3 Microgrid Power Source.

Keeping Current

Demand for three-phase power is growing much faster than the availability of three-phase service, particularly in rural and agricultural areas of the nation. In the late 80's, when Rountree established the sand mine, three-phase service was even harder to find.

Rountree's open dredge system ran a rotary phrase converter to convert the single-phase service to three-phase power. A dredge pumps material from the lakebed to a processing plant, where sand is washed, drained, dried and prepared for delivery.

The sand mine operates three production lines six days a week, 360 days a year. All said, upwards of ten different motors run 10-12 hours a day, creating a huge demand for consistent power.

In the dog days of a Georgia summer, temperatures and humidity soar. Locals crank up the air conditioning, which maxes out the local power grid. On top of that, lightning strikes two to three times a week, causing power surges and outages, tripping the rotary phrase converters and kicking them off.

"We'd have to run out there and restart it quickly, or the whole system would get gunked up: all the pipes would clog with material, it was a big mess," Rountree said.

It was a common problem. And with production shut down

from 15 minutes to six hours, it was more than just a nuisance, it was expensive. If crews were unable to re-start the converters before a jam was created, they'd have to manually clear the jam, which meant unbolting pipes, unplugging the pipes, rinsing the system, and restarting the production line. From Rountree's perspective, that meant he was paying to clear the jams and paying for the production—so his labor costs were basically doubled for the time spent cleaning.



The Rountree sand mine operates three production lines six days a week, 360 days a year. (All photos courtesy of SPPS)

A Powerful Solution

Rountree, tired of the labor costs to restart the motors and clean up clogged production lines, approached the local utility company, which provided the rotary phase converters, to see if there were any other alternatives. They recommended Single Phase Power Solutions, producers of high horsepower single-phase motors, specifically their 1-to-3 Microgrid Power Source utilizing the patented BELLE Written-Pole motor. Generating clean, stable, three-phase power with the pair of 100 hp 1-to-3's has simplified the power process and resulted in more reliable and consistent power, even in the heat of summer.

Every morning, Rountree starts a motor by the water pump. From there, he can hear the strain on the 1-to-3 Microgrid Power Sources, and when it settles (after a few seconds), he hits the start button. Power flows throughout the plant, pulling the first tons of material up for the day.

“It’s a lot simpler than I thought it was going to be,” Rountree said.

The 1-to-3 allows weak single-phase lines to deliver three-phase power with excellent voltage regulation and precise 60 Hz frequency. The generator output provides well-balanced power capable of starting and running Rountree’s largest production lines, despite running ten motors with no breaks. Fresh water lines feed the flow to the plant, flowing through a 10-inch line to a clarifying tank which drains and provides a preliminary scrub of the material. From here the flow goes to the log washers, fine aggregate screws and then to a conveyor belt.

While the process is not terribly complex, all aspects of production are powered by three-phase motors. When power outages cause material jams, it requires a bit of elbow grease to clear them.

The Single Phase Power Solutions equipment has been in place for over five-plus months now, through the hottest days of the summer, without fail. No motors kicking off, no running out to get everything back online before the material clogs pipes, and most importantly, no production downtime.

Each of the 100 hp 1-to-3 Microgrid Power Sources generates 100 hp of total power which can power several motors. One of those motor can be equal to ½ of the 1-to-3’s output, or 50 hp, with the remaining power distributed among



Rountree Construction runs a surface sand mine for the ready-mix industry, masonry products and sand for golf courses.

smaller motors totaling the other ½ of the capacity. The largest motor that Rountree powers is a 30 hp freshwater pump which feeds the wash plant.

“Any sort of disruption would kick out the old rotary phase converters,” Rountree said, “but the Single Phase product has run very constant, with no problems.”

Since the local utility owns the equipment and sells the three-phase power to Rountree, he has not noticed a decrease in his rates. But he is pleasantly surprised with uptime that his plant achieves due to the stable power supply generated by the 1-to-3’s. **PTE**

For more information:

Single Phase Power Solutions
Phone: (877) 430-5634
www.sppowersolutions.com

Jim Wahl is owner of Wahl Marketing Communications. He works with several industrial clients and is based in Cincinnati, Ohio.

Ben Morris works for Single Phase Power Solutions in Cincinnati, Ohio.



Rountree Construction has had zero downtime since utilizing Single Phase Power Solutions equipment.

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Improvement of the Noise and Vibration Behavior of an Electromechanical Brake Booster — an Integral Approach

Dr.-Ing. J. Fechler, Dipl.-Ing. S. Oberle, Dipl.-Ing. (FH) M. Knöpfle,
B. Eng. V. Merz

Introduction

The automotive world faces a tremendous change. Autonomous driving and electrification are two big topics in this context that are pushing this change. The demand for higher comfort, higher safety and tightened environmental requirements drive as well the technological change from former mechanical actuators to electro-mechanical systems in new vehicles. This can be observed especially for braking and steering systems.

One of these new arising technologies and systems in this context is the electro-mechanical brake booster from Robert Bosch (Ref. 1). This new and innovative system replaces more and more the “old” vacuum boosters; the first generation was rolled out in 2013. In the meantime, the second generation has entered the market. The iBooster can be used for all different types of drive concepts like electric, hybrid or standard vehicles. It is also a cornerstone for automated driving as it allows new driver-assisted functions to be set up, e.g. — emergency braking and traffic assist. This set of new functions and concepts results in strong requirements for good noise, vibration and harshness behavior (NVH) of the system — especially if it is used in electric vehicles and if it is activated without a driver demand by the assistance systems of the vehicle.

The electro-mechanical part of the iBooster consists of a permanent magnet synchronous motor, a three-stages gearbox with a spindle as the last stage (Figs. 1 and 2). The complete geartrain is assembled in a housing made out of sheet metal. The motor with the motor pinion is screwed to the housing. The housing of the iBooster itself is screwed to the bulkhead of the car and this screwing is the main interface to the vehicle.

The materials of the gears are metal and plastic. The motor pinion and the spindle are made out of metal, all other gears out of performance plastic materials. The plastic gears are produced by injection molding.

All components of the electromechanical drivetrain, as well as the housing, are designed accordingly to achieve the strong NVH requirements. After the start of production a project was set up to find further potential and to improve the NVH properties of the booster. This paper describes these investigations to separate the different influence factors of the system’s NVH behavior and to tap possible potential of improvement.



Figure 1 iBooster Gen2 (Picture: Robert Bosch GmbH).

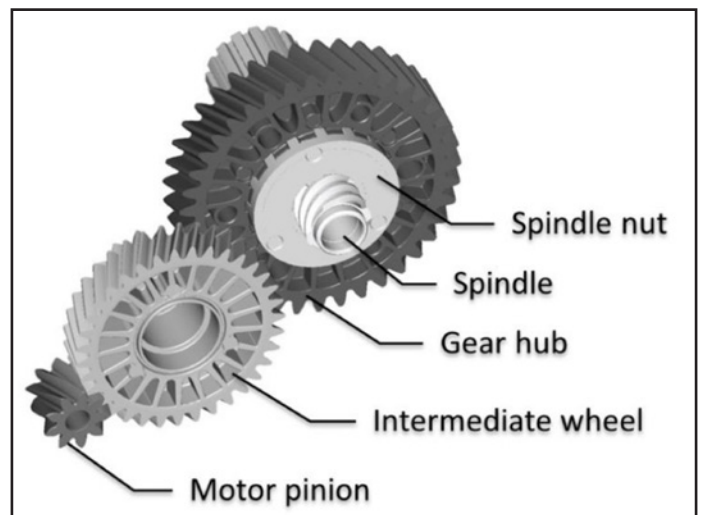


Figure 2 Geartrain.

Approach

It is well known that the noise and vibration behavior of a system is influenced by a number of parameters and factors. An acoustical optimization of the system has therefore to follow a holistic approach and investigate all the aspects of the acoustic transfer path (Fig. 3).

The analyzed and investigated unit of the iBooster is complex, and due to this the approach of the investigation needs to be divided in four steps:

1. Definition of the system boundaries
2. Assessment of the influence factors and definition of samples
3. Definition of measurement setup and analysis procedure
4. Measurement, analysis and conclusion

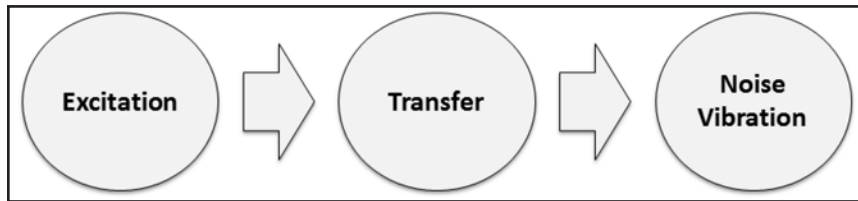


Figure 3 Acoustic transfer path.

Definition of System Boundaries

The basis of the investigations is the standalone iBooster system, requiring that all testing and analysis to be conducted on the test bench and not in the vehicle. The system boundaries are limited to the test bench to avoid any influence of the vehicle and to achieve a neutral environment for the assessment.

The investigations focus mainly on the excitation by the geartrain and the transfer of this energy to its surrounding components; surrounding components mean in this context the bearings, the housing and the interface to the vehicle. The transfer of the excitation to the position where the booster is screwed to the vehicle is of high importance. A low excitation at this interface results almost directly in a good noise and vibration ambience in the compartment.

The eigenfrequencies of the system are directly linked to its mechanical setup and design. The interaction between these eigenfrequencies and the dynamic excitations affect the noise and vibration of the system significantly.

Unfortunately the system eigenfrequencies can't be changed so easily for samples as this would mean a complete change of the mechanical setup and the system design; they therefore have to be seen as fixed boundary conditions. The eigenfrequencies of the system have been identified by an experimental modal analysis and cross-checked upfront with a finite element calculation to judge their influence on the NVH behavior. Based on these results the critical frequency bands have been determined.

The first stage of the geartrain is the main driver for the vibration. For this reason the focus lays especially on the first gear stage. The macrogeometry is changed by setting up motor pinions and intermediate wheels with different gears and helix angles.

Motor pinions with a lower number of teeth (7 instead of 9) and a higher number of teeth (13 instead of 9) are tested to see the influence on dynamic excitation by the gears it-

self and to change the meshing frequencies. Higher and lower numbers of teeth lead to different motor speeds at which the eigenfrequencies of the systems are met (Fig. 4); this could help to reduce the level of the excitation forces. The pairing gear of this stage also needs to be changed. The impact of the changes was simulated up front by finite element simulations.

The quality of the micro geometry of the gears is essentially given by the manufacturing process. The intermediate wheel is molded out of plastic material. Therefore the production process of the intermediate wheel was changed from injection molding to milling. It is expected that a higher quality level of the micro geometry can be achieved by the milling process.

Last but not least the transfer path between the origin of the dynamic excitation (the gears) and the housing as the

Assessment of the Influence Factors and Definition of Samples

The dynamic system has a lot of different influence factors on the acoustic behavior. Out of this plurality the following factors have been deduced for the investigation:

- eigenfrequencies as a significant system property
- Macrogeometry of the gears, i.e. — the number of teeth and the shape of the teeth
- Microgeometry and the quality of the gears, which are linked to the production process of the parts
- Transfer path itself

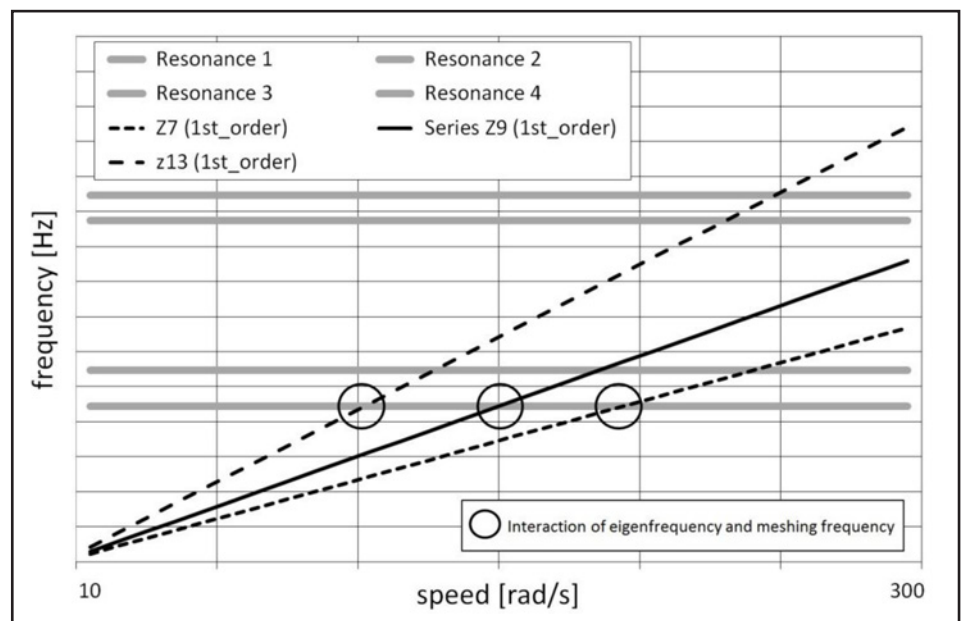


Figure 4 Critical Eigen frequencies of the system and gear meshing frequencies.

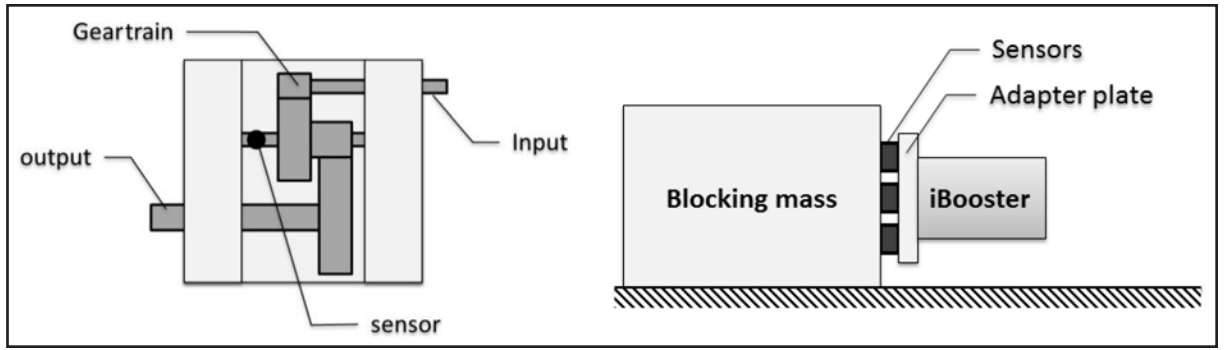


Figure 5 Test benches: geartrain, blocked forced.

interface to the vehicle is changed. It is obvious that damping this transfer path is adequate method to reduce the amplitude of the excitation.

Table 1 Investigated measures and intended influence (extract)		
Measure	Excitation	Transfer path
Number of teeth (motor pinion): z = 7 vs. z = 9 (series) vs. z = 13	●	●
Manufacturing process (intermediate wheel): Milling vs. injection molding	●	
Additional damping element		●

A higher damping is applied by changing the bearing system in such a way that an additional rubber element is mounted within the bearing of the intermediate wheel. The vibration energy should be significantly reduced by this measure.

Definition of the Measurement and Analysis Procedure

All the measurements are carried out on the test bench level. An important requirement of these measurements is that the chosen test setup needs to be as representative as possible to allow a transfer of the results to the later application, i.e. — an acoustic improvement in the vehicle. The measurements are done in two steps to reach this requirement.

In the first step the standalone geartrain without the spindle and any other system components, e.g., the housing, is measured at different speeds and loads on a special gear test bench (Fig. 5); the vibrations are measured at the shaft of the intermediate wheel. This position corresponds to the interface between geartrain and housing in the real system. The vibrations are measured by structure-borne sound sensors. The chosen setup offers a good comparison of the different defined variants on the component level.

In the next step the measured gears are mounted in a complete iBooster system and the system is measured on a so-called “blocked force test bench” (Fig. 5). This measurement procedure allows judging the impact of the investigated change on a system level. The basics and theoretical

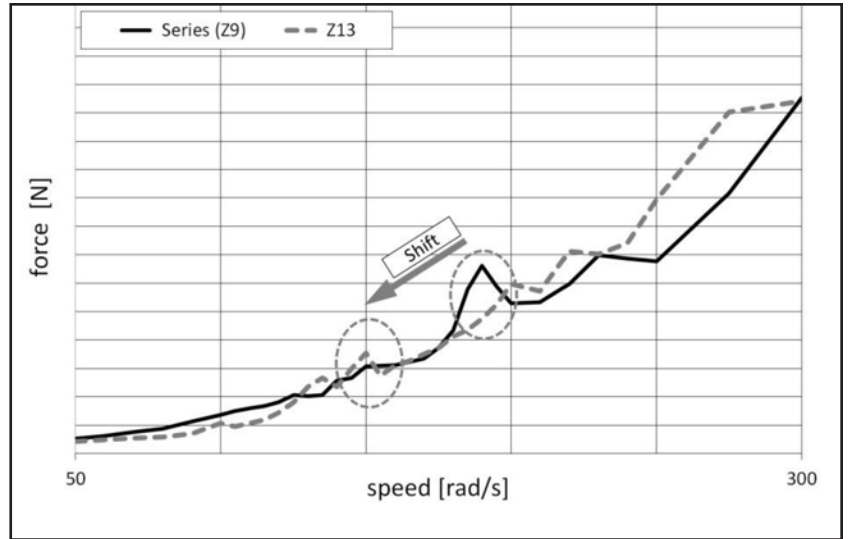


Figure 6 Number of teeth: Z13 vs. Z9 | influence on force.

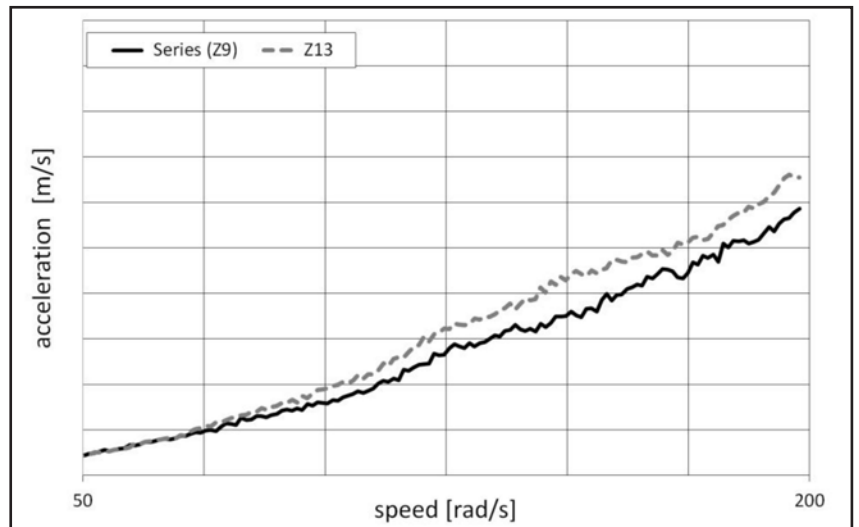


Figure 7 Number of teeth: Z13 vs. Z9 | influence on vibration.

background of this measurement procedure can be found in (Refs. 3–4).

The iBooster is mounted at a huge blocking mass in this blocked force bench. The mounting is done at the same interface as it would be done in the vehicle. Force sensors are positioned between the blocking mass and the adapter plate. This test setup allows the measuring of the dynamic forces that are transferred between the booster and the environment. These

dynamic forces are used for the comparison of the different variants. The investigated measurement conditions are derived from a specific use case given by a braking situation in the vehicle in respect to load and speed. Also, the frequency band that has to be improved is given by the use case in the vehicle. The tests have been carried out at motor speeds that were constantly changed from 500 to 3,000 rpm and an input torque of roughly 1.3Nm. The analyzed frequencies are within the band between 500 to 1,000 Hz.

The dynamic properties of the test benches have to be taken into account for the interpretation of the results. They limit the maximum frequency that can be measured and analyzed. These limitations have been determined before by appropriate tests to avoid a misinterpretation of the results.

Results

Different number of teeth of the motor pinion. The change of the number of teeth has two targets. First, the motor speed at which the meshing frequency of the gears interferes with the eigenfrequency of the housing should be changed. Second, the macrogeometry of the teeth is changed to reduce the dynamic excitation forces of the gears; this is basically only possible by an increase of the number of teeth. A reduction often results in higher excitation forces due to a poorer contact ratio if it is not compensated by other changes like the helix angle of the teeth.

Looking at the dynamic forces measured on the blocked force test bench, it can be seen that the increase of the number of teeth of the motor pinion ($z=13$) causes a lower motor speed, at which the interference of the meshing frequencies and the eigenfrequencies happens (Fig. 6); the elevation of the force level is also diminished. A cross-comparison with the results of the geartrain test bench shows that the lever of the even higher dynamic meshing forces is not as significant as the speed shift (Fig. 7).

By a lower number of teeth ($z=7$) the interference between the meshing frequencies and the system eigenfrequencies is shifted to higher motor speeds. The higher speed means, however, high energy in the systems and hence higher dynamic forces at the interface of the booster (Fig. 8).

The increase of the dynamic forces at higher motor speeds for the configuration $z=13$ can be explained by system eigenfrequencies that aren't met with the standard configuration $z=9$.

Influence of the manufacturing process. Figures 9 and 10 show the influence of the manufacturing process on the vibration and

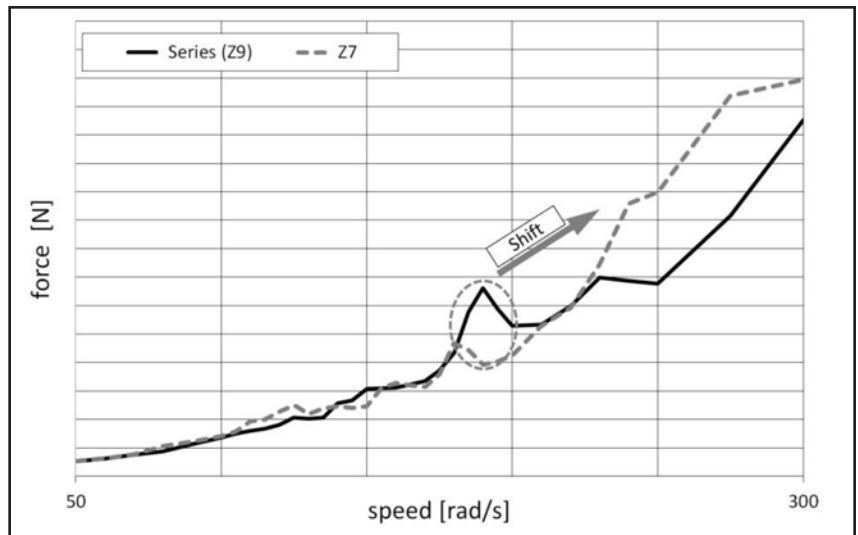


Figure 8 Number of teeth: Z7 vs. Z9 | influence on force.

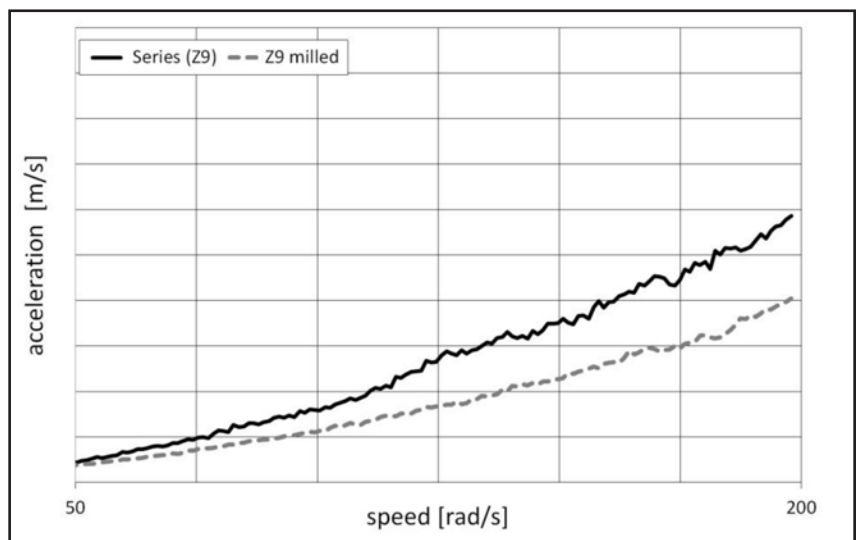


Figure 9 Manufacturing process | influence on vibration.

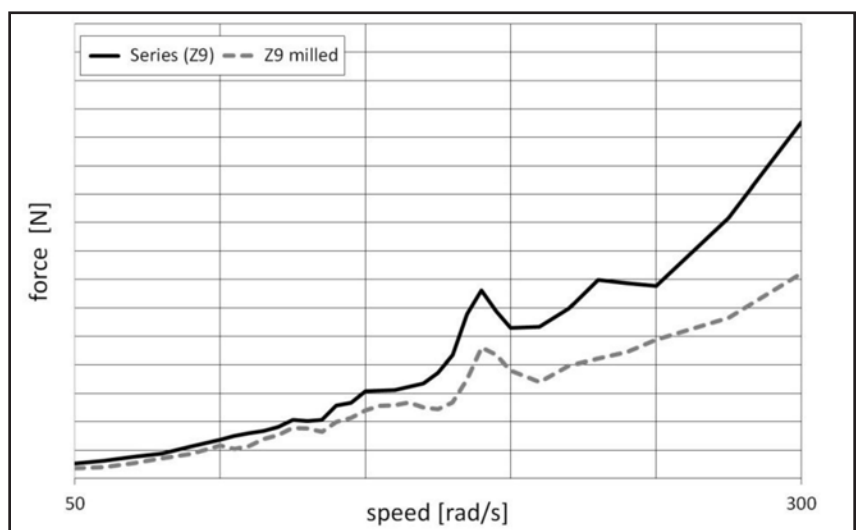


Figure 10 Manufacturing process | influence on force.

dynamic forces. All gear parts (metal and plastic) are produced in the prototype shop of IMS Gear by a 5-axis milling machine instead of the serial process that is set up for the production of high volumes.

The results of the geartrain test bench show a reduction of the vibration level (Fig. 9). This reduction can also be determined by the blocked force test bench. The characteristic of the force level over speed isn't changed by this measure. The level of the forces at the interface is lowered, but the eigenfrequency at roundabout 180 rad/s is still hit. The result can be seen as conformation of the influence of the parts quality. The better the quality, the lower noise and vibration level can be reached.

Additional damping of the transfer path.

Damping the transfer path between the origin of the dynamic excitation and the position where the dynamic forces are radiated as airborne sound often seems to be a promising solution for better NVH behavior. Therefore additional rubber elements are placed in the bearing system of the intermediate wheel for this setup.

The impact of this change is impressive. The good results of the geartrain measurement (Fig. 11) can be transferred to the blocked force test bench (Fig. 12). The improvement is significantly higher compared to other measures. The interference of the meshing frequency of the geartrain stays at the same speed. It can be noted that the characteristics of the dynamic force level is kept while the height of the level is lower. The reduction of the dynamic force level is at its highest at high motor speeds.

Summary and Outlook

The NVH behavior demands more and more attention in the development of electromechanical actuators — especially for electric vehicles. This article has shown how the NVH behavior can be influenced and how the tough targets can be achieved. A holistic approach that covers the complete acoustic transfer path is described.

It can be stated that it is always a number of factors that determine the “good sound” of the system. In this special case, a damping of the transfer path shows the best results, followed by the macrogeometry of the teeth and the quality of the parts. A combination of all measurements can lead to an even higher reduction.

This outcome can be different for other systems. A harmonization of all influence factors and a cross-check with other requirements like the performance, the durability and mechanical robustness is therefore essential. Solving these challenges leads to the best solution for the customer.

These investigations have been carried out through a mutual project between Robert Bosch and IMS Gear. Special thanks must be expressed to team of Robert Bosch for their support by doing the test and measurements on their test

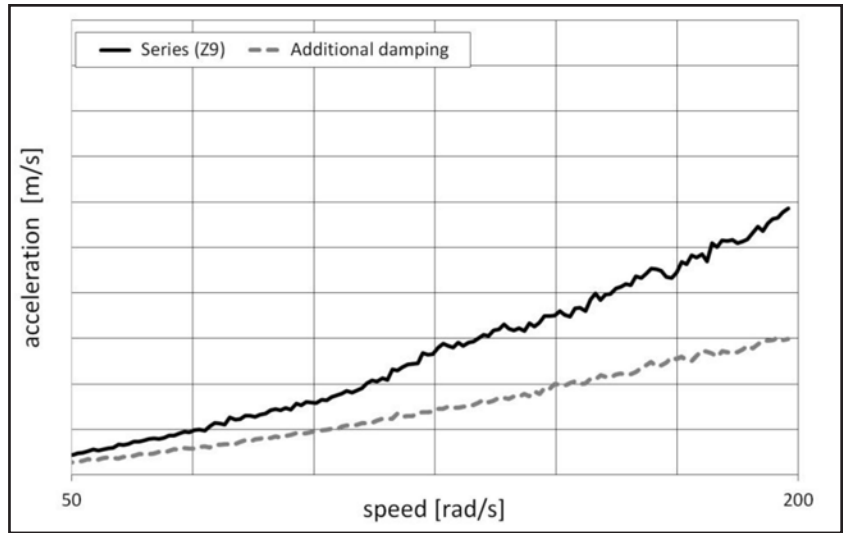


Figure 11 Additional damping | influence on vibration.

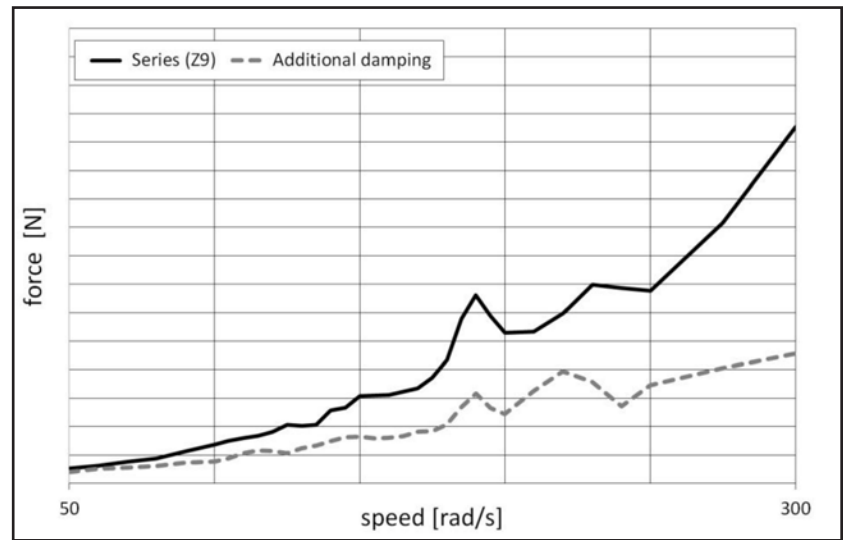


Figure 12 Additional damping | influence on force.

benches and for their noteworthy dedication. **PTE**

For more information. Questions or comments regarding this paper? Contact Jens Fechler at jens.fechler@IMSGEAR.com.

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Dr.-Ing. Jens Fechler earned his degree in mechanical engineering at Studies Mechanical Engineering, RWTH Aachen University (1992–1997). He then served as a research assistant (1997–2002) at Institut für Maschinenelemente und Maschinengestaltung, RWTH Aachen University, Germany. He received his doctorate in 2003. From 2003–2006 he was a NVH Engineer at ZF Friedrichshafen AG, Friedrichshafen, Germany, and from 2006–2019 he was senior manager R&D Actuators, IMS Gear SE & Co. KGaA, Donaueschingen, Germany. Since 2019 Fechler has served as director R&D, Actuators, IMS Gear SE & Co. KGaA, Donaueschingen, Germany.



Dipl.-Ing. Stephan Oberle earned his degree in mechanical engineering (1983–1990) at Technische Universität Karlsruhe, Degree: Dipl.-Ing. Maschinenbau. His professional career (all at IMS Gear SE & Co. KGaA, Donaueschingen, Germany) began in (1991–1993) as development engineer design and optimization; (1994–1999) as development manager for gear design and optimization; (1999–2001) as testing manager, establishing of components testing and installation of acoustic lab; and (2001–2019) as senior engineering manager, gears and components; since 2019 Oberle has served as director R&D, gears and components.



After an apprenticeship (1999–2003) in mechatronics, **Volker Merz** earned a bachelor of engineering degree (2011) at the University Constance, Germany. Since 2011, Merz has worked as an acoustics engineer in the R&D department of IMS Gear SE & Co. KGaA, Donaueschingen, Germany



Dipl.-Ing. Michael Knöpfle served an apprenticeship (1999–2002) as a precision mechanic, Schwenningen, Germany. From 2002–2006, he gained his degree in mechanical engineering at the University Furtwangen, Germany. Since 2006, Knöpfle has worked as project engineer, R&D department, IMS Gear SE & Co. KGaA, Donaueschingen, Germany.



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Hybrid Transverse Magnetic Flux Motors — AKA Stepper Motors and Hybrid Servos

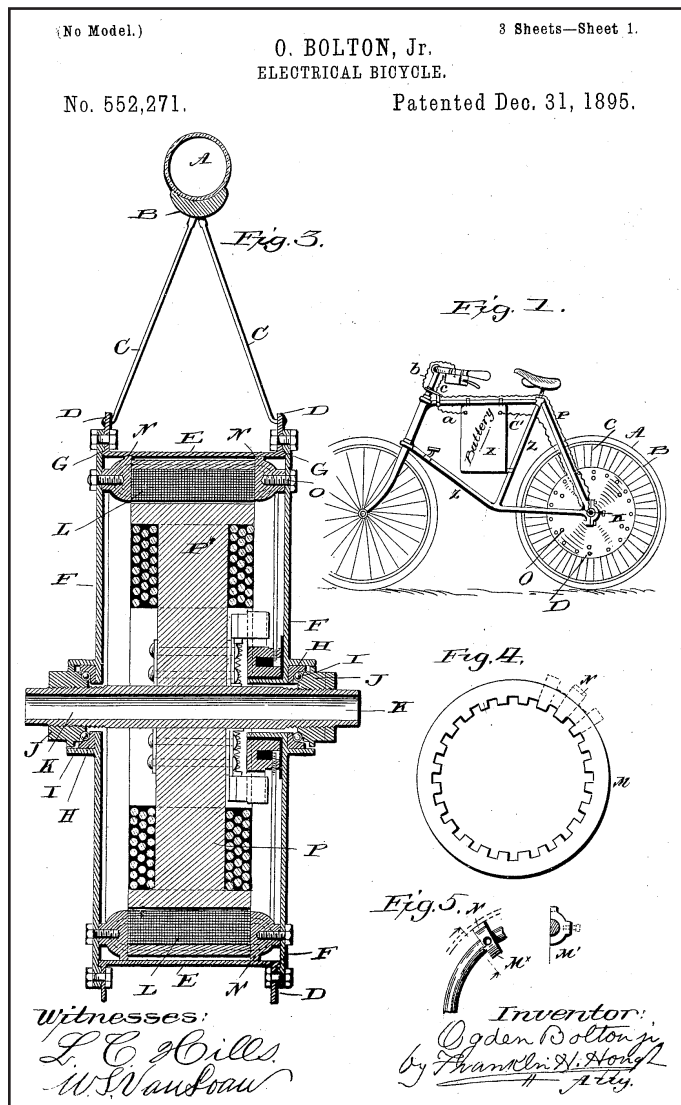
Donald Labriola P.E.

This is the first of a series of articles on permanent magnet transverse magnetic flux motors — AKA step motors. These articles will be covering the development history and the various drive technologies used with these motors — both open and closed loop. There is a long history of interest in this motor type, as it has a very high continuous torque density and a very high motor quality factor (torque/square-root of power) for a given form. Their simple construction helps reduce costs while also improving reliability. This first article covers the development of the motor over more than a century.

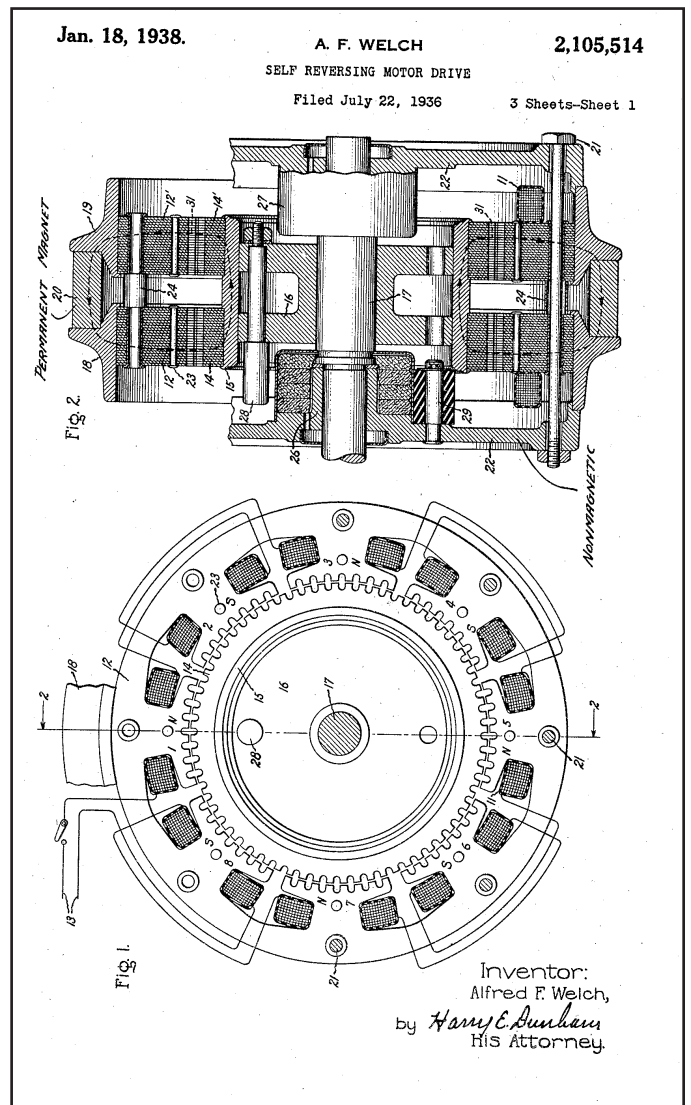
The earliest transverse magnetic flux motor (of which I am aware) is described in U.S. patent 552271, which was designed as a brush motor for an electric bicycle hub

motor — patented Dec. 31, 1895. It uses 6 driven coils that are mechanically commutated. The motor is “inside-out” with the center being the stator electrically wired through the ends of the center mounting rod, while the outside armature (rotor) connects to the bicycle wheel. This is a variable reluctance design, as it has no permanent magnets being used, nor a field winding. The coil windings for transverse flux motors are relatively simple and concentrated, thus minimizing copper losses, while the magnetic flux follows a more complex path in three dimensions. Many smaller teeth are used to increase the pole count, which helps trade torque for speed. This is typical of the “transverse flux” design.

US2105514 from July 1936 looks closer to a modern step motor, except that the biasing magnet is placed axially in a



Early variable reluctance transverse flux motor (US552271)



Early 50:50 laminate Transverse magnetic flux – Stator PM design (US2105514)

circumferential gap in the stator, while the rotor has the two toothed rotor poles. This motor is a single-phase motor and must be manually started up in the desired direction; it automatically reverses when it encounters a blockage. A rewiring of this motor would yield a step motor — operating very similarly to the planar Sawyer motor.

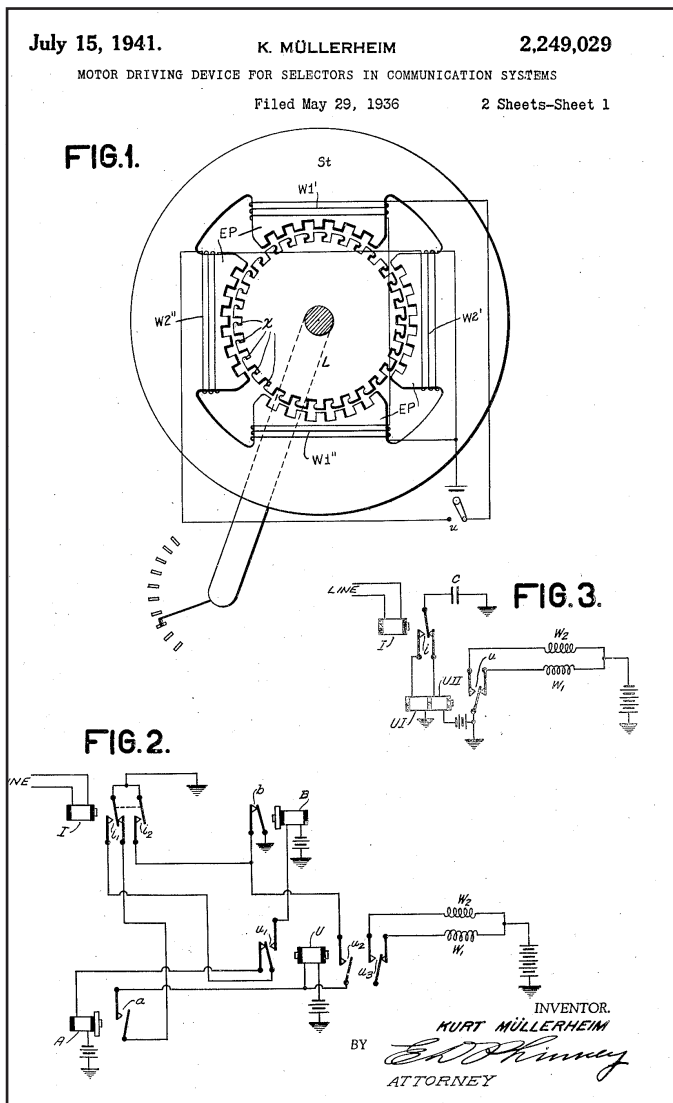
US2249029 shows both 2- and 3-phase step motors used to direct the dialing of the old rotary phones (now quite obsolete), which sent out the number dialed as a series of clicks. The motor responded to these current pulses by moving a contactor across a set of contacts. This machine is a variable reluctance design, as no axial magnet in the rotor is described in the patent.

US2589999 is the first patent (I have documented that) that shows all the elements of the modern hybrid step motor. It has only 4 stator poles, arranged as 2 phases, to be driven from the AC line with a split capacitor design to generate sine and approximately cosine waveforms. The rotor has a single disk magnet that is oriented in the axial direction between two rotor pole pieces, with the teeth offset between the two halves of the rotor. The teeth of the rotor and the

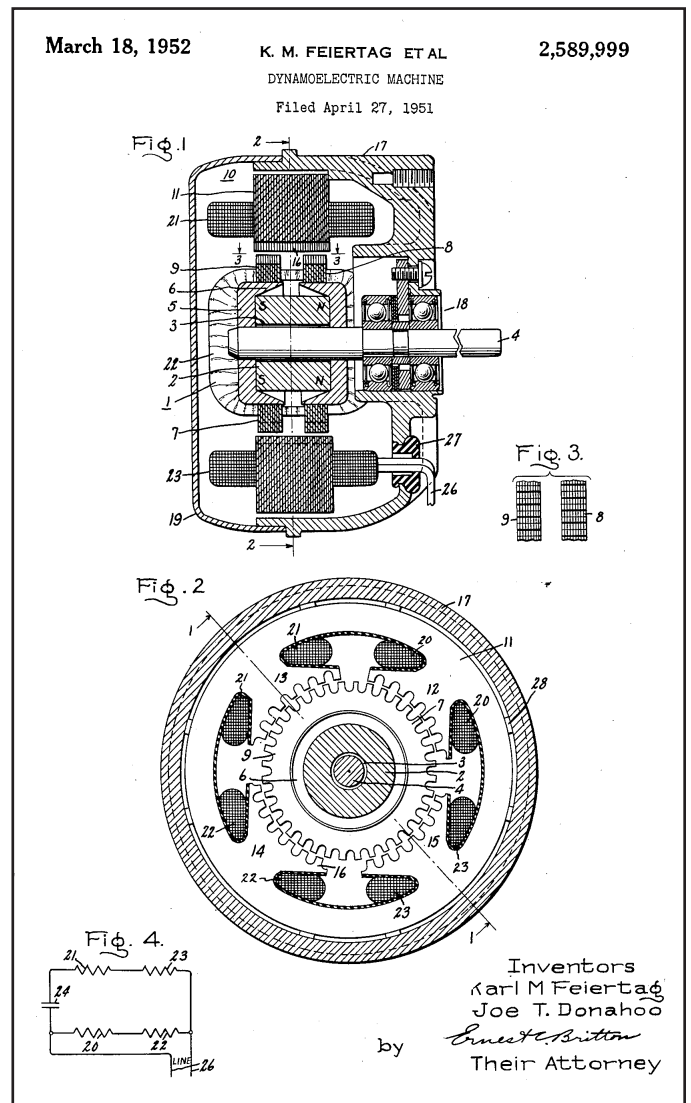
stator have the same pitch, so this motor would be similar to a full-step motor, i.e. — the design would not support effective microstepping.

US2982872 shows a motor with the rotor and stator teeth designed to have different pitches. This reduces the torque ripple by not having all the teeth simultaneously align between rotor and stator. The rotor has an axially polarized magnet with two pole caps that have the teeth offset to produce a gap on one side pole and a tooth on the opposite pole. Again, the split capacitor design drives one phase of the coil from the line voltage and the other through a capacitor to generate a phase shift to set the direction of motion. Reversing which coil is directly driven and which is phase-shifted by the capacitor determines the direction of motion. This motor could be run synchronously from the AC line voltage for applications like record players, thus all but eliminating most of the gearing.

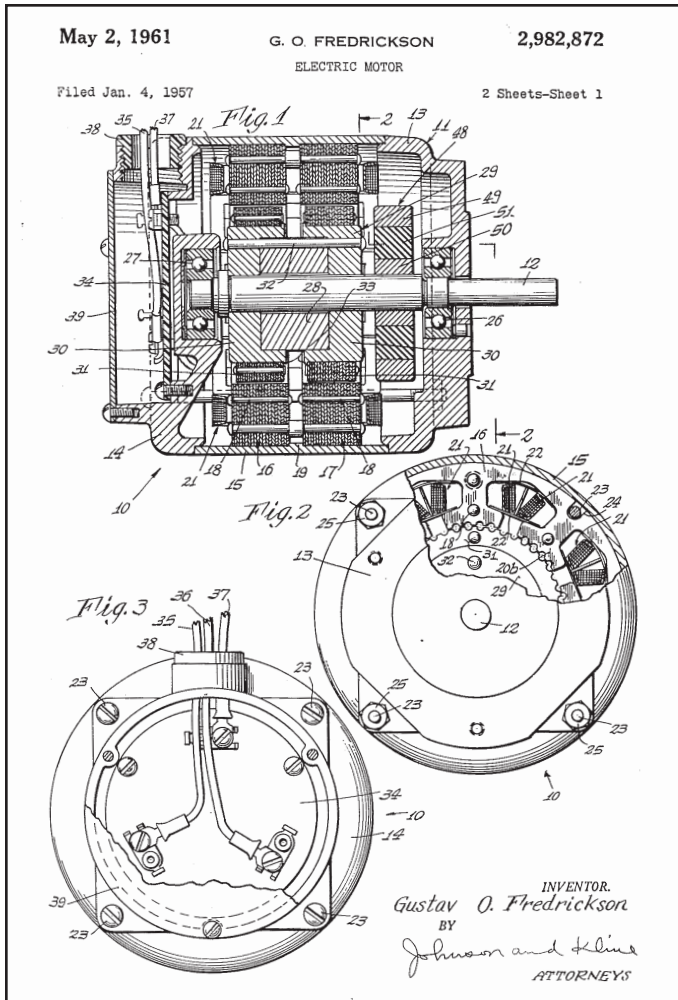
US3343014 refers to the above motor design, but finally takes the “step” to driving this with a motor with a bipolar square wave drive circuit to cause the motor to move 1.8 degrees at each successive switch combination in the sequence



Early Variable reluctance Transverse magnetic flux step motor (US2249029)



2-Phase Permanent Magnetic Transverse Magnetic Flux Motor (US2589999)



48:50 Low Cog 2-Phase Permanent Magnet Transverse Magnetic Flux Motor (US2982872)

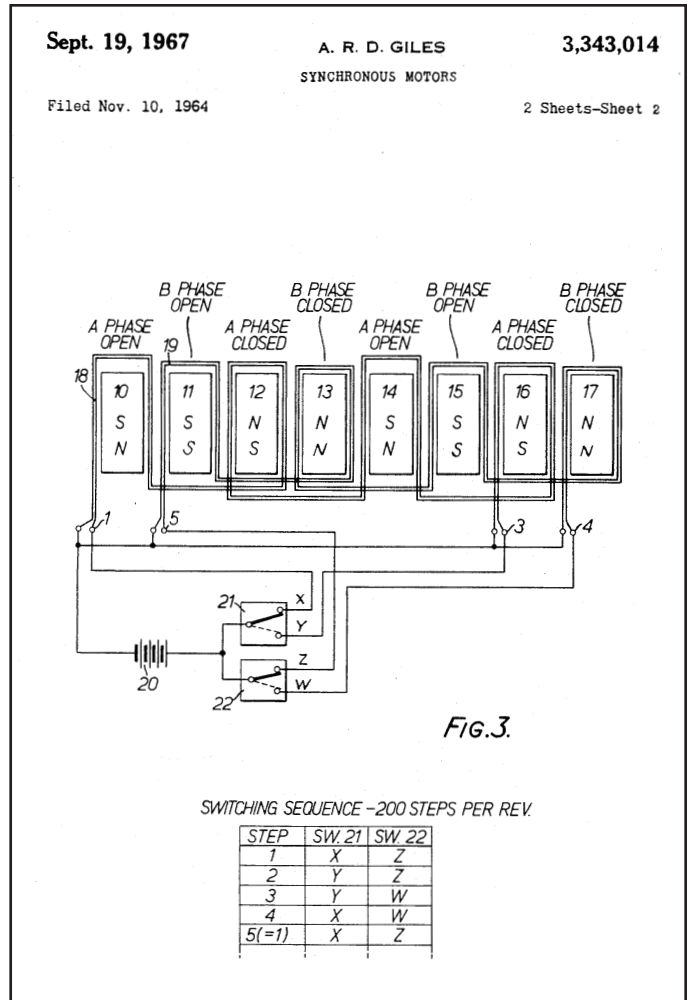
table, i.e. — 200 steps per revolution.

There have continued to be many improvements in this motor type — more than 100 additional patents — but I will stop here as it brings us very close to the modern step motor designs.

Summary

The history of the transverse magnetic flux motor shows that this design was motivated by the need for high torque in direct-drive operations. The transverse magnet flux design allows for many more rotor poles than there are windings by putting multiple teeth on the stator pole piece associated with each winding. The resulting high pole count of the motor enables the design to produce high torque

The permanent magnet transverse flux motor uses a single rotor magnet in a 100-pole motor design. A 100-pole face magnet non-transverse-flux design would require one- or two-magnets-per-electrical-pole, and would need a much more complex stator as well. The transverse magnetic flux motor uses a simple stacked rotor and stator design with few, compact coils. This makes for a simpler and lower-cost design. The transverse design, which uses three dimensions for flux flow, brings the iron to the copper rather than the other way around. This reduces the non-productive end turns in

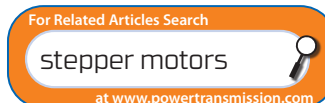


Operation of Traditional Full-Step Stepper (US3343014)

the coils, which only contribute copper losses and do not assist in torque generation. **PTE**

For more information. Questions or comments regarding this article? Contact Don Labriola at don_labriola@quicksilvercontrols.com.

Donald P. Labriola II, president and founder of QuickSilver Controls, Inc., specializes in servo controllers and motors, with a special focus on cost-effective motion control. He has been granted eleven US patents as well as numerous international patents. His background includes over 40 years of motion control including 20 years in medical instrument design. He enjoys gardening, camping and Ham radio - and motion control!



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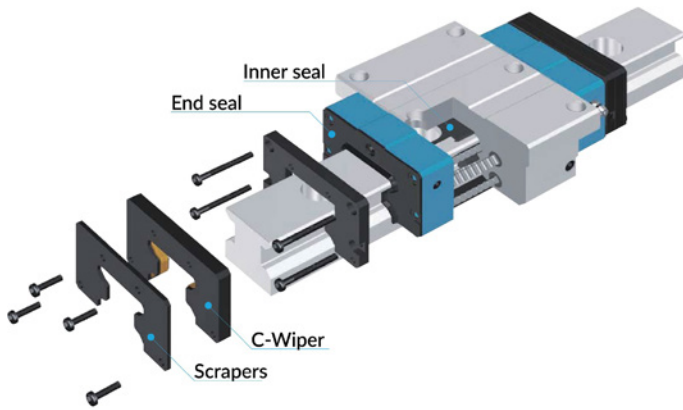
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IKO

OFFERS LINEAR GUIDES FOR ROBOTICS COMPETITION

A team of middle- and high-school students in Gibsonton, Florida are showing off their math and science skills by designing, building and programming a competitive robot using IKO International linear guides. With IKO in their corner, the team is outscoring rivals and setting records along the way.

They call themselves Neutrinos 6433, and the team competes in the FIRST Tech Challenge at a Central Florida tournament held in Lakeland, Florida. FIRST (For Inspiration and Recognition of Science and Technology) inspires innovation and leadership in young people through engaging, team-based robotics challenges. The challenges are designed to demonstrate the accuracy, timing and precision of the robot. For example, one match pitted four robots against each other inside a ring. Competitors were given a task that tested their robots' ability to maneuver around the ring, and to grasp, arrange and stack Lego-like blocks.



IKO Guides and Guidance

The Neutrinos 6433 team discovered IKO while researching potential linear motion guides to design into the robot. IKO International sponsored the Neutrinos 6433 team and supplied the linear motion guides that helped lead the robot to victory. IKO was also available to mentor Neutrinos 6433, and the team tackled their challenges with little assistance, using the following IKO motion guides:

MX linear motion guide. One of the highest performing and dependable guides available. The MX Series guide features a slide unit that operates on a balanced set of four cylindrical rollers housed in a rigid casing, giving it high load capacity and exceptional stiffness and resistance to moment loads. This construction maximizes accuracy, produces a more compact design than ball-type units, and it gives the robot its streamlined size and excellent maneuverability. The MX Series is available in four different lengths — including an extra-long unit MXL that's 1.4 times the standard slide unit length — so the students were able to achieve long extensions to stack items with smoothness and precision. The MX Series also offers a high load capacity and C-Lube technology for long-term, maintenance-free operation — because when you're battling for robotic supremacy, you can't slow down to lubricate your guide.

LWL linear motion rolling guide. The LWL Series incorporates two rows of stainless-steel balls arranged in a four-point contact design with the raceways. Although small, it provides stable accuracy and rigidity due to its simple design even in operations under fluctuating loads with changing direction and size or complex loads.

LWF linear motion rolling guide. This series provides continuous linear motion thanks to a wide track rail and highly rigid slide unit. Two rows of large-diameter steel balls and a four-point contact design with the raceways ensure high stability and accuracy, even under fluctuating and complex loads. The wide rail also supports large moment loads in the axial direction.

The Neutrinos Come Up Big

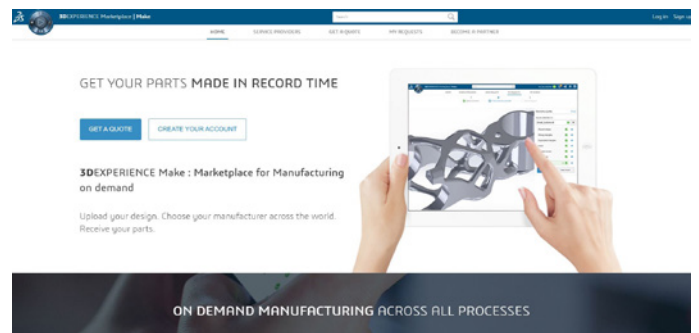
The results have been impressive! While Neutrinos teams have performed well in their previous eight years in the Challenge, this year's team made significant gains. Neutrinos 6433 achieved front-runner status, boasting the highest scores and highest average score among the other 20 participating teams. Not only did Neutrinos 6433 produce high scores, they also posted back-to-back world record scores before being eclipsed by another team. As of this writing, Neutrinos 6433 have the highest average score among teams from around the country. That's no small feat! Thanks to their hard work, skill and determination plus exceptional linear guides from IKO, Neutrinos 6433 is clearly the team to beat. (www.ikont.com)

Dassault Systèmes and Xometry

PARTNER TO OFFER INSTANT PART PRODUCTION IN DESIGN ENVIRONMENT

Dassault Systèmes and Xometry recently announced their partnership to provide customers with a seamless, integrated way to produce parts that accelerates the concept to manufacturing process. Engineers using Dassault Systèmes' Solidworks and Catia applications will have automatic and immediate access to Xometry price quotes on MAKE Marketplace for manufacturing parts, without leaving their design environment.

Engineers can now play a greater role in the design to manufacturing aspect of part production by focusing on the shape of a prototype as well as the cost to produce it. Whereas sourcing manufacturing price quotes from service providers



used to require a dozen clicks in a web interface, it now takes place instantaneously in a one-click immersive experience integrated with Solidworks and Catia. Engineers can view Xometry price quotes on their screen in the context of their design, and click to have it manufactured, all while retaining the option to get instant or manual quotes from other MAKE Marketplace suppliers.

“We launched the MAKE Marketplace in 2018 to make it easy for customers to design and manufacture. Our partnership with Xometry takes this a step further,” said Sébastien Massart, head of corporate strategy, Dassault Systèmes. “Customers can order high quality additive manufacturing or CNC machining parts in one click at the right price, thanks to Xometry instant quoting capabilities. This is all part of our vision to continuously reduce the friction that customers face going from design to manufacturing.”

Through this partnership, Xometry becomes the first “prime partner” of Dassault Systèmes’ MAKE Marketplace. This new category recognizes qualified service providers having industrial-grade quality certifications, and production capacities to answer demanding needs as well as high satisfaction rates. Dassault Systèmes plans to add other “prime partners” to the 3DEXPERIENCE Marketplace ecosystem.

“Engineers need the right tools to do their job successfully, and this includes working with a responsive, trusted manufacturing partner,” said Randy Altschuler, CEO, Xometry. “As the leader in 3D printing and on-demand manufacturing, we have served many customers in the MAKE Marketplace since its launch. Through our deeper partnership with Dassault Systèmes, we can directly connect with customers and make a commitment to provide a quote on every customer query. It’s all about faster manufacturing.” (www.3ds.com)

Siemens Digital Industries

MINDSPHERE NAMED IOT SOFTWARE LEADER

The Industrial Internet of Things (IIoT) has the potential to significantly improve global productivity and growth, with Accenture estimating that this latest wave of digital innovation will accelerate the reinvention of sectors that account for almost two-thirds of world output and add US \$14.2 trillion to the global economy by 2030. As companies around the world continue to develop IIoT strategies and implement solutions, they are increasingly partnering with Siemens and choosing *MindSphere*, the cloud-based, open Internet of Things (IoT) operating system, as the foundation of their IIoT programs. Recently, Siemens was among the select companies that Forrester invited to participate in The Forrester Wave: Industrial IoT Software Platforms, Q4 2019 evaluation. In this evaluation, Siemens’ *MindSphere* was cited as a Leader in Industrial IoT Software Platforms. Over the past year, *MindSphere* significantly grew its partner program, and announced major new customer wins and Siemens’ expansion of the *Mendix* platform to include cloud and app services for digital engineering and IoT powered by *MindSphere*, which is at the heart of its *Xcelerator* portfolio.



According to Forrester, “*MindSphere* builds on Siemens’ strength in industrial equipment and controllers but isn’t limited to interacting with Siemens hardware. The company continues to tell a strong story about the importance of digital twin, and *MindSphere* plays a key part in turning this vision into something pragmatic and implementable. *MindSphere* is well suited to customers with existing investments in the Siemens ecosystem but also deserves the attention of any industrial company interested in tapping Siemens’ deep domain knowledge and the experience it’s gained from its own internal digital transformation.”

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can transform this data into productive business results using powerful industrial applications with advanced analytics. *MindSphere* is a secure and scalable industrial end-to-end solution from asset connectivity to actionable business insights utilized to increase productivity and efficiency across the entire enterprise.

“MindSphere has continued to grow and strengthen over the past year, and we now have over 500 MindSphere partners including Microsoft, AWS, Arrow and Alibaba, which has helped fuel success in the Chinese market where we recently launched the partner program,” said Ray Kok, senior vice president and general manager, cloud application solutions at Siemens Digital Industries Software. “We are proud to be recognized as a Leader within the Forrester Wave report and will work to build on this momentum to continue to help our customers achieve their goals.” (www.sw.siemens.com)

BCA Bearings

AWARDED 2019 RISING STAR SUPPLIER OF THE YEAR

NTN, the parent company of BCA Bearings, is proud to be awarded the 2019 Rising Star Supplier of the Year award by the Auto-Wares Group of Companies. The award was announced and presented at the recent Auto-Wares Group annual sales meeting in Grand Rapids, MI.



“It is a great honor to be recognized by Auto-Wares with this award,” remarked Charles Harris, director of automotive aftermarket sales, “Supporting the needs of our distributor partners is the foundation of our automotive aftermarket business, so it is extra special knowing that this award was voted on by Auto-Wares’ leadership, sales team and store personnel. We are very proud to win this prestigious award.”

The Auto-Wares Rising Star Supplier of the Year Award is presented annually to recognize recently approved suppliers that show excellent sales growth potential and exhibit outstanding performance in distributor and store-level changeovers. (bcabearings.com)

Victrex

CREATES JOINT-VENTURE TO MANUFACTURE PEEK IN CHINA

Victrex recently announced the creation of a joint-venture between its subsidiary, Victrex Hong Kong Limited, and Yingkou Xingfu Chemical Company Limited, to build and operate a new PEEK polymer manufacturing facility in Liaoning, China, subject to certain performance conditions, including finalizing land purchase and permit applications.

Victrex, which will be the majority partner and lead the joint-venture, will benefit by further differentiating and complementing its portfolio of PEEK and PAEK grades, in anticipation of a range of significant long-term growth opportunities across several end markets in China, as well as aligning with China’s ‘Made in China 2025’ initiative, where specifying domestically produced PEEK in certain applications is expected to gain momentum.

Victrex already has an established relationship with its joint-venture partner through its monomer supply chain, with Yingkou Xingfu having significant experience of developing and operating chemical facilities in China which meet international quality, process and environmental standards.

This builds on Victrex’s recent appointment of a general manager for China and an increased commercial presence, as well as its strong technical service offering to customers, which includes its existing Technical Center in Shanghai. The investment sets the stage for Victrex to serve some of its regional customers from a local facility and in a more diverse way. Victrex will also oversee the management of process know-how and intellectual property during development of the polymerization process.

“While we already manufacture a range of PEEK and PAEK grades, this will enhance our portfolio, making us even better positioned in a region where we have seen strong growth in recent years and continue to see attractive opportunities, aligned to our know-how and strong technical and application development capabilities. Overall, we believe this is a good entry point to a China manufacturing operation, working with an established partner and offering an attractive returns profile,” said Jakob Sigurdsson, chief executive of Victrex. (www.victrex.com)



April 1–5—The MFG Meeting 2020 Fort Lauderdale, Florida. The Association for Manufacturing Technology (AMT) will present The MFG Meeting in early April. “Presentations focus on the most important issues in the market today—transformational technology, economic forecasts, business leadership, and industry best practices to attract a variety of interests and all leadership levels. As always, we include many social activities for relaxed networking with peers as well as a program for spouses,” said Pat McGibbon, chief knowledge officer, AMT. The Al Moore AMT Leadership Award—given annually to members of the manufacturing technology community who have demonstrated a lifetime of dedication in the manufacturing industry—will be awarded to two industry legends: Lee Morris of Morris Group and Brian Papke of Mazak Corporation. For more information, visit www.amtonline.org.

April 13–17—AGMA Basic Training for Gear Manufacturers-Spring Chicago, Illinois. Learn the fundamentals of gear manufacturing in this hands-on course. Attendees will gain an understanding of gearing and nomenclature, principles of inspection, gear manufacturing methods, hobbing and shaping. Utilizing manual machines, develop a deeper breadth of perspective and understanding of the process and physics of making a gear as well as the ability to apply this knowledge in working with CNC equipment commonly in use. This course is taught at Daley College. A shuttle bus is available each day to transport students to and from the hotel. Class times will be Monday 12:00 pm–5:00 pm, Tuesday–Thursday 8:00 am–5:00 pm, and Friday 8:00 am–12:00 pm. Instructors include Dwight Smith, Peter Grossi and Allen Bird. For more information, visit www.agma.org.

May 19–21—AGMA Gearbox CSI Concordville, PA. Attendees will gain a better understanding of various types of gears and bearings. Learn about the limitation and capabilities of rolling element bearings and the gears that they support. They will grasp an understanding of how to properly apply the best gear-bearing combination to any gearbox from simple to complex. Class will be from 8:00 am–5:00 pm each day. This course will be taught by Raymond Drago and Joseph Lenski, Jr. For more information, visit www.agma.org.

June 1–4—CleanPower 2020 Denver, Colorado. The Windpower Conference and Exhibition will continue as the heart of CleanPower, with the addition of exhibition space and conference programming for utility-scale solar, storage, and other clean energy technologies. By incorporating these technologies into a single exhibition hub, CleanPower will create efficiencies for exhibitors and attendees with pan-renewable business models. Pure play businesses will benefit from increased show traffic and opportunities to build beneficial partnerships across the cleantech industry. Exhibitions include Energy Storage America, AWEA WindPower and Solar America. Chris Brown, president of Vestas’ sales and service division in the U.S. and Canada, and Teresa Mogensen, senior vice president of Energy Supply at Xcel Energy, will provide vision and leadership defining CP 2020 conference program objectives, including the selection of session topics and speakers. For more information, visit www.cleanpower.org.

June 3–5—SPAR 3D Expo & Conference 2020 Chicago, Illinois. For close to two decades, SPAR 3D has been the premier international event for the application of 3D technology in industry. The surge in 3D innovation and commercial growth is literally changing the way professionals work across multiple industries, from AEC to asset management, mapping to manufacturing, insurance to infrastructure, process to power, civil engineering to surveying, and more. Conference content covers 3D technologies from input to output, from 3D sensing to 3D processing to 3D visualization tools. The show is co-located with AEC Next Technology Expo, a show supporting the architecture, engineering and construction communities. For more information, visit www.spar3d.com.

June 14–16—2020 EASA Convention Nashville, TN. The Electrical Apparatus Service Association, Inc. (EASA) is an international trade organization of over 1,800 electromechanical sales and service firms in nearly 80 countries. Through its many engineering and educational programs, EASA provides members with a means of keeping up to date on materials, equipment, and state-of-the-art technology. The 2020 EASA Convention features insights from plant maintenance customers, emerging and disruptive technologies, marketplace trends on motor driven systems, and a range of technical sessions focusing on improving electromechanical equipment. Another feature of the EASA Convention is the three-day exposition featuring the industry’s leading manufacturers showing the latest in electric motors, drives and controls, pumps, generators, and other electromechanical equipment. The exposition features an open-floor format for attendees to talk face-to-face with companies that serve the electrical apparatus industry. The theme this year is “Gain the Advantage.” For more information, visit www.easa.com.

July 13–17—Hannover Messe 2020 Hannover, Germany. Some 6,000 companies from all around the world will present a broad array of industrial products and solutions. The innovations on display will include a wealth of logistics solutions from multiple backgrounds, distributed across several display categories. Among the providers of these solutions are such names as Autostore, Hänel, Metalsistim, STILL, Toyota Materials Handling, Sick, Siemens, SEW, Amazon Web Services, Microsoft, Oracle, PSI, SAP, Software AG and viastore systems. They will highlight the benefits of digitalization and present solutions for the digital management and control of tomorrow’s logistics processes. Small IT firms will also be there thanks to an IT group pavilion. Hannover Messe will also feature a dedicated speaking platform for providers of logistics services. Organized in partnership with the German logistics journal DVZ, the platform will be known as CAMP Logistics. It will be located in Hall 4 and include a dedicated presentation forum where industry experts will discuss a range of highly topical supply chain issues, such as blockchain, green energy, drones, low-cost sensor solutions for warehouses, big data analytics and risk assessment, and startups in logistics, to name but a few. For more information, www.hannovermesse.de.

Power Transmission Engineering



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

EDITORIAL

Publisher & Editor-in-Chief

Randy Stott
stott@agma.org

Senior Editor

Jack McGuinn
mcguinn@agma.org

Senior Editor

Matthew Jaster
jaster@agma.org

Associate Editor

Alex Cannella
cannella@agma.org

ART

Art Director

David Ropinski
ropinski@agma.org

ADVERTISING

Advertising Sales Manager

& Associate Publisher

Dave Friedman
friedman@agma.org

China Sales Agent

Eric Wu
eric.wu@eastcotec.com

Materials Coordinator

Dorothy Fiandaca
fiandaca@agma.org

CIRCULATION

Circulation Manager

Carol Tratar
tratar@agma.org

Circulation Coordinator

Barbara Novak
novak@agma.org

ACCOUNTING

Luann Harrold
harrold@agma.org

MANAGEMENT

President

Matthew Croson
croson@agma.org

FOUNDER

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

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The Coolest Cylinder in Michigan

You might not expect a humble cylinder to garner more attention than a luxury boat or a giant, shiny stage prop, and yet that's just what happened in Michigan's latest contest celebrating local manufacturers' contributions.

Alex Cannella, Associate Editor

This year's second annual "Coolest Thing Made in Michigan" award had, as one might expect from the name, some pretty cool things in the running. A luxury pontoon boat that looks like a sports car with turbines, right down to the LED light trim; a massive art construction of 3D modeled steel wings that was the centerpiece onstage at Aerosmith's most recent tour; and a universal remote you can connect to your phone.

And yet, the eponymous coolest thing of all — the device that took the actual award — was a cylinder. With so many flashier contenders, that's a bit of an eyebrow raiser at first glance, isn't it?

But Peninsular Cylinder's booster cylinder, a custom job done for FTI Machine Worx, is in fact pretty cool. The engineers at Peninsular are no strangers to custom jobs, but even by their standards, this one was a doozy. Designed as an amplifier for faster cycle rates and pushing higher pressure into a hydraulic system, Peninsular's cylinder demanded wildly different specifications from the norm: 20 cycles per second, a shorter stroke, and the ability to spike pressure from an input of 1700 psi up to an output of 11,000 psi. And thanks to those unique demands, the cylinder has found an equally interesting niche: product testing.

As Peninsular's president, Henry Haver, broke it down, you have two options for testing. Digital testing is cheaper, while actual real world validation testing gives you better results at the cost of a hefty bill. The booster cylinder, however, is one way to achieve that validation testing on a more affordable budget.

"Our product is a stopgap," Haver said. "For a lot less money, anyone who wants to build some type of a testing machine, they can actually do that real world validation testing."

The booster cylinder Peninsular entered into the contest this year is the result of years of hard work and iterative improvements on that design. So after all that blood and sweat, it's no small surprise that when the Coolest Thing Made in Michigan came around and the Michigan Manufacturers Association asked for submissions, this was the one product above all others they put forward.

The contest itself was decided via simple popular vote, but considering Peninsular wasn't even the biggest company in the running, that just makes their win all the more impressive. After all, in a competition like this, you would expect all the attention to fall on the flashy, finished products like that pontoon boat instead of the engine that runs it. But here was an unlikely and rare moment where the spotlight was suddenly shining on a single component, where eyes outside of the industry were suddenly paying attention to this product.

And according to Haver, that very unlikelihood is what set a fire under the entire company.

"It's probably rare that you get an opportunity to say 'look



Peninsular Cylinder recently took home the Coolest Thing Made in Michigan award for their work on a custom booster cylinder. Pictured left to right: Chadwick Conte, senior marketing strategist at Peninsular Cylinder Company, Chuck Hadden, MMA president and CEO, and Bud Haver, president of Peninsular Cylinder Company.

at what we did..." Haver said. "It just triggered us right away to say 'hey, we should do this.' Just a matter of satisfaction. Everybody is very proud of what we do here."

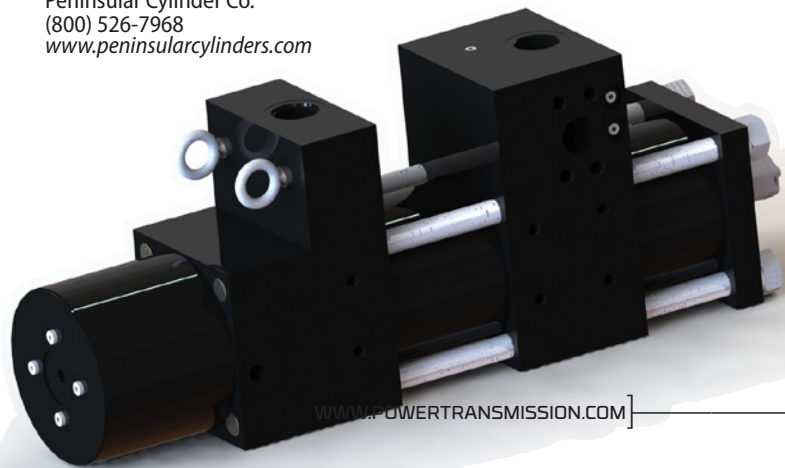
"We did as much of a grassroots effort as we could," Chadwick Conte, senior marketing strategist for Peninsular Cylinder Co., said. "All the employees were all fired up about it — the entire team. We wouldn't have even reached the top ten had it not caught fire."

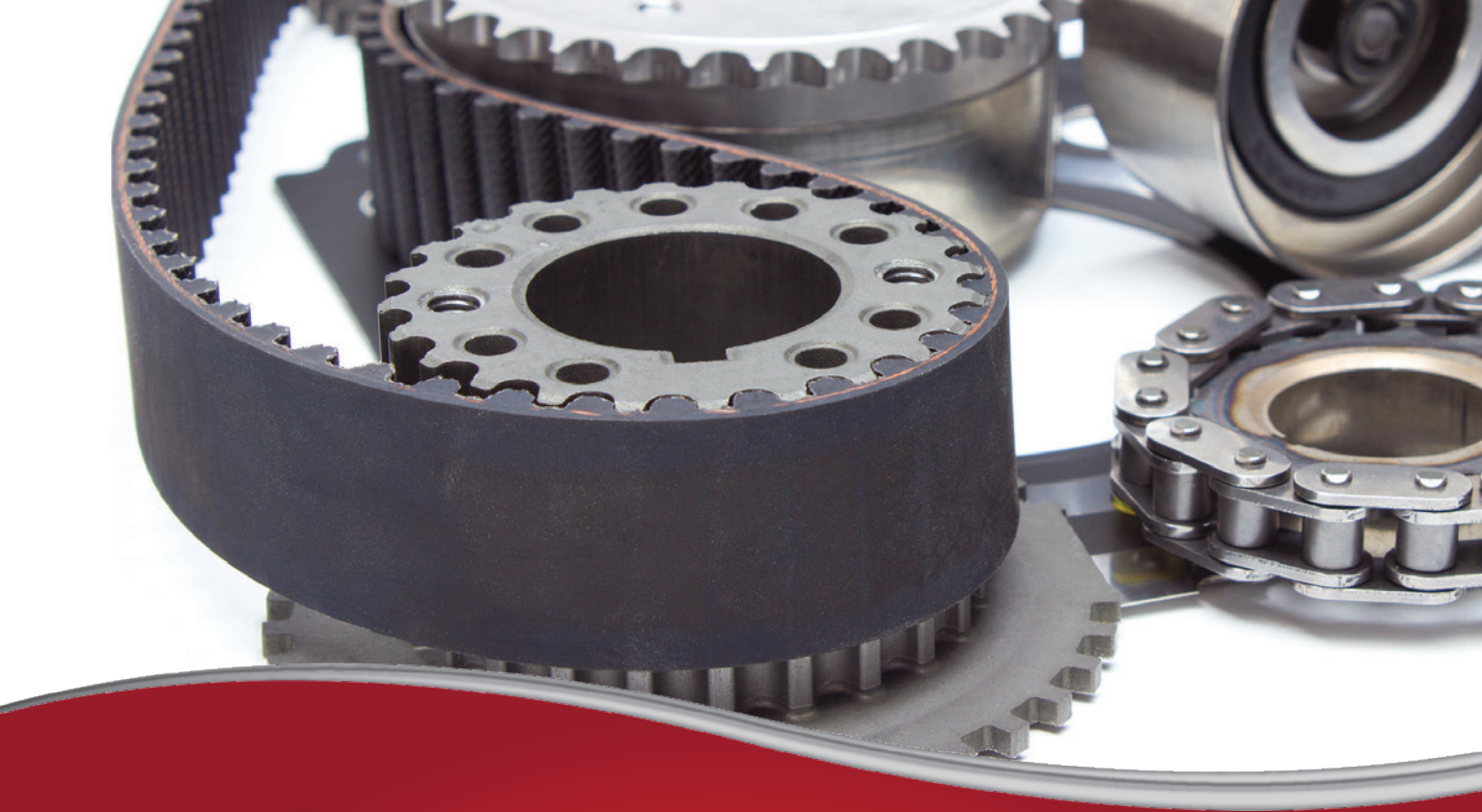
According to Conte, that campaign pulled in plenty of help from outside the company, with all the usual friends-and-family votes you would expect, but also a number from the company's own nation-wide network of customers when the contest became a talking point among the sales team. And it all kept gaining momentum up until the day of the contest, culminating in that first place trophy and a celebration once their representatives got back home.

It's a victory lap they're still enjoying, and no doubt will for months to come. The award is a nice feather in the company's hat for the sales department to point to. But the part about the experience that seems to be sticking with the company most is the excitement that comes from being able to emerge from behind the scenes to be recognized for all their hard work. **PTE**

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