

# Power Transmission Engineering®

FEBRUARY 2022

# ENERGY

SMART, SUSTAINABLE, EFFICIENT COMPONENTS

## TECHNICAL

[Continuous  
Evolution  
of Machine  
Components]

[Thermal  
Performance in  
DC Motors]



[www.powertransmission.com](http://www.powertransmission.com)

*Power Transmission Engineering* is  
now published by The American  
Gear Manufacturers Association



# The best protection you may never need



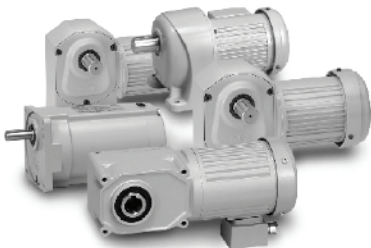
Brother Gearmotor makes such an outstanding product that they offer a 5-year limited warranty...we've never had to use the warranty.

**RYAN MILLER,**

Owner and Engineer Manager  
Southeastern Technology Automation



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



**Call us today for a sample gearmotor to try out.**

**brother**  
at your side

866.523.6283  
BrotherGearmotors.com

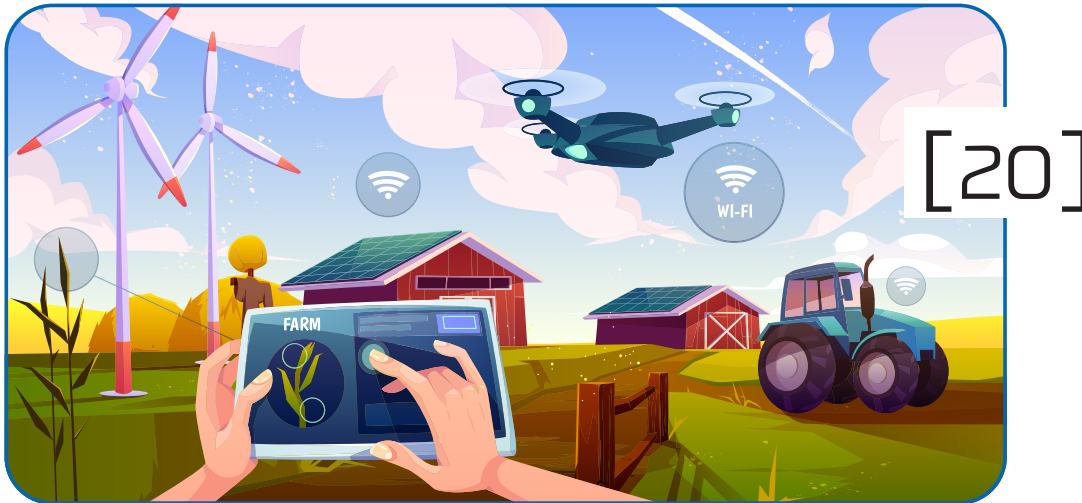


# Power Transmission Engineering®

FEBRUARY 2022



A Publication of  
The American Gear  
Manufacturers Association



## FEATURE ARTICLES

- [18] **The Art of the Balance**  
Balancing impellers and rotors saves money and improves performance and safety.
- [20] **Energy Initiative**  
The need for smart, sustainable and efficient components.
- [24] **Solar-Powered Waste Management**  
Finbin implements sustainable waste containers with igus bearings.

## TECHNICAL ARTICLES

- [30] **Machine Elements — Shaping the Future through Continuous Evolution**  
Does Moore's Law apply to machine elements such as gears, bearings and mechanical components?
- [35] **Improve Thermal Performance for Ironless Brush DC and Brushless DC Motors**  
Designers of motor-driven systems must account for thermal issues that can hinder a system's performance and efficiency.

## Stay Connected



Follow us on Twitter  
[twitter.com/#!/PowerTransMag](https://twitter.com/#!/PowerTransMag)



Connect with us on LinkedIn  
[www.linkedin.com/groups/Power-Transmission-Engineering-PTE-2950055](https://www.linkedin.com/groups/Power-Transmission-Engineering-PTE-2950055)



Subscribe Online  
[www.powertransmission.com/subscribe.htm](https://www.powertransmission.com/subscribe.htm)

Vol. 16, No. 1. POWER TRANSMISSION ENGINEERING (ISSN 2331-2483) is published monthly except in January, May, July and November by The American Gear Manufacturers Association, 1840 Jarvis Ave., Elk Grove Village, IL 60007, (847) 437-6604. Cover price \$7.00. U.S. Periodicals Postage Paid at Elk Grove Village IL and at additional mailing offices. Send address changes to POWER TRANSMISSION ENGINEERING, 1840 Jarvis Ave., Elk Grove Village, IL 60007.

The American Gear Manufacturers Association makes every effort to ensure that the processes described in POWER TRANSMISSION ENGINEERING conform to sound engineering practice. Neither the authors nor the publisher can be held responsible for injuries sustained while following the procedures described. Postmaster: Send address changes to POWER TRANSMISSION ENGINEERING, 1840 Jarvis Avenue, Elk Grove Village, IL, 60007. ©2022 Contents copyrighted by THE AMERICAN GEAR MANUFACTURERS ASSOCIATION. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher. Contents of ads are subject to Publisher's approval.

FIND OUT MORE NOW AT:  
WWW.NEUGART.COM/EN-US



## POWERFUL SOLUTIONS FOR RACK AND PINION DRIVES.

Planetary gearboxes with mounted pinion

A gearbox/pinion combination developed from a single source is the guarantee of ideal technical coordination for your rack and pinion drive.

CONTACT:  
**Neugart USA Corp.** | 14325 South Lakes Drive  
Charlotte, NC 28273 | USA  
Phone: +1 980 299-9800 | sales@neugartusa.com



# Quicksilver Controls SilverMax™

## Integrated Hybrid Servos

Motor + Encoder + Controller + Driver

High Efficiency Over Wide Speed Range  
Highly Programmable  
Handles Large Inertia Mismatch  
NEMA 23 and 34

Bringing Our 23 years of  
Hybrid Servo Expertise  
to Your Project!



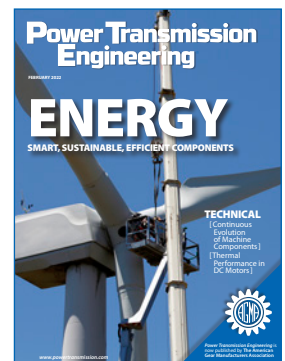


+1 909 599 6291  
[www.QuickSilverControls.com](http://www.QuickSilverControls.com)

# Power Transmission Engineering

VOL. 16, NO. 1

- [04] **PTEExtras**  
**PTE Videos: Cleanpower 2021** brought clean energy thought leaders to Salt Lake City; **Schaeffler** provides space drive technology at the Indy Autonomous Challenge; Event Spotlight: **MIM2022**.
- [06] **Publisher's Page**  
What Are the Limits?
- [08] **Product News**  
**Heidenhain** introduces new digital shop floor software; **Mach III** torque limiters eliminate damaged belts; **Eaton** introduces variable valve actuation technology for commercial trucks; **NTN** releases ceramic ball bearings for electric motors, and more.
- [28] **Engineering sMART**  
Products and services marketplace.
- [40] **Industry News**  
**Schaeffler** celebrates 75th anniversary; **Atlanta Gear Works** grows engineering team; **Regal Rexnord Corporation** acquires **Arrowhead Systems**.
- [45] **Calendar of Events**  
**March 5–12:** IEEE Aerospace Conference 2022, Big Sky, MT; **March 16–18:** EPTDA Annual Convention, Warsaw, Poland; **March 21–24:** Gear Dynamics and Gear Noise Short Course 2022, Columbus, OH; **March 22–24:** AGMA Gearbox CSI, Concordville, PA.
- [46] **Advertiser Index**  
Contact information for every advertiser in this issue.
- [47] **Subscriptions**  
Renew your free subscription today.
- [48] **Power Play**  
Motorizing a Hand-Cranked Street Organ.







# DODGE

## The Diamond Standard.

**Our mission is to reliably equip our customers with the safest, highest quality mechanical power transmission solutions to achieve their strategic goals.**

Dodge, an RBC Bearings company, is introducing a new look for a trusted name in industry. As always, our team is committed to providing expert solutions that keep industry moving forward. And we will continue raising standards and developing forward-thinking innovations for our customers to reduce downtime, improve reliability, and operate safely. Because to perform at your highest level, you need the best. That's Dodge.

**[Learn more at dodgeindustrial.com](http://dodgeindustrial.com)**

**PTE Videos**

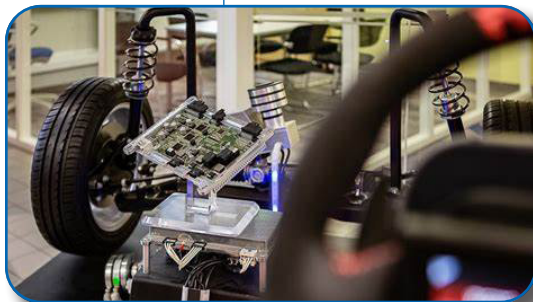
**CleanPower Recap**

*CleanPower 2021 in Salt Lake City brought together industry and thought leaders to unite and move clean energy forward in-person at the most anticipated clean energy trade show in years. Here are some highlights from the December event. Here's a quick recap:*

[www.powertransmission.com/videos/CleanPower-2021-Recap/](http://www.powertransmission.com/videos/CleanPower-2021-Recap/)



**Schaeffler Provides Space Drive Technology at the Indy Autonomous Challenge**



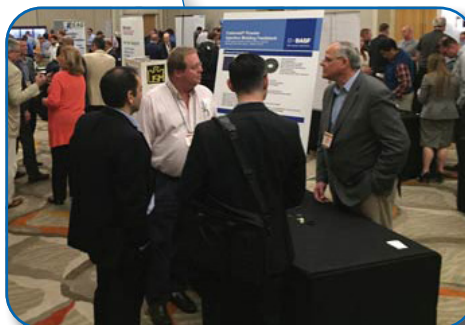
Schaeffler congratulates the TUM Autonomous Motorsport team from Technische Universität München - School of Engineering and Design for winning the Indy Autonomous Challenge Powered by Cisco! The team recorded the fastest 2-lap average speed of 135.944 on the Indianapolis Motor Speedway and went home with the \$1 million grand prize:

[www.powertransmission.com/videos/Schaeffler-Provides-Space-Drive-Technology-at-the-Indy-Autonomous-Challenge/](http://www.powertransmission.com/videos/Schaeffler-Provides-Space-Drive-Technology-at-the-Indy-Autonomous-Challenge/)

**Event Spotlight: MIM2022**

MIM2022: International Conference on Injection Molding of Metals, Ceramics and Carbides is a global conference and tabletop exhibition highlighting advances in the metal injection molding (MIM) industry, with two days of technical sessions focusing on the latest innovations in metal injection molding. For more information, visit:

[www.powertransmission.com/news/11665/MIM-2022/](http://www.powertransmission.com/news/11665/MIM-2022/)



**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](mailto:stott@agma.org)

**Senior Editor**  
Matthew Jaster  
[jaster@agma.org](mailto:jaster@agma.org)

**ART**

**Art Director**  
David Ropinski  
[ropinski@agma.org](mailto:ropinski@agma.org)

**ADVERTISING**

**Advertising Sales Manager & Associate Publisher**  
Dave Friedman  
[friedman@agma.org](mailto:friedman@agma.org)

**Materials Coordinator**  
Dorothy Fiandaca  
[fiandaca@agma.org](mailto:fiandaca@agma.org)

**CIRCULATION**

**Circulation Manager**  
Carol Tratar  
[tratar@agma.org](mailto:tratar@agma.org)

**ACCOUNTING**

Luann Harrold  
[harrold@agma.org](mailto:harrold@agma.org)

**MANAGEMENT**

**President**  
Matthew Croson  
[croson@agma.org](mailto:croson@agma.org)

**FOUNDER**

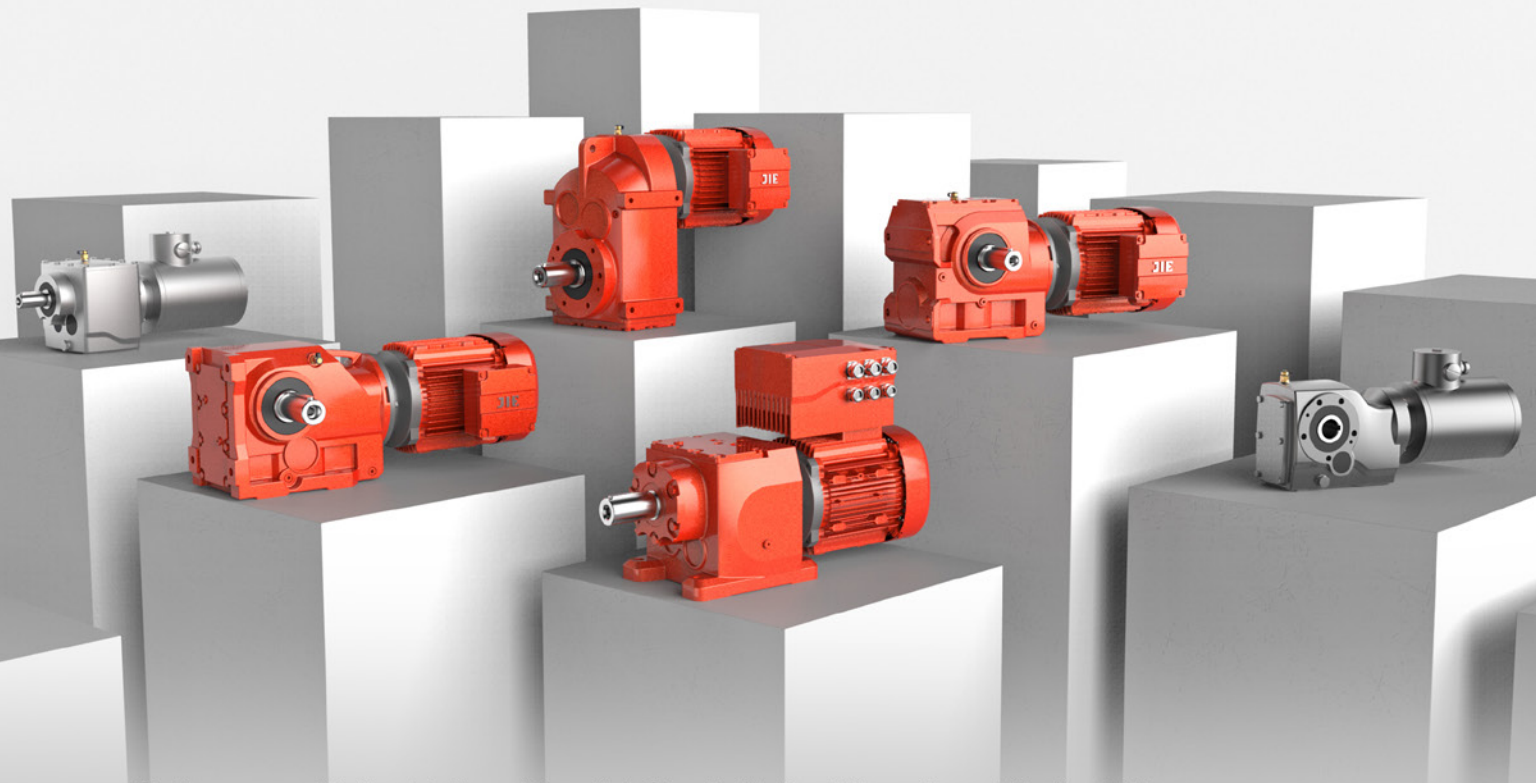
Michael Goldstein founded Gear Technology in 1984 and Power Transmission Engineering in 2007, and he served as Publisher and Editor-in-Chief from 1984 through 2019. Michael continues working with both magazines in a consulting role and can be reached via e-mail at [michael@geartechnology.com](mailto:michael@geartechnology.com).



**PTDA**  
Channeling the  
Power of Industry



- *Local Inventory*
- *Quick Delivery*
- *Great Service*
- *Top Quality*



*Options are Helical Inline, Parallel Shaft, Helical Bevel and Helical Worm;  
Available in both cast iron and stainless steel housing.*

[www.jie-drives.com](http://www.jie-drives.com)

[Info@jie-drives.com](mailto:Info@jie-drives.com)

+1 630 580 9986



# What Are the Limits?



**Power Transmission components are pretty mundane, right?** Gears and bearings can only be arranged so many ways, after all. You'd think by now that we'd have discovered every possible way to make mechanical devices as strong and efficient as possible.

But that's not so. In fact, this issue we have a rare treat for you. It's a technical article that's really more of a think-piece. The article I'm talking about is "Machine Elements - Shaping the Future through continuous Evolution," which you can find on page 30. The article is written by some of the world's top researchers working in the area of mechanical power transmission components.

The authors propose that we still have plenty of gains to be made with those components. In fact, they argue that there's something akin to Moore's Law that can be applied in our industry. Moore's Law famously predicted the doubling of semiconductor capacity every year since 1965—a prediction that has largely held true.

And although there's no evidence of anything approaching anywhere near an annual doubling of capacity in any of the capabilities of mechanical components, the authors have demonstrated that there *have* been significant increases in certain areas every year.

For example, the torque densities of wind turbine gearboxes have increased by about 5% per year since the 1990s. Similarly, the authors have shown how frictional losses in tapered roller bearings have decreased by about 4% per year since 2011. And while those improvements are more in the range of 4-5% per year, they're still improvements, built on the previous year's improvements.

A skeptic might argue that these researchers are simply promoting their work in order to secure the next round of funding and projects. But the gains are real, and they're being implemented in products you use every day.

Better designs produce better efficiencies. Better materials provide better strength. Improved manufacturing technologies create tighter tolerances.

Perhaps most importantly, components are no longer considered as just components. They're part of a system, and the system is being investigated as a whole. Computer modeling has advanced to the point where those systems can be analyzed and optimized in ways that were never before possible. Sensors and electronics add new data that continues to feed the progress.

So what does this mean for those of us who work in mechanical power transmission components? To me, it means the future is bright. New products and technologies continue to be introduced every day. Some of it comes from academic research. Some of it comes from industrial R&D. But some of it comes from good old-fashioned creative engineering—something our readers have in abundance.

We'll keep bringing you information about the latest advances, no matter where they originate. You keep reading, and creating, and advancing the capabilities of power transmission components.

Just like with Moore's Law and computer chips, there probably are physical limits to what's possible. But we haven't reached them yet.

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

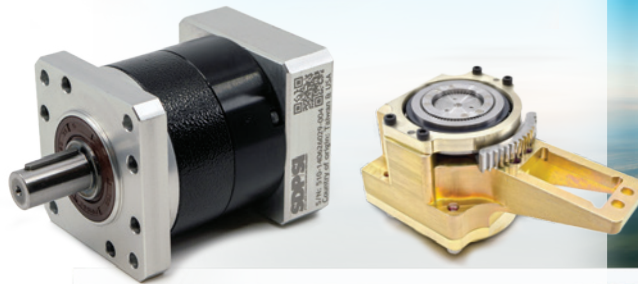
Facing a design challenge? SDP/SI engineers provide problem solving, customized solutions. With over 70 years of engineering development and precision manufacturing experience, SDP/SI is a proven partner to the most recognized names in medical, aerospace, defense, and robotics industries.



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



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



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



# Heidenhain

## INTRODUCES NEW VERSION OF STATEMONITOR

In answer to requests from machine tool users around the world, Heidenhain introduces version 1.4.0 of its popular *StateMonitor* software platform enabling remote monitoring and data evaluation during real-time manufacturing. First introduced in 2019, *StateMonitor* has become an important option with Heidenhain TNC controls to digitally connect and evaluate machine tool data on company networks as part of the Industry 4.0 initiative to boost efficiencies. Connected devices could include CNC control systems of varying brands as well as PCs and Web-based mobile devices such as tablets or smartphones.

Designed to highlight data usage and encourage time-saving workflow methods using clear-cut charts and graphs, the new *StateMonitor* V1.4.0 now offers even more benefits. One of the many new features often requested and now available in *StateMonitor* V1.4.0 is the ability to monitor tools within a connected machine. This now allows users to collect current tool usage data and avoid unnecessary costs due to premature tool replacement. The new software also now can view countdowns for any programs running.

Other important new functions include the ability to now view monitored signals on the Machine

Status page, as well as String Signal data. Also, users can now customize the machine status by adding additional ones and changing to their liking when the machine is considered “Productive”. All these were added per past users’ requests.

And unlike in past, an interested customer now has the option to purchase a single machine license and can add on the more common five-machine license (*StateMonitor* Option 1) later if desired. The *StateMonitor* Single Machine license already contains the “OPC UA Interface” so machines with 3rd-party CNCs can be connected as well.

Another significant offering with this new version is a provision of additional *StateMonitor* Software Maintenance and Support from Heidenhain. This software maintenance plan gives customers the ability to easily upgrade the software each time a new release is available.

[www.heidenhain.us](http://www.heidenhain.us)







***PRECISE. ROBUST. AVAILABLE.***

### **ServoClass® Couplings**

- Zero-Backlash & High Torsional Stiffness
- Engineered Performance for Reliable 24/7 Operation
- Servo-Rated for Reversing, Positioning, Precision
- Low Inertia / Low Misalignment Reaction Loads
- Perfect for High Accuracy Actuator Systems
- Engineering Assistance / **Fast** Delivery



[www.zero-max.com](http://www.zero-max.com) 800.533.1731

**ZERO-MAX®**

# Mach III

CUSTOM TORQUE LIMITERS  
ELIMINATE DAMAGED BELTS

Mechanical Friction Torque Limiters from Mach III are designed to slip so that the torque never exceeds a pre-set amount during momentary overload, protecting the drive and other components from damage. A recent application involving pharmaceutical machinery demonstrates these principles and also highlights the company's ability to design and deliver custom torque limiters quickly.



## Friction Creates Challenges on a Conveyor Belt

The company, a pharmaceutical equipment manufacturer, contacted Mach III after breaking four belts while testing a new machine they had designed for a customer. The issue involved a section of the conveyor where packaged pharmaceutical products accumulated against a hard stop. From there, a suction device was supposed to lift the products to another station for transport. However, whenever the products reached this hard stop, friction between the pharmaceuticals and the rollers created a spike in torque, causing the 20 mm textured belt that drove the rollers to break. This belt was driven by a pulley that connected to the output shaft on the gearbox.

After investigating the motor, gearbox and belting, engineers determined that a torque limiter, placed on the gearbox output shaft, would prevent the belt from breaking when set to a slip torque of approximately 100 lb-in. A big challenge, however, was the small amount of space available for this component. The output shaft of the gearbox had a diameter and length of 30 and 80 millimeters, respectively.

In addition, the torque limiter had to be able to withstand washdown.

## Achieving the Required Torque in a Limited Installation Space

To meet these requirements, Mach III designed a torque limiter that utilizes a stack of Belleville springs to provide the required torque capacity. They mounted the pulley that drives the belt directly on the torque limiter. Due to this design, the company didn't have to alter the machine frame or reposition any existing components. Rather, the torque limiter fit within the existing space on the gearbox shaft. Outfitted with an enclosed aluminum housing, the torque limiter also successfully met the application's washdown requirements.

[www.machiii.com](http://www.machiii.com)

# Eaton

INTRODUCES VARIABLE VALVE  
ACTUATION TECHNOLOGIES FOR  
COMMERCIAL TRUCK INDUSTRY

Eaton has announced its Vehicle Group has introduced a complete portfolio of variable valve actuation (VVA) technologies to help commercial vehicle manufacturers meet forthcoming emissions regulations in China. The regulations are expected to be significantly more stringent than current standards.

"Automakers that manufacture vehicles for the China market are researching how to achieve future emissions regulations," said Fabiano Contarin, product director, Commercial Vehicle Valvetrain, Eaton's Vehicle Group. "Eaton is the right partner to support



this effort because of our considerable experience helping European and U.S. auto and truck makers develop emissions-reducing technologies."

Eaton's VVA solutions are based on two building blocks: 1) a rocker with a switchable capsule, and 2) a split rocker for full deactivation. By combining these two building blocks, several VVA strategies can be utilized in virtually any engine architecture—single and dual overhead cam, as well as cam-in-block engines—and engine displacement ranging from 2.0 liters to 15.0 liters.

## Vehicle Group's CDA technology lowers CO<sub>2</sub> and NO<sub>x</sub> simultaneously

Cylinder deactivation (CDA) is a VVA technology that involves deactivating the intake and exhaust valve opening, as well as the fuel injection on some cylinders when an engine is running at low load. This increases the temperature of the exhaust gases, allowing the nitrogen oxide (NO<sub>x</sub>) aftertreatment to remain efficient at low load and decrease carbon dioxide (CO<sub>2</sub>) emissions.

CDA is an ideal solution for commercial vehicles that make frequent stops, such as sanitation or delivery trucks. It decreases both NO<sub>x</sub> and CO<sub>2</sub> simultaneously, making it more efficient than other technologies that cut NO<sub>x</sub> at the expense of increased CO<sub>2</sub>. CDA can reduce NO<sub>x</sub> by more than 40% and CO<sub>2</sub> by 5%–8%.

## Late intake valve closing technology reduces emissions

Eaton also offers Late Intake Valve Closing (LIVC), which delays the closing of the intake valve, so the effective compression ratio is lower than the expansion ratio. LIVC increases the thermal efficiency of the engine, improving fuel economy and reducing CO<sub>2</sub> emissions. Reducing the amount of airflow through the engine with a shorter intake stroke raises the exhaust temperature by 40 degrees Celsius, contributing to the thermal management of the aftertreatment. Overall, LIVC can reduce CO<sub>2</sub> by 1%–2%, and is most efficient for applications such as over-the-road trucks.

[www.eaton.com](http://www.eaton.com)



SEPT. 12-17, 2022 • MCCORMICK PLACE, CHICAGO

# FIN

# ND



Technology demonstrated by Mazak MegaStir

**HYBRID MACHINING**



# IMTS 2022

INTERNATIONAL MANUFACTURING TECHNOLOGY SHOW  
DIGITAL MANUFACTURING. IMPLEMENTED.

EXPERIENCE  
THE POWER OF  
**HYBRID MACHINING**

**MAZAK MEGASTIR**

Hybrid multitasking technologies can add immediate value through efficiency increases inherent in additive, hotwire, gear turning, and friction stir welding. Experience Mazak MegaStir and the complete Mazak Hybrid product line at IMTS 2022.

REGISTER NOW AT **[IMTS.COM/SHOW](https://www.imts.com/show)**

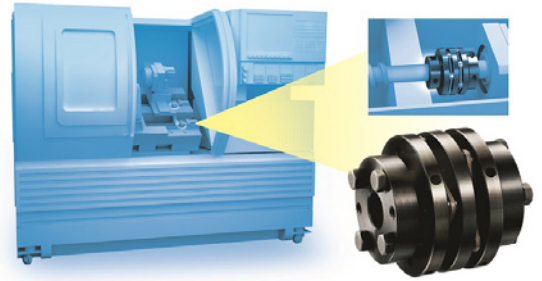


# Miki Pulley

COUPLING MODEL SUITABLE FOR BALL SCREW APPLICATIONS IN MACHINING CENTERS

Miki Pulley's latest model SFF Coupling is ideal for large ball screw applications on high performance machining centers. These couplings have a robust design providing high torque and high RPM operation.

The SFF Coupling offers exceptional torsional stiffness and strength. These couplings have rugged designed steel hubs with black oxide finish. This proven Miki Pulley coupling design assures accurate machining center shaft rotation with precise control. The coupling's flexible element gap dampens conductive heat transfer from motor to output shaft. Also important, the coupling provides limited shaft misalignment to alleviate premature system bearing wear.



The coupling's aerodynamic profile decreases noise while optimizing performance at high speeds. Simple yet reliable, SFF couplings are available in single and double element configurations. Bores can be arranged with clamp, taper-lock or keyed styles for specific application requirements. Basic SFF coupling specifications are:

- Maximum RPM: 18,000
- Maximum allowable torque: 221.27 ft-lbs (800 Nm)
- Bore size range: 0.709"–3.15" (918 mm–80 mm)
- Backlash: Zero
- Ambient operating temperature: -40°C–120°C (-40°F–248°F)

[www.mikipulley-us.com](http://www.mikipulley-us.com)



YOUR **BEST SOURCE** FOR METRIC MOTORS, GEARBOXES & COOLANT PUMPS

## RIGHT ANGLE WORM GEARBOXES

Available with stainless steel output shaft

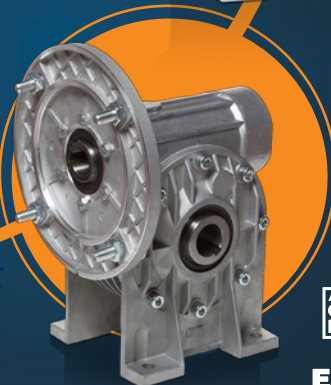
Hollow, or solid output shaft in single or double design

Single & double reduction available

Ratios of 5:1 to 100:1  
(single stage reduction)

Ratios up to 10000:1  
(combination gearboxes)

Variety of input and output mounting combinations in each frame size.



Toll Free: **1-800-661-6413**  
Fax: **1-905-629-2852**

[www.lafertna.com](http://www.lafertna.com)  
[sales@lafertna.com](mailto:sales@lafertna.com)

# NORD

## OFFERS RELIABLE TECHNOLOGY FOR AIRPORT BAGGAGE HANDLING SYSTEMS

NORD's introduction of the DuoDrive integrated gear unit and motor, IE5+ synchronous motors, and NORDAC ON/ON+ variable frequency drives add to their intelligent drive solutions that satisfy the specific demands of the airport industry.

NORD is committed to meeting demands of existing and future airport baggage handling systems. Their units deliver reliable operation and control that is required in airport applications such as lifts, conveyors, pushers, and indexers. For applications such as angled belt conveyors, NORD decentralized electronic control products with external braking resistors control both speed and positioning with extreme precision. These complete, single-sourced units are also compact and easy to service and maintain, benefiting areas where space is limited.

NORD solutions for the airport industry include:

### IE5+ Synchronous Motors

NORD's new generation of IE5+ motors utilize a reduced noise, high efficiency design suited to areas in airports that are acoustically sensitive, such as check-in or baggage pick up. The motors present flexible mounting solutions whether it is direct mounted to a gearbox or mounted to a NEMA or IEC adapter. These motors meet the highest efficiency standards and are designed for reducing variants and lowering operating costs. The two frame sizes, 70 and 90, offer a power range from 0.5–3 hp and a speed range from 0–2100 rpm. IE5+ synchronous motors are outfitted with an integrated encoder that can be programmed for precise control over speed, synchronization, and position.

### DuoDrive Gear Unit and Motor in One Design

NORD's DuoDrive is an innovative unit that combines the high efficiency of IE5+ motors with a single-stage helical gear unit, all in one housing. DuoDrive is optimized for the airport

industry through the significant high system efficiency of up to 92%, high power density, and quiet operation. The compact, smooth design allows for easy installation and optimal space utilization. Thanks to the integration of IE5+ motor technology, this design results in reduced Total Cost of Ownership and fast Return of Investment. DuoDrive provides power ranges from 0.5–2 hp and has flexible attachment options of a B5 flange or B14 flange.

### NORDAC ON/ON+ Compact Variable Frequency Drive

An economic solution for IIoT environments, NORDAC ON was developed with the specific requirements of hori-

to ensure baggage is not getting lost, damaged, or backed up. A breakdown in a baggage handling system could result in a backlog as well as costly repairs and delays. NORDAC ON provides the ability to customize the electronic controls specifically to airport application and conveyor needs, resulting in a highly reliable and efficient system with less downtime.

### NORDAC PRO SK 500P Variable Frequency Drive

The NORDAC PRO is a compact, centralized variable frequency drive that provides versatility for all applications. The integrated Ethernet interface can be configured for each parameter, al-



zontal conveyor technology in mind as well as complete interaction with the new IE5+ synchronous motor (NORDAC ON+). This frequency drive can be wall-mounted or motor-mounted and comes equipped with an integrated Ethernet interface and full Plug-&-Play capabilities for fast and simplified installation. Airport conveyor lines must operate with precision and reliability

allowing for precise control of drive systems. A USB interface allows for voltage-free parametrization and is usable even if the main power is disconnected. The parameter structure is compatible with all NORD variable frequency drives and there is an SD card slot for storage and transfer of the parameter data.



## LogiDrive Complete Drive System Solution

The LogiDrive solution combines a highly efficient 2-stage bevel gear unit with an IE5+ Permanent Magnet Synchronous Motor (PMSM), and a decentralized variable frequency drive. This modular system reduces the number of variants and saves on Total Cost of Ownership through standardization of geared motor versions. The inclusion of the IE5+ motor minimizes overall costs for the lifespan of the unit, achieves greater efficiency, and provides a faster return on investment. NORDAC LINK provides a decentralized VFD solution that has full Plug-&-Play capabilities for easy commissioning and low maintenance. LogiDrive works especially well with baggage handling systems due to maintaining high efficiency even in partial load ranges and low speeds.

## NORDCON APP with NORDAC ACCESS BT

The NORDCON APP is a visualization solution that enables drive monitoring, fault diagnosis, analysis, and quick access to parameters from a Bluetooth-enabled device. The app also features a Help function, video tutorials, and direct contact options to send service requests straight to the NORD support team. In combination with the NORDAC ACCESS BT Bluetooth stick, this solution offers convenient mobile visibility of drive data while still granting full drive control. The Bluetooth stick also allows users to access and upload parameters drive to drive, drive to PC, and PC to drive.

## Condition Monitoring for Predictive Maintenance

NORD's condition monitoring solution records drive and status data with the objective of maintaining machines and plant productivity. Data is collected from analog, digital, or virtual sensors to determine when there is a drive

issue and allows for scheduled downtimes before they turn into unplanned, costly repairs. This system is also able to calculate the optimal time to change the oil by measuring its temperature over time. This enables the drive to run effectively and efficiently with minimal wear on the components.

## Two-Stage Helical Bevel Gear Units Performance and Design

NORD's two-stage helical bevel gear units feature a significant power range of 0.16–12.5 hp, making them ideal for conveyor applications where high speeds are required. Two-stage helical bevel units support high axial and radial load capacities with a torque range of 443–5,842 lb-in and the innovative high-strength aluminum alloy design enables a wash-down ready surface at a remarkably light weight. NORD's two-stage helical bevel gear units are robust, reliable, and offer high efficiency with smooth operation ideally suited for airport baggage systems.

[www.nord.com](http://www.nord.com)

Did you mean: *DieQua Corporation?*

## The search is over!

For quality screw jacks that give you all the options in a complete package with the most advanced designs, look no further than DieQua.

- 8 ZE sizes with lifting capacities up to 20 tons
- 3 sizes servo compatible
- Precision machine and ball screws
- Standing and rotating versions
- Multiple spindle end connections and driving nut designs

To finally find what you're looking for, check us out on the web, or give us a call.



**ZIMM** USA  
by **DIEQUA**

[screwjacks.com](http://screwjacks.com)  
800-459-5845



# Beckhoff Automation

## ANNOUNCES COMPACT, COST-EFFECTIVE STEPPER MOTOR TERMINAL

With the new EL7062 dual-channel EtherCAT Terminal, Beckhoff enables the direct connection of two stepper motors in the medium power range of up to 3 A and for a voltage range of 8–48 V. With flexible parameterization and minimized channel costs, the flexible motion interface is ideal as a low-cost drive for a wide range of stepper motor applications.

In an extremely compact form factor, the 24-mm-wide EL7062 EtherCAT Terminal contains two stepper motor output stages, two digital inputs for limit switches and one encoder interface per channel for a wide range of 5 V encoders. Via parameterization, the EL7062 flexibly adapts to the connected stepper motor and its corresponding application requirements. With regard to the input encoder signal, the module supports the entire spectrum of TTL encoders (5 V differential, single-ended/open collector). Very high-resolution microstepping ensures extremely smooth and precise motor operation.

The maximum total output current is 6 A, typically to operate two 3 A stepper motors. This can also be configured variably—for example, the motion interface could be configured for a 2 A and 4 A motor. With the ZB8610 fan module, which is available as an accessory, the maximum power even increases to 5 A per channel. The dual channels in the EL7062 significantly reduce the price compared to single-channel solutions.

[www.beckhoff.com](http://www.beckhoff.com)



## High-Speed Bearing Testing

North America's *Largest Independent Bearing Testing & Inspection Facility*

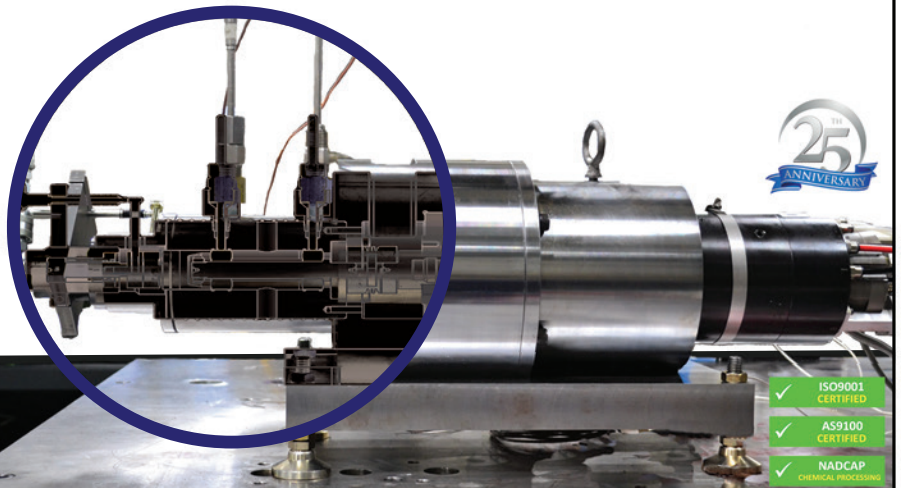
### Evaluating:

- ✓ Power Loss
- ✓ Fatigue Life
- ✓ Cage Design
- ✓ Accelerated Wear
- ✓ Surface Treatments
- ✓ Lubricant Efficiency

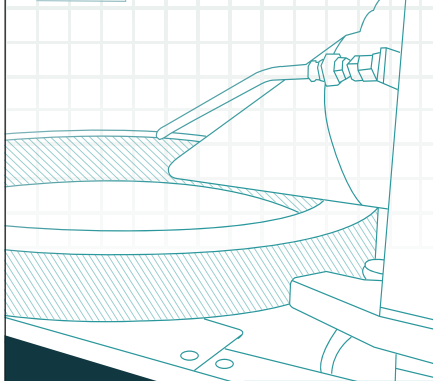
Bearing Testing in support of Electric Vehicles of the future with NES High-Speed Testers



Napoleon Engineering Services  
sales@nesbearings.com  
nesbearings.com  
Olean, NY USA  
(877) 870-3200



# FORGING AHEAD OF THE PACK



MADE IN THE  
**USA**

**Fast.  
No Fine Print.  
No Premium.**

At McInnes Rolled Rings, we provide quality products, shipped fast. And we partner that with exceptional customer service to forge the perfect partnership with our customers.

**McINNES  
ROLLED RINGS**

**1.877.736.4409**

[www.McInnesRolledRings.com](http://www.McInnesRolledRings.com)

## NTN

### RELEASES CERAMIC BALL BEARINGS FOR ELECTRIC MOTOR APPLICATIONS

NTN Bearing Corporation of America is pleased to announce ceramic ball bearings for electric motor applications as its latest product offering. NTN's new series of ceramic ball bearings has been specifically designed to prevent electrical arcing in a variety of applications.

"We are elated to offer yet another high-quality bearing solution to our customers," exclaimed James Misch, director of marketing and technical services, NTN. "The electric motor industry in particular presents numerous challenges due to the nature of the industry and the potential exposure of bearings to stray electric currents. This new product innovation is designed to combat multiple potential failure modes, giving our customers peace of mind that their operations will not be impacted by unexpected downtime."

Robustly designed with steel rings and cages but featuring ceramic balls instead of standard steel balls, NTN ceramic ball bearings are useful in many different applications found within a variety of industries including the electric motor industry. Due to ceramic being nonconductive, the material is ideal for applications where stray currents are present.

NTN's ceramic ball bearing offering comes with two shields, electric motor grease, and C3 clearance as standard. We stock some of the most common bearing sizes while offering bearings with bore diameters up to 65mm, and our entire offering has

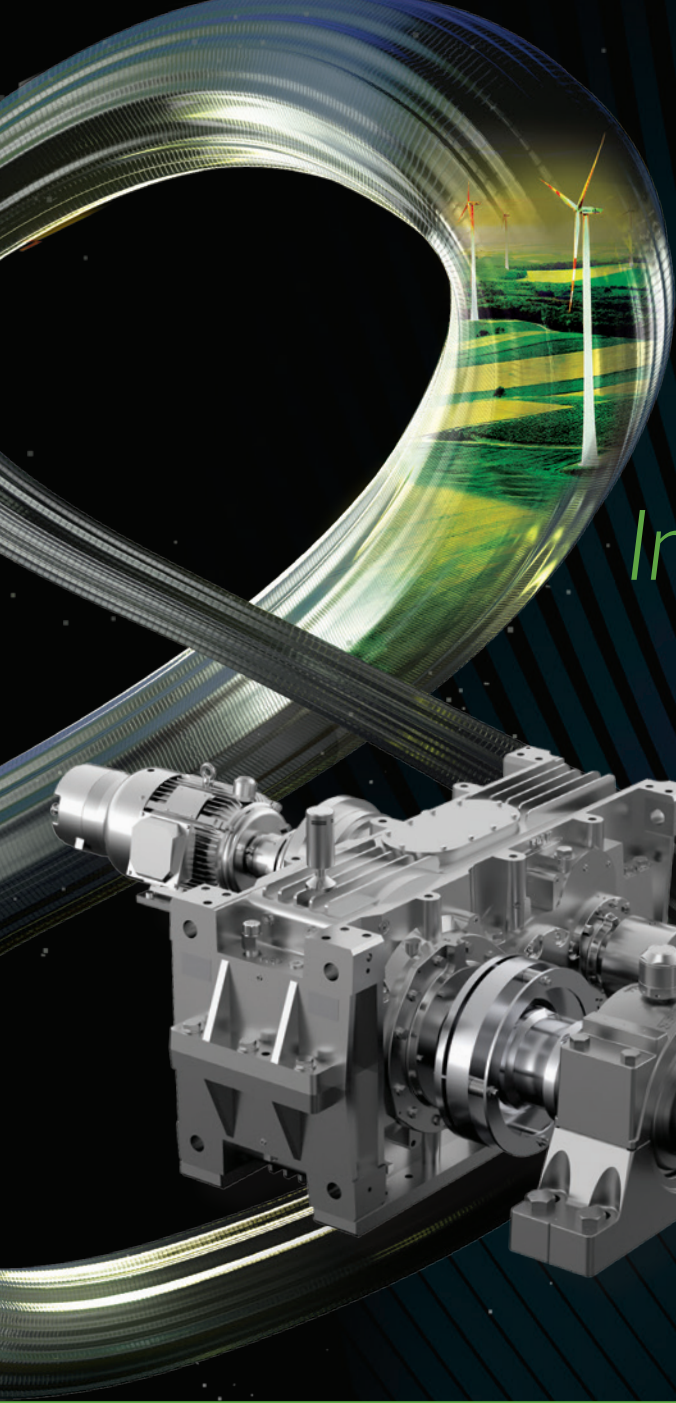


ISO standard dimensions for easy interchangeability. Additionally, the ceramic material of these bearings generate less heat allowing longer service intervals than the steel ball equivalents. NTN's ceramic ball bearings offer a cost-effective solution to combat stray electric currents and other harsh operating conditions.

Additional information on ceramic ball bearings can be found on Bearing Finder. Designed to aid distributors, design engineers, and end users in finding the perfect bearing or related product to use in any application, Bearing Finder is hosted on a proprietary platform that offers a customizable part search tool, interactive and downloadable CAD illustrations, comprehensive part interchanges, and exhaustive data sets.

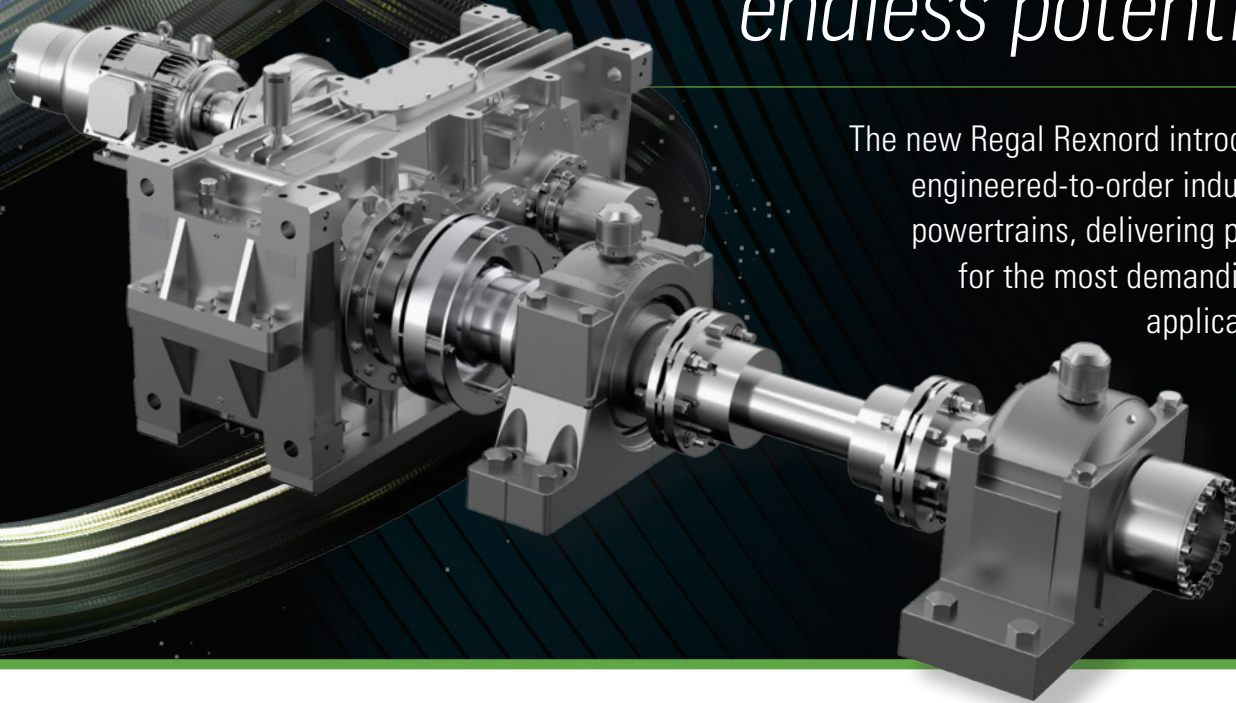
[NTNAmericas.com](http://NTNAmericas.com)





# *Industrial powertrains that drive endless potential*

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



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

Read about Regal Rexnord and our prominent brands. Go to [regalrexnord.com](http://regalrexnord.com).

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

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

All trademarks, service marks and company names are the property of their respective owners.  
© 2022 Regal Rexnord Corporation, All Rights Reserved. MCAD21056E • MB0122E

## **Regal** **Rexnord**™

**Creating a better tomorrow™...**

[regalrexnord.com/powertrain](http://regalrexnord.com/powertrain)

# The Art of the Balance

Nathan Maxwell, Motion

**While sitting at a tire shop a while back, I could not help but overhear a customer tell the mechanic he could only afford to pay for the new tires, but not to pay the extra twenty dollars to get them balanced.**

I thought to myself, "I hope that this mechanic explains that the extra twenty dollars spent to balance is going to save this person hundreds of dollars down the road." Even vehicle tires require balancing to keep them from vibrating and damaging the other drive train components. In the near future, without balancing the tires, this person is going to be stuck buying all new tires and possibly drivetrain components. The average cost to buy tires today is not exactly cheap. So, when you think about it, the extra twenty dollars to balance is well worth it.

The same goes for impellers and rotors for pumps and motors. Many of us feel that balancing impellers, rotors, etc. is not that important of a procedure. In fact, it is quite the opposite.

## Importance of balancing

Impeller and rotor balancing are a crucial part to keeping our pumps and motors running. Why do we balance? There are many reasons that balancing is important, but here are some major ones:

- Extended product life
- Increased safety
- Lower operating cost
- Improved performance
- Increased bearing life
- Reduced noise/vibration
- Reduced stress/wear
- Reduced power loss
- Reduced repair cost

## Reasons for unbalance

What causes unbalance? Any of the following can cause an unbalance in your rotating equipment:

- Design
- Heat
- Assembly errors

- Misalignment
- Flexing
- Density changes
- Nonsymmetry (oval or egg shaped)
- Environmental conditions
- Damage to the impeller
- Bearing Failure

How is balance corrected? This is done by adding material, material removal and shifting of material. Let's dive in deeper to get a better insight on what types of balancing are applicable to your rotating equipment.

If an impeller or rotor is out of bal-

## Types of unbalance conditions

**Static unbalance** is the condition in which the central principal axis is displaced only parallel to the shaft axis. For example, a large pulley or an impeller on a single shaft with bearings is considered static unbalance.

**Dynamic unbalance** is the condition in which the central principal axis is not parallel to and does not intersect the shaft axis. For example, a rotor out of an electric motor or a split-case impeller assembly is considered dynamic unbalance.



Exploding bearing.

ance, bearing failure can result from the consequential vibration. Vibration is the number one cause of bearing failure. The center of the shaft (or center of gravity) is where the impeller, when it is properly balanced, will want to spin. If it is not properly balanced, the center of gravity will move to the principal axis of inertia, which runs parallel to the center of gravity line. Corrections can be made anywhere on the impeller or rotor, provided the net effect is in line with the rotor's center of gravity.

**Couple unbalance** is the condition in which the central principal axis intersects the shaft axis at the center of gravity. For example, a railroad wheel assembly is considered couple unbalance.

**Quasi-static unbalance** is the condition of the unbalance for which the central principal axis intersects the shaft axis at a point other than the center of gravity. For example, a great scenario for quasi-static unbalance is an electric motor and blower wheel assembly.

The two main types of balancing on



rotating equipment are static and dynamic. How do we determine what type of balance procedure must be done for the correct application? Most impellers will be static balanced to a G-6.3 per ISO 21940-11 standard, and rotors will be balanced to the same standard as impellers. We determine static balance by focusing on the impeller itself and nothing coupled to it (shaft, bearings, etc.). That is due to the impeller being larger/heavier than the bearings. That is when you will want to static balance.

The best scenario to dynamically balance would be rotors that go in a motor because there is equal weight on both sides. Rotors can also be classified as couple unbalance. In addition, on each side of a rotor shaft will be the bearings that the rotor will spin. You will also want to dynamically balance a split-case impeller assembly (the shaft is coupled on both sides by bearings and bearing housings) for the same reason. It acts almost identically to rotors in terms of how they operate.

When dynamic balancing, you will be removing/adding material on either side of the rotor/impeller to create equal balance on both sides. This will create smooth operation with vibration being almost nonexistent. It will also increase performance, as the rotor/impeller will spin without straining the bearings. With less strain, you will have minimal power loss when it comes to an impeller under a load. Loads on impellers consist mainly of water pressure fluctuations. A load on a rotor will consist of a blower attachment or fan to help cool the motor down. However, the main cause of stress on a rotor is vibration. If the rotor cannot spin freely without vibration you will experience power loss as the rotor will not be able to output the torque needed to operate whatever it is coupled to.



Cooling fan balance.

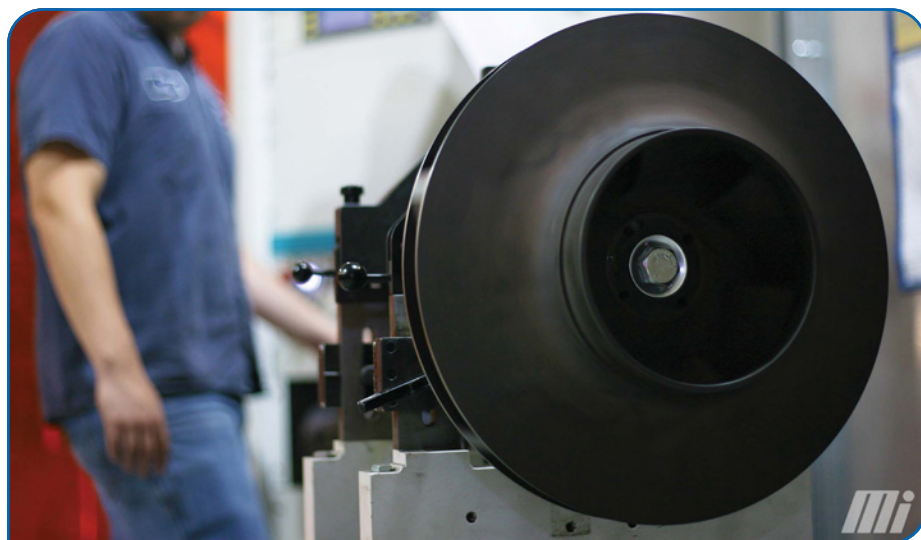
### Balance for Maximum Performance

Balancing impellers and rotors will save hundreds, even thousands of dollars in downtime, keep repair costs low, improve performance—and above all else—improve safety. This is why balancing is so important. We all want better product quality, bearing life and optimal performance. After all, good money is spent on the pumps and rotors to keep your business going. Your

pumps and rotors are assets and should be treated with care. **PTE**

*For more information, visit [Motion.com/pte](http://Motion.com/pte) or discover Motion's pump solutions blog here: [Motionind.biz/3EzqzE7](http://Motionind.biz/3EzqzE7).*

**Nathan Maxwell** is a shop technician at Motion's Process Pumps location in Omaha, Nebraska. A certified welder, Maxwell has 16 years of experience in welding, fabrication, machining, CNC and lathe operation, drilling, and plasma cutting, as well as five years in robotic welding and programming, and five years in process pumps.



Impeller and rotor balancing are a crucial part to keeping pumps and motors running.



# Energy Initiative

## The need for smart, sustainable and efficient components

Matthew Jaster, Senior Editor

With a global population projected to grow to almost 9.7 billion by 2050, accessing energy remains a significant challenge around the world.

For energy applications like wind, solar, oil/gas, and hydropower, components need to be smarter and more sustainable. They need data-driven metrics to prevent downtime and outages. Smarter components will continue to increase in the coming years, particularly in the energy market.

### Regal Rexnord Optimizes Gearboxes for Energy Applications

“Conserving our planet’s resources and using them efficiently are extremely important to Regal Rexnord’s customer base,” said Joe Bierschbach, technology manager – gearing, Regal Rexnord. “Using a gearbox with optimal efficiency for each application is also essential. We know a solar power application requires rigorous gearbox specifications to properly take advantage of the finite amount of sunlight while using the minimal amount of power to articulate the panels.”

Bierschbach said that the oil and gas industry is trending toward more efficient electromechanical solutions that



The Regal Rexnord Perceptiv services team is an extension of the maintenance team on the ground. This partnership ensures that each customer maximizes uptime (courtesy of Regal Rexnord).

will leave a smaller footprint while not compromising productivity.

“Historically, a customer had two options. The first option was to rebuild/replace gearboxes on a prescribed maintenance cycle based on historical failures. The second was to wait until the gearbox broke during operation and the customer experienced downtime. Neither option is ideal when you

consider the cost of unplanned downtime and unnecessary rebuilds,” he added.

Today, Regal Rexnord highly recommends that a customer take advantage of Perceptiv intelligence diagnostics and monitoring for their gearbox and use this data made available through this system to plan downtime, rather than react to unplanned downtime. In this regard, Bierschbach said that Regal Rexnord is a one-stop shop for gearbox users in the energy industry.

“Our experts are available to specify the initial gearbox selection, monitor that gearbox while in operation, notify the customer of any necessary maintenance, and deploy to the field to perform that maintenance. If a full rebuild is needed, Regal Rexnord has an industry-leading rebuild facility that can restore a customer’s assets to like-new condition,” he said.

The level of monitoring for gearboxes has increased exponentially over the last several years. Regal Rexnord is at the forefront of this advancement



Perceptiv allows users to proactively predict any issues before they occur (courtesy of Regal Rexnord).



with its Perceptiv intelligence offering, which allows users to proactively predict any issues before they occur. Customers partner with Regal Rexnord to perform predictive maintenance and can forecast when rotating elements need to be serviced. This approach allows maintenance to be scheduled proactively at times where it will cause the least disruption, rather than to interrupt normal production. Regal Rexnord is committed to staying at the forefront of new and more accurate ways of monitoring the health of our customers' most critical assets.

According to Bierschbach, gearboxes fail for numerous reasons, but one of the most prevalent is inadequate maintenance. "Users typically perform the prescribed oil changes but unfortunately ignore other components of the gearbox. While maintenance teams have the best intentions, some of the most critical components such as the bearing, seals and gears are overlooked. In the past, these components could only be monitored visually. At Regal Rexnord, we pride ourselves in taking the subjectivity out of predicting maintenance and gearbox failure. The Regal Rexnord Perceptiv services team is an extension of the maintenance team on the ground. This partnership ensures that each customer maximizes uptime and is warned early of pending gearbox failure," Bierschbach said.

Efficiency, uptime and extended maintenance intervals will be drivers for innovation in the coming years. At Regal Rexnord, these trends will be monitored by sophisticated Perceptiv services packages that will become a standard offering customized for each gearbox.

"Regal Rexnord's ability to offer the complete industrial powertrain to customers in the energy sector will hit each driver," he added.

[www.regalrexnord.com](http://www.regalrexnord.com)

## Philadelphia Gear Focuses on a Sustainable Future

With the emergence of the movement to reach Net Zero emissions by 2050, the role of Philadelphia Gear as part of the larger network of nationwide gear and motor repair facilities that make up Timken Power Systems has never been more vital. Timken Power Systems' broad electromechanical knowledge and capabilities help its customers save money and, most importantly, contribute to a more sustainable economy by extending the lives of mission-critical equipment and parts that are essential to keeping the world in motion.

"Greater efficiency has always been a core value of our gear operations and innovations, and now this legacy has been expanded to include aftermarket repair services for motors, bearings, and control systems," said Carl Rapp, group vice president, Timken Power Systems. "Our new offering allows our customers to leverage our engineering capabilities to develop more sustainable solutions that extend the life of essential machine parts while reducing

cost, waste, and the downstream carbon footprint. And we've seen these efforts make a big difference as our industrial repair and service business helps to reduce the environmental impact by recycling more than 1,000 tons of steel and 75 tons of copper each year from service parts that can't be reused."

Rapp said customers often ask themselves two important questions when deciding between buying a new gearbox or repairing it: Is the equipment salvageable? What is the opportunity cost of removing critical equipment from service and waiting for a new replacement versus having it repaired?

"Downtime, for many of our customers, first and foremost means the loss of power for millions of homes during times when they need it most. Secondly, those types of outages can translate into mounting financial losses for energy companies ranging in the hundreds of thousands of dollars each day their equipment is out of service. And with lead times for new equipment that could span up to four



Philadelphia Gear drivetrain system includes new electric motor, right-angle pump drive, and control system.

months (in many cases), the decision becomes simple, and the need for a high-quality, versatile repair facility that offers onsite service and superior manufacturing capabilities can quickly become evident,” Rapp said.

And how is data-driven manufacturing and IIoT solutions helping gearbox customers today?

“The importance of collecting, understanding, and continuously monitoring critical data has always been a crucial part of our business. Those

efforts can be traced back before computers, where we recorded customer equipment information into logbooks which we’ve since scanned and added to a searchable database that’s now part of our massive electronic data archive. Some of that information dates back to the 1950s and 60s, and remarkably our engineers will still often refer to it to help service equipment that continues to run in the field today. So, whether it’s expanding our network capabilities, adding more advanced

instrumentation, or investing in new machinery, we see the role of tools like these only growing in the decades to come.”

An excellent example of this effort, throughout the past year and a half during the COVID outbreak is that our facilities offer customers 100% remote, real-time witnessing of gearbox inspections, load testing, and progress monitoring through video and online conferencing technology.

The most common answer the company hears regarding gearbox failure is lubrication challenges. Rapp said that continued reliability, successful operation, and the long life of power transmission equipment are largely dependent upon the constant supply of lubrication oil of the proper quantity, quality, and condition.

“So, whether it’s the wrong type of oil to match the operating requirements, an improperly specified lube system, or the lack of a proper routine maintenance plan, lubrication issues can cause anything from minor to catastrophic gearbox failures. Thus, when designing a gearbox, the importance of selecting the appropriate lubricant, type of lubrication system, and integrating the proper instrumentation for condition monitoring cannot be understated and are vital factors that will affect the longevity and performance of every gearbox,” Rapp said. “During the design phase of our gearboxes, our engineers find it essential to work closely with customers to gain a deeper understanding of the application and the environmental conditions to design the optimal system type and recommend the best maintenance schedule to increase the performance and longevity of their equipment.”

Trends in recent years include customers moving from “off-the-shelf” products to working with companies that offer superior manufacturing capabilities and can also serve as a trusted advisor to provide more comprehensive solutions. Rapp anticipates this trend to continue to evolve and grow as energy customers are now tasked with not only adapting their technology but retuning their processes to fit within the Net Zero 2050 agenda.

ustsubaki.com

## YOUR **TSUBAKI** SIDEKICK FOR PINPOINTING SPROCKET WEAR.

*Optimize your operations and avoid unscheduled downtime with patented Smart Tooth® Sprockets. Strategically-placed Wear Indicator technology provides a visual indication when your sprocket needs to be replaced, eliminating the guesswork associated with worn sprockets. Now you have the ability to identify and schedule drive system maintenance before critical component failure occurs, extending chain life and reducing the overall cost of equipment ownership. Smart Tooth® Wear Indicator Sprockets — only from your reliable tsidekick, Tsubaki.*

THERE'S NO ROOM  
FOR WEAK LINKS WITH...

### SMART TOOTH® SPROCKETS

- › Extend chain life with right-on-time, proactive maintenance
- › Prevent catastrophic failure and unexpected downtime
- › Eliminate the guesswork associated with worn sprockets
- › Reduce your equipment costs
- › Just look for the BLUE

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

©2019 U.S. Tsubaki Power Transmission, LLC. All Rights Reserved.

**TSUBAKI**  
LEADING THE MOVEMENT



“As a result, we’ve seen energy providers moving towards developing more complex hybrid systems to fill the gap until they achieve fully sustainable carbon-neutral solutions. So, in a nutshell, this translates to the need for companies to be closer to their customers, understand their evolving needs, and develop a fully customized solution that’s adaptable, efficient, and affordable. And most importantly, we see this as a core competency that doesn’t end just inside the gearbox but extends across all electrical and mechanical systems, including electric motors, generators, and control systems that help support their rotating equipment,” Rapp added.

Philadelphia Gear and Timken Power Systems will continue to advance its products and technologies in the future.

“We’ve implemented several software tools to help meet this need, including finite element analysis, computational fluid dynamics, parametric modeling, and online configuration tools to aid in shortening lead times and developing more efficient and better-designed equipment. We’ve applied this training and these principles across our entire network of Timken Power Systems facilities, so our gear, motor, and control systems experts are versatile and prepared to adapt and grow with our customers’ evolving needs,” Rapp said.

[www.philagear.com](http://www.philagear.com)

## Dunkermotoren, Part of AMETEK, Inc., Provides Auxiliary Drive Solutions for Energy Applications

Dunkermotoren delivers solutions for the fields of combustion, wind, solar and water energy. “We are not doing the main drives, but auxiliary drives such as actuators (solar tracking), locks and valves. We are also providing motion solutions for equipment such as the autonomous solar panel cleaning robot from SolarCleano, or for equipment of the maintenance of wind turbines,” said Stefan Tröndle, product manager at Dunkermotoren. The SolarCleano is a solar panel cleaning robot that can be managed by one person using a remote control. It can clean a solar panel in a single pass returning the solar cells to full productivity.

Dunkermotoren is committed to providing more efficient and productive technologies for the energy market like the motion solutions it provides for the SolarCleano.

“Our DC-motors are not addressed by the existing energy standards but do exceed the requirements in terms of efficiency. When a pneumatic solution is replaced by an electrical motor and gearbox solution from Dunkermotoren, the efficiency is improved from approximately 5 to 70 percent,” Tröndle said.

The most common answer the company hears regarding gearbox failure in energy applications includes selecting the wrong-sized products based on unclear requirements, according to Tröndle.

“Our new planetary gearbox series PLG xx SL and the spirotec gearbox STG 65 with exceeded lifetime, might be a suitable solution for less gearbox failure,” he added.

The PLG series, for example, has the highest continuous torque capacity of all types of gearboxes; at the same time, they have a very compact design, low weight, and excellent gear efficiency of typically 97%. The planetary gearboxes are also maintenance-free. The STG series has gearboxes with right-angled output. The core element of the series STG is the spiral wheelset. It enables to reliably transmit high moment with comparatively small center distance in a small space.

Dunkermotoren’s components are monitored using a variety of IIoT solutions. With the IIoT functionality of Dunkermotoren’s motor and gearbox combinations, for example, it is possible to read the current consumption and the temperature. If one of the values is going up, this can indicate that the product is wearing out and needs to be replaced within the next overhaul.

It is already possible to read information such as temperature, current draw and hours of operation (operating hours counter).

Tröndle believes the trends in the energy market in the future are clear. “All motion products will have an IIoT interface. Dunkermotoren has the right interfaces for the motors and gearboxes,” he added. “These trends will include more efficient solutions with higher power density as well as more sensing capabilities via IIoT.”

[www.dunkermotoren.com](http://www.dunkermotoren.com)

### The Optimal Path

The path forward is to optimize plants and processes by upgrading the individual components as well as the complete electrical and mechanical systems. Digital solutions will continue to play a significant role in the energy market as the gearboxes, motors and drives continue to evolve. **PTE**



Solar panel cleaning robot (courtesy of SolarCleano 2021).

# Solar-Powered Waste Management

## Finbin implements sustainable waste containers with igus bearings

igus GmbH

**An overflowing waste bin in a park: pizza boxes piled up, coffee cups, napkins and beer cans on the ground.** Cities all over Europe have been fighting against such a deluge of waste for years. Corona exacerbates the problem because people spend more time outdoors.

“With classic rubbish bins, waste management in most cities is now reaching its limits. Many metropolitan areas in Finland, for example, had to empty public waste bins up to four times a day even before the pandemic,” said Antti Kinnunen, marketing manager at Finbin.

The Finnish company’s answer: a waste bin called CitySolar, which compresses waste and thereby has a much

higher capacity. A waste bin that is connected to the Internet and triggers an emptying before reaching the maximum fill level.

“With CitySolar, we are making a contribution to reducing disagreeable waste scenes in cities and improving the CO<sub>2</sub> balance in waste management. Up to four out of five trips can be avoided with the networked waste bin,” Kinnunen added.

### Less emptying: solar-powered compactor compresses waste

Visually, CitySolar is reminiscent of the robot R2-D2 from *Star Wars*—only somewhat larger, more angular and less noisy. Its operation is simple: a passer-by opens the waste flap by hand

or by foot. Once the flap has closed, an electric press compresses the waste. It is done so effectively that a container with a capacity of 240 liters can hold 1,500 liters of waste—with a total weight of up to 600 kilograms. The waste bin can do this work anywhere, independent of the public power grid. Because the engineers have installed solar panels on the roof. In addition, a lithium-ion battery that stores power for cloudy periods and the night. This means that energy is available for the waste compactor around the clock. Indoors, CitySolar is not dependent on solar energy. The waste bin can be connected to the conventional power grid here.



Finbin’s bins compress waste by a factor of six and report their fill level via the Internet.





As soon as the flap is closed, the waste compactor starts working. The energy is supplied by the solar module on the roof of the bin.

### Maintenance-free components

To increase the sustainability of the novel waste bins further, the engineers have made every effort to use components that do not require maintenance. After all, every maintenance operation causes CO<sub>2</sub> emissions — solely through travel to the site. Finding such components was not always easy. An example: the plain bearings for the mechanics of the press and the skirting board. Classic bearings made of metal were out of the question for the job. Why? First, because there would be a risk of corrosion with high humidity. Second, because the lubrication of metal bearings can lead to several problems. It would combine with dust and dirt and, over time, become a paste that reduces the bearing's sliding ability, making the system less smooth and, in the worst case, leading to failure.

To avoid these problems, the engineers set out to find lubrication-free plain bearings made of high-performance plastic. "We looked at bearings from different manufacturers thoroughly," Kinnunen recalled. "Durability and reliability were the main criteria and the reason why we chose plain bearings from igus."

### Durability proven on the test rig

Iglidur G plain bearings (GFM-1214-12) are used in the mechanics of the pressing plant. A test in the igus in-house laboratory, the largest test laboratory in the industry, proves how

wear-resistant the bearings are compared to classic metal bearings. In the test, the bearings were pivoted on a gas-nitrided, St52 steel shaft — with a load of 30 Mpa and a speed of 0.01 meters per second.

"In the case of the metal bearings, the sliding layer was already worn after 60,000 cycles," said Stefan Looockmann-Rittich, head of the iglidur bearings business unit. "The iglidur G plain bearings, on the other hand, showed almost no signs of wear even after 200,000 cycles. They are ideally suited for reliable and maintenance-free use in wind and weather for many years."

The plain bearings are therefore also installed in the skirting board and in the waste flap — here in combination with double flange bearings of the iglidur M250 series.

### Waste bin reports filling level via the Internet

However, the electric waste bin from Finbin is not only low-maintenance, but also smart. Sensors are installed inside the container to measure the fill level. In addition, a SIM card connects CitySolar to the Internet. The bin can continuously transmit the fill level to *FinbinCare*.

The cloud-based waste management software works with GPS tracking technology and shows waste companies what the fill level of individual bins is on a map. Via an API interface, the waste bins can alternatively be connected to waste management systems.

## THIN ENOUGH?

BXR Brakes

- Up to 480 in-lbs static
- Up to a 1.125" bore
- 19 watts or less
- Produced for over 10 years

Our Innovative design features a very thin profile, reducing weight and saving space.

For more information:  
Call: 800.533.1731  
[www.mikipulley-us.com](http://www.mikipulley-us.com)

“CitySolar’s fill level information is based on a patented measuring system developed in-house, which is one of the most accurate systems on the market,” said Kinnunen. “Thanks to this information, companies can deploy personnel resources in a more targeted manner, and unnecessary trips to almost empty bins are a thing of the past. So are bins that overflow.”

Finbin’s internet-linked waste bins can be admired in more and more cities — no longer just in Scandinavian cities such as Oslo, Helsinki and Finland, but now also in Hvar in Croatia and Verona in Italy. Cities are flexible when it comes to costs. You can either buy CitySolar for around 5,000 euros each or rent it for a monthly fee. Finbin therefore offers enough flexibility for further applications. “The facilities make them ideal for events or festivals, for example,” said Yrjo Ojanen, the designer of the Finbin. “They can actually make the world a bit greener.” **PTE**

[www.finbin.fi](http://www.finbin.fi)  
[www.igus.com](http://www.igus.com)

For Related Articles Search

plastic bearings

at [www.powertransmission.com](http://www.powertransmission.com)



A passer-by opens the waste bin via a skirting board. Plain bearings made of high-performance polymers from igus ensure long-lasting and maintenance-free operation without external lubricants.



# Hungry for More



Everything you  
need if you buy  
gears, bearings,  
motors, couplings  
and clutches.

## Power Transmission Engineering

- Product and Industry News Updated Daily
- Directory of Mechanical Power Transmission Suppliers
- Exclusive online content in our e-mail newsletters
- Back Issues and Article Archive
- Calendar of Upcoming Events for power transmission professionals

FREE SUBSCRIPTION!

[www.powertransmission.com](http://www.powertransmission.com)



Custom Engineering,  
Prototype Work,  
Precision Machining,  
Assemblies and  
Standard Components

[www.nordex.com](http://www.nordex.com)

Your online source for Gears, pulleys, shafts,  
bearings, couplings, fasteners, custom gear boxes,



[Sales@Nordex.com](mailto:Sales@Nordex.com) [Eng@Nordex.com](mailto:Eng@Nordex.com) 203-775-4877

ISO9001:2015 & AS9100D, ITAR Registered, NIST.SP800-171R1,  
Trace Certified, Class 100 clean room

Subscribe TODAY



IT's FAST. IT's EASY.  
IT keeps YOU in the KNOW.

[www.powertransmission.com/  
subscribe.htm](http://www.powertransmission.com/subscribe.htm)



**B&R**  
MACHINE AND GEAR CORP

[BRGEAR.COM](http://BRGEAR.COM)



## TELCO MOTION



For over 35 years, TelcoMotion has been bringing together the world's largest selection of quality motion control assemblies, components, and parts—coupled with the industry's top experts and engineers—to create optimized solutions for every project.

TelcoMotion carries a wide variety of motors including BLDC, PMDC, Gearmotor, Stepper, blower, and the AC motors. Email us about your custom-

Visit us at  
telco-gearmotor.com  
sales@telcointercon.com

## Inline Helical Speed Reducers

An extremely compact design provides highly reliable, space saving performance for the most demanding applications.



- 14 sizes, 1 - 75 HP
- Multi-stage Ratios
- NEMA, IEC, or Servo Motor Adapters
- High Efficiency & Low Backlash
- Multiple Mounting Configurations

**DIEQUA**  
Corporation

diequa.com/pte 800-292-9135

## High Performance Bevel Gearboxes

The Tandler Spiral Bevel gearbox is both precise and ideal for demanding applications where robustness and high torque density are required.



- 9 sizes
- 15 ratios
- Low backlash
- Customizable

**DIEQUA**  
Corporation

diequa.com/pte 800-363-2145

## Power Transmission Engineering online!

It's like your own professional superpower.

Stronger, faster and smarter than your average website, [www.powertransmission.com](http://www.powertransmission.com) offers everything you need to supercharge your engineering-oriented organization.

- Complete archive of articles on engineered components
- Directory of suppliers of gears, bearings, motors and other mechanical power transmission components
- Product and Industry News updated daily
- Exclusive online content in our e-mail newsletters
- The Bearings Blog
- Calendar of upcoming events
- Comprehensive search feature helps you find what you're looking for — *faster than a speeding bullet!*

[www.powertransmission.com](http://www.powertransmission.com)

# Machine Elements – Shaping the Future through Continuous Evolution

E. Kirchner, A. Hasse, M. Hofer, G. Jacobs, S. Puchtler, B. Schlecht, K. Stahl, M. Weigand

The well and the wheel—some of the oldest inventions of mankind—were themselves already dependent on machine elements. Over the years, ropes as the oldest class of machine elements enabled numerous innovations such as draw wells, sailing and later aircraft construction. Machine elements have always been at the center of numerous innovations. More than ever, the further development of classic machine elements, such as gears and bearings, enables innovative solutions for tomorrow's problems: a stocktaking.

## Machine Elements Are Everywhere

In everyday speech, even technophobes use machine elements in many places to figuratively represent their opinions. Sayings such as “Don't reinvent the wheel” or “Sand in the gears” are ubiquitous, generally understood and accepted. It is also impossible to imagine everyday life without the symbolism of machine elements. Just imagine searching for the settings on a smartphone without the stylized gear wheel, the Mainz coat of arms without the wheel, or the Rotary Club without the machine elements in its trademark



Figure 1 Machine elements in everyday life as a symbol for the settings on the smartphone, in heraldry using the example of the Mainz wheel, and as a symbol of charitable organizations.

(Fig. 1). Many people are not aware of the fact that many machine elements originate from a development spanning thousands of years and that today it is impossible to imagine modern mechanical and plant engineering products without them.

This article, developed by the Wissenschaftliche Gesellschaft für Produktentwicklung (Scientific Society for Product Development, WiGeP), analyzes the evolution of two selected classes of machine elements, formulates a law to describe their development in terms of Moore's law and extrapolates into the future. While transistors, for whose architecture Moore's law was originally formulated (Ref. 1),

have now physically reached the highest spatial density, the authors believe that much is still achievable in machine elements due to the possibilities for synthesizing new system solutions. Despite the very long history of individual machine elements, they are constantly being developed further and digitalization offers machine elements a high potential for innovation.

## Continuous Power Enhancement

The evolution of machine elements and their future as an element of design are analyzed here using the example of rolling bearings and gears. Due to the bearing as a functional unit, the invention of the wheel about 6600 years ago became a sustainable innovation. With the wheel centered and guided by the bearing, the acting forces were supported (Fig. 2, left). A modern wheel bearing has the same basic functions, can also transmit the drive power practically without loss and, in many cases, also provides high-resolution rotational speed information via specific sensors (for example, in a modern ABS system).

A similar development can be observed in the example of linear guides (Fig. 3). Whereas about 4600 years ago wooden rollers as rolling elements facilitated the construction of pyramids, with modern slides guidance accuracies in the range of micrometers are

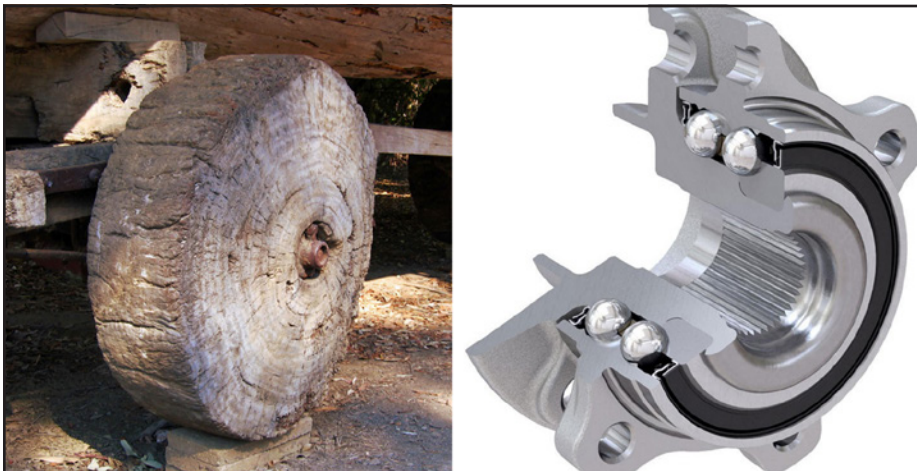


Figure 2 Improved performance of the wheel bearing. From the unlubricated plain bearing to the lifetime-lubricated double-row angular contact ball bearing in back-to-back arrangement with form fit connection to the cardan shaft (right-hand image courtesy of SKF, Ref. 2).



possible due to advances in manufacturing technology for the hardened and precision-ground rolling elements as well as the preload of the rolling contacts. An integrated position measurement system can resolve the same accuracy. Low-friction seals and optimized rolling contacts have made it possible to continuously reduce friction losses over the past decades.

### Moore's Law

In 1965, Gordon Moore made a prediction about the development of semiconductor technology (Ref. 1). His prediction is known as Moore's law and states that the number of transistors per unit area will double every year, corresponding to an exponential increase. Moore's law has so far proven to be largely correct. However, the further reduction in the size of transistors is likely to reach its limits in the coming years. Alternatives to conventional transistor design or new approaches to chip architecture are needed for the future (Ref. 3).

Whether Moore's law can also be applied to machine elements will be considered in this section. In order to be able to assess the further development of machine elements and the technical systems assembled from them, suitable quantification on the basis of technical characteristics is necessary.

### Torque Density of Gearboxes for Wind Turbines

In wind turbines, the increasing rotor diameters led to an increase in the rated power. At the same time, a reduction of the rotor speed is necessary to maintain the permissible blade tip speed (Ref. 4). This results in a high increase in input torque. To evaluate the development of gearboxes for wind turbines, the torque density as a quotient of the rated torque of the gearbox and the weight of the gearbox is suitable (Refs. 5, 6).

Figure 4 suggests an annual increase in torque density of about five percent. This corresponds to an exponential increase as in Moore's law, although at a lower growth rate.

The development of torque density is due, among other things, to lightweight construction, new materials and coatings, and optimized macro- and

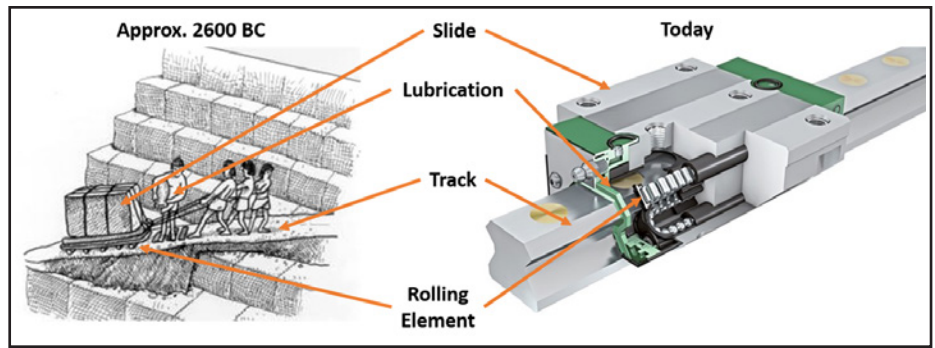


Figure 3 Performance increase using the example of the linear guide. On the left with wooden rolling elements and sand as an adhesive in the open system, on the right with grease-lubricated precision rollers as a closed system. (Left image copyright Vladimir Filipovic, ZUNS, Belgrade / La main à la pâte. Right image courtesy of Schaeffler).

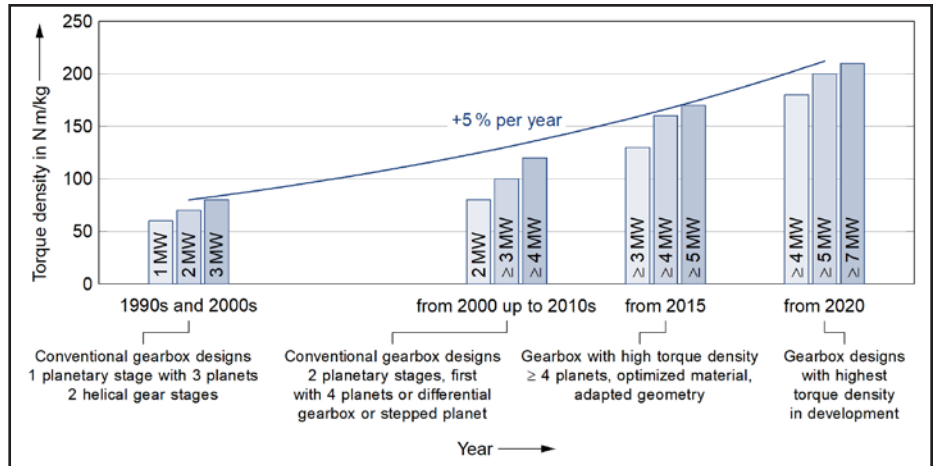


Figure 4 Development of torque density of gearboxes for wind turbines (based on Ref. 6).

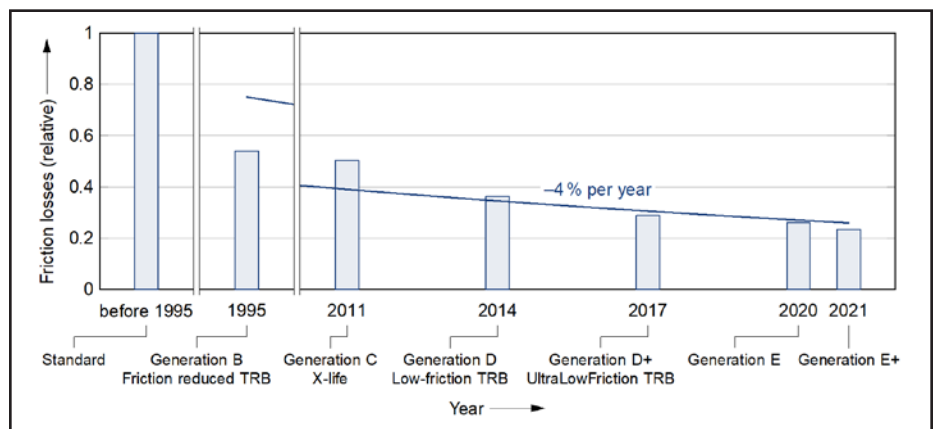


Figure 5 Development of friction losses of tapered roller bearings (TRB) (based on Ref. 8).

micro-geometries (Ref. 6). Smaller plain bearings allow higher power densities by load sharing on more planets and enable new gear concepts (Ref. 7).

### Frictional Losses of Tapered Roller Bearings

In addition to the increase in load carrying capacity, today ever greater demands are being formulated for the energy efficiency of machine elements.

Figure 5 shows the development of

friction losses of tapered roller bearings over time. Friction decreases exponentially and roughly follows the plotted curve of an annual decrease of four percent.

Improvements were achieved, among other things, by improving the surface quality of bearing rings and rolling elements, adapting the flange and cage geometry and the lubricants. To reduce friction while maintaining the necessary load carrying capacity, application-related,

computer-aided design optimizations are carried out (Ref. 8).

### Significance of the Validity of Moore's Law for Machine Elements

For the two examples presented, a similar exponential development can be seen, albeit one that extends over a longer period of time, as with Moore's law. In the case of other industrial gear units, too, it has been possible over the years to significantly increase calculation accuracy and to incorporate application knowledge and findings from a wide variety of application areas into development, which has led to an increase in torque density and an increase in bearing service life and efficiency (Refs. 9, 10). In summary, the continuous further development is based on the one hand on an improvement of individual machine elements, and on the other hand on the development of new concepts for technical systems.

### Machine Elements Open Up New Possibilities

The further development of machine elements goes well beyond increasing power density or reducing friction losses. Innovations in the field of machine elements also open up entirely new possibilities for increasing the functionality and sustainability of machines and plants.



Figure 7 Sensor bearing for measuring force, lubricant condition and speed (courtesy of HCP Sense).



Figure 6 Geared turbofan — planetary gear stage (left) and comparison of Airbus A320-200 and Airbus A320 neo (right). (Left image courtesy of Pratt & Whitney, Right image courtesy of Airbus).

### Geared Turbofan

In aircraft engines of the latest generation, a planetary gear stage as shown in Figure 6 is used between the core engine and the fan to reduce the speed of the fan to about 1/3. Due to the lower circumferential speeds of the fan blades, the fan can be made larger and thus the bypass ratio can be increased considerably, which reduces fuel consumption by up to 20%. In addition, the larger bypass ratio results in noise emissions that are also up to 20% lower. The first generation of these engines is already on the market; the second generation of these engines — currently under development — will be able to achieve the same reductions once again and is expected to run on up to 100% synthetic fuels. The large number of aircraft equipped in this way is already making a significant contribution to the environment. Since the economic efficiency is also increasing at the same time,

this technology is rapidly gaining widespread acceptance.

Figure 6 on the right shows the Airbus A320 neo (neo = new engine option) equipped with geared turbofans compared with the A320-200. The significantly larger diameters of the new generation of engines compared with the older generation can be clearly seen.

The gears thus make a major contribution to achieving today's important environmental and climate protection goals.

### The Rolling Bearing as a Sensor

The integration of sensor technology is becoming increasingly important in the era of Industry 4.0 and poses challenges for design engineers, particularly in the case of limited installation space. Therefore, various approaches are being researched to integrate sensor functions into machine elements.

The rolling bearing has emerged as the preferred source of process data for parameterizing digital twins in order to obtain high-quality data with comparatively little effort. For example, conclusions can be drawn about the operating condition of the bearing by measuring the electrical properties (Fig. 7). Since the lubricant film thickness and the deformation in the contact depend on the load, the electrical properties of the rolling element raceway contact change measurably as a function of the load. The determined load data can be used, for example, for process monitoring or incorporated into a real-time service life model that enables improved estimation of the remaining life span. In addition, a statement can be made about the lubricant condition, which exhibits altered electrical properties as



aging progresses.

Further research and subsequent market introduction of these approaches have the potential to make the benefits of Industry 4.0 easier and more cost-effective to harness. Design engineers can resort to a familiar catalog of machine elements and at the same time integrate additional sensor functions into the product.

### Additive Manufacturing of Rolling Bearing Rings

Elsewhere, new manufacturing processes favor potential innovations in the field of machine elements. Additive manufacturing is a case in point: A process has been developed for selective laser melting of M50NiL steel, which is used, for example, in the high-temperature bearings of the main shaft of aircraft engines. Additive manufacturing of the outer ring allows targeted and efficient cooling of the bearing (Fig. 8). By separating cooling and lubrication, the weight, coolant flow and operating temperature of the bearing can be reduced and the efficiency of the engine significantly increased (Ref. 11).

### Future Applications

Based on the analysis of the previous performance increase of machine elements in chapter 2, the confirmation of a Moore's law and the discussion of examples which have enabled continuous performance or functionality increases through continuous further developments in the field of machine elements, a look at the medium-term future will now be taken on the basis of an electric vehicle drive, because electric vehicles will always require machine elements and in the vast majority of cases also transmissions. If we take Moore's law as a basis for the continuous increase in the maximum speed of electric motors, which is driven by the need for powerful and cost-optimized drives with a simultaneous reduction in magnetic material for both economic and ecological reasons, we quickly recognize the growing challenges for rolling bearings, seals, gear teeth and, not least, lubricants. Rolling bearings, seals and gear teeth must be upgraded to cope with the increasing speeds in the 30,000 rpm range. The faster switching

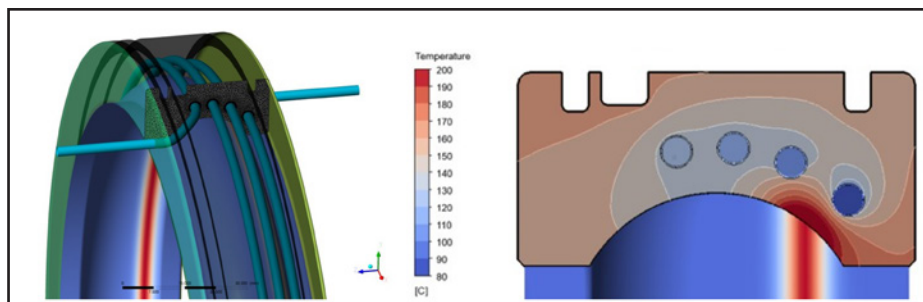


Figure 8 Additively manufactured outer ring with integrated cooling channels (Ref. 11).

times of the converters must not lead to spontaneous discharges as a result of significantly greater voltage gradients in the functional surfaces of gear teeth or rolling bearings. In the case of the intended joint cooling and lubrication of the electric machine and reduction gearbox, the lubricant must not age to a significantly greater extent as a result of the shorter thermal load changes when passing through the drive system and oil cooler; furthermore, the reliable functioning of the lubricant must be ensured even at voltages in the kV range. Last but not least, in order to meet the demand for energy efficiency, further work should be done on friction reduction, because the ecological leverage is huge (Ref. 12).

### Conclusion

Many developments that are described in public as disruptive are based on the constant progress in machine elements. The next innovation push through the digitization of machine elements is currently being prepared in basic research (Ref. 13). The measurement of previously hardly accessible quantities in direct proximity to the process will lead to a steady increase in new functions at the system level. The ability to synthesize architectures and topologies, which, as shown in the previous sections, build on the improvement of machine elements to open up significant functional progress at the system level, must include the new possibilities of machine elements in the education of students. The future validity of Moore's law for machine elements requires that the fundamentals be maintained or improved; only then can technical progress be achieved as a necessary means of solving the current environmental challenges.

### Acknowledgement

The authors gratefully acknowledge the work done by Mr. Steffen Puchtler in translating the German manuscript into this English version to serve the international mechanical engineering community! **PTE**

### References

- Moore, G. E. 1965. "Cramming more components onto integrated circuits." *Electronics*. Volume 38, No. 8, pp. 114–117.
- Köllner, Ch. 2017. SKF entwickelt reibungsarme Radlager. URL: [www.springerprofessional.de/tribologie/fahrzeugtechnik/skf-entwickelt-reibungsarme-radlager/13334862](http://www.springerprofessional.de/tribologie/fahrzeugtechnik/skf-entwickelt-reibungsarme-radlager/13334862). Accessed: 7/23/2021.
- Porsche Engineering. 2021. Automobilentwicklung auf dem Sprung. *Porsche Engineering Magazin* issue 1/2021.
- Schelenz, R. 2013. Schwachwindanlagen. ETN Innovation & Forschung Windenergie NRW, Düsseldorf.
- Winergy. 2014. 1981 – 2014 | 100 Gigawatt weltweit ausgelieferte Leistung an Windenergie-Getrieben. Das 100-Gigawatt-Magazin.
- Lubenow, K., Schuhmann, F. and Schemmert, S. 2019. "Requirements for wind turbine gearboxes with increased torque density with special attention to a low-noise turbine operation." Conference for Wind Power Drives 2019, Aachen.
- ZF Wind Power. 2019. "Plain bearings as a viable alternative to roller bearings." PES Wind Talking Point. URL: <https://cdn.pes.eu.com/v/20180916/wp-content/uploads/2019/11/PES-W-4-19-ZF-Talking-point-1.pdf>. Accessed 6/7/2021.
- Stahl, T., Rumpel, R. and Wirth, P. 2021. Neue Lösungen für noch weniger Reibung – Die neue Generation reibungsoptimierter Schaeffler-Kegelrollenlager. In: VDI (Hrsg.): Tagung Gleit- und Wälzlagerungen. Online-Tagung, 03.-04.05.2021.
- SEW-EURODRIVE and ANSYS. "SEW-EURODRIVE: Stop. And Go!" URL: <https://www.cadferm.net/de/de/cadferm-informiert/cadferm-newsroom/cadferm-journal/sew-eurodrive.html>. Accessed: 7/16/2021.
- Getriebebau NORD. Produktkataloge G2000 und G1000. URL: <https://www.nord.com/de/dokumentation/kataloge/kataloge.jsp>. Accessed: 7/16/2021.
- Mirring, P., Rottmann, A. and Merklein, C. 2020. "Selective Laser Melting (SLM) of M50NiL - Enabling Increased Degrees of Freedom in New Design Concepts." *Bearing Steel Technologies. 12th Volume, Progress in Bearing Steel Metallurgical Testing and Quality Assurance*, pp. 261–276. DOI: <http://>

doi.org/10.1520/STP162320190071.

12. Gesellschaft für Tribologie e.V. 2019. Tribologie in Deutschland - Querschnittstechnologie zur Minderung von CO<sub>2</sub>-Emissionen und zur Ressourcenschonung. Eine Expertenstudie der Gesellschaft für Tribologie e.V. URL: <https://www.gft-ev.de/de/tribologie-studie-co2-minderung/>. Accessed: 7/12/2021.
13. DFG-Schwerpunktprogramm 2305. Sensorintegrierende Maschinenelemente. Wegbereiter der flächendeckenden Digitalisierung. URL: [www.spp2305.de](http://www.spp2305.de). Accessed: 7/15/2021.

For Related Articles Search

research

at [www.powertransmission.com](http://www.powertransmission.com)

### Prof. Dr.-Ing. Eckhard Kirchner

studied Mechanical Engineering and Applied Mechanics at the former Technische Hochschule Darmstadt and at the Norwegian Institute for Technology in Trondheim. He received his Dr.-Ing. degree from TU Darmstadt in 1999 and spent 16 years in the automotive world, ranging from design and calculation departments with increasing management responsibility to program manager for a dry dual clutch transmission program. He worked for Adam Opel/General Motors, Schaeffler and Siemens in the area of conventional and electric drive systems. Since 2016 he has been full Professor for Product Development and Machine Elements at TU Darmstadt with a research interest in next generation machine elements and the respective development methods.



### Prof. Dr.-Ing. Alexander Hasse

studied Mechanical Engineering with a specialization in Aerospace Engineering at the TU Dresden until 2007 and received his Dr.-Ing. degree from ETH Zurich at the Laboratory of Composite Materials and Adaptive Structures in 2011. After Post-doctoral research within the Pioneer Fellowship Program at ETH Zurich until 2012, he was Co-founder and head of engineering at Monolith AG. From 2014, he was professor for mechatronic systems in mechanical engineering at the chair of Engineering Design of the department of Mechanical Engineering of the Friedrich-Alexander-University Erlangen-Nuremberg. In 2018 he was appointed professor for machine elements and product development and head of the Institute of Design Engineering and Drive Technology at Chemnitz University of Technology.



**Michael Hofer** is currently a Research Associate at the Gear Research Center (FZG) at the Technical University of Munich. His research focus is on the development of computational models for gear boxes, especially for planet gears with consideration of the elastic deformation of the gear wheel body. He studied mechanical engineering at the Technical University of Munich.



### Prof. Dr.-Ing. Georg Jacobs

studied Mechanical Engineering with a major in Engineering Design at the RWTH Aachen University and received his Dr.-Ing. degree at the Institute for Fluid Power Drives and Controls (IHP, today IFAS) in 1993. He then was chief engineer at the institute until 1996 when he began his industry career at the Müller Weingarten AG. Later he worked for Mannesmann Rexroth AG in Lohr and later for Bosch Rexroth AG in Ulm in the end as Executive Vice President R&D Business Division Hydraulics. In 2008 he was appointed professor at the RWTH Aachen University and is today Head of the Institute for Machine Elements and Systems Engineering (MSE) and Director of the Chair for Wind Power Drives (CWD).



**Steffen Puchtler** is a research associate at the Institute for Product Development and Machine Elements (pmd) at the Technical University of Darmstadt. His field of research is modeling and simulation of electrical characteristics of rolling bearings. He graduated in Mechanical and Process Engineering at the Technical University of Darmstadt.



### Prof. Dr.-Ing. Berthold Schlecht

studied Mechanical Engineering at the Universität Duisburg, Germany, and obtained his Dr.-Ing. degree in 1993. He worked for Krupp Fördertechnik, in the end as Head of Design for Open Pit Mining Technology. From September 1999 to April 2002 he was appointed Managing Director of Maschinen- und Stahlbau Dresden and of Schlosser-Pfeiffer GmbH. Since January 2001 he has held the Chair of Machine Elements at the TU Dresden with specialization in drive technology, fatigue strength calculation and multibody system simulation.



### Prof. Dr.-Ing. Karsten Stahl

studied Mechanical Engineering at the Technical University of Munich (TUM) and received his Dr.-Ing. degree in 2001. He joined the BMW group holding management positions in Dingolfing, Oxford and Munich. In 2011 he was appointed Chair of the Institute for Machine Elements, since then he leads the Gear Research Center (FZG). His research focuses on experimental, simulative and analytical studies of fatigue strength, tribology, NVH, materials and life analysis of gears and gear elements with the aim of developing methods and tools for reliable determination of life, efficiency and vibration characteristics. Prof. Stahl is author of several hundred scientific publications, board member of several scientific associations, head of DIN and ISO working groups, editor of several journals and president of the VDI International Conference on Gears.



### Prof. Dr.-Ing. Michael Weigand

is full professor at Technical University Wien in Vienna since 2008. Besides teaching Machine Elements and Transmissions for Aviation, his research covers development of new helicopter gearboxes (e.g. transmissions for helicopter Ka-62 together with Zörkler in Austria) and new concepts like transmissions with variable ratio e.g. for new fast rotorcraft concepts. He organizes the Working Group Aviation at Vienna University of Technology and is representing Austria in IFAR (International Forum for Aviation Research). In IFAR he leads Initiative "Vertical Lift" in which 15 nations discuss future rotorcraft applications. Before joining TU Wien Michael Weigand studied Mechanical Engineering at TH Darmstadt (diploma 1985) and finished his doctoral thesis 1991 also at TH Darmstadt. He then worked for P.I.V. transmission systems in Germany and Taprogge Ges.mBH, a supplier of power station equipment. From 2002 till 2007 he worked for ZF Luftfahrttechnik GmbH in Kassel (Germany), being responsible for several helicopter transmissions including the Main Gearbox of the H-135 helicopter of Airbus Helicopters and the business unit of test stands for helicopter transmissions and helicopter rotor blades.





# Improve Thermal Performance for Ironless Brush DC and Brushless DC Motors

Daniel Muller, Application Engineer, Portescap

Designers of motor-driven systems must account for thermal issues that can hinder a system's performance and efficiency. As a motor converts electrical energy into mechanical energy, power losses occur, and those losses tend to be higher in magnitude when the delivered mechanical power is larger. Inside the motor, thermal energy creates a temperature rise that will result in a heat transfer from warmer to colder due to conduction and convection. Eventually the heat carries outside the motor.

This article will examine heat transfer and mitigation conditions and challenges for both ironless brushed and brushless DC motors. Understanding these considerations will help ensure you select the best DC motor design for your application.

## Thermal Phenomena Dictates Motor Performance

Electric motor manufacturers must ensure that the internal temperature of the motor never exceeds its various components' maximum allowable temperature. Depending upon design and materials used, the thermal phenomena will dictate motor performance. When it comes to improving performance without overheating and damaging internal components, designers typically have two options:

- Minimize the losses: Improve power conversion efficiency by generating less heat for a given mechanical power output, thus delivering greater mechanical power without affecting heat.
- Improve the motor's ability to dissipate heat by leading the generated thermal energy to its surrounding environment so that the internal temperature rise lessens. This allows greater thermal energy creation for the same internal temperature rise.

Heat transfer in a motor can be compared to adding water to a bathtub that is simultaneously leaking (Fig. 1).

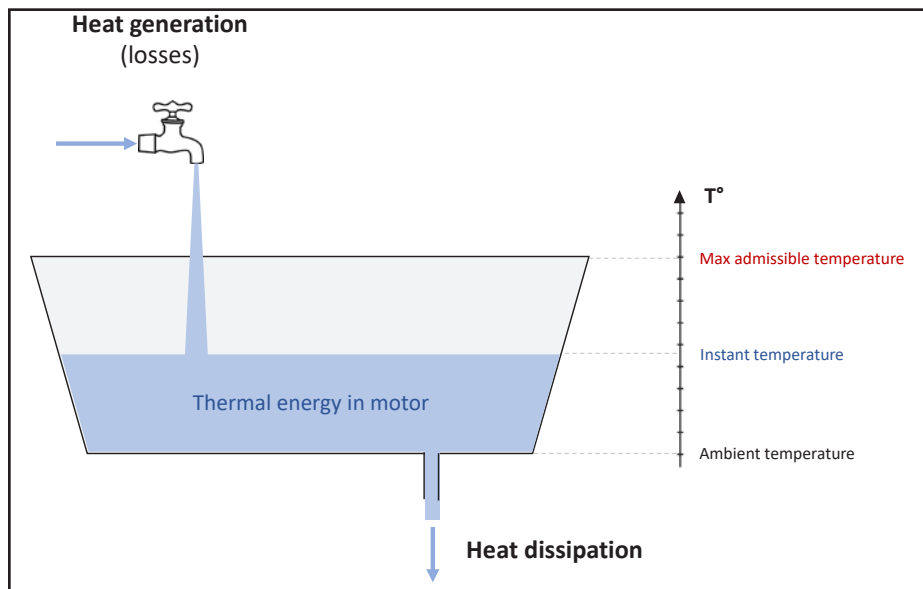


Figure 1 Heat transfer in a motor is analogous to adding water to a bathtub that is simultaneously leaking.

Water flow from the faucet corresponds to the thermal energy generated inside the motor. As soon as water collects in the bathtub, the pressure at its bottom will cause water to leak, similar to heat dissipation. The higher the water level, the higher the pressure at the tub's bottom and, therefore, a greater flow of leaking water.

Similarly, heat dissipation of a motor is proportional to the delta between the inside temperature of the motor and the outside, or ambient, temperature. But as water flow depends on the diameter of the outlet hole, heat dissipation also depends on thermal resistance, which defines the difficulty involved in transferring heat out of the motor. The lower the thermal resistance, the easier and faster the heat will carry outside the motor, as shown in Equation 1:

$$P_{dissipated} = \frac{T_{motor} - T_{amb}}{R_{th}} \quad (1)$$

where:

- $P_{dissipated}$  Heat dissipation power (W)
- $T_{motor}$  Motor internal temperature (K)
- $T_{amb}$  Ambient temperature (K)
- $R_{th}$  Thermal resistance (K/W)

A bathtub has a finite capacity and will overflow if its water level is exceeded. Similarly, motor components have a given thermal capacity. When the motor's internal temperature exceeds a certain level, components can suffer damage within seconds. The motor's rated performance must also meet the requirement of maintaining a temperature within the allowable operating range.

The coil is typically the motor's most critical component since this is where Joule heating occurs. Excessive temperatures will cause the insulation coating around the copper wire to melt and permanently harm the motor.

## Steady-State Operation: Ironless Brush DC Motors

A coreless brush DC motor is typically designed as a self-supporting coil rotating in the air gap between a permanent magnet and the housing, which are both part of the stator.

The joule heating power produced in the rotating coil is directly linked to its electrical resistance and to the current running through it. There is no iron

loss since the rotor is ironless, as seen in Equation 2:

$$P_{joule} + R \times I^2 \quad (2)$$

where:

- $P_{joule}$  Joule heating power
- $R$  Electric resistance of the coil ( $\Omega$ )
- $I$  Electric current flowing in the coil (A), depending on the torque constant of the motor and on the load torque.

As the coil temperature rises, heat transfers in two steps: from the coil to the tube, and from the tube to the ambient environment (Fig. 2). These two steps have different thermal resistances since individual materials have distinct thermal conductivities, and the shape, mass and surface area of each part also influence heat transfer.

**Heat generation and dissipation are balanced at steady-state.**

Assuming the electrical current flowing through the coil is not excessive, the coil temperature will rise and the heat dissipation will increase up to a point where heat dissipation and heat generation will be balanced. At this point, the thermal energy in the motor is constant over time and component temperatures will no longer vary.

Similar to the bathtub simultaneously losing exactly as much water per second as the faucet is adding, the coil stabilizes at a certain temperature as the water level stabilizes at a given height. Should the coil temperature be slightly above this stabilized value, the slightly increased dissipation power will allow the temperature to return to the stabilized value and reach steady state.

It is possible to calculate the steady temperature of the coil as a function of

the electric current, the electric resistance, the thermal resistances and the ambient temperature, since the heat dissipation is balanced with heat creation at steady state (Eq. 3):

$$P_{joule} = R \times I^2 = \frac{T_{coil} - T_{amb}}{R_{th1} + R_{th2}} = P_{dissipated} \quad (3)$$

$$T_{coil} = R \times I^2 \times (R_{th1} + R_{th2}) + T_{amb}$$

**Electrical resistance increases as the temperature rises.** Considering that the electrical resistance of the coil depends on its instant temperature, and that the coil temperature is now much higher than the ambient temperature, the real electrical resistance of the coil at a given temperature must be taken into account (Eq. 4):

$$R_{T_{coil}} = R_{22} \times (1 + \alpha \times (T_{coil} - 22)) \quad (4)$$

where:

- $R_{T_{coil}}$  electrical resistance of coil ( $\Omega$ )
- $R_{22}$  electrical resistance of coil at 22°C ( $\Omega$ )
- $\alpha$  temperature coefficient of resistance for copper (0.0039/°C)
- $T_{coil}$  coil temperature (°C)

Over time, depending on the thermal time constant, the coil temperature increase slows down until it reaches its final steady-state temperature (Fig. 3). If the electric current is now higher due to, for example, a heavier torque load, the coil stabilizes at a higher temperature. The highest acceptable stabilized coil temperature must not exceed the coil's maximum allowable temperature as specified by the copper wire manufacturer. This defines a maximum electric current value that can be back-calculated with the previous formula, which is usually referred to as "rated current" or "maximum continuous current" in motor specifications. Because torque and current are proportional if there isn't saturation, it also defines the "rated torque" or "maximum continuous torque."

### Steady-State Operation: Brushless DC Motor

Brushless motors use the same working principle as brushed motors: Laplace force applied to an electron moving in a magnetic field. The brushless motor is different in two ways: the coil is fixed in the stator, and the permanent magnet

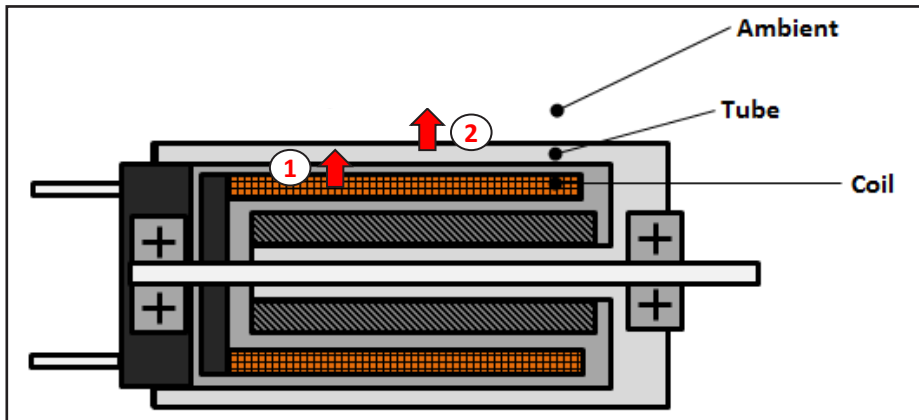


Figure 2 Heat dissipation in a coreless brushed DC motor.

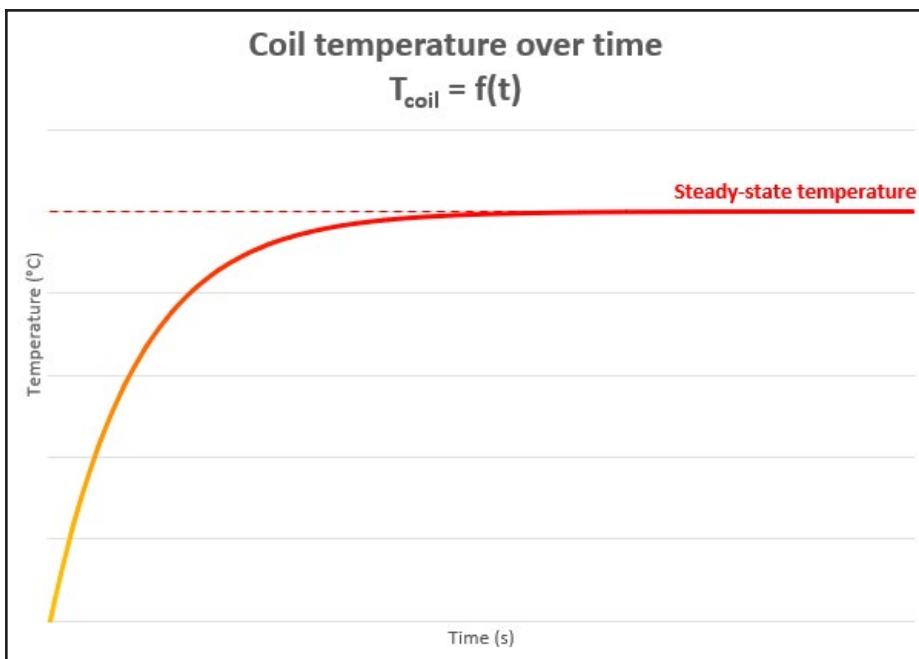


Figure 3 The coil temperature stabilizes at a given temperature when the current is constant over time.



rotates with the shaft. Phase commutation is performed electronically (Fig. 4).

**Iron losses also create heat inside the motor.** When a moving magnetic field interacts with the stator, which contains iron laminations in order to close the magnetic field inside the motor, iron losses occur. Iron losses are caused by current circulating in the lamination created by the magnetic flux and create heat inside the stator, adding to the joule heating already produced in the coil. Since iron losses are proportional to the motor speed, they can be neglected at low speed. However, they tend to become greater than joule losses at high speed. Therefore, the torque must be kept lower at high speed.

Returning to the water analogy, the bathtub would be supplied by two water sources: one depicting joule losses and the other iron losses (Fig. 5).

Brushless motors can reach much higher speeds than brushed motors because they are not limited by a mechanical brush-collector commutation system. The split between the two heating sources can be seen as a trade-off between joule losses at high torque and low speed, and iron losses at high speed and low torque. However, the thermal challenge remains the same: keep the coil temperature below its maximum, allowable temperature.

### Thermal Resistance Impacts Motor Performance

When heat travels from the coil to the outside environment, one thermal resistance is intrinsic to the motor design and the other depends on both the motor's design and surroundings. Creating a contact between the motor and another body having a high thermal conductivity will help the motor dissipate heat and operate at a cooler temperature. Options include:

- Wrapping the motor body with an additional tube or sleeve.
- Adding an air flow around the motor body to promote convection.
- Mounting the motor front face onto a metallic body.

Depending on the configuration and more importantly the material thermal conductivity, those surrounding elements can either help or prevent the

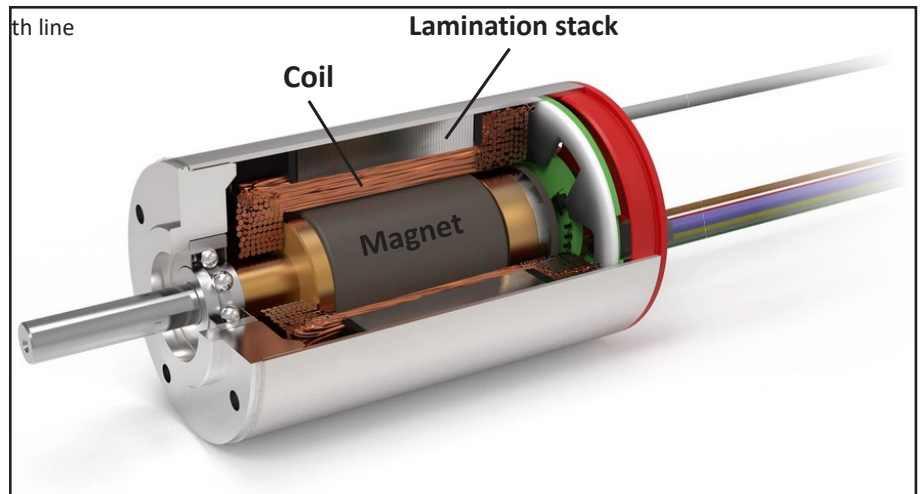


Figure 4 Brushless DC motor construction.

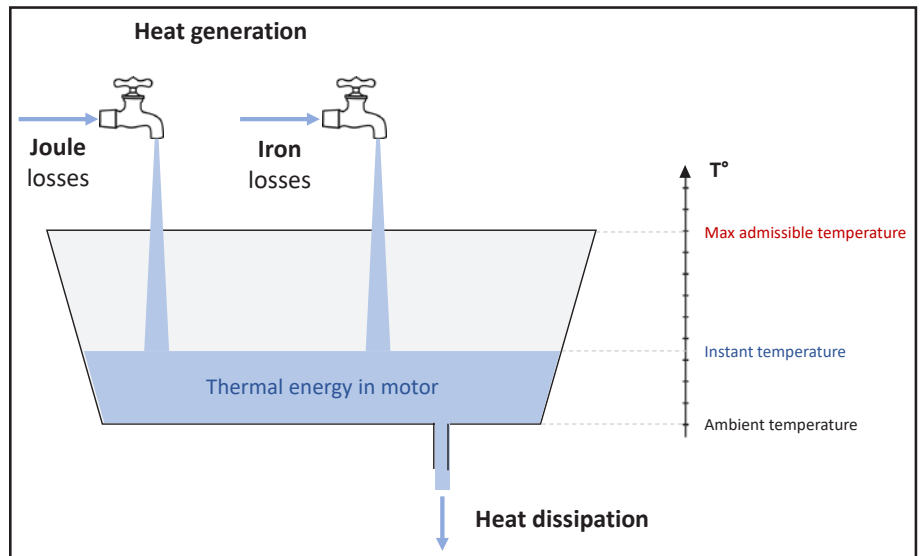


Figure 5 A water analogy depicting heat transfer in a BLDC motor with dual heat sources.

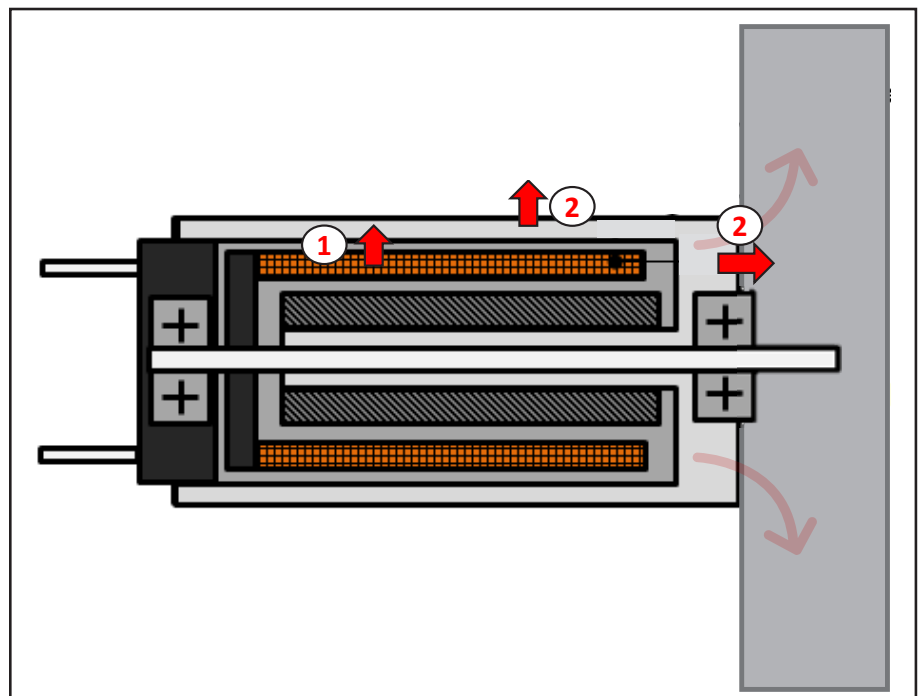


Figure 6 Heat dissipation through external elements in contact with the motor body.

motor from dissipating its heat to the outside environment.

In most cases, a motor is installed on metallic parts and mounted from its front face onto a metal stand or frame. The favorable thermal conductivity of metal will help drain heat out of the motor (Fig. 6), providing better cooling than surrounding the motor with air only. For this reason, the thermal resistance value can be modified to reflect greater cooling capability. This modification will depend on the motor's mounting configuration in the application as well as material, size, surface area and thermal capacity. Similarly, a bathtub with a larger outlet diameter can drain water faster, without a higher water level (or pressure) (Fig. 7).

While every application is different, a good rule of thumb is to consider half the  $R_{th2}$  thermal resistance value in the thermal calculation. This results in a higher rated torque—and maximum continuous torque—for the same maximum coil temperature.

Motor designers and manufacturers like Portescap engage with customers early in their development process to assess the dissipation capability of a motor or a motor-gearbox assembly—once installed in the application—to ascertain the working conditions and leverage the full potential of the motorized system.

### Peak Torque During Transient Operation

Some applications require high torque for a short duration only. Industrial screwdrivers require speed during the run-down phase and then peak torque during the tightening phase which lasts approximately a second or less. You can supply a motor with an electric current that exceeds the motor's maximum continuous current as long as the coil temperature does not exceed its maximum allowable temperature. This means that the duration of this operation should be limited.

In our parallel bathtub, the faucet opens suddenly with a very strong flow of water. The prevalent choice of considering a peak torque for a short duration of just a few seconds typically allows a designer to neglect the heat dissipation due to its longer time constant and consider the system adiabatic (Fig. 8).

The water level quickly rises, and the bathtub fills within seconds. Similarly, the coil temperature will reach its maximum allowable temperature within seconds. This formula gives the temperature of the coil over time when heat dissipation is neglected for a short time:

$$T_{coil}(t) = \frac{R \times I^2}{C_{th}} \times t + T_{amb} \quad (5)$$

where

$t$  time (s)

$C_{th}$  Thermal capacity of the coil (J/K)

This shows that the thermal capacity of the coil also matters. A higher thermal capacity allows the coil to withstand a peak current for a longer time or a higher peak current for the same duration. Indeed, the larger a bathtub, the longer it takes to fill.

Slotless brushless motors are particularly well-suited motors for short peak torques:

- The slotless stator design makes it possible to reach high torque with high current, typically 10 times the motor's maximum continuous torque with 10 times higher current. Different slotted designs have the torque limited due to magnetic saturation, making such a high current pointless as it pertains to torque outcome.
- Slotless coil designs can accumulate a large amount of thermal energy thanks to their higher thermal capacity.

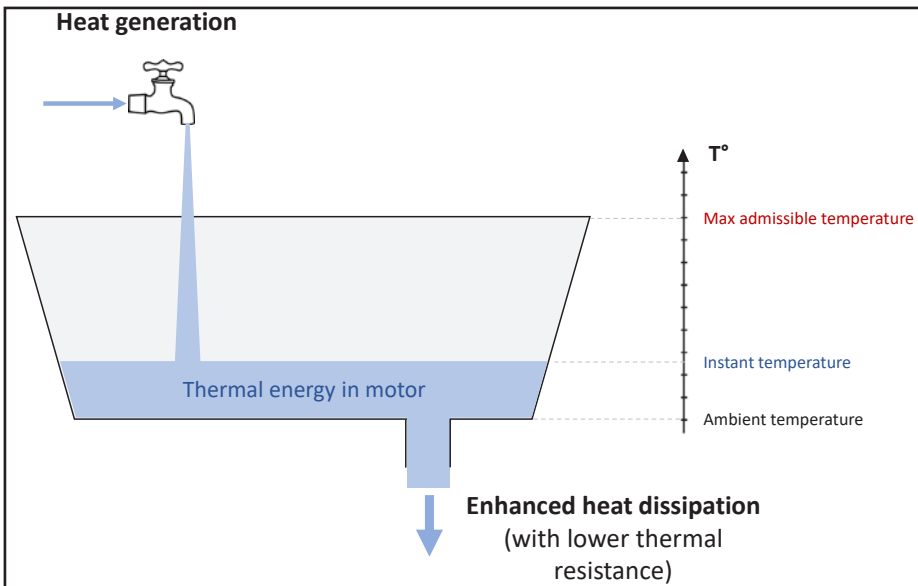


Figure 7 A water analogy depicting increased heat dissipation due to lower thermal resistance. Because the water level is lower, more torque can be used with more heat generation before the level reaches its maximum allowable temperature.

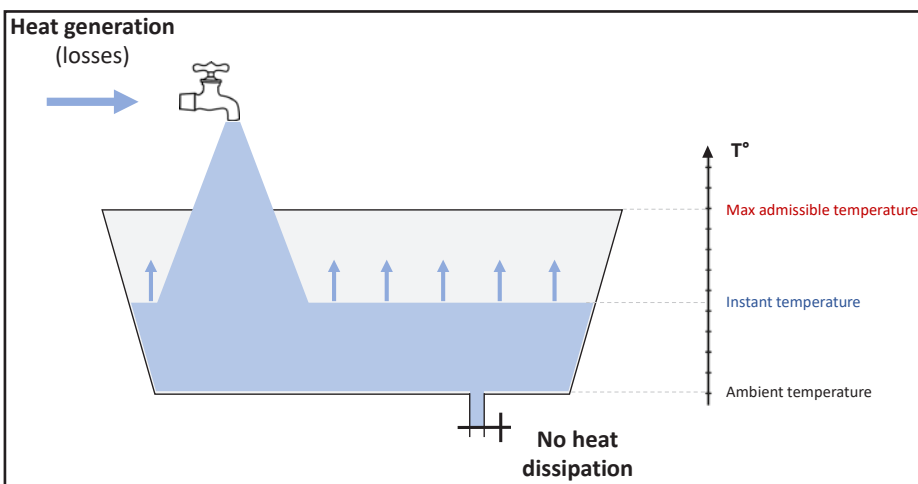


Figure 8 A very high current is considered for a short time, to the extent that designers neglect the dissipation.



Motor suppliers should have an engineering team that engages with customers interested in peak torques to help define the best solution, given each application's specific challenges.

### Periodic Duty Cycle During Transient Operation

In some cases, the application's torque requirement is a given torque profile that is repeating over time. To some extent, the highest torque during the cycle can exceed the motor's maximum continuous torque, depending on the torque profile and the duration of each step in the cycle.

If the duration of one cycle, or repeating period, is significantly shorter than the thermal time constant, designers typically consider an equivalent continuous torque value, or current value, that can be calculated as a quadratic mean (RMS, root mean square), due to joule heating being proportional to  $I^2$ :

$$I_{RMS} = \sqrt{\frac{1}{T} \int_0^T i^2(t) dt} \quad (6)$$

where:

$I_{RMS}$  Root mean square value of the current (equivalent to a continuous current, in terms of heat generation) (A)

$T$  Duration of a given duty cycle (s)

$i(t)$  Instant electrical current (A)

Once the root mean square (RMS) current is defined, it can be considered a continuous value over time as long as it is not greater than the motor's maximum continuous torque. Remember that the impact of the thermal resistance—depending on the motor's environment in the application—also plays a role, since we are assimilating this case to a steady-state operation while still supposing the period of the duty cycle is shorter than the thermal time constant.

### Brushless DC Motor with Active Air Flow Cooling

Because heat management is key to a motor's performance, engineers have found alternative ways to further improve the way motors handle heat. For example, some stator designs have an integrated air path so that air flow can carry heat away from the motor. This would focus on the massive heat convection inside the motor instead of re-

lying mainly on heat conduction. This additional heat sink can be viewed as a reduced thermal resistance as it helps drain heat out of the motor.

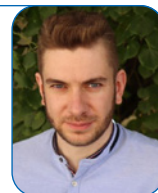
In some cases, the air flow can be driven by an external source such as compressed air. But when the motor is embedded in a portable device or in any environment with no compressed air available, a fan integrated on the motor shaft can drive the airflow through the motor body as it is operating. In this case, the higher the motor speed, hence fan speed, the stronger the airflow and the lower the thermal resistance. Therefore, the torque capability of such motors can be surprisingly higher at high speed than at low speed since the heat dissipation is drastically improved when the fan runs faster. This is true, to some extent, because the fan driving air applies a load torque to the motor and eventually creates additional heat at very high speed.

### Look for a Motor Supplier That Understands Your Challenges

When it comes to electric motor performance, heat management is critical. Motors can be improved to address many challenges, according to each application's duty cycle, environment and critical success factors such as delivering the highest torque, highest speed, best energy efficiency to prolong battery life, or operating at the coolest possible temperature. Be sure to seek a motor supplier that offers extended support, understands customers' challenges and can drive their customers' success by helping them choose the best fitting DC motor for each application. **PTE**

[www.portescap.com](http://www.portescap.com)

**Daniel Muller** joined Portescap in 2014 as an application engineer, working closely with customers from various industries in Europe to define motion solutions that best meet their application needs. He graduated from the Ecole Nationale Supérieure en Génie des Systèmes et de l'Innovation in Nancy, France.



# 60 Years Trusted

ROBOTICS • AEROSPACE • DEFENSE • TRANSPORTATION • MEDICAL

When high torque gear failure is not an option, engineers call on Spiroid.



Spiroid's skew-axis, high torque gears enable world-class power density in a small footprint.



Learn more at: [SpiroidGearing.com](http://SpiroidGearing.com) • 320-762-7133

# Schaeffler

CELEBRATES 75<sup>TH</sup> ANNIVERSARY

It is one of the greatest “Made in Germany” success stories: The global automotive and industrial supplier Schaeffler is celebrating its 75th anniversary. Dr. Wilhelm Schaeffler and his brother Dr.-Ing. E.h. Georg Schaeffler laid the foundation for today’s company when they founded Industrie GmbH in Herzogenaurach in 1946. This marked the starting point of a company that today employs more than 83,900 employees at around 200 locations in more than 50 countries. Three originally independent companies – INA, LuK and, FAG – grew together to form a global technology leader with the DNA of a family business. Accordingly, Schaeffler is celebrating 75 years of progress, technological innovation, and economic success with a virtual anniversary ceremony for all its employees as well as selected industry and government guests.



## Success based on pioneering spirit, innovations, and strategic acquisitions

From 1950 onwards, the company’s rapid rise was made possible by the cage-guided needle roller bearing, a brilliant invention by Dr.-Ing. E.h. Georg Schaeffler, which revolutionized motion and mobility in the automotive and industrial sectors.

This invention laid the foundation for the company’s continuing global success. In 1965, the Schaeffler brothers decided to invest in LuK Lamellen und Kupplungsbau GmbH in Bühl (Baden), where the Automotive Technologies division is now based. The company became a technological leader with innovative products such as the diaphragm spring clutch, dual-mass flywheel as well as a variety of engine components. Since 1999, LuK has been a fully owned entity of Schaeffler.

In 2001, Schaeffler took over FAG Kugelfischer Georg Schäfer AG in Schweinfurt, making Schaeffler the world’s second-largest manufacturer of rolling bearings. The successful IPO of Schaeffler AG followed in 2015. Today, the three product brands INA, LuK, and FAG are united under the Schaeffler corporate brand.

“Schaeffler’s pioneering spirit has always been crucial to the success of the company. Even throughout its challenging phases, the company has demonstrated a high degree of resilience and a constant willingness to view profound change as an opportunity. As shareholders, we are particularly aware that this success, spanning several decades, is primarily driven by our committed employees around the globe, as

well as our customers and suppliers,” explains Georg F. W. Schaeffler, family shareholder and chairman of the supervisory board of Schaeffler AG.

## Transparent and scientific handling of the company’s history

To mark the company’s anniversary, the Schaeffler family arranged for their history, which is inextricably linked to the company’s history, to be systematically researched. To that end, the family successfully engaged the services of renowned historian Prof. Dr. Gregor Schöllgen. As part of the anniversary celebrations, Schaeffler is presenting the results of the research, which also covers the period prior to the company’s founding in 1946, on a newly designed website that showcases not only the history, but also the people and the technological innovations they represent (link below). The comprehensive description and analysis entitled “Schaeffler. A biography of a family and their company” by Prof. Dr. Schöllgen will be released by the publishing house Deutsche Verlags-Anstalt in early December.

“Schaeffler has always demonstrated an extraordinary capacity for innovation and a high level of social responsibility,” says Prof. Dr. Schöllgen. “The curiosity and future-oriented focus that drove the two founders still remain the key strengths of this traditional family company today.”

## Establishment of the Schaeffler Foundation

To mark Schaeffler’s 75th anniversary, Schaeffler AG and IHO Holding are establishing the Schaeffler Foundation in an effort to emphasize the social responsibility of the Schaeffler Group and its family shareholders. The Schaeffler Foundation will receive an initial foundation capital of 3 million euros, which will be established in equal parts by Schaeffler AG and IHO Holding. This capital will be increased each year through additional donations, in combination with the simultaneous incorporation of existing activities, such as the Schaeffler FAG Foundation. The Foundation will be active worldwide and concentrate primarily on three focus areas: 1) Climate and Environmental Protection, 2) Research and Science, and 3) Education, Qualification and Equal Opportunity.

With its Roadmap 2025, the Schaeffler Group has clearly positioned itself strategically with a view to the future. It consistently focuses the company, with its three divisions, on transformation in ten customer sectors in order to remain the preferred technology partner for its customers in the future. Sustainability and digitalization are at the center, supported by five focus areas around topics such as CO<sub>2</sub>-efficient drives and renewable energies.

“As long as there is motion, there will be Schaeffler. At Schaeffler, innovation, quality, an understanding of systems, and manufacturing excellence combine to form a common and strength. With this strength and the DNA of the family-owned company, we are optimally equipped for the future,” says Klaus Rosenfeld, CEO of Schaeffler AG.

[www.schaeffler.com/history](http://www.schaeffler.com/history)



# Atlanta Gear Works

GROWS TEAM WITH GEORGIA TECH GRADUATE

Atlanta Gear Works has grown its engineering team — again — with its first Georgia Tech graduate, **Corinna Draghi**. Draghi comes with two other firsts for the company: she's the first woman engineer and the first with a degree in aerospace engineering.

Draghi's first full-time job after graduation was as a mechanical engineer working with the inventor of the directly driven centrifugal shot-blast wheel. Her responsibilities included 2D- and 3D-mechanical design and project management of custom-designed heavy industrial shot-blasting machinery used for finishing structural rebar, propane tanks, heavy earth-moving equipment components and other steel and aluminum components requiring a specific finish.

In addition to hands-on experience and knowledge of fabrication and fit-up processes for heavy industrial machinery, she wrote reference and maintenance manuals, cost analyses and multi-million-dollar quotes.

"I learned a lot about hardware and grades of steel and spent a lot of time in steel mills," she said. "All of that is applicable to what we do at Atlanta Gear Works."

In reality, her mechanical engineering training started in childhood.

"I grew up with a machine shop in my basement," she said, referring to the shop her father operated in the basement of the family home, manufacturing labeling and filling machines for chemical companies that use bottles and conveyors.

"He built everything from memory," she said. "Ironically, what I didn't know as a child was that he was also doing gearbox repair."

Draghi joined AGW during the pandemic and immediately took advantage of every opportunity offered to her. Since joining the company, she has achieved OSHA certification and was a speaker on the Women in Manufacturing panel at the AGMA 2021 Motion & Power Technology Expo in St. Louis in September.

"I was impressed with her mix of hands-on experience and mechanical design/CAD capabilities," said Chris Dale, VP-Engineering at AGW. "Rarely do we find an engineer who has both gear and gearbox experience. Since we know we will have to train them, we look for someone who is willing to learn and will fit in with our family of engineers."

[Atlantagear.com](http://Atlantagear.com)



# Piezo Motion and iMotion Inc.

ANNOUNCE DISTRIBUTION PARTNERSHIP

Piezo Motion and iMotion Inc. together announce a distribution partnership. Piezo Motion is a developer and leading manufacturer of precision motor technology. iMotion Inc., based in Colorado, is a manufacturer's representative serving leading original equipment manufacturers ("OEMs") for over 15 years.

Piezo Motion's unique technology will enable iMotion to provide their customers with unmatched accuracy in a compact motor. Piezo Motion's multifaceted rotary and linear motors are built to provide a stable, accurate motor that is designed specifically for OEMs that require ultimate speed, size and accuracy.

"The value of the Piezo Motion's unique technology fills a big gap in the market," explains Darl Gagliano, president of iMotion. "With traditional piezo technology, the cost was always a factor. What is exciting is Piezo Motion brings this technology into a cost-competitive mode. We are very excited for this partnership."



Piezo Motion motors are used globally for a variety of applications. These include laboratory instruments, biomedicine, optics, semiconductors, nanotechnology industries, and industrial electronic and automotive systems, along with an expanding portfolio of products that combine performance with dramatically lower cost over conventional piezo solutions.

"We are thrilled that Piezo Motion's distribution network continues to grow and this partnership will provide local service to major OEMs," said Hassan Kotob, chairman and CEO of Brain Scientific. "Piezo Motion's technology continues to disrupt the market, and we are pleased to have iMotion's expertise to further expand our reach."

[Piezomotion.com](http://Piezomotion.com)

## CC-Link

REACHES MILESTONE FOR OPEN INDUSTRIAL NETWORK COMMUNICATION

The CC-Link Partner Association (CLPA) has reached new heights in its aim to promote and advance state-of-the-art open industrial communications technologies. With over 4,000 active members currently enrolled, the organization offers a clear example of the key role that industrial partnerships play in the successful creation of smart factories, also known as e-F@ctories.

The CLPA, one of the fastest growing industrial automation technology organizations in the world, is well-known for developing the CC-Link IE family of open industrial networks, which are specifically designed to enable digital manufacturing strategies at the core of the e-F@ctories of the future.



The high quality and advanced technologies leveraged by the CC-Link IE range, which drive next-level performance and functionality in automation devices, is one of the main reasons behind the association's continuous worldwide expansion over the years. In effect, product vendors can rely on proven industrial communications solutions while users can benefit from a broad range from certified, interoperable automation components.

In particular, the open industrial network technologies offered by the CLPA are used as default within the entire Mitsubishi Electric portfolio. Therefore, businesses can develop automation solutions that are compatible with those of a leading industry giant. Also, they can benefit from its support to drive sales by means of global marketing activities offered through the company's e-F@ctory Alliance.

Roy Kok, senior partnerships and alliance specialist at CLPA, comments: "We couldn't be prouder to see our organization becoming increasingly popular as well as our solutions being broadly adopted to support futureproof digital transformation strategies. As we continue to add more partners and users, we look forward to helping companies worldwide create highly interconnected e-F@ctory systems that drive productivity."

[www.cc-link.org/en/clpa/members/index.html](http://www.cc-link.org/en/clpa/members/index.html)

## Siemens Digital

EXPANDS COLLABORATION WITH AWS FOR CLOUD-BASED DIGITAL TRANSFORMATION

Siemens Digital Industries Software and Amazon Web Services, Inc. (AWS) have announced an expansion of their collaboration, which combines Siemens' deep industry expertise with cloud services from AWS to help industrial companies accelerate digital transformation in the cloud. Together, AWS and Siemens plan to drive adoption of Siemens' Xcelerator as a Service and make Siemens' Xcelerator portfolio of integrated software, services, and application development platform more accessible, scalable, and flexible. Xcelerator as a Service acts as a catalyst for fast and predictable digital transformation—including by gaining new manufacturing insights, automating processes, and deploying connected services—and offers customizable solutions for any starting point on the digital journey.



"Siemens and AWS are coming together to help companies speed engineering efforts, optimize factory operations, and enhance customer experiences from chip to edge to cloud," said Tony Hemmelgarn, president and chief executive officer at Siemens Digital Industries Software. "We're excited to combine our proven cloud and industrial experience in this expanded partnership and simplify the journey for our mutual customers to become digital enterprises."

The strategic collaboration agreement between AWS and Siemens will see the companies cooperate to support customers; expand cloud capabilities in Siemens' Xcelerator as a Service portfolio; explore opportunities for innovation; and develop and take to market new solutions. One area of collaboration is digital twin technology, where Siemens and AWS will accelerate adoption and democratize new digital twin solutions using AWS IoT TwinMaker, a newly launched AWS service that makes it faster and easier to create digital twins that incorporate multiple data sources. Siemens' Xcelerator portfolio is already integrated with over 60 AWS services, and with the addition of AWS IoT TwinMaker, customers can apply AWS IoT TwinMaker to develop increasingly powerful digital twin solutions that are compatible with Siemens' design, simulation and manufacturing software.

"Working together, Siemens and AWS will make it easier for industrial customers to use Siemens' comprehensive digital twin technology and AWS's cloud services to deliver new



manufacturing insights, automation, and connected services,” said Bill Vass, vice president of engineering at AWS. “Together, we’ll bring new cloud-based digital transformation solutions to market that will help companies of any size address industrial complexity and turn it into competitive advantage.”

[www.sw.siemens.com](http://www.sw.siemens.com)

## Xometry

ACQUIRES THOMAS

Xometry has announced the acquisition of Thomas (**Thomasnet.com**), a leader in product sourcing, supplier selection and digital marketing solutions. The cash and stock transaction, valued at \$300 million, is expected to close this week. Xometry’s rapidly growing digital marketplace provides real-time access to global manufacturing capacity and demand, helping accelerate the digitization of the manufacturing industry.

# Xometry

The acquisition of Thomas is expected to rapidly expand Xometry’s buyer and seller base, significantly enhancing Xometry’s global digital marketplace for manufacturers. Xometry also expects to leverage Thomas’ marketing and data services to deliver an unmatched suite of end-to-end services for sellers with additional fintech and digital marketing products.

“Xometry and Thomas share a common mission of championing the digital transformation of the manufacturing industry, one of the largest sectors of the global economy and the foundation for innovation everywhere,” said Randy Altschuler, CEO of Xometry. “Thomas brings strong brand equity, trusted and extensive relationships, proprietary data and advanced full-funnel marketing services – assets that perfectly complement our digital marketplace. Together, we will introduce new services, cross-sell to our combined base and expand our suite of products, particularly in fintech and digital marketing.”

“Thomas has a long and proud history of bringing active buyers and sellers together on our Thomasnet.com platform and providing the data and marketing services that inform decision-making,” said Tony Uphoff, President and Chief Executive Officer of Thomas. “In joining forces with Xometry, we’re uniting our products with the power of the Xometry marketplace so we can do even more for industry together.”

An industry leader in on-demand manufacturing, Xometry connects enterprise buyers across industries such as aerospace, consumer products, defense, industrial, automotive, medical, energy, robotics, green-tech and more with sellers of custom-manufactured parts worldwide. At the end of Q3 2021, Xometry had 26,187 active buyers, including nearly 30% of the Fortune 500. Leveraging AI and machine-learning

technology, the Xometry marketplace provides immediate pricing, delivery lead times and quality assurance in a highly fragmented environment, as well as a suite of financial products that enable manufacturers to grow their businesses.

Thomas brings deep relationships with highly qualified enterprise buyers and engineers. The company’s industry leading Thomasnet.com platform boasts more than 1.3 million registered users (including 93 percent of Fortune 1000 companies) and more than 500,000 commercial and industrial sellers, including 45,000 diversity certified sellers. Every year, more than 20 million sourcing sessions are initiated on Thomasnet.com, generating extensive first-party buyer intent data across multiple sectors.

[Xometry.com](http://Xometry.com)

## Regal Rexnord

ACQUIRES ARROWHEAD SYSTEMS

Regal Rexnord recently announced that it has completed the strategic acquisition of Arrowhead Systems (“Arrowhead”), based in Oshkosh, Wis.

Arrowhead is a global leader in providing industrial process automation solutions, including conveyors, palletizers and depalletizers to the food and beverage, aluminum can and consumer staples (household goods, hygiene products, among others) industries. Arrowhead’s broad and deep capabilities in palletizing and conveying include a full suite of aftermarket services and solutions, which have been augmented through robust digitization investments to support industrial internet of things (IIoT), artificial intelligence (AI) and predictive maintenance capabilities.



## ARROWHEAD SYSTEMS LLC

A Regal Rexnord Company

Commenting on the transaction, Regal Rexnord CEO, Louis Pinkham, said, “Strategically, Arrowhead is everything Regal Rexnord looks for in an acquisition. It increases our exposure to attractive, high-growth end applications. In addition, its highly engineered products and solutions, including digital capabilities, are differentiated and highly valued by its customers. Arrowhead’s growth strategy is also consistent with our mindset of driving innovation with purpose — purposeful for our customers and for our planet — considering its offering directly supports rising consumer demand for more environmentally friendly packaging, particularly a migration away from single-use plastics to aluminum cans.

“Regal Rexnord and Arrowhead have highly complementary

offerings that are expected to deliver enormous value to our customers. We are particularly excited about the complementary nature of Arrowhead and our ModSort modular transfer and diverter stations, which are fast becoming important ‘last-mile’ components in e-commerce warehouse applications, but have much broader applicability in other end uses, including those where Arrowhead focuses,” added Pinkham.

Regal Rexnord’s innovative ModSort modular transfer and diverter stations can be easily added into new or existing conveyor systems to provide high-precision, 360-degree steering functionality for very lightweight items, such as polybags. ModSort modules, along with Regal Rexnord’s offerings of conveyor belts, chains, guides and components—now coupled with Arrowhead’s conveying and palletizing subsystems and its design, fabrication and assembly capabilities—position the company to offer more value-added solutions to its customers, and do so in a broader array of end applications.

[www.regalrexnord.com](http://www.regalrexnord.com)

## Motion

COMPLETES ACQUISITION OF KAMAN DISTRIBUTION GROUP

Motion Industries, Inc. has completed the purchase of Kaman Distribution Group for a purchase price of approximately \$1.3 billion in cash, effective January 3, 2022.



The strategic addition of KDG to Motion will significantly boost the latter’s concentration in core industrial products and services as well as in the growing technical/automation arenas, including precision engineering. As a leading power transmission, automation and fluid power industrial distributor and solutions organization with operations throughout the U.S., KDG provides electro-mechanical products, bearings, power transmission, motion control and electrical and fluid power components to MRO and OEM customers. Headquartered in Bloomfield, Connecticut, KDG’s 1,700 employees serve more than 50,000 customers.

“It’s a very exciting time; this transformative move will be highly beneficial to everyone involved, especially for customers of our combined entities,” said Motion President Randy Breau. “Our customer service will be the best it’s ever been with deepened and expanded capabilities. In addition, KDG shares many of our same cultural beliefs, principles and ambitions, including our commitment to providing superior service and value to our customers. We look forward to welcoming the highly talented KDG associates to the Motion team.”

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

## Nook Industries

SELLS FAMILY BUSINESS TO ALTRA INDUSTRIAL MOTION CORP.

Nook Industries, Inc. has announced that it has sold the family-owned business to Braintree, Massachusetts based Altra Industrial Motion Corp. The Nook business, which will be integrated into Altra’s Thomson operating company in its Automation & Specialty (“A&S”) segment, expands the



breadth of Altra’s linear products offering. Altra was deemed an excellent strategic fit as the Nook family evaluated potential suitors to acquire the 52-year-old business founded by Joseph H. Nook Jr. in 1969.

“The Nook family is pleased to have found a strong strategic buyer with a history of not only preserving, but also building upon the products, brand equity and core competencies of their acquisitions. We are excited about the tremendous opportunities created by joining Altra’s industry leading suite of motion control products and brands. It was important for us to find a buyer that would build upon my father’s legacy” said Joseph H. Nook III, Nook’s chief executive officer and president. “We also want to thank the Nook employees, past and present, that helped build my father’s dream into the Company it is today. Our family will be forever grateful to the dedicated and hard-working employees of Nook Industries.”

KeyBanc Capital Markets, Inc. acted as financial advisor to Nook and Calfee, Halter & Griswold LLP served as legal advisor.

[www.altramotion.com](http://www.altramotion.com)



### March 5–12—IEEE Aerospace Conference 2022

**Big Sky, Montana.** The International IEEE Aerospace Conference, with AIAA and PHM Society as technical cosponsors, is organized to promote interdisciplinary understanding of aerospace systems, their underlying science and technology, and their applications to government and commercial endeavors. The annual, week-long conference is set in a stimulating and thought-provoking environment. The 2022 conference will be the 43rd in the series. Plenary sessions feature internationally prominent researchers working on frontiers of science and engineering that may significantly impact the world we live in. Registrants are briefed on cutting edge technologies emerging from and intersecting with their disciplines. Each year, a large number of presentations are given by professionals distinguished in their fields and by high-ranking members of the government and military.

[www.aeroconf.org](http://www.aeroconf.org).

### March 16–18—EPTDA Annual Convention 2022

**Warsaw, Poland.** EPTDA's Annual Convention is highly acclaimed by PT/MC professionals as the leading event in the industry, providing outstanding time- and cost-saving solutions for expanding business networks and enhancing knowledge. The event attracts 350–400 entrepreneurs and leaders of well-respected PT/MC distributor and manufacturer companies, together with their guests. Offering invaluable opportunities to network with peers and potential contacts, both formally and informally, this renowned event also presents inspiring and thought-provoking educational programs and business case studies for the member and non-member attendees.

[www.eptda.org/event/eptda-2022-abc-warsaw/](http://www.eptda.org/event/eptda-2022-abc-warsaw/)

### March 21–24—Gear Dynamics and Gear Noise Short Course 2022

**Columbus, Ohio.** The purpose of this unique short course is to provide a better understanding of the mechanisms of gear noise generation, methods by which gear noise is measured and predicted, and techniques employed in gear noise and vibration reduction. Over the past 40+ years about 2,450 engineers and technicians from over 380 companies have attended the Gear Noise Short Course. The course is of particular interest to engineers and technicians involved in the analysis, manufacture, design specification, or utilization of simple and complex gear systems. Industries that find this course helpful include the automotive, transportation, wind-energy, process machinery, aircraft, appliance, general manufacturing, and all gear manufacturers. The course material is covered in such a way that the fundamentals of gearing, gear dynamics, noise analysis and measurements are covered first. This makes the course appropriate to the gear designer with minimal knowledge of noise and vibration analysis as well as to the noise specialist with little knowledge of gears.

[www.nvhgear.org](http://www.nvhgear.org).

### March 22–24—Gearbox CSI

**Concordville, PA.** A good understanding of individual failure modes and the failure scenarios that led to the actual system failure is an essential skill to designing gear/bearing systems that will operate properly for their full design life. In this course, instructors will define and explain the nature of many gear and bearing failures and discuss and describe various actual failure scenarios. In addition, a detailed primer on bearing technology prefaces the failure scenario discussions. Attendees will gain a better understanding of various types of gears and bearings.

[www.agma.org/education/advanced-courses/2022-gearbox-csi/](http://www.agma.org/education/advanced-courses/2022-gearbox-csi/).

### April 4–8—AGMA Basic Training for Gear Manufacturing - Spring

**Chicago, IL.** Learn the fundamentals of gear manufacturing in this hands-on course. Gain an understanding of gearing and nomenclature, principles of inspection, gear manufacturing methods, and 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.

[www.agma.org/education/advanced-courses/2022-basic-training-for-gear-manufacturing-spring/](http://www.agma.org/education/advanced-courses/2022-basic-training-for-gear-manufacturing-spring/)

### April 25–29—Hannover Messe 2022

**Hannover, Germany.** Hannover Messe 2022 focuses on industrial transformation, which is driven by two megatrends: digitalization of industry and a reduction of CO2 emissions. Digitization covers topics such as networking, data analytics, the Internet of Things, platforms, artificial intelligence and IT security. Companies that want to remain globally competitive must take advantage of digitalization to develop, manufacture and sell products faster and more efficiently. In Hannover, companies from the electrical engineering, mechanical and plant engineering, software and IT sectors will be demonstrating how the automation and digitalization of entire production and business processes can succeed. Innovative solutions enable industry to react responsibly to growing political and social debates about environmental protection. At Hannover Messe, companies from the energy sector, among others, will be presenting how industrial companies can significantly reduce their energy consumption and CO2 emissions. With these future technologies, industry makes a significant contribution to reaching national and international climate goals.

[www.hannovermesse.de](http://www.hannovermesse.de)

**CALL FOR PAPERS!**

Are you sitting on an idea for a technical paper but wondering where to present it? Do you have one already written, sitting on your desk, gathering machine dust?

How about *Power Transmission Engineering*? We are always looking for gearing- and power transmission component-relevant technical papers for publication in the magazine and in its digital version. Having your work appear in *Power Transmission Engineering* guarantees you an audience of the most experienced and discriminating industry players. You say your work has not been peer-reviewed? Not a problem, as we are lucky—and thankful—to have on-hand some of the most experienced and brilliant minds in the industry—our technical editors. So if your work “passes muster” and is published, you’ll know you were reviewed by the best—and most demanding.

Chances are you’ll be creating the paper under the auspices of the company for whom you work or own, or for one of the various industry-relevant associations. That means they as well will bask in the reflected glory that accrues with publication in *Power Transmission Engineering*.

For publication guidelines and more information, please contact Randy Stott at [stott@agma.org](mailto:stott@agma.org)

**B&R Machine and Gear**

Page 28  
[www.brgear.com](http://www.brgear.com)

**Brother Gearmotors**

Inside Front Cover  
[BrotherGearmotors.com](http://BrotherGearmotors.com)

**Designatronics**

Page 7  
[www.sdp-si.com](http://www.sdp-si.com)

**Diequa Corp.**

Pages 14, 29  
[www.diequa.com](http://www.diequa.com)

**Dodge Industrial**

Page 3  
[dodgeindustrial.com](http://dodgeindustrial.com)

**IMTS**

Page 11  
[IMTS.com/Show](http://IMTS.com/Show)

**ITW Heartland**

Page 39  
[spiroidgearing.com](http://spiroidgearing.com)

**JIE USA**

Page 5  
[www.jie-drives.com](http://www.jie-drives.com)

**Lafert North America**

Page 12  
[www.lafertna.com](http://www.lafertna.com)

**McInnes Rolled Rings**

Page 16  
[www.mcinnesrolledrings.com](http://www.mcinnesrolledrings.com)

**Miki Pulley**

Page 25  
[www.mikipulley-us.com](http://www.mikipulley-us.com)

**Napoleon Engineering Services**

Page 15  
[www.nesbearings.com](http://www.nesbearings.com)

**Neugart USA**

Page 2  
[www.neugart.com/en-us](http://www.neugart.com/en-us)

**Nordex Inc.**

Page 28  
[www.nordex.com](http://www.nordex.com)

**PBC Linear**

Outside Back Cover  
[pbclinear.com](http://pbclinear.com)

**Quicksilver Controls**

Page 2  
[www.QuickSilverControls.com](http://www.QuickSilverControls.com)

**Regal Rexnord**

Page 17  
[Regalbeloit.com/powertrain](http://Regalbeloit.com/powertrain)

**SDP/SI**

Page 7  
[www.sdp-si.com](http://www.sdp-si.com)

**SEW-Eurodrive**

Inside Back Cover  
[www.seweurodrive.com](http://www.seweurodrive.com)

**Telco Intercontinental Corp.**

Page 29  
[telco-gearmotor.com](http://telco-gearmotor.com)

**U.S. Tsubaki**

Page 22  
[ustsubaki.com](http://ustsubaki.com)

**Zero-Max**

Page 9  
[www.zero-max.com](http://www.zero-max.com)



# Power Transmission Engineering®

# FREE SUBSCRIPTION

20PTEALL

## Please Respond

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

- YES** I want to receive/continue to receive **Power Transmission Engineering**
- NO** Thanks anyway, but I don't need the world's best publication on mechanical components.

Name \_\_\_\_\_ Job Title \_\_\_\_\_  
(please print)

Signature \_\_\_\_\_ Date \_\_\_\_\_  
(required)

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

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

E-mail \_\_\_\_\_ \*

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

## How is THIS LOCATION involved with power transmission products? (Check all that apply)

- WE MAKE power transmission products
- WE BUY power transmission products
- WE SELL power transmission products (Distributors, sales reps, etc.)
- WE DESIGN products with power transmission components in them
- Other (please describe) \_\_\_\_\_

What is your company's principal product or service? \_\_\_\_\_

\_\_\_\_\_

## MAILING INFORMATION

NAME:

JOB TITLE:

COMPANY:

ADDRESS:

- Check if this is a home address

CITY:

STATE/Province:

ZIP/Postal Code:

PHONE:

FAX:

**If your label is incorrect or incomplete, please update it above!**

**FAX to 1-847-437-6618**

SCAN to: [subscribe@powertransmission.com](mailto:subscribe@powertransmission.com)

# Motorizing a Hand-Cranked Street Organ

Joseph L. Hazelton, Contributing Editor

Ron Walters became interested in hand-cranked street organs when he saw one playing in a video. He summed up his reaction with: “How cool is that.”

He wasn’t interested in just listening to the organ, though. He wanted to build one — and motorize it. He wanted to take the organ, a mechanical device, and make it more mechanical by adding power transmission components.

A hand-cranked street organ is, of course, a pneumatic device. But, it’s also a mechanical device. Its parts include bearings, clutches, and a drive system that consists of a belt and two pulleys.

Adding more power transmission parts was natural for Walters. Although retired for 25 years, he spent his professional career as a mechanical engineer. “I’ve been building stuff all my life,” he said.

Walters decided to build a specific type of street organ, a John Smith Senior 20. Now, playing a Senior 20 manually is straightforward. You turn the organ’s handwheel, which operates two bellows. They accumulate air, compress it, and force it into a regulator. The regulator uses that air to pressurize a box.

Inside the box is the organ’s music roll, a strip of perforated paper wrapped around a spool. There’s also a second spool for taking up the roll as it’s played. When played, the roll moves from one spool to the other, passing over a tracker bar. Connected to this bar are 20 hoses, each one leading to an organ pipe. Working together, the roll and bar release pressurized air through one or more pipes at a time, playing the organ’s music.

To motorize this process, Walters installed a 24-volt DC motor inside the organ’s case, running the motor at just 12 volts. He also installed a motor controller.

Normally, as a manual machine, a Senior 20 has one belt drive, which is for the music roll’s rewind mechanism. The rewind drive is on the organ’s back panel and has two pulleys, one manually driven, for rewinding the music roll.

To motorize the organ, Walters created a second belt drive, one with three pulleys. The drive pulley is connected to the DC motor. The driven pulley is the organ’s handwheel. And the third pulley is an idler, which redirects the belt so it doesn’t rub against a nearby part.

However, Walters wanted the motor to play the music *and* rewind it. So, he made a ‘rewind’ belt that loops around the rewind mechanism’s two pulleys and around the motor’s pulley, and he installed his motor controller with a forward/reverse switch. Also, for up-tempo playing of the music, the controller includes a speed control.



Ron Walters built a type of hand-cranked street organ that’s called a John Smith Senior 20 organ. He also motorized it by adding power transmission parts.

See the video: <https://youtu.be/LuxJI2oDBOM>

To play the music roll, you loop a second, longer belt around the motor’s pulley, the handwheel, and the idler pulley. Then, you flip the forward/reverse switch to its forward setting.

To rewind the roll, you take off the ‘play’ belt and put on the shorter rewind belt. You disengage the mechanism’s clutch by pushing down on the clutch’s lever and pulling it towards you. At that point, the take-up spool can spin freely; the music roll can be rewound. Then, you flip the switch to its reverse setting. To re-engage the clutch, you push the lever away from you.

Walters powers the motor with a 12-volt battery that he keeps in a small, wooden box. He connects the motor and battery by taking the organ’s power cord and plugging it into the battery box’s electrical socket.

To modify his Senior 20s, Walters used his imagination and drew on his experience as a mechanical engineer. To build them, he worked from plans bought on the web. However, he described the plans as not detailed. So, to help other builders, he created a series of videos for his YouTube channel, Ronald Walters, which is at [www.youtube.com/c/RonaldWalters2010](http://www.youtube.com/c/RonaldWalters2010). The series is 33 videos, a step-by-step process for making a Senior 20. He also created seven other videos on motorizing the organ.

Today, Walters keeps his Senior 20s in his backyard workshop, but he’ll take friends out there and play the organs for them. That’s when the benefit of motorizing them is clear. “It’s quite easy to just turn it on and let it play for somebody,” Walters said. **PTE**



## Stressed out?

Juggling too many motion control projects while trying to keep up with new technology can be overwhelming! It's time to contact an SEW automation specialist.

Our exclusive software modules empower you to perform complex automation very simply and **without** experience. Or, we can provide a complete package, including project planning, software, components, commissioning, and worldwide support.

Either way, relax... We got this!





# Simplicity<sup>®</sup> Plain Bearings

## A Linear Solution Built for All Extremes

Harsh Environments

Vibration Damping

Extreme Heat  
+200°C

Welding

Extreme Cold  
-240°C

Dust

Metal Debris

Washdown

 **PBC Linear**<sup>™</sup>

Request a **FREE** Sample at:  
[bit.ly/SimplicityBearing.com](http://bit.ly/SimplicityBearing.com)

6402 E. Rockton Road, Roscoe • Illinois 61073 USA • +1.800.962.8979 • [pbclinear.com](http://pbclinear.com)

