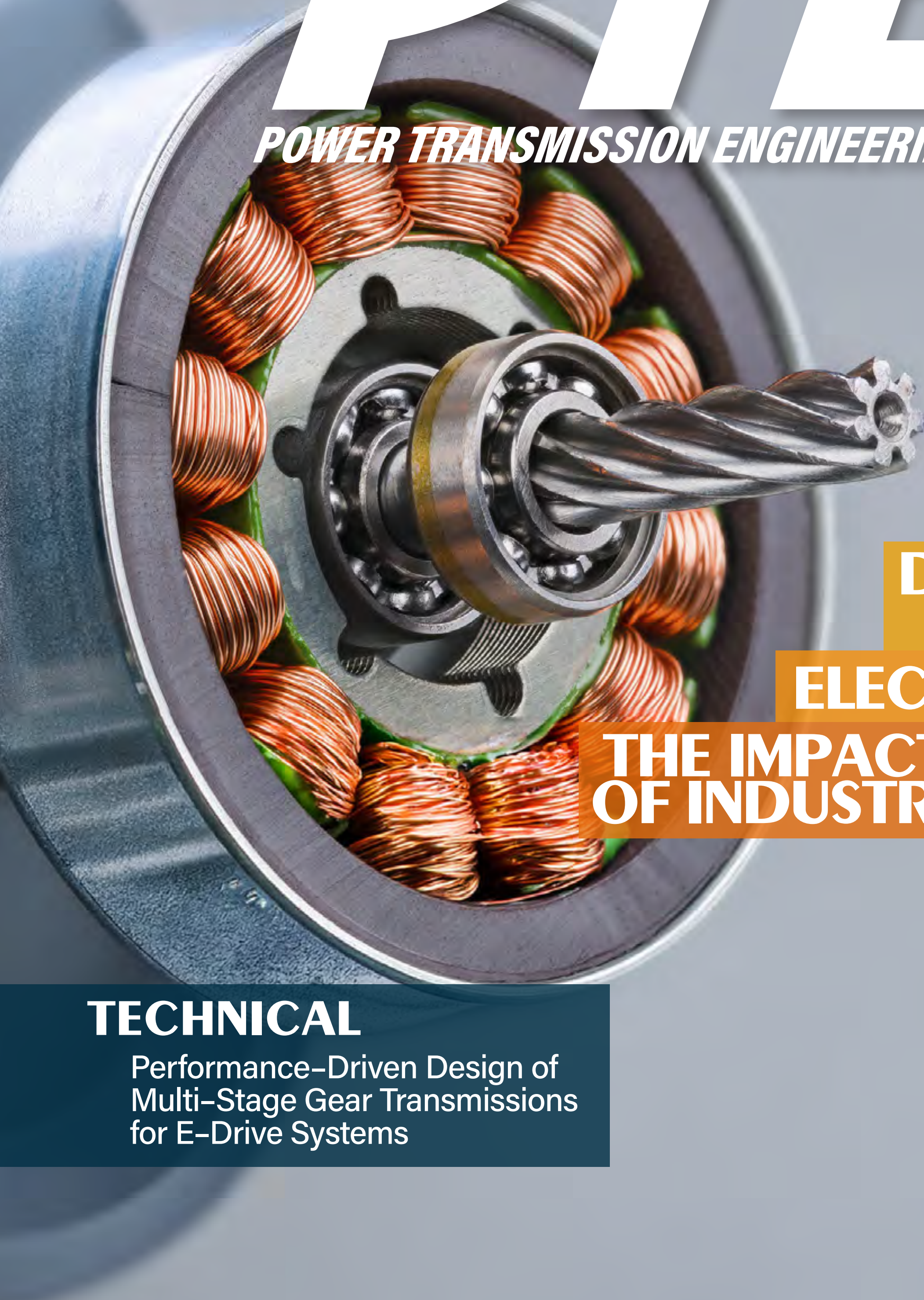
PTE

POWER TRANSMISSION ENGINEERING™

JUNE
2026



DATA-DRIVEN PREDICTION
ELECTRIFICATION
THE IMPACT & VIABILITY OF INDUSTRIAL MOTORS

TECHNICAL

Performance-Driven Design of Multi-Stage Gear Transmissions for E-Drive Systems

Affordable Industrial Enclosures

Built to shield. Designed to last.

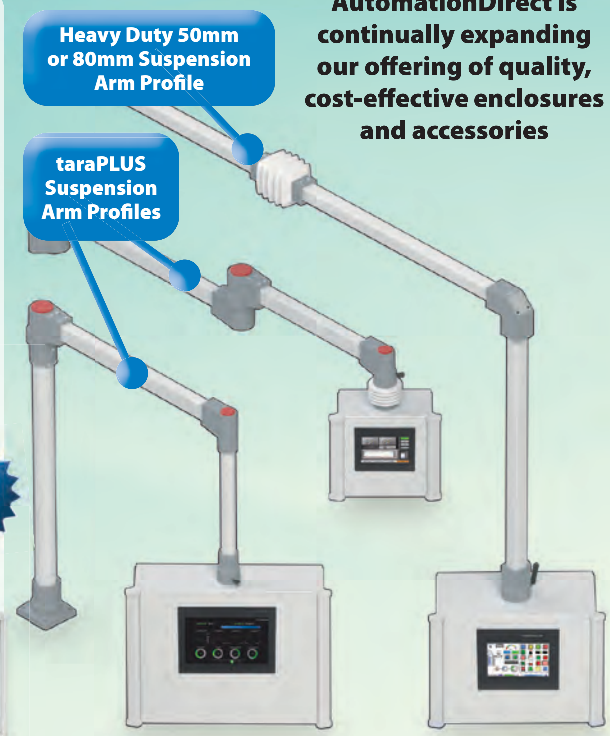
NEW! Hammond ACE Series HMI Enclosures & Suspension Arm Systems

Enclosures starting at 949.00 (ACE12126LG)

The Hammond Aluminum Command Enclosure (ACE) series provides a versatile, flexible solution for housing today's most advanced operator interfaces, including the popular C-more CM5 HMIs. With removable front panels, quarter-turn latches, and oil-resistant gaskets, ACE enclosures offer easy machining and reliable protection. Hammond's taraPLUS suspension arm system combines sleek, modular arms and integrated wire management to improve operator comfort. Hammond Heavy Duty suspension arms deliver greater load capacity with robust 50mm and 80mm profiles ideal for supporting bigger enclosures.

HAMMOND MANUFACTURING.

AutomationDirect is continually expanding our offering of quality, cost-effective enclosures and accessories



NEW! Quadritalia OK Series 2200mm Modular Enclosure Components

Components start at $46.00 (CPR602)

The Quadritalia OK series 2200mm modular enclosure system combines seamlessly fitting components such as frame rails, doors, panels,and subpanels with a full range of accessories like side doors, partition panels, plinths, swing panels, switches, and interlocks to deliver a highly adaptable, flexible enclosure solution for industrial, electrical, and data applications.

QUADRITALIA

FIBOX Enclosing innovations

NEW! Fibox Miniature Cases, Subpanels, & Accessories

Starting at $24.50 (ULTPCM090706)

Fibox MNX and TEMPO series polycarbonate miniature cases are engineered to deliver durable, adaptable protection for every installation need.

- MNX series miniature cases with knockouts are UL listed and rated NEMA 4X & 6, providing protection against harsh and hostile environments
- TEMPO series miniature cases with knockouts are built for quick and efficient installation

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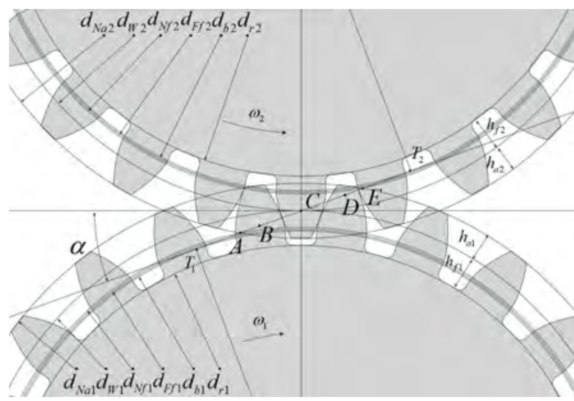
FEATURE ARTICLES

20

TECHNICAL ARTICLES



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ABMA® American Bearing Manufacturers Association

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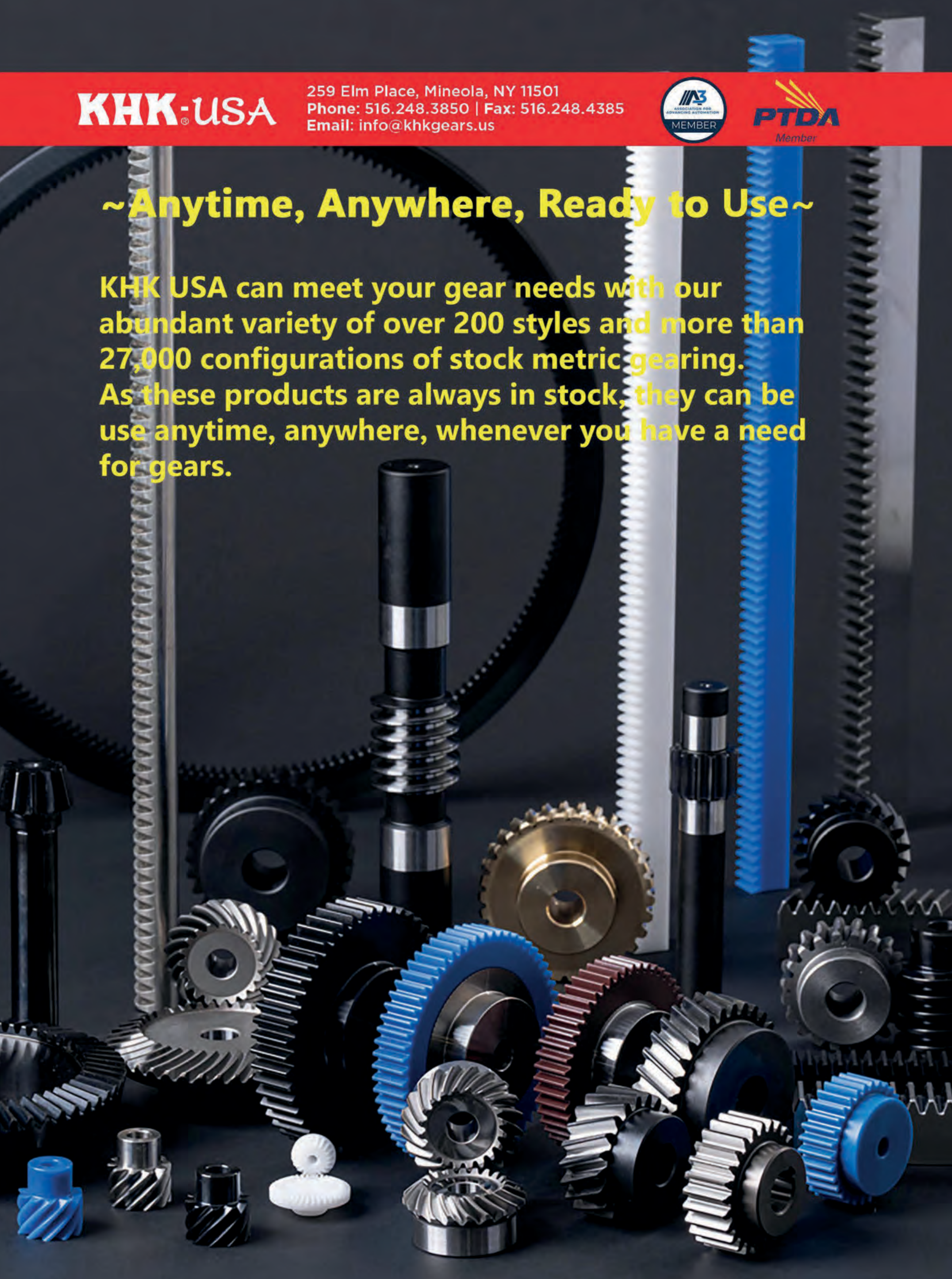

PTE REVOLUTIONS

With the upcoming 250th anniversary of America, we're looking at some key manufacturing legacy companies pivotal to innovation here in the United States:

The Hilliard Corporation: 120 Years of Engineering and Innovation

Since 1905, The Hilliard Corporation has turned innovation into a tradition. From a single clutch to a global portfolio of motion control, braking, and filtration solutions, our journey has been defined by engineering expertise, quality, and excellence.

powertransmission.com/videos/the-hilliard-corporation-120-years-of-engineering-and-innovation

Engineering Legacy: Diamond Chain Company (1890)

Diamond Chain Company got its start in 1890 as Indianapolis Chain & Stamping Company, manufacturing bicycle chain in Indianapolis, Indiana. The company's founders selected the diamond as their trademark because it symbolized perfection.

powertransmission.com/engineering-legacy-diamond-chain-company-1890

Engineering Legacy: Carlyle Johnson (1900)

Carlyle Johnson has played a significant role in American industry since the very beginning of the twentieth century. The technological advances introduced by Moses Carlyle Johnson and the company he founded have improved both the efficiencies of production and the health and safety of factory workers nationwide.

powertransmission.com/engineering-legacy-carlyle-johnson-1900

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Michael Goldstein founded *Gear Technology* in 1984 and *Power Transmission Engineering* in 2007, and he served as Publisher and Editor-in-Chief from 1984 through 2019. Michael continues working with both magazines in a consulting role and can be reached via e-mail at *mwg42@hotmail.com.*

Closeup of electric motor rotor with worm gear, ball bearing and inductors. Copper wire winding on electromagnetic coils with metal sheets inside steel bushing of electrical engine.

Less Distraction, More Interaction

Matthew Jaster, Director, Editorial Content

Today, we travel back in time to 1996 when the Red Line train was a maze of passengers reading either the *Chicago Tribune* or the *Chicago Sun Times*. You couldn't find a seat where you wouldn't accidentally get hit in the face by someone flipping the pages of a big, bulky newspaper.

Some passengers would flip through the latest edition of *The Chicago Reader*; others would merely listen to music or work on a crossword puzzle. These activities are equally important to train commuters in 2026, but the content typically funnels through our smartphones.

Our universal attention spans are waning.

Have you tried to read a comprehensive *New York Times* or *National Geographic* article on your phone? If I'm being honest, it's difficult just to reach the finish line without constant distractions. The content creators, AI overlords and data junkies will throw as much editorial and advertising content at you as humanly possible.

Alerts interrupt every sentence: This celebrity just died. This politician said this. This soap is better for your skin, seriously, click on the soap, it's 75 percent off the actual retail price.

Do it. Buy the soap. While supplies last.

Information has reached an obscene level of interruption, so much so we no longer give long-form content the time and patience it truly deserves. Sadly enough, there are many individuals who prefer it this way.

The good news is that B2B trade publications do not suffer from this information overload because mobile technology is an ancillary product offering. Sure, you can access the latest gear, bearing and motor trends on your smartphone, but if you'd like to read an in-depth feature on ABB's motor technologies (p. 20), it's better to wait until you're back at your office or looking at a physical copy of the magazine.

Less distraction, more interaction.

91 percent of our readers use desktop computers to access technical articles, case studies and feature content online. They like to read it without data scientists trying to steer them in ten different directions.

You can't truly appreciate a technical article on the performance-driven design of multi-stage gear transmissions for e-drive systems (p. 32) on your smartphone. You could try reading how model-based design and digital twins transform diagnostic accuracy (p. 16) on your Apple Watch, but it's not really feasible. Can you imagine downloading a story on Emerson's automation technologies (p. 24) via your Eddie Bauer smart glasses and reading said article while walking down the street? No thank you.

The subject matter in *PTE* and *GT* tends to work better in print or on your desktop computer. This is where long form content truly shines.

Consider this recent quote from editors at National University, "Long-form content is making a comeback as audiences crave more depth in their online content. This opens the door to greater targeting possibilities as consumers seek more in-depth information on their path to conversion."

Magazine articles, podcasts, social media, YouTube videos, you name it, they're all looking at more immersive, higher quality content strategies in 2026–2027. The fast food, dopamine-induced Instagram and TikTok highlights only work so long before audiences suffer from brain rot. The alternative is an in-depth, editorially sound examination of the technologies and products you need to succeed in manufacturing.

Our editorial team leans towards a *quid pro quo* strategy where you tell us the obstacles you're facing in mechanical power transmission, and we'll spend the proper amount of time addressing these challenges.

As always, we're here to help. Matthew Jaster can be reached at *jaster@motionpower.org*.

PTE

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Motion + Power: Why Your Industry Association Isn't Just for Manufacturers

Jenny Blackford, President, Motion + Power Manufacturers Alliance (MPMA)

If you work with gears, bearings, or any mechanical power transmission component—as an OEM, an engineer specifying equipment, or an operator keeping production lines running—chances are you've heard of AGMA or ABMA. You may have used their standards without realizing it. What you may not know is that those two organizations merged in May 2025 to form the Motion + Power Manufacturers Alliance, and that this new alliance was built with you in mind.

I stepped into the role of MPMA President in early April, bringing nearly 25 years of experience working alongside the gear and bearing industries. In that time, I've watched the supply chain grow more complex, more interconnected, and more dependent on the kind of shared knowledge and standards infrastructure that only a unified industry association can provide.

MPMA's mission is to serve as the global network for technical standards, education, and business information for manufacturers, suppliers, and users of mechanical power transmission components. Users. That word is intentional. The problems you face—specifying the right component, understanding emerging technology, finding qualified talent, navigating a shifting regulatory environment—are the same problems driving our agenda for the next five years.

So what does MPMA offer someone on your side of the supply chain? Our brand rests on four pillars, and each one is relevant to you.

Technical. MPMA maintains and advances more than 150 standards and publications—the same standards your suppliers reference when they design and manufacture the components you depend on. Understanding those standards isn't just useful; it gives you a stronger foundation for specifying equipment, evaluating suppliers, and protecting your operations. MPMA's technical committees are where those standards are built and refined, and customer voices belong in that conversation.

Education. Whether you're an engineer early in your career or a senior technical leader, the power transmission landscape is evolving faster than any one company can track. MPMA's growing education platform—including in-plant training, online courses, and emerging technology webinars and committees—is designed to meet professionals at every stage. If your team works with mechanical power transmission equipment, there's a program built for them.

Network. MPMA connects more than 400 member companies across the full power transmission supply chain. MPT Expo, our flagship trade show in October 2027, brings manufacturers, suppliers, and increasingly, their customers together in one place. For engineers and procurement professionals looking to evaluate technology, build supplier relationships, or benchmark against industry peers, that network has tangible value.

Voice. The regulatory and policy environment affecting manufacturing is shifting. Trade policy, workforce development, technical standards adoption—these issues don't stop at the factory. MPMA is actively building its advocacy presence so that the power transmission industry's perspective is heard where decisions are made. As a user of this technology, your challenges deserve a voice in that effort too.

The next five years will bring real change to this industry—in trade, technology, and the talent pipeline that keeps operations running. MPMA is investing in programs, partnerships, and platforms to help our members navigate all this, but an alliance is only as strong as the breadth of perspectives it represents.

If you've never thought of MPMA as your association, I'd like to change that. I'm here to hear from this community—what challenges are you facing, where are the gaps, and how can MPMA respond? Reach out and tell me.

The power transmission industry works because every part of the supply chain does its job. MPMA should work the same way.

Jenny Blackford can be reached at *blackford@motionpower.org*.

PTE

Jenny Blackford

BOSCH REXROTH
Offers Factory Automation Solutions at Automate 2026

Bosch Rexroth will be exhibiting its diverse factory automation solutions at Booth #2810 at Automate 2026 in Chicago, as manufacturing continues to transition to a more automated environment via advanced, modern technology. Bosch Rexroth's portfolio provides a full range of solutions that encompasses high-end components, digital engineering tools, interactive exhibits and live demonstrations of working systems. Among the demos are:

Bosch Rexroth's TS conveyors will be on display at the booth, which are being leveraged across a variety of industry verticals and applications, including the new TS 7plus, the first conveyor capable of transporting payloads up to 3,000 kg. Both the TS 2plus and TS 7plus are built on Bosch Rexroth's aluminum framing, which has been the industry standard for more than 40 years.

Visitors to the Automate booth will also see Bosch Rexroth's complete ctrlX Automation offerings, including a cabinet-free display of ctrlX Drive, as well as the ctrlX Core controller, and Bosch Rexroth's high-speed smart conveyance solution, ctrlX Flow HS.

Additionally, Bosch Rexroth will showcase ctrlX OS and its ability to seamlessly integrate advanced technologies through an app-based ecosystem. By leveraging applications from Bosch Rexroth and industry partners, along with edge hardware capable of AI acceleration, the demo illustrates how ctrlX OS simplifies the integration of modern robotics and AI-driven vision systems.

Among the linear technology elements on display will be an interactive hologram showcasing Bosch Rexroth's complete catalog of linear motion components, including screws, bearings and linear modules. There will also be a Cartesian robot and a Smart Function Kit for Pressing demo, where visitors can see how components are leveraged within an automated pressing application.

Finally, there will be a touch table at the center of the booth, which will feature this factory automation display where attendees can engage and further learn how Bosch Rexroth serves a variety of factory automation needs.

Bosch Rexroth's specialists will be on hand throughout the show to provide insights and guidance on crafting effective strategies for smarter and more efficient factory automation solutions with safety at the forefront. Visitors are encouraged to visit Bosch Rexroth's subsidiary, Kassow Robots, at Booth #2036.

boschrexroth-us.com/automate

ZERO-MAX
Showcases Coupling Advancements at Automate 2026

Zero-Max will be showcasing advancements with their CD Power-Series Couplings, the new ServoClass Floating Shaft/Line Shaft Coupling line, as well as developments with new technologies at the Automate Show (Booth #12027)

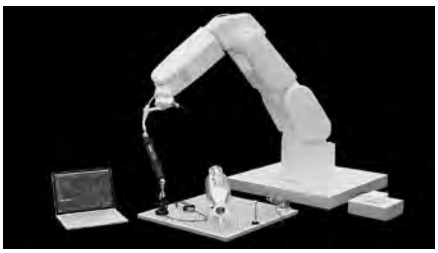
Zero-Max is known worldwide for their high-performance flexible shaft couplings, overload safety couplings, right angle gear drives, keyless shaft bushings, overhung load adaptors and other precise motion control components.

Zero-Max also provides the Miki Pulley brand of spring-actuated brakes and electro-magnetic brakes and clutches ideal for the growing robotics, AGV, and AMR industries. Zero-Max is known for innovative designs, high quality, high performance, and durability. Zero-Max and Miki Pulley products provide solutions for applications in automated assembly machines, autonomous mobile robots, material handling equipment, conveyors, automated workholding, motion control equipment, and other high performance industrial machinery.

"As North America's largest automation and robotics event, Automate 2026 is the ideal setting for us to demonstrate our latest advancements and interact with industry professionals looking for automation solutions," said Brian Mishuk, vice president of sales and marketing at Zero-Max. "We are excited to meet with attendees, discuss their challenges, and demonstrate how the Zero-Max and Miki Pulley products can help solve their motion control needs."

zero-max.com

RENISHAW
Highlights Robotic Efficiency at Automate 2026



Renishaw will highlight its latest solutions for maximizing robot performance and manufacturing efficiency at Automate 2026, taking place June 22–25 at McCormick Place in Chicago.

At Booth #3853 (South Building), Renishaw will present a range of technologies designed to improve robot accuracy, reduce downtime, and enhance process control across automated manufacturing environments.

A key feature of the exhibit will be the U.S. debut of Renishaw's RCS (Robot Calibration System) demo cell, showcasing live demonstrations of cell recovery and in-field robot calibration. These solutions enable manufacturers to quickly recover from collisions or process interruptions, restore accuracy, and significantly reduce unplanned downtime.

In addition to robot calibration technologies, Renishaw will also exhibit its Equator-X dual-method gauging system, demonstrating fast, flexible measurement for high-throughput production environments. The system supports both absolute and comparative gauging, helping manufacturers maintain process control while adapting to changing production demands.

Renishaw will further highlight its portfolio of position and motion control encoders, which play a critical role in robotic performance. These encoders provide precise feedback for robotic joints, enabling accurate positioning, smooth motion control, and repeatable performance across a wide range of applications.

Renishaw encoders are specifically designed to address the unique requirements of robotic systems, including:

- Large robotic joints (shoulders, elbows, hips, knees): AksIM-2 and AksIM-4 Dual Concentric encoders deliver true absolute positioning, improved repeatability, and reduced system complexity.
- Space-constrained or misalignment-prone joints: Orbis encoders provide high-speed operation with flexible installation options.
- Small, lightweight joints (grippers and dexterous hands): Compact solutions such as RM08 and AksIM-Mini offer ultra-small form factors, high accuracy, and true absolute position feedback.

These encoder technologies enable direct, high-precision feedback at every joint, supporting advanced robotic applications—from industrial automation to collaborative robots and dexterous robotic hands. Their compact, non-contact designs and high-speed capabilities make them well-suited for demanding environments where reliability and performance are critical.

renishaw.com/industrial-automation

TRELLEBORG
Launches Reduced Carbon Footprint EPDMs

Trelleborg Sealing Solutions marks a step change in the environmental impact of critical industrial polymers with the launch of two ethylene propylene diene monomer (EPDM) rubber grades demonstrating up to a 55 percent lower product carbon footprint (PCF).

The range of reduced carbon footprint materials features a 70 Shore A and an 80 Shore A material with uncompromised performance compared to traditional EPDMs. Project Manager Dr. Jekaterina Miller says: "Our new reduced carbon footprint EPDMs are created from raw polymers based on non-fossil sources derived from renewable ingredients such as cooking oil, straw, forestry residue and tall oil.

"The materials offer significant environmental benefits because the feedstock comes from circular sources. Although it achieves up to a 61 percent reduction in carbon footprint in compound form, the final formulations are comparable to traditional EPDM elastomers made from fossil-sourced inputs, ensuring equivalent application performance.

"Based on this circular feedstock, the materials offer 'no compromise' alternatives that substantially lower the carbon footprints of our customers' products. Using recognized methodology, we calculate that molded articles made from the 70 Shore A and 80 Shore A materials can achieve up to a 33 percent and 55 percent reduction in PCF respectively."

The range comprises the 70 Shore A hardness E7T11 and 80 Shore A E8T12, both ideal for the production of O-Rings, gaskets and custom-engineered products. The grades are suitable for solutions in the automotive, processing, manufacturing, automation, energy, agriculture, and construction and mining equipment sectors.

They seal applications in engines, doors, pumps, valves, line connector seals, household appliances, air cylinders, solar panels, marine hatches and doors, and an array of functions for heating, ventilation, air conditioning, freezing and refrigeration.

Developing the new materials in partnership with sustainability leader and raw materials supplier Arlanxeo, the two EPDM compounds are created from polymers derived from used cooking oil, straw, forestry residue and tall oil. In compound form, E7T11 has a carbon footprint reduction of 51 percent and E8T12 a carbon footprint reduction of 61 percent compared to traditional materials. Arlanxeo's bio-circular EPDM grades are ISCC PLUS certified using the "mass balance approach" which tracks the use of bio-circular feedstock in the production of their rubber. This guarantees that the volume of bio-circular products sold under the Keltan Eco-BC polymers label is consistent with the source feedstock.

Trelleborg then combines the EPDM with a combination of recycled carbon black derived from sources such as used tires, and other sources, to create the compounds.

To ensure the validity of the methodology for PCF calculations, Trelleborg worked with Sphera Solutions, experts in sustainability and operational risk management software platforms. The methodology is in the process of being validated by DEKRA, an internationally recognized certifying authority.

trelleborg.com

DUNKERMOTOREN Introduces Noise-Optimized E90R LN Spring-Applied Brake

With the redesigned E90R LN spring-applied brake, Dunkermotoren expands its brake portfolio with a solution that delivers quieter operation, precise control and uncompromising safety, even in the most demanding applications.

The E90R LN is based on the proven fail-safe principle: when de-energized, the brake engages automatically and securely holds the load. When power is applied, a magnetic field pulls the armature plate, releasing the braking force. This ensures maximum operational safety, particularly in the event of power failure or emergency stop scenarios.

As part of the latest design update, Dunkermotoren placed a strong focus on acoustic performance. A newly optimized driver design significantly reduces play between the driver and the armature plate. This minimizes vibration and rattling, resulting in noticeably smoother and quieter operation. The improved acoustic behavior enhances not only user comfort, but also the perceived quality of the entire drive system.

"In many modern machines, noise has become a decisive quality criterion—especially in sensitive environments such as medical technology," says Michael Burgert, product manager brakes at Dunkermotoren. "With the E90R LN, we offer a spring-applied brake that combines proven safety and durability with a clearly perceptible reduction in operating noise."

Thanks to its compact design, the E90R LN integrates easily into existing drive concepts. Typical applications include medical devices, automation and packaging machinery, conveyor systems and all applications where smooth motion, precision and acoustic comfort are essential.

With the noise-optimized E90R LN spring-applied brake, Dunkermotoren once again demonstrates how engineering precision, fail-safe functionality and user-oriented design come together to create reliable, high-quality drive solutions.

dunkermotoren.com

NTN BEARING
Unveils ROX to American Markets

NTN Bearing Corporation of America (NBCA) is pleased to announce the launch of the ROX spherical roller bearing product line to the American markets. This product line is specifically designed to withstand the extreme conditions of aggregate, mining, and heavy industrial environments.

ROX is a unique solution designed using NTN's expertise in the aggregate and mining industries. The spherical roller bearing features double metal shields affixed to the cage. This patented technology durably protects the inside of the bearing from external contamination while improving grease retention.

"We are thrilled to be able to offer our customers the newest of our cutting-edge solutions," said Kris Leming, product manager, NBCA. "Combining robustness, ease of use, and proven performance, ROX sets a new standard for reliability in heavily contaminated industrial environments. This new solution completes one of the most extensive ranges on the market and confirms NTN's commitment to providing sustainable, high-performance solutions adapted to the realities of the field."

Perfectly interchangeable with standard open bearings of the same size, ROX is designed to operate in particularly demanding environments: abrasive dust, mud, vibration, shock, and wide temperature variations (-40°F to +400°F). The metal shields effectively block the entry of dust and debris, and nitriding the shields considerably improves resistance to impacts, which are very prevalent in aggregate and mining. The absence of contact with the outer ring ensures zero friction and allows for misalignment of up to 2 degrees, as well as play control.

Tests carried out on the product have shown a twofold increase in minimum service life when compared to standard solutions. With optimized grease retention, ROX also reduces re-lubrication frequency by more than 50 percent. ROX reduces maintenance, decreases unplanned downtime, and improves productivity.

`ntnamericas.com`

AUTOMHA AND COMAU

Showcases Integrated Logistics Automation Solutions at Modex 2026

Automha and Comau presented their synergistic portfolio of integrated logistics automation solutions at Modex 2026.

The joint portfolio covered all phases of the logistics flow: inbound product handling, intelligent storage strategies, automated storage and retrieval, order preparation and synchronized shipping.

"In a global landscape where flow efficiency has become a critical competitive factor, we are bringing our long-standing expertise to new, dynamic segments," Coma CEO Pietro Gorlier said. "By integrating Comau's robotics, mobile automation and digital capabilities with Automha's expertise in automated storage systems, we offer a comprehensive modular ecosystem. Our goal is to simplify the automation of complex processes, providing customers not only with productivity and scalability but also with enhanced operator ergonomics through our wearable solutions."

At Modex, Automha unveiled for the first time NOVA AI, showcasing it through a live demo. NOVA AI is an artificial intelligence assistant natively integrated into AWMS (Automha Warehouse Management System) that leverages real-time plant data to interpret operations, events and anomalies, enabling faster issue analysis and more efficient process management. Built on a multi-agent architecture and accessible via a conversational interface, it delivers contextual insights without the need for manual data consultation, improving efficiency and reducing intervention times.

During the event, visitors saw Quaterways, Automha's multidirectional shuttle system designed to move orthogonally along aisles and easily access accumulation channels to enable fully automated storage and retrieval operations.

Managed through the AWMS, the solution allows operators to optimize storage density while maintaining flexibility and real-time control. Its capability to manage multiple pallet formats within the same channel and dynamically optimize travel paths makes it well suited for high-mix logistics environments such as those typical of 3PL and e-commerce operations.

Quaterways introduces a multidirectional movement logic, allowing the shuttle to operate continuously and smoothly along main aisles and within storage channels. This approach enables significantly reduced cycle times, increased storage density, simplified system architecture and improved operational flexibility, especially in high-variability environments.

Integrated with the AWMS, Quaterways offers high versatility, enabling maximum storage density, operational flexibility and real-time control. Its capability to manage multiple pallet formats within the same channel and dynamically optimize travel paths makes it well suited for complex logistics environments, such as those typical of 3PL and e-commerce operations.

Pallet Runner GTR and Pallet Runner 4D solutions, the latest evolutions of Automha's shuttle technology for multidepth pallet storage, were also on display. The system is available in multiple standard configurations designed to accommodate different pallet types and load units, while maintaining full compatibility with major racking systems and forklifts, ensuring easy integration into both new and existing warehouses.

Comau also presented its MyMR autonomous mobile robots, developed in collaboration with Milvus Robotics. Built to Comau's quality standards, with Comau acting as an integrator in developing the innovative AMR product, MyMR robots provide flexible, infrastructure-free material transport between storage areas, workstations and production lines.

Key advantages of the MyMR platform include a robust fleet management system, rapid deployment without fixed infrastructure, flexible navigation capabilities and advanced safety features that allow the mobile robots to operate efficiently alongside people and existing equipment.

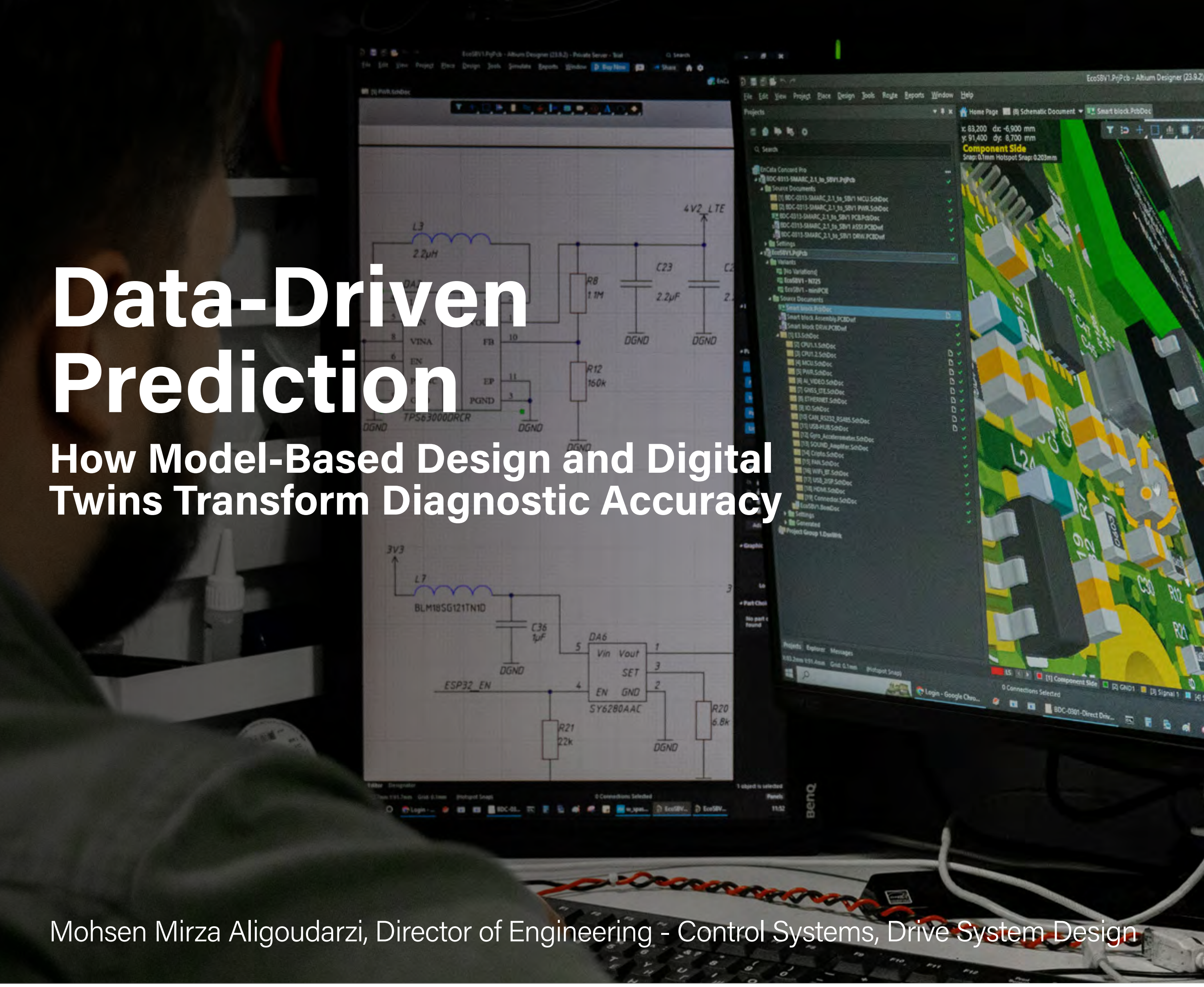
Comau's MATE-XT GO wearable robotic exoskeletons, designed to support operators during repetitive or physically demanding tasks by reducing shoulder strain, was also on display. The device can help improve worker ergonomics and productivity in applications such as truck unloading, manual sorting and warehouse handling activities.

comau.com

Data-Driven Prediction

How Model-Based Design and Digital Twins Transform Diagnostic Accuracy

Mohsen Mirza Aligoudarzi, Director of Engineering - Control Systems, Drive System Design



Drive System Design bridges the gap between engineering reality and data-driven prediction. **(All images: Drive System Design)**

Across sectors, the same operational truth is becoming harder to ignore: downtime has a direct impact on revenue. It ripples into supply chains, disrupts mission readiness, compromises service levels and, in some environments, creates genuine safety risk.

Yet many maintenance strategies are still built around scheduled servicing and reactive repair. One strategy replaces parts "just in case", the other replaces them after the damage is done. Both carry cost, disruption and waste. Neither have caught up to a world where products are more complex, more connected, and customers expect more functionality with faster turnaround—with less tolerance for failure.

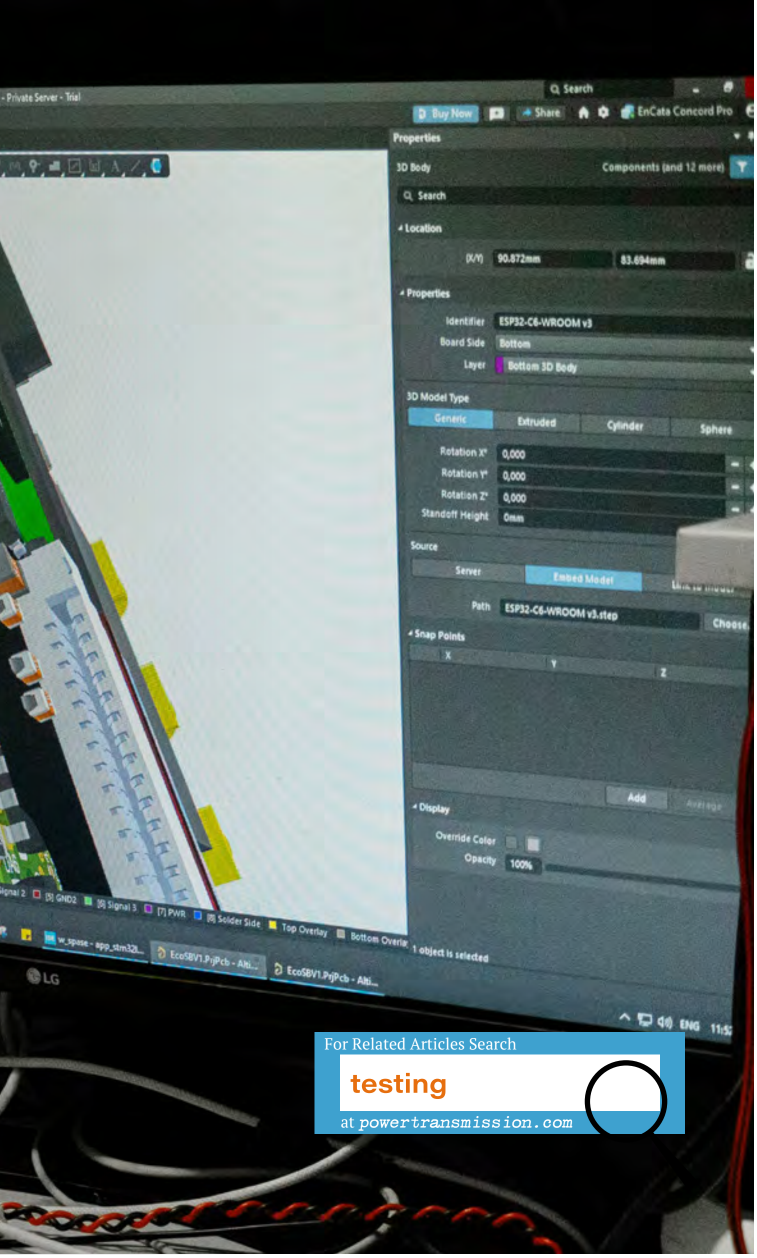
This is why health management systems and predictive maintenance have become an operational necessity. The goal is to reach a careful balance of detecting when degradation will occur, diagnosing it correctly, and determining when the most cost and time-effective moment is to act without sacrificing safety. Not too late, and not too early.

The Value of Turning Data into Decisions

Sensors are everywhere now. Land based vehicles, aircraft, manufacturing lines and industrial equipment generate streams of vibration, temperature, current, pressure and performance data. The temptation is to assume that more data automatically leads to better predictions.

A classic example is a rotating component, such as a wheel-end bearing, a gearbox stage or motor assembly which operates across changing speeds, loads and environments. The system moves between low and high rotational speeds; it sees transient conditions, temperature changes, variable torque demands, road or runway inputs and unexpected events.

Without engineering insight, it's easy to trigger false positives which send vehicles in for inspections that they don't need, ground aircrafts unnecessarily, or stop a production line because of suspicions about one cog. False positives are not a minor inconvenience; they are a cost center. They erode trust in



the system and push teams back toward traditional preventative schedules.

Equally, a false negative diagnosis can be worse than no diagnosis. In defense applications, a breakdown can impact live military operations. In aerospace, uncertainty drives conservative replacement schedules that inflate cost. In manufacturing, a small, undetected degradation can quietly reduce product quality before the line stops altogether.

So predictive maintenance isn't a "data problem." It's a decision problem: when do you intervene, why and what action is justified?

How Model Based Design Predicts the Future

This is where model based design can be applied as the practical bridge between engineering reality and data-driven prediction.

A model-based approach starts by treating the *system*, rather than a *dataset*. It uses physics-based modelling to

Increased Ingenuity & Flexibility in Farmington Hills

Matthew Jaster, Director, Editorial Content

Drive System Design's (DSD's) original U.S. facility housed a loaded transmission efficiency test rig and additional driveline test equipment for transmissions, supercharger gearboxes, hydraulics and lubrication analysis. The new Farmington Hills, MI. facility, a few miles from the original location, is much larger and allows DSD to tackle larger design and testing applications outside of automotive.

"One of the major drivers to moving to a larger facility was gaining projects and customers outside of automotive," said Jason Schneider, director of electrified powertrain at DSD. "We're handling jobs for commercial vehicles, defense and off-highway applications that require more torque, larger diameters, etc., much larger projects than what you traditionally see in automotive design."

A move paying off as DSD is gaining a larger, more versatile customer base here in the United States. I visited the facility last fall and can only describe it from a journalist's perspective as a cross between a laboratory and a LEGO project where test cells are transformed, rearranged and extremely versatile, supporting customers with a variety of different engineering scenarios.

There are test cells affectionately known as "Beauty and the Beast" where one area is streamlined, compact and efficient and the other is a gigantic, monstrosity of components built for power. It's entertaining to imagine how these workspaces change every few months and how much fun the engineers have in creating new systems with new testing parameters.

"The goal was to have everything under one roof," Schneider said. "Our expanded footprint allows us to handle the engineering, design, analysis, development, testing all right here and deliver validated hardware from a single location."

The expansion also came from customer requests wondering if DSD was planning to expand to meet the changing energy requirements found in today's engineering systems. "We wanted the extra space to set up test environments and solve real world problems and create custom solutions for their unique applications. The facility is about three and a half times the size of our original location," Schneider added.

DSD recently achieved Cybersecurity Maturity Model Certification (CMMC) Level 2, reinforcing its commitment to the highest standards of cybersecurity for customers operating in defense and aerospace.

This certification confirms full compliance with all NIST SP 800-171 requirements and authorizes the business to manage and protect federal

[*continued on next page*]

contract information and controlled unclassified information across the Defense Industrial Base. Following an independent third-party assessment with a C3PAO, DSD received certification for CMMC—the US Department of Defense's cybersecurity framework for organizations handling sensitive defense information.

This milestone reinforces DSD's expert ability to combine specialist propulsion engineering with the secure handling of sensitive program information.

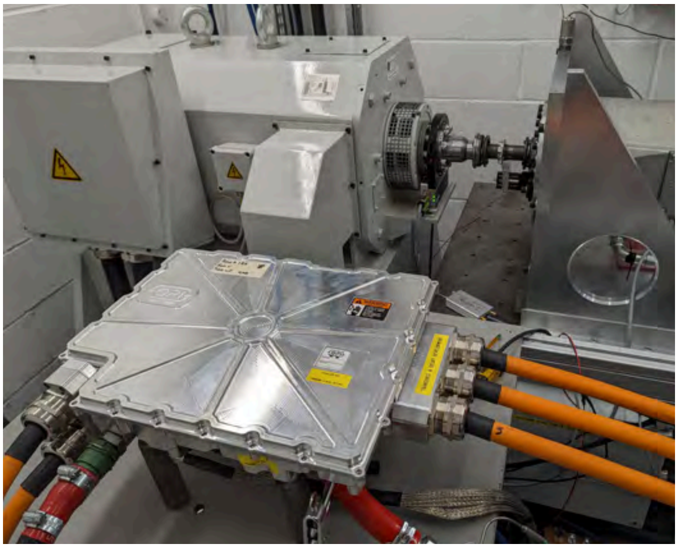
"The move also opened up additional testing opportunities," Schneider said. "If a customer has the hardware ready to go and they just need the test cells we can create the environments they need here in Farmington Hills. The flexibility and versatility of the equipment allow us to cover electrification across several key industrial segments."

DSD accelerates the development of next-generation powertrains through simulation-led design, advanced testing and a unique global delivery model.

represent how components should behave, how failures can emerge, and what 'healthy' looks like across operating conditions. Done well, it provides a reference against which real-world data can be interpreted.

Take the rotating component example. With the right physical model, it becomes possible to simulate operational loading, vibration response and degradation pathways, and then understand how these evolve over time. That might include building a model that can estimate when wear reaches a threshold that should trigger inspection, or when a bearing is likely to need replacement after a given duty cycle. The point is not to predict definite replacement after a certain number of hours or miles; it is to create a defensible engineering basis for predicting remaining useful life and planning intervention.

This is the core advantage of model-based design in health management: it makes prediction interpretable at pace. Rather than waiting for long-term field data to accumulate, engineering teams can explore failure behavior virtually, test assumptions early, and refine diagnostics before a system reaches the end of its life.



Machine learning and data analytics add the most value when they're grounded in physics-based engineering like this test conducted at DSD's facility in Michigan.

Why Computing is Changing What's Economically Viable

Cloud computing, high-performance processing, and accessible AI tools now make it more realistic to run complex models alongside streaming data. As predictions can be updated in near real time when conditions change, models can be richer, diagnostics can be more granular, and lifecycle decisions can be made dynamically rather than on fixed schedules.

Machine learning and data analytics add the most value when they're grounded in physics-based engineering. They help cut through noisy real-world data to improve diagnostic accuracy, handle variability across real duty cycles, and speed up decisions from detection to action. This reduces unnecessary maintenance and avoids costly downtime.

The core advantage of model-based design in health management is that it makes prediction interpretable at pace.

Crucially, this shift makes health management viable in sectors where cost previously made it hard to justify. When the computation and analytics become scalable, the conversation moves from "Can we afford to do this?" to "Can we afford not to?"

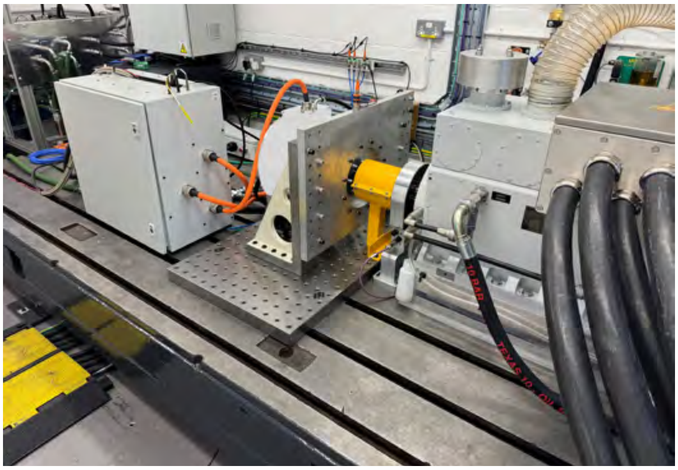
Predictive Maintenance as a Lifecycle Strategy

The organizations that gain the most won't treat predictive maintenance as an add-on module. They'll build it into the lifecycle strategy in how systems are designed, validated, operated and improved.

That means designing for observability (what you measure and why), designing models that reflect realistic failure modes, and building analytics that prioritize reliability over novelty. It also means focusing on the operational consequences: avoided downtime, reduced unnecessary part replacement, improved asset availability, and better-informed overhaul planning.

As systems become more electrified, more software-defined and more operationally connected, the center of gravity shifts from designing components to managing performance over time. Reliability becomes a design outcome as opposed to just a maintenance objective.

Health management and predictive maintenance are the goals. Model based design is the enabler. Data analytics and machine learning accelerate this, but only when rooted in the realities of physics, operating context and failure behavior.



Test cells measure realistic failure modes that focus on operational consequences of the drive systems.

The organizations that bring these tools together will reduce downtime. But they'll also make smarter lifecycle decisions, protect revenue, reduce waste and build systems that can be trusted, not only when they're new, but when they're years into service.

`drivesystemdesign.com`

The Impact and Viability of Industrial Motors

ABB Strengthens Product Line for Cement and Aggregate Applications

Matthew Jaster, Director, Editorial Content

These motors achieve cooler running operation for longer life which means longer bearing life. This translates to longer motor life. **(All images: ABB)**

There's a running theme throughout concrete and aggregate producers where the motors in crushers, conveyors and pumps need to operate efficiently, extend equipment life and cut downtime—easier said than done when dealing with dust, vibration and massive shock loads. These daily challenges can be the difference between having reliable onsite equipment or navigating the costs associated with unplanned failures.

We have learned covering these MRO topics for years in *PTE* that no matter what precautions you put in place, unplanned failures on a production line can cause major losses. Courtney Pickett, product specialist at ABB NEMA Motors and Stefanie Casimir, global product marketing manager for ABB NEMA Motors recently shared insight on new motor technologies in these harsh, industrial markets.

"Our customers are looking for products that are going to last in these harsh environments," Pickett said. "We're pushing for higher efficient motors, highly sustainable motors that will counter rising energy costs and comply with the various regulation requirements."

Far too often, Pickett and Casimir see general-purpose motors (standard motors) being installed in these severe duty environments.

"This is not the same motor you should be running for a pump or a fan in a clean environment," Casimir added. "They do not meet the harsh requirements you find in concrete or aggregate and they certainly don't last long enough. It is important to have a robust supply chain and the right motors readily available when an upgrade is needed."

Pickett noted these motors are getting pummeled out in the field—taking hits from rocks and other debris. They need to outlast the warranty period and provide the maximum operating efficiency a severe duty motor SHOULD provide.

To specify the best motor for the application, ABB collaborates closely with the customers to gain efficiency in overall system performance. "Many of our customers aren't taking a systematic approach when addressing the next generation of motor technology," Pickett said. "It's important to consider efficiency improvements early on in the process."

On June 1, 2027, the U.S. Department of Energy (DOE) will require higher efficiency levels for a wide range of industrial motors. In a recent study by ABB, it was reported that this will be the most significant update in more than a decade. The timing is critical. Electric motors are the backbone of industrial productivity, powering pumps, compressors, conveyors and HVACR systems. They consume more electricity than any other industrial technology. Globally, motors account for more than 40 percent of power use, and in the United States they draw more than a trillion kilowatt-hours each year, costing $112 billion. Even modest efficiency gains across fleets of motors can reshape the economics of entire industries. The new DOE standards reflect that reality. For engineers, it becomes an exciting opportunity to guide smarter designs, lower costs and deliver measurable sustainability progress.

Real-Time Monitoring

The ABB Ability Smart Sensor converts traditional motors into smart, wirelessly connected devices. "This enables users to monitor the health of their motors and to plan maintenance in advance offering vibration, load and temperature data in real time," said Pickett.

By combining connectivity and data analytics these sensors focus on making the motor efficient, predictable and safe even in the most hazardous environments.

"They're not manufacture-specific so they can easily attach to any of the equipment to calculate energy savings and management whether it's a conveyor, pump, or motor," said Casimir. "These are particularly effective in hard-to-reach applications where safety is a concern for your operators. This condition monitoring technology eliminates the need for a human to physically go to the unit for inspection.

Using these data-driven tools onsite allows plant operators to assess, manage and optimize powertrains, giving them more time to focus on plant improvements and strategical tasks.

ConExpo Highlights

Despite all the conversations about energy regulations and efficiency requirements, attendees at ConAgg/ConExpo earlier this year were more concerned about the longevity of the equipment.

"These were the conversations we were having during the show," said Pickett. "We offer a variety of application-specific motors intended for use in certain areas and we want to make sure they're getting the most optimized motor solution to meet their critical equipment needs."

ABB NEMA motors are essential components used to run equipment in industries such as food and beverage, oil and gas, mining & aggregate, and water & wastewater and in applications like those which move air, liquids, and units.

The heavy-duty frames on these motors can endure harsh operating conditions, while reducing the risk of damage under high-stress loads.

ABB NEMA Super Premium motors can offer up to 40 percent lower energy loss in comparison with a NEMA standard efficient (IE2) induction motor.

With a catalog as extensive as ABB's, the search for the perfect solution can be daunting.

"The customization capability is what they really like about our products," said Casimir. "We provide custom modifications for our OEM partners, and this is something we're quite excited to offer."

Technologies at the show included ABB Baldor-Reliance Crusher Duty motors, designed for belt-driven rock crushers, pellet mills and other applications requiring motors rated for high starting and peak torques.

The ABB Baldor-Reliance HydroCool XT is a water-cooled motor that is quiet and versatile, requiring little to no maintenance, which can perform in the toughest environments.

The water-jacket cooling technology extends motor life while saving space, energy and maintenance costs.

The DP200 Crush+ exceeds demands for reliability and safety in the harshest environments, raising the standard of motors used for crushers and other applications. Engineered with the user in mind, it delivers high starting and breakdown torque alongside flexibility and design modularity. Built upon the proven SD200 framework, its rugged and reliable design optimizes performance, efficiency and total cost of ownership.

SD100 Severe Duty motors are built for demanding applications, offering high efficiency, durability and reliability in harsh environments, making them ideal for industries where long-lasting performance under heavy loads is essential. These powerhouse motors are tailor-made for the rigors of severe duty industries. SD100 motors offer the ultimate in rugged construction, cool operation, high performance, and application flexibility.

The Future of Motor Technology

While the world continues to debate energy efficiency, Pickett is interested in seeing where else motor technology will evolve in the coming years.

"We are starting to see motor technology shift as the current generation of AC motors, for example, are reaching their limits. They are about as efficient as they're going to get. We are excited to see how and when these industrial motors will evolve further," Pickett said.

Where else will the focal point be outside of efficiency or custom motor requests?

"In many cases, it's no longer about the motor, but the entire system. The time is coming when we are going to need to evolve the technology into something else entirely," said Casimir. "We're going to see things change in motors in areas like material handling, food and beverage as well as these industrial markets."

ABB Baldor-Reliance SP4 motors achieve NEMA Super Premium efficiency across-the-line, independently of a drive. The SP4 product line builds on the simplicity of ABB's proven AC induction motors and features a range of durable motors tailored to meet diverse, severe-duty applications. These motors are compatible with pumps, fans, compressors, and conveyors and are ideal for all industries. The new cast-iron motors cover a power range of 25 to 300 hp and the rolled steel models are available in ¼ to 20 hp.

Both Pickett and Casimir acknowledge that the competition is starting to catch-up so it's pushing the team to make even more robust motor products.

"We're really excited to show off the motor technologies we're working on in the next couple of years to enhance everything from motor design to service and support and motor monitoring," said Pickett.

The modular design of ABB NEMA motors offers a high level of flexibility for customers and makes it easy to upgrade or retrofit existing systems in the field or implement future equipment designs and requirements.

"One more thing I'll add is we've been in the market for 100+ years and have a very large portfolio of motor technologies to draw from," Casimir said. "Even in industries like concrete or aggregate where change doesn't happen overnight, we're excited to enhance our product offerings and deliver solutions that will keep our customers equipment running for a long time."

new.abb.com/us/us-motion-business-area/motors-and-generators/abb-nema-motors

PTE

Production Power

Four Trends Driving the Adoption of Automated and Smart Manufacturing Workflows

By Georges Mankarious, Director – Factory Automation, Emerson

Automation and smart technologies are fundamentally changing what manufacturing environments look like — and more importantly, what they can achieve. Rewriting the rules of flexibility and efficiency, automated and digitalized workflows make it possible to produce more complex products in less time with less waste.

According to a recent survey of 600 manufacturing executives by Deloitte, 80 percent plan to invest at least a fifth of their improvement budgets in smart manufacturing initiatives. (*deloitte.com*). Most respondents believe smart manufacturing initiatives will drive market competition and change the way products are made.

Here are four trends driving the adoption of automated and digitalized workflows and examples for how transformed workflows address these challenges.

Reshoring initiatives and skilled labor shortages

For the last few years, reshoring has been near an all-time high in the United States. By bringing production closer to end markets, reshoring is a viable strategy to build more resilient and sustainable supply chains in the face of economic pressures and instability. However, for many companies, this means operating in higher-cost regions where skilled workers may be in short supply.

The Emerson Bonneville manufacturing facility implements automated configuration, simulation and machining to deliver fully customized Aventics XV valve systems in just five days. **(All images: Emerson)**

Transforming manufacturing workflows through automation and digital tools can simplify, streamline or replace manual tasks, freeing up skilled personnel for more valuable responsibilities. This can include online product configuration tools or software that converts product configurations into machining data, which simplify and streamline engineering and programming tasks.

OEM online configuration tools make it faster and easier for engineers to configure components that specifically meet application requirements, streamlining engineering tasks. Additionally, precisely specifying components can minimize time required for assembly.

Speed and quality expectations

Today, operational efficiency is more than a cost lever; it's a core competitive advantage. The ability to consistently maintain rapid throughput without sacrificing quality or performance is essential to earning customer trust and competing in the modern marketplace.

Automation and digital transformation of workflows can often perform previously manual tasks in a fraction of the time with a level of accuracy that maintains or even improves product quality. These savings significantly accelerate production timelines and increase throughput to better meet aggressive schedules.

For instance, software that automatically generates CAD models of product components, machining instructions and simulation files to validate tool paths can prevent errors and move designs into production much sooner.

Shifting demands and increasing customization

Shorter product cycles and greater expectations for customization all create significant operational challenges. In this environment, speed and flexibility are critical for long-term competitiveness.

Automated, smart workflows can often handle both low-volume, high-mix orders and high-volume production to ensure on-time product delivery. Deploying scalable technology and processes makes it possible to use the same infrastructure without adding labor or sacrificing speed.

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Aventics XV valve systems can be configured in more than 100 million ways, enabling machine designers to precisely tailor pneumatic automation to their applications.

Sustainability and regulatory compliance

With corporate sustainability commitments and evolving environmental regulations, manufacturers and the upstream OEMs that support them must find ways to reduce overall energy use, minimize waste and optimize resource consumption, all while remaining efficient and competitive.

Smart devices and flow sensors continuously monitor compressed air consumption, pressure stability and system performance in manufacturing equipment. Condition monitoring and predictive maintenance allows operators to identify leaks, inefficiencies or wear early — improving both uptime and energy efficiency. Real-time monitoring also gives operators live visibility into equipment status, throughput and resource utilization, enabling rapid response when conditions change.

Achieving more through automation and smart manufacturing

To meet customer demand and remain competitive in today's market, modern manufacturers must set tighter production schedules to produce more complex products. At the same time, they must meet corporate sustainability targets and evolving regulations while facing labor shortages and skills gaps. Automation and digitalized workflows provide both speed and flexibility manufacturers need to simultaneously meet these challenges and their business goals.

emerson.com

Automated Workflow Delivers Fully Configured Valve Systems Within Five Days

The challenge: With about 100 million possible configurations, Aventics Series XV pneumatic valves from Emerson are designed for extreme flexibility. Engineers can specify valve size, electronics, fieldbus protocol, pressure regulators, shut-off valves, flow modules and pressure-supply modules to match their exact application, making each order unique.

To meet aggressive lead-time commitments, the Emerson Bonneville manufacturing facility in the French Alps had to find a way to produce the configured, fit-for-purpose valves on an industrial scale.

The solution: The Emerson manufacturing team developed a fully automated workflow for producing the Aventics XV valve platform that converts product configurations into production-ready components.

Customers use an intuitive online configuration tool to precisely specify their valve system per application requirements. Once the system receives the order, software automatically generates 3D CAD models of the valve base and modules, machining instructions for cutting and drilling and simulation files to validate tool paths and detect potential collisions. After validation, the data is sent directly to CNC machines for production of the aluminum valve bases and components.

The outcome: By implementing automation and smart manufacturing initiatives, the Emerson Bonneville facility can deliver Aventics XV valve orders in just five days or less. The Emerson team eliminates 2-4 hours of manual work per order by automating the programming and setup process for each Aventics XV configuration, a significant reduction in engineering and setup time. Customer configurations are converted into production-ready machine programs within 10 minutes rather than hours, while automated simulation and validation processes minimize errors, scrap and rework.

Most importantly, this successful framework gives machine builders accelerated access to reliable, high-quality, fit-for-purpose valve systems, getting their products to market faster, too.

Smarter Drives, Smarter Systems

Nidec Drives Provides FAE with Complex Drive Control Solutions

Matthew Jaster, Director, Editorial Content

The E200 is a recycling system dedicated to processing HDPE plastic material, mainly bottles for personal and household hygiene products. **(All images: Nidec Drives)**

In high-demand industrial environments like plastic recycling and extrusion, system efficiency, thermal management, and drive reliability are critical to operational success. FAE SRL, specialists in electrical panel design for OEMs in the plastics sector across Italy and Switzerland, needed a drive solution that could meet the rigorous demands of continuous operation, high power density, and seamless integration with modern control architectures.

With a long-standing relationship with Nidec Drives, the company turned to Commander C300 and Unidrive M700 drives to power its latest generation of extrusion systems.

For more than 40 years, FAE has been a globally active Italian company that designs and delivers custom automated systems for industrial clients. A trusted provider of automation engineering services; FAE aids factories and production lines to run more efficiently, safely, with less intervention, and following internationally recognized quality management practices. Responding to global competition and market demands FAE adopted lean management and lean production, thus entailing their operations are streamlined to reduce waste, improve efficiency and manufacturing processes are optimized for better quality and faster delivery.

For their latest project, FAE once again turned to Nidec Drives building on decades of trust, product reliability, and exceptional technical support that have defined their long-standing partnership.

What is a Plastic Material Regeneration System?

Also known as plastic granulation or extrusion recycling, this process converts landfill-sourced or post-consumer plastic waste into reusable plastic granules. These granules support a circular economy by serving as raw materials for new plastic products.

To do this, plastic waste is collected and organized by type such as, polyethylene terephthalate, high-density polyethylene, low-density polyethylene and polypropylene. Proper sorting is crucial to ensure quality and avoid contamination. They then go through a thorough wash to remove dirt, labels, and residues, to prepare for processing.

Clean plastic is then shredded into small flakes. If the material is too light, it may be densified, a process that compacts it to improve handling and extrusion. The flakes are fed into a hopper containing a screw mechanism that pushes the material into an extruder. Inside, the plastic is melted and formed into long strands. These strands are then cooled and cut into uniform plastic granules, also known as pellets, which are then ready for reuse in manufacturing.

Why does this matter? This process not only diverts plastic from landfills, reducing environmental pollution and conserving space, but also significantly lowers the demand for new plastic production, which is energy intensive and reliant on fossil fuels. This places responsibility and opportunity firmly in the hands of manufacturers. By regenerating plastic into reusable granules, OEMs can reduce their carbon footprint and contribute to a more circular economy. Global environmental regulations have tightened, industries are facing increased pressure to adopt sustainable practices, and recycling plastic granules have emerged as a critical resource. Widely used across sectors such as packaging, construction, consumer goods and automotives, they offer a cost-effective and eco-friendly alternative to new plastic materials. Thus, not only does it support sustainability goals, but also enhances supply chain resilience by reducing dependence on raw petrochemical inputs.

FAE's Approach to Plastic Regeneration

Powered by a carefully engineered combination of mechanical precision and intelligent drive control, this complex system relied on Nidec Drives solutions for their ease of integration, compact design, and communication flexibility. All of which make up key features that align with the demands of their advanced recycling systems.

At the heart of the operation are Commander C300 drives, which control conveyor belts and pumps throughout the system, ensuring smooth and efficient material flow.

Nidec Drives supplied drive control technology to enhance FAE's recycling systems.

For the high-power demands of the extruders and densifiers, FAE implemented three M700 drives, 500 kW each, a choice driven by their compact footprint, simplified commissioning, and ability to meet power and control requirements without compromising panel space or thermal management.

Commissioning was carried out via Connect software through Profinet, which significantly reduced setup time, compared to other systems that can take up to an hour to program. Nidec Drives intuitive interface allowed FAE to complete the process in just 15 minutes. This ease of programming, combined with competitive pricing and short

Nidec Drives Upgrades Servo Solutions with EnDat3

Nidec Drives has unveiled a major upgrade to its servo solutions, delivering full packages for Heidenhain's next generation EnDat 3 encoders. These comprise of Digitax HD and Unidrive M700 drives, Unimotor hd motors and a selection of standard cut-to-length cables and premade connectors. Ideal for more compact machines, Nidec Drives' solutions with EnDat 3 encoders brings smarter and faster systems. Key benefits include single cable 2-wire technology for simplified cabling, smaller panel sizes and faster commissioning as well as enhanced diagnostics such as real-time monitoring of vibration, temperature and encoder health for predictive maintenance.

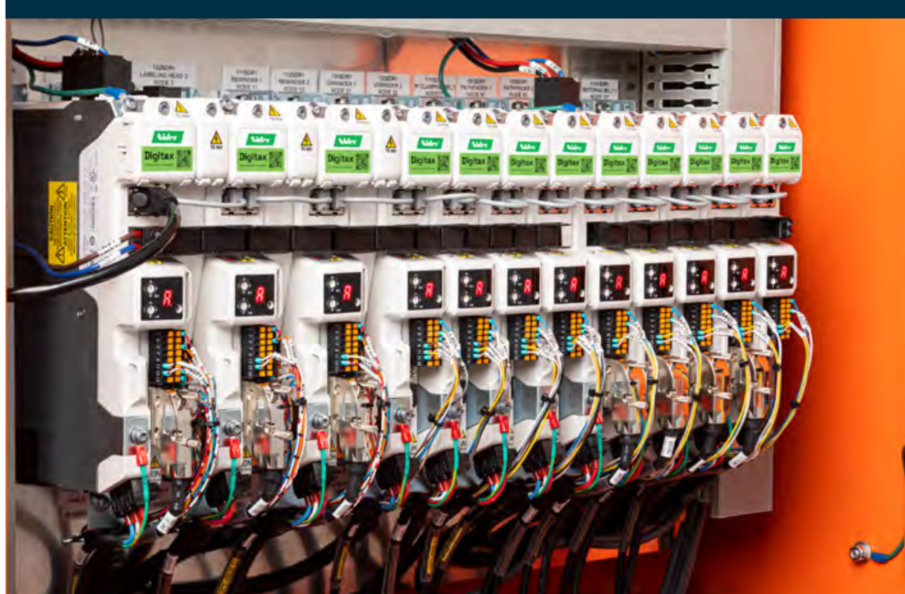
"The support for EnDat 3 disposed many of the traditional pain points associated with system setup and performance tuning. As a product team, our goal is to simplify the complex and empower our customers to innovate faster. Introducing new tools and features ensure we provide a major leap forward in usability, diagnostics and flexibility," said Ian Shorthose, product manager for motion at Nidec Drives

All Nidec Drives EnDat servo solutions work out of the box with electronic nameplate data ensuring all components are properly matched. Each Unimotor hd EnDat encoder is pre-programmed for instant recognition, so your system configures itself on power-up with no manual intervention required.

System optimization is made simple with the latest Connect V3 commissioning software which ensures rapid, error-free set-up taking minimal time using step-by-step support.

After its recent significant update, Connect has been reimagined with servo systems at the core of its redevelopment. Whether you're a motion control expert or a first-time user, Connect makes commissioning fast, reliable, and user friendly.

"Through the integration of EnDat and Nidec Drives, evolution turns into synergy," added Oscar Arienti, sales manager automation division, Heidenhain Italy. The advancement of our EnDat encoder platform, combined with Nidec's servo drive technology, expands the product portfolio, enhances application versatility, reduces commissioning times, and ensures high precision and operational reliability."



Measurable efficiency gains were achieved using Nidec's drive technology on the plastic regeneration system.

delivery times, helped FAE stay on schedule and within budget.

The system's design also accounted for flexibility. While the densifier isn't continually in use, it plays a crucial part when processing lighter materials, helping to ensure consistent feed into the extruder. Thanks to the adaptability of the drive system, integrating this component posed no operational challenges. Proving FAE's trust was well placed in a company that shares a commitment to innovation in sustainable manufacturing.

Real World Energy and Cost Savings

By selecting Nidec Drives products, FAE achieved more than just performance, they unlocked measurable efficiency gains. Compared to alternative solutions, the M700 drives reduced panel power dissipation by up to 2,800 watts, resulting in an estimated 24,528 kWh of energy saved annually. This translates to approximately £3,679 in yearly cost savings, based on average industrial electricity rates. Beyond the direct energy reduction, the lower heat output also decreased the demand for panel cooling systems, contributing to further operational savings and improved system longevity. These benefits, combined with the compact size of the drives, allowed for a more streamlined panel design, maximizing space and minimizing thermal load.

The success of FAE's plastic regeneration system is a testament to the power of collaboration, innovation, and reliable engineering. FAE was not only able to achieve technical excellence but also benefited from simplified commissioning, reduced energy losses, and a streamlined panel design. Feedback from technicians and operators has been overwhelmingly positive, highlighting the system's ease of use and minimal technical issues.

FAE summed it up best: "We are very happy with the collaboration we are having with Control Techniques, and we expect even more partnerships for upcoming projects!"

As the demand for sustainable, high-efficiency systems continues to grow, partnerships like this one demonstrate how smart technology and trusted relationships can drive meaningful progress, both for business and the planet.

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Dual Drives: Load Sharing or Load Fighting?

A long conveyor is driven by two identical electric motors mounted on the head pulley. Each motor is connected through its own gearbox and controlled by a variable frequency drive (VFD). Both drives are set to the same speed reference.

Question:

In real operation, will the motors share torque equally?

Bonus:

If not, what typically happens—and what control strategy would you specify to correct it?

Join the discussion:

Comment at *linkedin.com/company/power-transmission-engineering* on LinkedIn or use ***#PTEBrainTeaser*** to share your answer.

Selected responses may be featured in an upcoming issue.

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Performance-Driven Design of Multi-Stage Gear Transmissions for E-Drive Systems

Luca D'Angelo, Dr. Claudio Autore, Dr. Marco Cirelli, and Prof. Pier Paolo Valentini

The electrification process involving urban mobility vehicles is pushing research into developing efficient and durable transmissions. The transmission system has the crucial role of transforming the electrical energy produced by the electric machine into mechanical power, which is subsequently delivered to the wheels through a gear reduction system. For this reason, in recent years, the development of predictive models for analyzing efficiency losses in gear transmissions has been one of the most discussed topics by scientists (Refs. 1, 2). Among the several architectures proposed, thanks to their versatility, multi-stage transmission systems represent one of the most adopted solutions, both because they allow motion to be transferred between distant axes and because they allow high gear ratios to be achieved, reducing the effects of excessive sliding, which inevitably leads to loss of efficiency and premature wear. However, the design of multi-stage transmission systems, especially in the preliminary stages of the project where little data is available, is complex and often driven by trial-and-error procedures. Optimization methods have recently been adopted to provide reliable solutions for single-stage gears to reduce mass and noise and improve efficiency (Refs. 3, 4). The results demonstrate how this approach can enhance the quality of transmission and reduce costs due to experiments. Recently, in existing literature, some techniques based on optimizing the multi-stage gear trains have been proposed (Refs. 5, 6, 7). Although Sundaresan et al. (Ref. 8) and Houser and Harianto (Ref. 9) notably consider manufacturing and geometric constraints at the early design stage, in most multi-stage transmission optimization studies, these aspects are simplified or addressed only in a preliminary filtering phase. However, effective gear design necessitates a thorough examination of the geometric-kinematic and the mechanical strength and efficiency aspects, which are closely interrelated. Both considerations are intricate and interconnected. To ensure the optimal performance of assembled drive gear systems, it is imperative to address them concurrently. In the present literature, the direct integration of manufacturing-related parameters (such as tooth interference reserve, tooth clearance, and tip thickness) into a macro-geometry multi-objective optimization framework for multi-stage systems remains less explored. This study directly tackles these challenges by introducing an innovative multi-objective optimization framework for designing multi-stage spur gear transmissions, explicitly integrating these constraints into the optimization process. The optimization strategy consists of two sequential phases: an in-depth characterization of the gear domain, defined by multiple macro-geometry parameters, followed by an optimization stage employing an elitist non-dominated sorting genetic algorithm (Ref. 10). To estimate both load-dependent and load-independent power losses, the methodology incorporates the *KISSsoft* (Ref. 11) power loss calculation, based on the Ohlendorf-Niemann formulation (Ref. 12), as well as the Anderson-Lowenthal (Ref. 13) model. Throughout the process, geometric, spatial, and dimensional constraints are strictly enforced, alongside safety requirements assessed through ISO standard safety factors (Ref. 14). As a result, the generated designs intrinsically satisfy dimensional requirements and manufacturing constraints, eliminating the need for post-optimization validation and ensuring enhanced performance. The proposed methodology is designed to be applicable to a wide range of gear transmission architectures. In this study, it is specifically applied to a two-stage transmission system, which is evaluated using two different layouts: one with a gear train that includes an idler and another with a counter-shaft arrangement consisting of four gears. For the two-stage application, the multi-objective optimization strategy was employed to define the Pareto front, a concept widely adopted in gear design optimization (Refs. 7, 15, 16) to evaluate trade-offs between conflicting objectives. The front is the locus of all the compromise (Pareto-optimal) solutions for which one cannot further improve one objective function without inevitably degrading the other one. In this context, it provides a clear framework for comparing design alternatives, enabling a comprehensive comparison of trade-offs between efficiency and weight. The final selection of the optimal design is ultimately the designer's responsibility. This decision can be assisted by various decision-making tools such as fuzzy logic, which is generically implemented to assess robustness and uncertainty (Ref. 17). The case study results reveal that the most efficient solutions in both configurations generally tend to exhibit a high tooth count, a small module, and wide face widths. In contrast, designs optimized for minimal weight are often associated with larger modules but more compact geometries. Moreover, the compound arrangement offers greater design flexibility, enabling smaller gear diameters and a more uniform distribution across the feasible design space and thus the Pareto front.

Methodology

A design process typically involves a goal-oriented exploration within a defined search space, influenced by certain constraints and variable limits. While optimization algorithms can assist in this process by utilizing computational power to improve convergence toward an optimal solution, their effectiveness may be compromised if the problem is unclear. As a result, the process might converge quickly to a solution that is not optimal, or it could take too long to arrive at an adequate result. Therefore, the mathematical representation established through carefully selecting objectives, variables, and constraints, highlighted as the first stage (green) in the design optimization procedure shown in Figure 2, is crucial for the success of the design process.

Multi-Stage Gearbox Transmission System and Design Variables

Gear trains are transmission systems generated by the serial connection of simple gear pairs. The architecture and the system's layout extremely influence the gear train's performance. However, even the macrogeometry of single gears plays a crucial role in power loss. For this reason, it is necessary to consider the geometrical entities of each stage gear at the optimization level, summarized in Figure 1.

According to ISO 21771 (Ref. 18), each involute spur gear is defined by its module, which represents one of the most essential parameters in gears. The tip and root diameters determine the shape of the involute tooth profile, hence the addendum and dedendum factors. Furthermore, the design pressure angle and the value of the manufacturing shift coefficient also influence the tooth profile.

With the rise of electric vehicles, gearbox compactness has become increasingly important. Consequently, in the discussed algorithm implementation, the pitch diameters were selected as design variables to address spatial constraints explicitly and to facilitate the definition of domain boundaries. Thus, to uniquely determine the module for each gear stage, whether composed of two gears or including idlers, the number of teeth and the pitch diameter are specified for at least one gear per stage, especially where specific dimensional requirements are present.

Moreover, to better accommodate dimensional constraints, instead of directly specifying internal gear ratios or the number of teeth for each gear, a variable is introduced representing the sum of the nominal center distances of the gearbox stages. By specifying the total gear ratio as part of the design input, this approach enables the algorithm to derive the key geometric and kinematic parameters for the remaining gears in the assembly, ensuring consistency with overall layout requirements.

Finally, for each gear, the pressure angles, profile factors, shift coefficients, and face widths are defined as design variables. Each of these design variables is subject to specific boundaries, which are established by design constraints or informed by the designer's expertise. A comprehensive list of all design variables considered is provided in the accompanying Table 1.

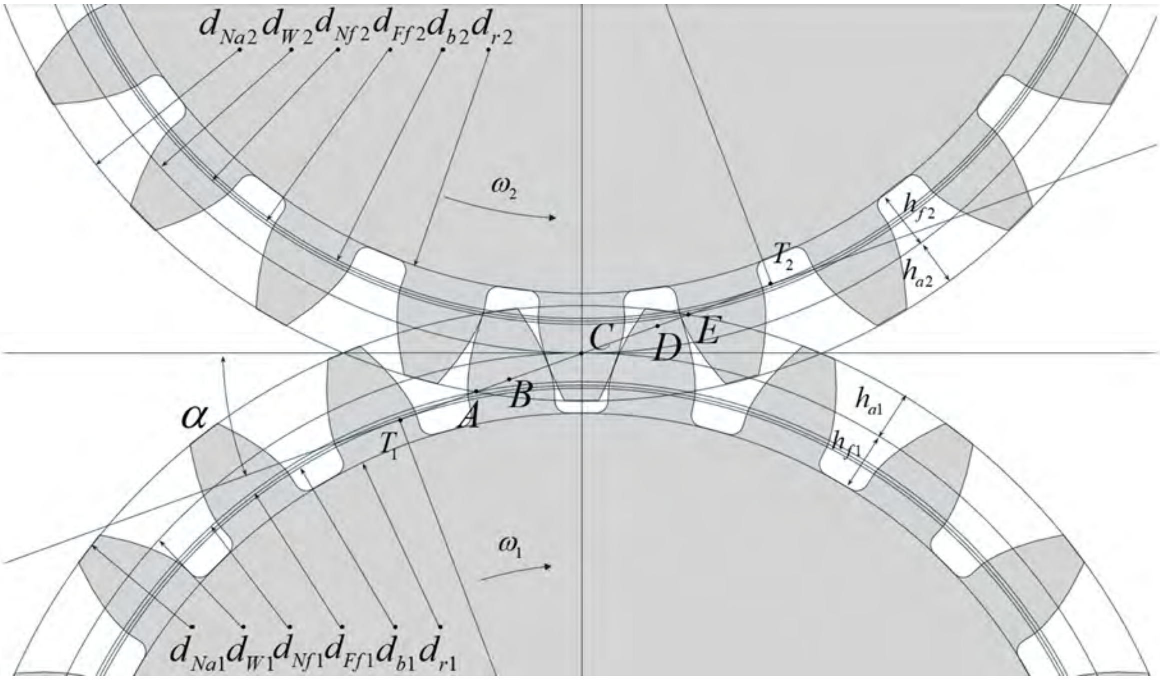

Figure 1—Gears parameters.

Parameter	Name	Parameter	Name
Sum of nominal center distances	Σ_a	Addendum factor gear i	$h_{a,i}$
Design pressure angle i–j	α_{ij}	Facewidth gear i	b_i
Nominal diameter gear 1	d_1	Input speed gear 1	n_1
Number of teeth gear 1	z_1	Input power	P_{in}
Nominal diameter gear 3 (compound)	d_3	Target transmission ratio	tau
Number of teeth gear 3 (compound)	z_3	Lubrication oil	μ, ρ
Profile shift factor gear i	x_i	Gear Material	E, σ
Dedendum factor gear i	$h_{f,i}$	Shafts position	(X_s, Y_s)

Table 1—List of the design variables.

Design Objective Function

The objective functions considered in this work are geartrain efficiency and total weight, aiming to design a transmission that maximizes efficiency while minimizing mass.

Geartrain Efficiency

Power losses in gearboxes arise from various mechanical sources (Ref. 19). In this study, only the gear-related losses are taken into account, which are generally classified into load-dependent and load-independent components. To calculate the total power loss, the following expression is adopted:

$$P_V = P_{VZP} + P_W \tag{1}$$

where P_{VZP} represents the load-dependent sliding losses, while P_W, accounts for load-independent windage losses.

According to the Ohlendorf-Niemann model (Ref. 12), the sliding power loss can be expressed as follows:

$$P_{VZP} = \mu_m H_v P_{in} \tag{2}$$

where P_{in} is the input power, μ_m is the mean coefficient of friction, and H_V is a dimensionless factor that depends on spur gear pair geometry (number of teeth z and helix angle evaluated at the base circle β_b) and contact ratios (overall transversal ε_α and access and recess transversal ε_1 and ε_2), given by:

$$H_V = (1+\tau)\frac{\pi}{z_1}\frac{1}{\cos(\beta_b)}(1-\varepsilon_a+\varepsilon_1^2+\varepsilon_2^2) \tag{3}$$

The mean coefficient of friction μ_m is a function of the normal tooth force, face width, the sum of pitch-line velocities, the rolling radius, and lubricant properties. It is calculated using the Niemann semi-empirical formulation:

$$\mu_m = 0.045\left(\frac{K_A F_{bt}}{b v_{\Sigma m}\rho_m}\right)^{0.2}\eta^{-0.05}X_R \leq 0.2 \tag{4}$$

where F_{bt} is the force exchanged in the tangential plane, b is the face width, $v_{\Sigma m}$ represents the rolling speed, ρ_m is the rolling radius, and η the oil dynamic viscosity at operating temperature. The correction coefficient X_R can be computed as:

$$X_R = 3.8\left(\frac{R_a}{d \cdot 10^3}\right)^{0.25} \tag{5}$$

and depends on the gear diameter d and surface roughness R_a.

Windage losses are relevant in high-speed applications such as EV drivetrains and are evaluated using the semi-empirical model by Anderson and Lowenthal (Ref. 13). The model estimates aerodynamic drag due to gear rotation in a lubricated air-oil mixture environment. Losses are computed as a function of gear dimensions, rotational speed, and fluid properties, as follows:

$$P_w = C_3\left(1+2.3\frac{b}{r}\right)n^{2.8}r^{4.6}(0.028\eta + C_4)^{0.2} \tag{6}$$

where C_3=2.82e-7,C_4=0.019 in SI units, while r is the pitch diameter, b is the gear's width, n is the rotational speed and η is the oil dynamic viscosity.

Geartrain Weight

The overall volume of the system is approximated as the sum of the volumes of each gear. Rather than modeling each gear tooth explicitly, the gear is represented as a disk with an outer diameter equal to the pitch diameter and an inner diameter corresponding to the defined bore. In this simplified approach, the volume of each gear is computed as the product of its cross-sectional area and face width. The total weight of the transmission can be calculated as:

$$W = \rho_{steel} V = \left(7.8e3 \frac{kg}{m^3}\right)\left(\sum_{i=1}^{n\ gears} \pi b_i \left(\left(\frac{m_i z_i}{2}\right)^2 - r_{bore}^2\right)\right) \quad (7)$$

This assumption reasonably approximates the bulk geometry while greatly decreasing computational effort.

Design Constraints

The constraints applied in this study are divided into three categories: geometric, layout, and safety constraints. Geometric constraints relate to the dimensions and form of individual gears and ensure the feasibility of each gear stage. Layout constraints address spatial and positional relationships between multiple gear stages, maintaining compatibility within the overall transmission architecture and satisfying specific requirements. Safety constraints concern the strength of the gears and are assessed through ISO standardized safety factors. All the implemented constraints are summarized and collected in Table 2.

Safety Constraints

The root and flank safety factors are the ratios between the modified value of allowable bending, σ_{at} , and contact, σ_{ac} , and the calculated bending (σ_t) and contact (σ_c) stress, as shown in Equations 8 and 9. The modification or service factors are Y_N stress cycle factor for bending strength, which is imposed 0.7 for idler and 1 for simple gears, Y_ϑ temperature factor, Y_Z reliability factor, Z_N stress cycle factor for contact stress and C_H hardness ratio factor for contact stress.

$$S_F = \frac{\sigma_{at} Y_N}{\sigma_t Y_\vartheta Y_Z} \geq S_{F,min} \quad (8)$$

$$S_H = \frac{\sigma_{ac} Z_N C_H}{\sigma_c Y_\vartheta Y_Z} \geq S_{H,min} \quad (9)$$

The calculation of bending stress v_t and contact stress v_c, as well as the corresponding unmodified allowable stress values, follow the procedures outlined in ISO 6336 (Ref. 14). These values are derived based on the applied tangential load, gear tooth geometry, and material properties.

Geometric Constraints

As shown in Table 2, geometric constraints are the most numerous and cover many aspects. Constraints on gear size can be enforced by setting bounds on the tip or dedendum diameters, ensuring sufficient manufacturability, or accommodating the presence of other surrounding components. Additionally, several constraints are imposed on meshing geometry. First, through the *KISSsoft* COM interface, it is possible to verify whether the gear pair defined by the design variables results in a consistent meshing configuration. Once consistency is ensured, safety margins can be applied to critical meshing parameters, many of which are sensitive to the defined tolerances. In this context, each parameter's lower or upper bound is used as a constraint to minimize or maximize. Geometric constraints of this type include minimum tip clearance, minimum interference reserve, minimum normal tooth thickness at tip, minimum transverse contact ratio, and maximum sliding velocity at tip.

Constraint	Type	Formula
Transmission consistency	Geometric	$consistency$=1
Maximum tip diameter of gear i	Geometric	$d_{a,i} < d_{max,i}$
Minimum root diameter gear i	Geometric	$d_{f,i} > d_{min,i}$
Minimum tip clearance	Geometric	$min(c_{min,i-j}) > c_{min}$
Minimum interference reserve	Geometric	$min(cF_{min,i-j}) > cF_{min}$
Minimum normal tooth thickness at tip	Geometric	$min(san_{min,i}) > san_{min}$
Minimum geometric contact ratio	Geometric	$min(\varepsilon_{\alpha,i-j}) > \varepsilon_{\alpha,min}$
Maximum sliding velocity at tip	Geometric	$min(v_{sl,tip,i}) < v_{sl,tip,max}$
Gear j axis inside required region	Layout	$C_j = (x_{ji}, y_{ji}) \in surf$
Target total transmission ratio	Layout	$\lvert \tau_{tot} - \tau_{req} \rvert \leq \Delta\tau_{max}$
Coprime number of teeth	Layout	$\bigcup_{i,j}^{n\ stage} MCD(z_i, z_j) = 1$
Root safety factor	Safety	$min(S_{F,i}) > S_{F,min}$
Flank safety factor	Safety	$min(S_{H,i}) > S_{H,min}$

Table 2—List of constraints implemented.

Layout Constraints

The final category of constraints concerns the overall geartrain architecture and its layout. The first constraint is the total transmission ratio between the input and output shafts, because the optimal design must preserve this ratio within a specified tolerance range around the target value. The second layout constraint involves the location of intermediate gears. Due to positioning or packaging requirements, it may be necessary for the projection of the center axis of an idler gear or a compound shaft to lie within a prescribed area. This admissible region is algorithmically defined as the union or intersection of circular zones or closed polygons. This method allows for an efficient geometric check to determine whether the projected axis lies inside or outside the specified region. Finally, a constructive constraint, which is often overlooked, has also been implemented regarding the number of teeth of meshing gears. They must be coprime, ensuring smooth transmission without common divisors that could lead to repeated contact patterns. In this way, homogeneous wear in each tooth will be ensured.

Optimization Process

After defining the problem, i.e., the design variables and their boundaries, the constraints, and the objective functions to be maximized or minimized, the optimization phase is carried out. The NSGA-II (Ref. 10) genetic algorithm was selected due to its efficient non-dominated sorting capabilities and its ability to populate the Pareto front uniformly. The Pareto front represents the set of optimal trade-off solutions in which no objective can be improved without degrading at least one other; in this context, it allows a direct comparison of different design alternatives balancing efficiency and weight. For each of the selected objective functions, it is good practice to perform separate single-objective optimizations in order to understand the evolution of the design solutions and assess the algorithm's performance with respect to the chosen design space and constraints. Subsequently, multi-objective optimization is performed to determine the Pareto front of non-dominated designs. In all cases, the optimization process follows the algorithm illustrated in Figure 2.

The process begins with an initial population generated using the Uniform Latin Hypercube (ULH) sampling method, which ensures a well-distributed set of design seeds. This method promotes uniform coverage of the design space, minimizes induced correlation among design variables, and maximizes the distance between sampled points. In the evaluation phase, each individual design is assessed by computing the values of the objective functions and constraint-related parameters. Once the entire population has been evaluated, the algorithm ranks the solutions based on objective values and constraint satisfaction. Specifically, feasible solutions are ranked according to Pareto dominance; feasible designs are always prioritized over unfeasible ones, and unfeasible solutions are ordered based on the number of violated constraints, with those violating fewer constraints ranked higher. Suppose the current generation count is less than the predefined maximum. In that case, parent designs are

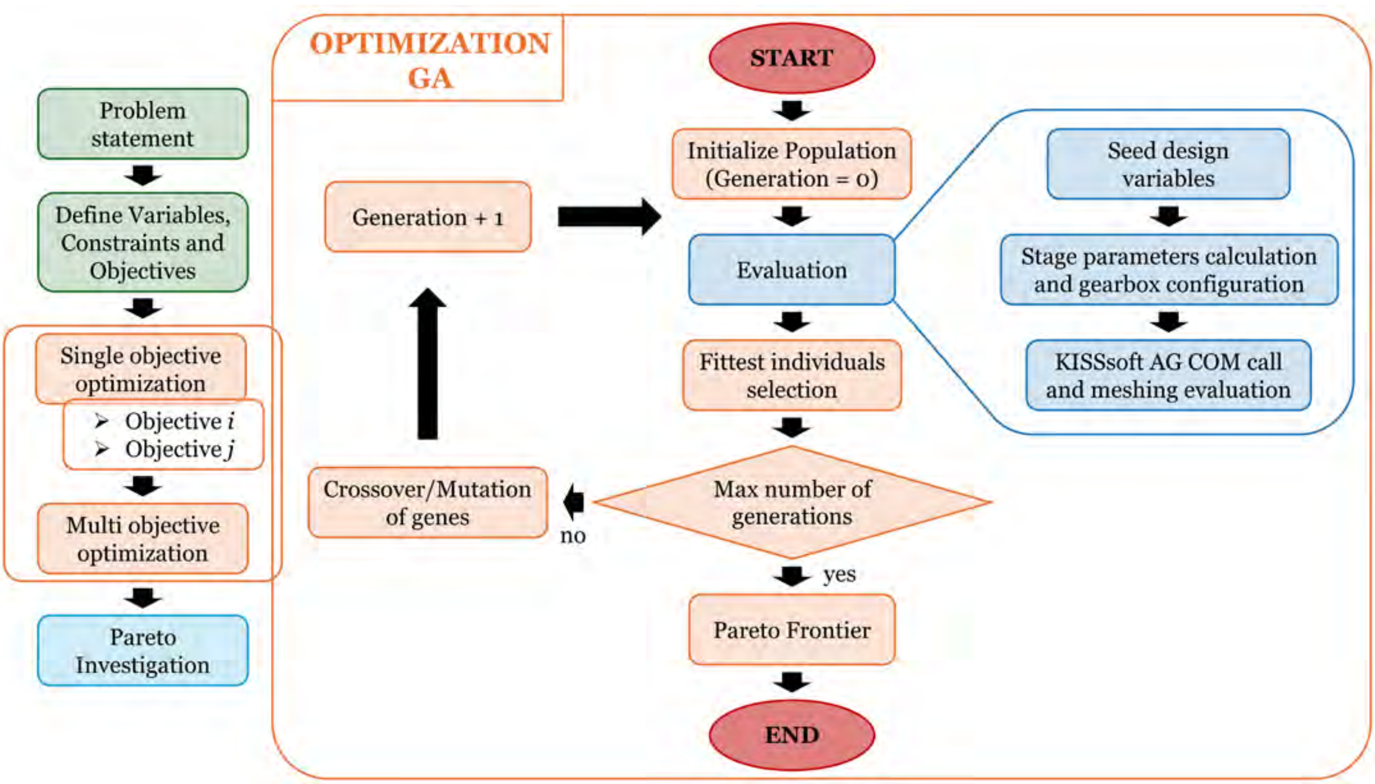

Figure 2—Optimized design procedure.

selected and used to create the remaining individuals of the new population by applying crossover and mutation of parents' genes according to predefined probabilities. At the end of this heuristic process, a total of *N* populations times *M* individuals will have been evaluated. Considering only feasible designs, the process yields either the Pareto front (in the multi-objective case) or the single optimal individual (in the single-objective case). For the geartrain design process considered in this work, the evaluation process consists of several steps implemented in Python, utilizing the *KISSsoft* COM interface. Starting from the design variables described in the section "Multi-Stage Gearbox Transmission System and Design Variables" and listed in the corresponding Table 3, the total transmission ratio, the pitch diameter, and the number of teeth of one gear per stage level, and the sum of nominal center distances are used to determine the gear modules and the number of teeth on the intermediate gears. By including the profile shift coefficients, the actual operating center distances for each stage are computed, allowing the whole layout of the transmission to be determined, given the fixed positions of the input and output shafts. In the case of the idler gear, its module and pressure angle are inherited from the mating gears, while its number of teeth is determined by the selected module and the center distances imposed by the layout. The feasible design range is thus defined by the spatial constraints set for the gearbox and the meshing conditions with both adjacent gears, while the remaining design parameters (e.g., profile factors) and constraints are selected within the same boundaries defined for all gears in the geartrain. To reduce computational cost, the layout calculation employs Erone's formula, which enables the determination of a triangle's area based solely on the lengths of its three sides. This allows for positioning all gears in the geartrain and, if requested, verifying that their centers fall within the specified spatial constraints. The operating center distances and all geometric parameters are then passed through the COM interface to *KISSsoft,* where root radii are computed, tolerances are applied, and all gear meshes in the transmission are analyzed under the specified input power and rotational speed. In particular, sliding power losses (evaluated as described in the "Design Objective Functions" section), safety factors, and meshing consistency are computed to assess the feasibility of the design. Finally, considering the established bore radius of each gear body, the volume and resulting mass of all gears in the transmission are calculated. Windage losses are estimated using the model proposed by Anderson and Lowenthal, and the total transmission efficiency is then obtained.

Case Studies

The methodology discussed in the previous chapters was applied to a case study based on a two-stage transmission layout previously presented in the literature (Refs. 20, 21), configured with an idler gear and gears' tooth numbers of 94-55-38, as well as operating pressure angles of 21.22 degrees and 21.02 degrees. The corresponding baseline compound configuration was defined by maintaining the same overall transmission ratio and keeping the positions of the input and output shafts unchanged. Figure 3 illustrates both baseline configurations, distinguishing the idler geartrain case from the equivalent compound layout. In fuchsia, the required domain for the intermediate gear center is shown. Starting from the initial layouts, the total gear ratio of the two-stage transmission was computed, along with the positions of the input and output gears. As previously described, these three quantities are treated as fixed parameters in the optimization process to identify the gear set's optimal layout and macro-geometry. The optimization process considers an operating condition characterized by a power input, P_{in}, and a rotational speed at the input shaft, n_1.

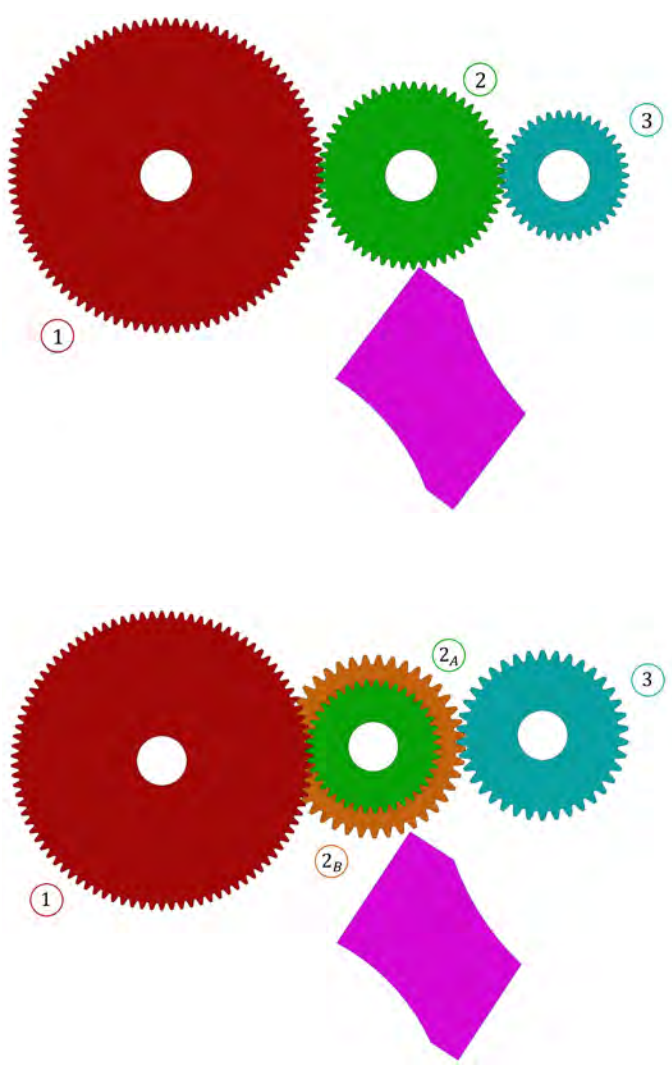

Figure 3—Baseline geartrain designs. On the top, the architecture with idler gears; on the bottom, the architecture with the compound shaft.

Parameter	Name	Value	Minimum	Maximum	Unit
Sum of nominal center distances	Σ_a	-	152.5	322	mm
Design pressure angle i–j	α_{ij}	-	18	27	°
Nominal diameter gear 1	d_1	-	75	180	mm
Number of teeth gear 1	z_1	-	30	250	-
Nominal diameter gear 3 (compound)	d_3	-	30	120	mm
Number of teeth gear 3 (compound)	z_3	-	20	100	-
Profile shift factor gear i	x_i	-	0	0.6	-
Dedendum factor gear i	$h_{f,i}$	-	0.7	1.4	-
Addendum factor gear i	$h_{a,i}$	-	0.6	1.3	-
Facewidth gear i	b_i	-	5	20	mm
Input speed gear 1	n_1	5000	-	-	rpm
Input power	P_{in}	125	-	-	kW
Target transmission ratio	tau	2.474	-	-	-
Lubrication oil	ISO-VG 220				
Gear Material	Grade 2, AGMA Steel, HRC58-64, case-hardened				
Shafts position	(0,0); (152.3,0)				

Table 3—List of the design variables adopted.

The optimization variables and their corresponding boundaries are defined based on the methodology described earlier.

Hence, limits on the input gear diameters are determined by maximum space constraints and, on the lower end, by design limitations due to the presence of other components or manufacturing constraints. Once the diameter bounds are selected, the corresponding gear tooth numbers are derived such that the gear modules for both meshing pairs fall within the range of 0.3 to 6 mm. All variables, their respective limits, and the fixed parameters for the optimization are listed in Table 3 for both configurations considered in the case study.

The constraints considered were previously discussed and are summarized in Table 4 below for the specific cases examined. In particular, as for the layout constraint, it is required that the center of the idler gear (or compound shaft) lies within the feasible domain illustrated in fuchsia in Figure 3.

The NSGA-II algorithm was run for 40 generations, starting from a population of 60 seeds, thus, 2400 evaluations. The algorithm was configured with a crossover probability of 90 percent and a mutation probability of 100 percent, incorporating controlled elitism to enhance the exploration of the design space and improve the uniformity of the solution distribution. Under these settings, the optimization process required approximately 2 hours on a 4.00 GHz multicore workstation (AMD Ryzen 9 8945HS).

Constraint	Formula
Transmission consistency	$consistency = 1$
Target total transmission ratio	$\lvert \tau - \tau_{req} \rvert = \left\lvert \frac{z_1}{z_{2A}} \frac{z_{2B}}{z_3} - 2.474 \right\rvert \leq 0.02$
Root safety factor	$min(S_{F,1}, S_{F,2A}, S_{F,2B}, S_{F,3}) > 1.2$
Flank safety factor	$min(S_{H,1}, S_{H,2A}, S_{H,2B}, S_{H,3}) > 1$
Maximum tip diameter of gear 1	$d_{a,1} < 180$
Minimum root diameter of gear 1	$d_{f,1} > 78$
Minimum root diameter gear 3	$d_{f,3} > 30$
Minimum tip clearance	$min(c_{min,12A}, c_{min,2B3}) > 0.5$
Minimum interference reserve	$min(cF_{min,12A}, cF_{min,2B3}) > 0.25$
Minimum normal tooth thickness at tip	$min(san_{min,1}, san_{min,2A}, san_{min,2B}, san_{min,3}) > 1$
Gear 2 axis inside required region	$C_2 = (x_{2i}, y_{2i}) \in surf$
Coprime number of teeth	$[MCD(z_1, z_{2A})] \cup [MCD(z_{2B}, z_3)] = 1$
Minimum geometric contact ratio	$min(\varepsilon_{\alpha,12A}, \varepsilon_{\alpha,2B3}) > 1.2$
Maximum sliding velocity at tip	$max(v_{sl,tip,1}, v_{sl,tip,2A}, v_{sl,tip,2B}, v_{sl,tip,3}) < 22\ m/s$

Table 4—List of constraints adopted in the case study.

Results and Discussion

The results of the multi-objective optimizations for the two configurations are presented in Figure 4 and Figure 5, for the idler gear configuration and the compound gear configuration, respectively. The central scatter plots in each figure display the evaluated designs in the total transmission efficiency versus weight space. In these plots, feasible solutions, thus those that do not violate any constraints, are highlighted in green, while unfeasible ones are shown in orange. Additionally, non-dominated solutions forming the first Pareto fronts are highlighted in blue and red, respectively. Across the entire optimization process, approximately 64 percent of the evaluated candidates were discarded because they had violated at least one manufacturing/design constraint. Considering individual constraints, tooth interference reserve was violated in 29 percent of the designs, insufficient clearance in 27 percent, minimum tooth tip thickness in 39 percent, and minimum contact ratio in 25 percent. These violation rates, being of relevant magnitude, highlight the importance of considering these constraints, as each has a significant impact on shaping and characterizing the feasible design space throughout the optimization process. In both figures, the designs with the highest efficiency are depicted on the right side of the scatter plots, while those with the lowest weight are presented on the left. These correspond to, or closely approximate, the results obtained from the single-objective optimizations aimed at individually maximizing or minimizing the two objectives. In addition to the three or four gears constituting the transmission, the figures depict, in red, the center distances between meshing gears and, in gray, the feasible region where the trace of the intermediate shaft axis must be located. The solid gray line defines the boundary within which this axis must reside. In contrast, the dashed gray lines represent the regions from which the axis must be excluded, in this case, two limiting circles. Considering both the designs of Figures 4 and 5 while also taking into account the trends of Figures 6 and 7, it is evident in both cases that, in order to reduce power losses due to sliding and thereby improve efficiency, the optimization algorithm tends to evolve toward solutions featuring a high number of teeth (see legends) and low modules. However, such evolution requires higher pressure angles and wider face widths to ensure adequate strength. These solutions, which are shown on the right side of each figure, are generally less compact and significantly heavier due to larger pitch diameters and gear widths. Conversely, the low-weight configurations are characterized by taller teeth, i.e., a higher module. This allows for stronger teeth, enabling narrower face widths and hence reduced diameters and overall transmission weight.

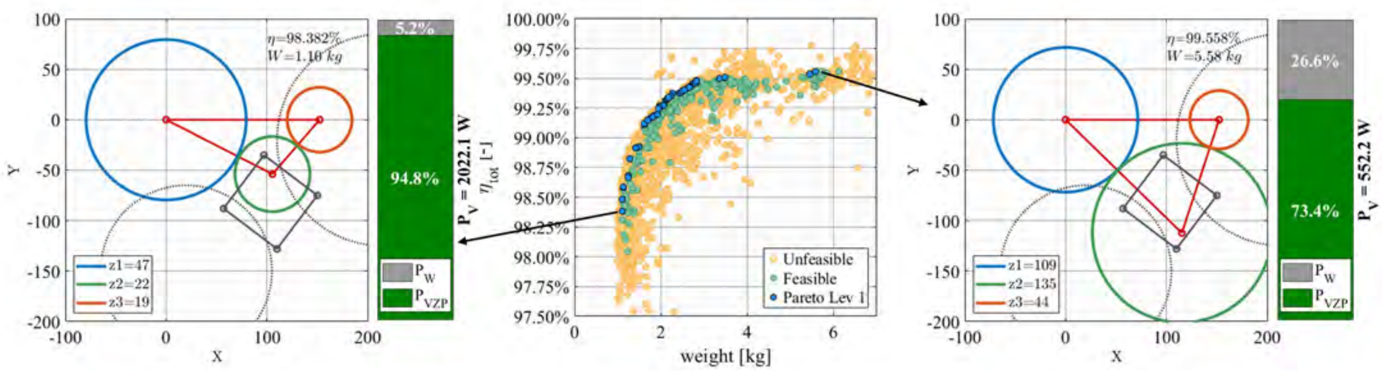

Figure 4—Results of the simple geartrain (idler).

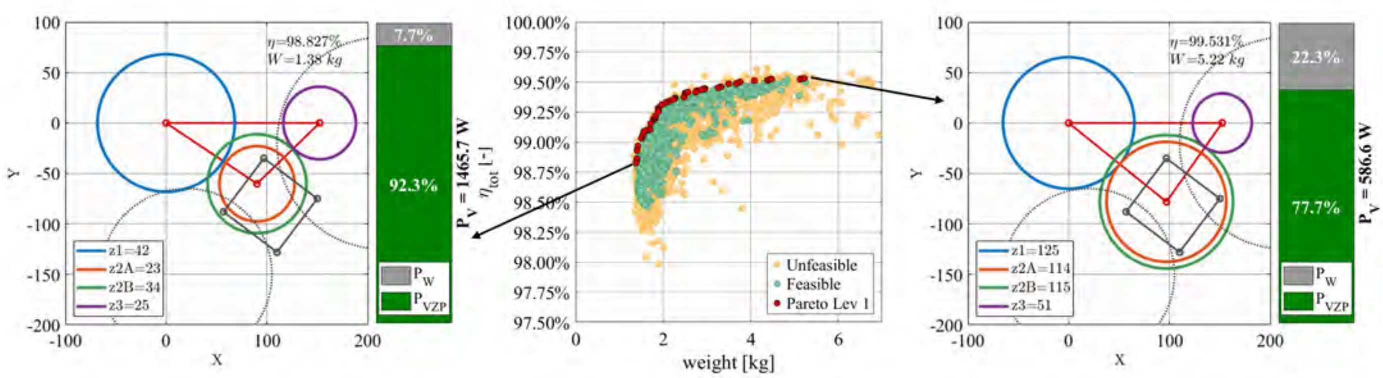

Figure 5—Results of the compound geartrain.

Comparing the results in Figure 4 and Figure 5, it can be observed that, under identical boundary conditions, the algorithm applied to the four-gear compound configuration can more uniformly and effectively populate the Pareto front. In contrast, the optimization applied to the idler gear configuration struggles to develop a well-defined front. This effect is partly due to the higher constraint violation rate in the idler case (77.62 percent of generated designs), primarily caused by simultaneous meshing conditions that increase interference reserve and clearance conflicts. Consequently, under the same number of evaluations, the algorithm finds it more challenging to generate feasible solutions. Finally, comparing the solutions presented on the Pareto front, both configurations exhibit similar efficiency levels. The constraints established in the case study enable idler gear solutions to achieve sliding power losses that are comparable to those of the compound configuration, despite requiring more in-plane space. Conversely, the compound configuration requires out-of-plane space and incorporates gear 2B, which results in an increase in windage power loss, aligning it with the idler configuration. Both figures reveal that windage loss along the Pareto front increases its ratio between approximately 5 percent and nearly 30 percent for both configurations. On the other hand, considering the weight objective, the idler configuration benefits from the absence of additional gears, rendering it lighter. However, the difference is not significant because the design flexibility of the compound configuration allows for the use of smaller gear diameters.

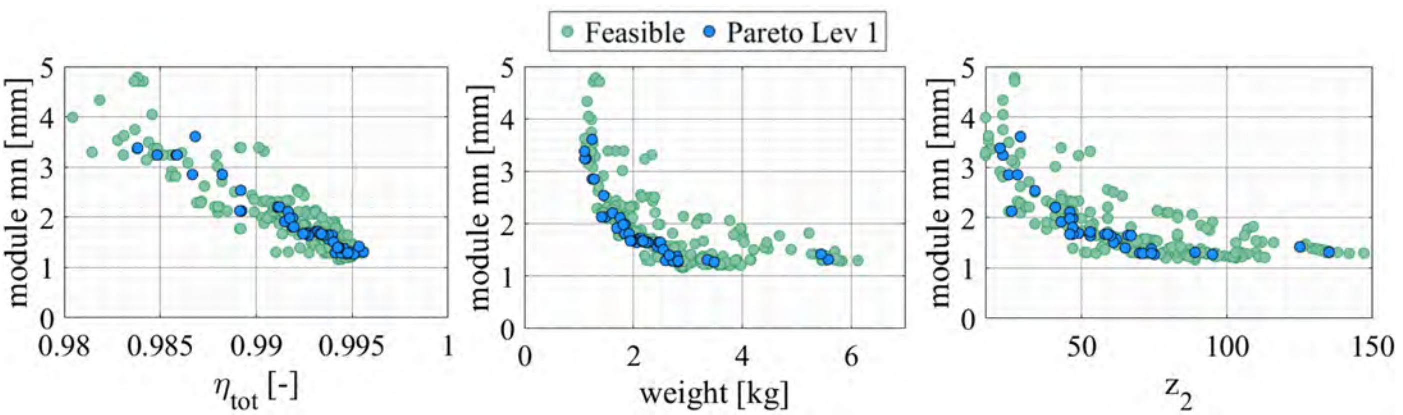

Figure 6—Simple geartrain (idler): correlation between module, idler number of teeth, efficiency, and weight for the feasible designs.

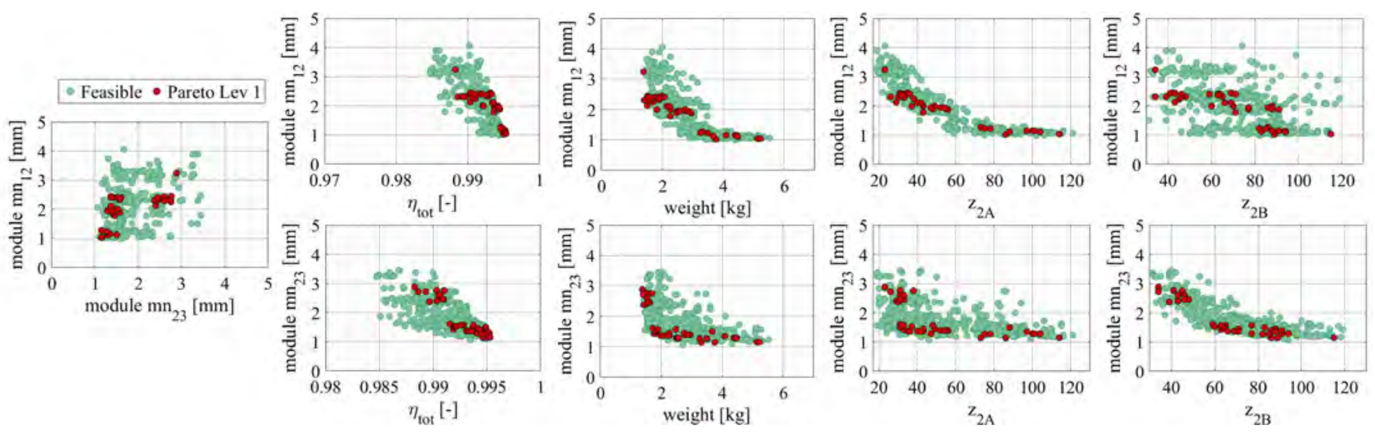

Figure 7—Simple geartrain (idler): correlation between stage modules, compound gears number of teeth, efficiency, and weight for the feasible designs.

Conclusion

This work has presented a performance-driven design procedure for multistage gear transmissions in the context of electric drive systems. With the rise of electric vehicles, gearbox compactness has become increasingly demanding; moreover, high-speed operating conditions demand that such transmissions be designed with a focus on both efficiency and weight, while also obeying system size constraints. The proposed optimization framework applies to both simple and compound geartrains. To enhance domain flexibility, the design variables include the pitch diameters, number of teeth, profile factors, shift coefficients, and the design pressure angle. Thus, ensuring a highly general and explorative design space. The algorithm also enables the explicit consideration of overall layout constraints, including specific positional requirements for intermediate gears. The enforcement of coprime gear tooth numbers, along with the incorporation of manufacturing tolerances and industrially relevant geometric constraints, guarantees that the resulting Pareto designs are not only theoretically valid but also practically feasible. Furthermore, the integration of *KISSsoft* through its COM interface guarantees result reproducibility and the level of formality expected in industrial contexts. For these reasons, the methodology is a valuable support tool for practical geartrain design, providing a more systematic alternative to traditional design of experiments (DOE) and trial-and-error approaches. Moreover, it allows for the formal integration of mathematically defined design constraints with best practices that experienced designers frequently use. The proposed procedure has been applied to a case study, in which Pareto-optimal designs were obtained for both a simple and a compound two-stage geartrain, given fixed positions for the input and output shafts and a prescribed overall transmission ratio. The results indicate that the compound configuration offers greater flexibility, allowing for a more comprehensive exploration of the feasible design space and, thus, a denser population of the Pareto front with the same number of algorithm iterations. While this work focused on mapping and populating the Pareto front, an important next step is the integration of decision-making techniques to guide the selection of a single preferred design according to application-specific priorities. Methods such as the linear programming technique for multidimensional analysis of preference (LINMAP), the technique for order of preference by similarity to ideal solution (TOPSIS), or fuzzy-logic-based robust ranking approaches could be employed to systematically evaluate the trade-offs between competing objectives, thus prioritizing efficiency over weight or balancing both for a specific duty cycle. This decision-making stage could be coupled with application-dependent definitions of design life and safety factors, possibly derived from load spectrum-based analyses such as the rainflow method (Ref. 22). Moreover, cost and manufacturability aspects could be explored, for example, when non-standard addendum/dedendum coefficients or pressure angles are involved, and discrete optimization with standardized gear profiles could be investigated to simplify production without significantly reducing performance. Additionally, new constraints could be implemented to consider the actual dimensions of the gear bodies, rather than just focusing on the axis projections, and to link gears across different stages, which would help prevent potential interference between shafts in compound configurations. Finally, it would be advantageous to validate the results using the contact-based loss and strength models provided by *KISSsoft*, assessing its computational effort and identifying any deviations from the current modeling approach.

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References

1. E. Esmail , E. Pennestrì and M. Cirelli, "Power-flow and mechanical efficiency computation in two-degrees-of-freedom planetary gear units: New compact formulas," *Applied Sciences,* Vol. 11, No. 13, p. 5991, 2021.
2. M. Autiero, M. Cirelli, G. Paoli and P. P. Valentini, " Data-Driven Approach to Estimate the Power Loss and Thermal Behaviour of Cylindrical Gearboxes under Transient Operating Conditions," *Lubricants,* Vol. 11, No. 7, p. 303, 2023.
3. S.-c. Kim, S.-g. Moon, J.-h. Sohn, Y.-j. Park, C.-h. Choi and G.-h. Lee, "Macro geometry optimization of a helical gear pair for mass, efficiency, and transmission error," *Mechanism and Machine Theory,* Vol. 144, p. 103634, 2020.
4. E. Ben Younes, C. Changenet, J. Bruy, E. Rigaud and J. Perret-Liaudet, "Multi-objective optimization of gear unit design to improve efficiency and transmission error," *Mechanism and Machine Theory,* Vol. 167, p. 104499, 2022.
5. D. Miler, D. Žeželj, A. Lončar and K. Vučković, "Multi-objective spur gear pair optimization focused on volume and efficiency," *Mechanism and Machine Theory,* Vol. 125, pp. 185–195, 2018.
6. M. Patil, P. Ramkumar and K. Shankar, "Multi-objective optimization of the two-stage helical gearbox with tribological constraints," *Mechanism and Machine Theory,* Vol. 138, pp. 38–57, 2019.
7. L. Cianciotta, M. Cirelli and P. P. Valentini, "Multi-Objective Optimization of Gear Design of E-Axles to Improve Noise Emission and Load Distribution," *Machines,* Vol. 13, p. 330, 2025.
8. S. Sundaresan, K. Ishii, and D. R. Houser, "A Procedure Using Manufacturing Variance to Design Gears with Minimum Transmission Error," *ASME. J. Mech. Des.*, Vol. 113, No. 3, pp. 318–324, 1991.
9. D. R. Houser and J. Harianto, "Design robustness and its effect on transmission error and other design parameters," *Gear Technology,* Vol. 20, No. 2, pp. 18–25, 2003.
10. K. Deb, A. Pratap, S. Agarwal and T. Meyarivan, "A fast and elitist multiobjective genetic algorithm: NSGA-II," *IEEE Transactions on Evolutionary Computation,* Vol. 6, No. 2, pp. 182–197, 2002.
11. KISSsoft AG, KISSsoft *User Manual,* Bubikon, Switzerland.
12. G. Niemann and H. Winter, *Maschinenelemente, Band 2,* Berlin: Springer, 1983.
13. N. E. Anderson and S. H. Loewenthal, "Effect of Geometry and Operating Conditions on Spur Gear System Power Loss," *Journal of Mechanical Design,* Vol. 103, pp. 151–159, 1981.
14. International Organization for Standardization, "ISO 6336: Calculation of load capacity of spur and helical gears–Part 1,2,3,5," Berlin, 2019.
15. Artoni, "A methodology for simulation-based, multiobjective gear design optimization," *Mechanism and Machine Theory,* Vol. 133, pp. 95–111, 2019.
16. K. Deb e S. Jain, "Multi-Speed Gearbox Design Using Multi-Objective Evolutionary Algorithms," *J. Mech. Des.,* Vol. 125, No. 3, pp. 609–619, 2003.
17. L. D'Angelo, M. Cirelli, O. Giannini and P. P. Valentini, "Fuzzy logic assessment of epistemic uncertainties in pseudo-rigid multibody gear models," *Proceedings of ISMA 2024–International Conference on Noise and Vibration Engineering and USD 2024–International Conference on Uncertainty in Structural Dynamics,* Vol. Leuven, pp. 4276–4290, 2024.
18. International Organization for Standardization, "ISO 21771-1:2024 Cylindrical involute gears and gear pairs Part 1: Concepts and geometry."
19. C. M. Fernandes, P. M. Marques, R. C. Martins and J. H. Seabra, "Gearbox power loss. Part II: Friction losses in gears," *Tribology International,* Vol. 88, pp. 309–316, 2015.
20. G. Liu and R. G. Parker, "Dynamic modeling and analysis of tooth profile modification for multimesh gear vibration," *Journal of Mechanical Design,* Vol. 130, No. 12, pp. 1214021–12140213, 2008.
21. G. Liu and R. G. Parker, "Nonlinear dynamics of idler gear systems," *Nonlinear Dynamics,* Vol. 53, No. 4, pp. 345–367, September 2008.
22. U. Kissling, "Use of duty cycles or measured torque-time data with AGMA ratings," 21FTM07: Fall Technical Meeting, pp. 48–54, 2021.

REGAL REXNORD
Announces Aamir Paul as Next CEO

Regal Rexnord Corporation recently announced that its board of directors has appointed Aamir Paul to serve as chief executive officer (CEO) commencing no later than July 1, 2026, upon the conclusion of his responsibilities with his current employer, Schneider Electric SE. The board has also determined that Paul will serve as a member of the board of directors effective upon the commencement of his employment with the company, with an initial term continuing until the company's 2027 Annual Meeting of Shareholders.

Aamir Paul

As previously disclosed on October 29, 2025, the board initiated a comprehensive search to identify a successor to current CEO, Louis Pinkham. To help ensure continuity and a smooth leadership transition, Pinkham will remain CEO until Paul's start date, at which time Paul will succeed him. Pinkham will also resign from the board of directors effective on his last day as CEO.

Paul, age 48, is a recognized leader with deep global experience across sales, strategy, and operations management having lived and worked in Europe and the U.S. He joins Regal Rexnord from Schneider Electric, a leading global energy management and automation company, where he serves as president of North America. Paul took over the North America business in 2022, at which time he also joined the executive committee, and proceeded to grow the business at double digit rates through 2025. In 2025, the business generated over $17 billion (USD) in revenue, employed over 43,000 people, and ran over 35 manufacturing facilities.

Paul joined Schneider Electric in 2013 and, during his tenure, held multiple senior leadership roles of increasing responsibility across sales, business operations, and commercial execution. Prior to Schneider Electric, Paul spent over 13 years at Dell Technologies in sales roles with increasing seniority, ultimately serving as senior vice president, global server solutions sales, where he led Dell's worldwide go-to-market strategy for servers and oversaw global sales for Data Center Solutions and High-Performance Computing.

"After a comprehensive search, the board concluded that Aamir is an exceptional leader who is well-prepared to guide Regal Rexnord through its next phase of growth" said Rakesh Sachdev, non-executive chairman of Regal Rexnord's board of directors. "The board is excited about many aspects of Aamir's background, but in particular, his long track record driving growth across complex global businesses, his commitment to building strong teams and developing talent, his ability to foster an innovation culture, and his deep experience in the core strategic Regal Rexnord growth markets, including data center and discrete automation. He also brings a strong appreciation for how leadership in energy efficiency and sustainability creates long-term value for a company's key stakeholders."

Sachdev continued, "On behalf of the Board, I want to again thank Louis Pinkham for his outstanding leadership and many contributions to Regal Rexnord. Part of Louis's enduring legacy will be the strength of Regal Rexnord's values, talent, and transformed portfolio, which we believe position the Company well for continued success. We wish him the very best in his future endeavors."

Added Paul, "As I have come to know Regal Rexnord, I have become increasingly excited about the tremendous growth potential of the Company's portfolio, its unique scale and scope, and its market-leading technologies. I look forward to further capitalizing on Regal's 80/20 operating philosophy to drive continued focus, execution, and value creation across the enterprise. I am eager to work with the talented team at Regal Rexnord and leverage my commercial and operational experience to help ensure the Company maximizes its full potential for its customers, its people, and its shareholders."

Paul holds a B.S. in chemical engineering from Northwestern University and has completed advanced management studies at The University of Chicago Booth School of Business and INSEAD. He serves as a board member of USG Corporation, a privately held manufacturer of building materials and innovative solutions. He is also actively involved in industry and civic leadership, serving on the boards of organizations including the National Association of Manufacturers (NAM), the National Electrical Manufacturers Association (NEMA), the National Association of Electrical Distributors, and the Executives' Club of Chicago.

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WEG AND SPINDRIVE
Partner to Deliver Next-Generation Oil-Free Motor Systems with Active Magnetic Bearings

WEG S.A. and SpinDrive has announced a strategic partnership. Unveiled at Hannover Messe 2026, the collaboration will integrate SpinDrive's AMBs and built-in IoT condition monitoring into WEG's electric motor offering, creating an oil-free, maintenance-free drive solution designed for the demands of modern industrial processes.

By combining WEG's global manufacturing footprint and extensive distribution reach with SpinDrive's advanced AMB solution, the partnership paves the way for a new category of electric motors designed for high volume industrial applications. Beyond higher efficiency and reliability, this collaboration directly supports industrial decarbonization by reducing energy losses, eliminating oil systems, and lowering lifecycle emissions. The use of active magnetic bearings enables higher rotational speeds and increased power density, allowing more compact motor designs with a significantly reduced footprint, critical for space constrained and next generation installations. This collaboration positions AMBs as the new standard where efficiency, sustainability, and performance are paramount, while SpinDrive's built in IoT capabilities provide continuous condition and performance monitoring with effectively maintenance free operation.

The partnership aims to serve applications that have oil contamination constraints, machines that work in harsh environments where higher reliability is needed, or stringent efficiency mandates make conventional bearing solutions increasingly difficult to justify. Together, WEG and SpinDrive will support OEMs and industrial end-users across compressors, blowers, turbines, pumps, turbomachinery, and high-speed spindles, among several other applications.

"The partnership with SpinDrive reinforces WEG's strategy to accelerate industrial decarbonization through more efficient and technologically advanced solutions. By combining SpinDrive's expertise in active magnetic bearings with our global electric motor portfolio, we are taking an important step toward increasing energy efficiency, reducing environmental impacts, and supporting our customers on their journey toward more sustainable operations," said Rodrigo Fumo, vice president of industrial motors, WEG.

"Teaming up with WEG is a transformational step for SpinDrive. WEG's leadership and reach, combined with our active magnetic bearing expertise and IoT condition monitoring platform, means we can now bring our technology quickly to hundreds of thousands of motor installations," said Janne Heikkinen, CEO, SpinDrive.

weg.net
spindrive.fi

GENNX360 CAPITAL PARTNERS

Announces Horsburgh & Scott's Acquisition of Franklin Machine & Gear

GenNx360 Capital Partners, a New York-based private equity firm focused on investing in middle-market industrial and business services companies, today announced that its portfolio company, Horsburgh & Scott, has acquired Franklin Machine & Gear, a provider of industrial gear and gearbox repair and replacement services.

H&S, headquartered in Cleveland, Ohio, is one of the leading providers of industrial gearing solutions. Founded in 1886, the company specializes in the design, engineering, manufacturing, and repair of custom gear and gearboxes for heavy industrial applications. H&S serves customers across a wide range of end markets, including steel, mining, energy, marine, and defense, from its facilities in Ohio, Illinois, Louisiana, and Ontario.

Franklin Machine & Gear ("Franklin"), based in Houston, is a family-owned full-service provider of gear and gearbox manufacturing and repair services. Since its founding in 1974, Franklin has been serving customers across various end markets with capabilities that include CNC turning and milling, gearbox rebuilding and repair, bevel gearing, gear hobbing and grinding, and other related services.

Franklin co-owners, Eddy and Larry Franklin, will stay with the combined business along with General Manager, Tom Patton, to continue serving Franklin's customers and driving growth for the combined business.

"We are excited to welcome Franklin Machine & Gear into the Horsburgh & Scott family. Franklin's precision machining and gear manufacturing capabilities are a natural complement to our existing platform, and their strong reputation in the Houston market will help extend our reach into the Gulf Coast region," said Randy Burdick, CEO of Horsburgh & Scott. "We look forward to working with Franklin's talented team as we continue to grow H&S into a comprehensive gearing solutions provider."

"Horsburgh & Scott shares our commitment to quality and customer service, and we are confident that Franklin will thrive as part of their platform. We are excited to continue serving our customers and to contribute to the growth of the combined organization," said Franklin co-owners, Eddy and Larry Franklin.

"H&S's acquisition of Franklin represents an important step in our growth strategy, adding precision machining capabilities and expanding the platform's geographic footprint into the Gulf Coast," said Monty Yort, a Managing Partner at GenNx360. "We are looking forward to continuing to execute upon the H&S growth strategy with Randy and his team."

GenNx360's H&S team includes Lloyd Trotter, Co-Founder; Monty Yort, Managing Partner; Latasha Akoma, Operating Partner; and Miles Oliver, Associate.

Baker Hostetler served as legal counsel to H&S and GenNx360.

horsburgh-scott.com

June 22–25

Automate 2026

Automate (Chicago) is North America's largest robotics and automation event with more than 1,000 exhibitors and 50,000-plus registrants. Topics include robotic automation, vision systems for quality control and inspection, motion control systems, AI and machine learning applications, collaborative robots, and industrial robots. Critical for understanding automation trends and includes comprehensive educational conference with 200-plus sessions. The Automate Conference agenda is designed for flexibility. Areas of interest include automation for beginners, robotics, industries and applications, technology, industrial safety, and beyond the sessions. A new development at the 2026 show is a dedicated Humanoid Robot Pavilion, sponsored by NVIDIA.

powertransmission.com/events/automate-2026

June 25–29

WorldPM2026

The Metal Powder Industries Federation (MPIF) presents the largest global powder metallurgy (PM) and particulate materials event that only happens once every six years in North America. The PM industry will come together with three conferences, the WorldPM2026, AMPM2026 and Tungsten2026, "sintered" into one global event in Montreal. The largest annual North American exhibit will showcase leading suppliers of metal powders, particulate materials, and metal additive manufacturing (AM)/3D printing process equipment, powders and products.

powertransmission.com/events/worldpm2026

June 30–July 1

Dritev 2026

The automotive congress Dritev (DRIvetrain Transmission Electrification Vehicles) offers the powertrain community an optimal platform for exchange. Every year, decision-makers, experts and industry leaders from around the world meet in Baden-Baden, Germany. Here, vehicle manufacturers and suppliers exchange ideas and early capture innovations, developments and challenges in drive technology. During the two-day congress, experts from OEMs, suppliers, and universities present practical lectures on new trends as well as classical topics in drive technology.

powertransmission.com/events/dritev-2026

July 15–July 16

WZL Gear Conference USA

The WZL Gear Conference USA will take place on July 15 and 16, 2026, at Klingelnberg America, Inc. (Saline, MI). This renowned conference brings together North American companies with the Laboratory for Machine Tools and Production Engineering (WZL) at RWTH Aachen University and offers a compact overview of current developments and research topics in gear technology. Participating companies will have the opportunity to network with leading experts, discuss trends, and gain concrete insights to apply in their daily work.

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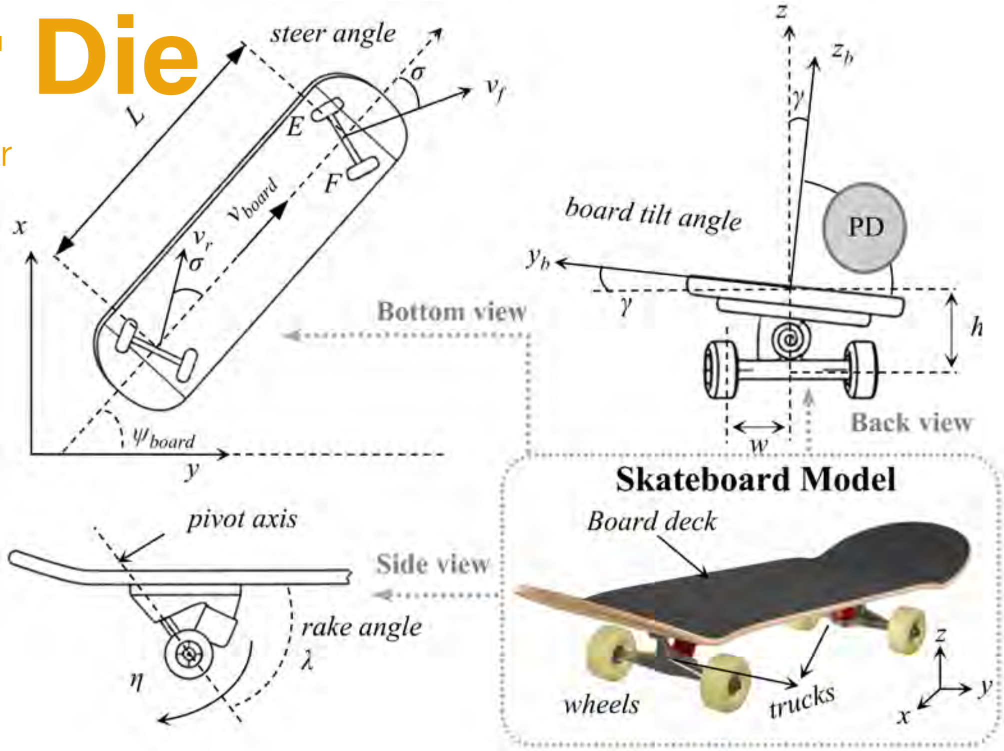
Skate or Die

Aaron Fagan, Senior Editor



Skateboard kinematic model showing the coupling between deck tilt and truck steering. **(Image: HUSKY Project)**

I learned to skateboard in rural New York in the 1980s, when the best trick instructions available were a few photos with brief, inscrutably koan-like captions in the California-based *Thrasher* magazine. What happened between the frames was up to your imagination and tolerance for pain. The phrase "skate or die" held a double meaning—hesitation is how you get hurt, and to ride is to live. But one thing every skater quickly and viscerally encountered—without a vocabulary—was the nature of the mechanics underfoot. There is no motor, steering actuator, throttle, or brakes; it is a small plank of maple plywood bolted to two truck assemblies with wheels, and it does nothing until a body stands on it and begins precarious negotiations with gravity.

This makes the skateboard a peculiar engineering problem. In most robotic locomotion—wheeled, legged, tracked—the robot controls its own actuators directly. Command a motor, get a response. But researchers from China Telecom's TeleAI Institute recently built HUSKY, a Humanoid Skateboarding System via Physics-Aware Whole-Body Control (RSS 2026), that does something fundamentally different. It rides a skateboard. All control authority must pass through a chain of passive, compliant, nonlinear elements the robot cannot modify—only learn to work with.

Consider what happens when a skateboarder turns. The rider shifts weight, tilting the deck. The tilt loads the polyurethane bushings in the truck, which deform progressively and allow the hanger to pivot around the kingpin. The pivot-axis geometry converts that tilt into a coordinated rotation of the axle. The wheels change heading. At no point does anyone command anything. The rider's body is the actuator, the bushing is the compliant element, and the ground reaction at the contact patch is the output—a chain of physics that only responds to forces.

The HUSKY team formalized this as a coupling equation mapping tilt angle to steering angle through the pivot-axis geometry—the foundation of the robot's control strategy. Electric motors driving through reduction gearboxes at the hips, knees, and ankles produce coordinated torques that must travel that same passive chain—rigid links to feet to deck to bushings to contact patches—before anything turns. Every link is a power transmission element. None of them take orders.

So what happens when your actuator and your output are separated by a compliant interface you don't control? The robot cannot stiffen the bushings mid-ride. It cannot change the kingpin angle. It can only generate torque and send it down the chain, trusting physics to deliver. The team characterized each board's compliance by tilting the deck, releasing it, and measuring the free-decay oscillation to extract torsional stiffness and damping—classical vibration analysis applied to a skateboard truck. Get the model wrong and the results are concrete: apply the compliant board's parameters to the stiff board, and the robot cannot even mount, because the real deck refuses to tilt under its step. Reverse the mismatch, and it over-leans and falls.

This is not only a skateboarding problem. It shows up anywhere a drivetrain includes a compliant coupling: steering systems, suspension linkages, soft robotic grippers. The skateboard just makes it elegantly clear because there is no motor at the output end—only physics, gravity, and a bushing that deforms however it's going to deform.

Most of engineering is the pursuit of predictability. A skateboard is a reminder that the more interesting problems begin where predictability ends. The HUSKY robot learned to work with that. So does every kid who steps onto a board for the first time. When I was growing up, some found their first hard fall terrifying and never stepped foot on one again. Others found the terror exhilarating and got right back on. Engineers are likely among the latter, not the former.

husky-humanoid.github.io

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