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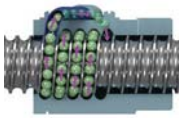

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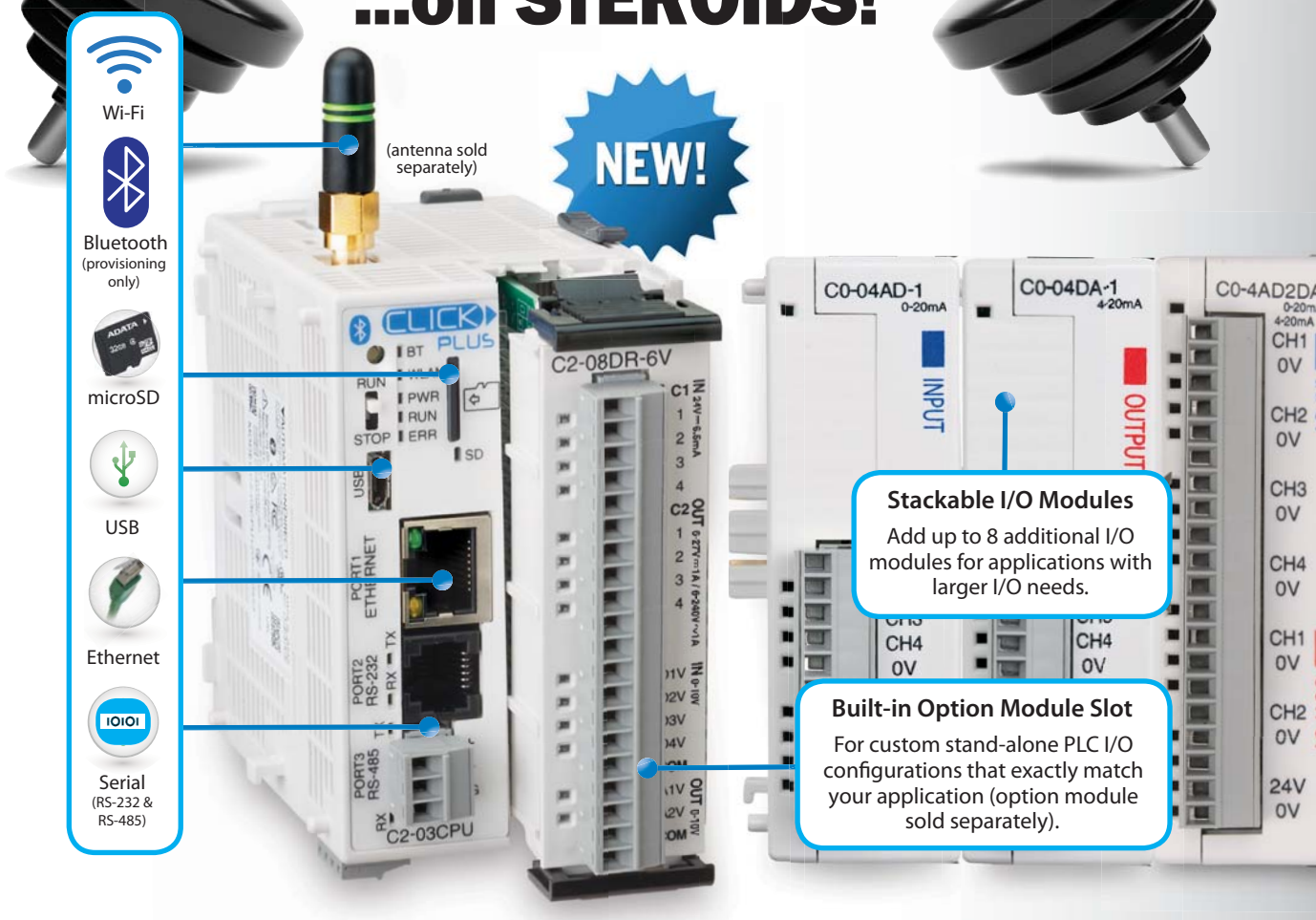

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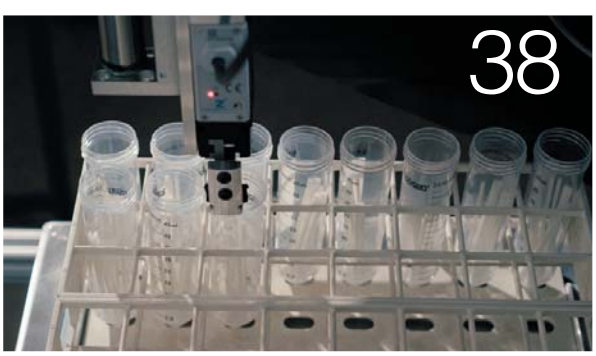

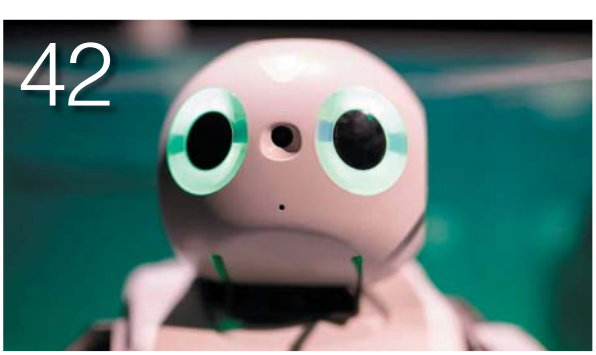

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ANOTHER LOOK

Sensor-Based IoT Platforms Monitor Vaccines at the Frontline

Tracking COVID-19 vaccines is a monumental effort that will go down in history as an exercise in overcoming an epic logistical hurdle. Sensors play a critical role in the vaccine delivery system.

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FROM THE ARCHIVES

Goldilocks' Automation: Not Too Much, Not Too Little

Automation can introduce inflexibility that decreases value and productivity—but too little automation can drive up labor costs.

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Redesigning the DESIGNER'S ROLE

Successful design has historically been the outcome of a trial-and-error approach, but technological advances are changing the rules of the game.

Spencer Silver is not a name you'd know at first glance, but he was partially responsible for one of the most successful products in global history. Silver died last month at the age of 80, and if you need to make a note to yourself to look up his biography, you might use one of his creations to do it.

A 3M chemist and researcher, Silver invented the glue that gave us Post-It Notes. Silver's unique glue composition could be stuck and unstuck repeatedly without harming the surface or losing adhesion. But while an interesting chemical discovery, there wasn't an obvious use for the glue until another 3M colleague, Art Fry, was looking for an easy way to put up a reminder that didn't require a pin or tape. Fry remembered the glue Silver has created, used it on a small piece of paper, and a product empire was born.

As in Silver's case, successful design is so often a matter of trial-and-error—and what first may look like an error is in fact a solution in search of a problem. But such an approach is viewed by those outside the design universe as expensive, often unproductive and as a result mostly unprofitable. Speed to market and eliminating the error part of the process have driven much of the innovations of the last few years, the COVID-19 vaccine most recent among them.

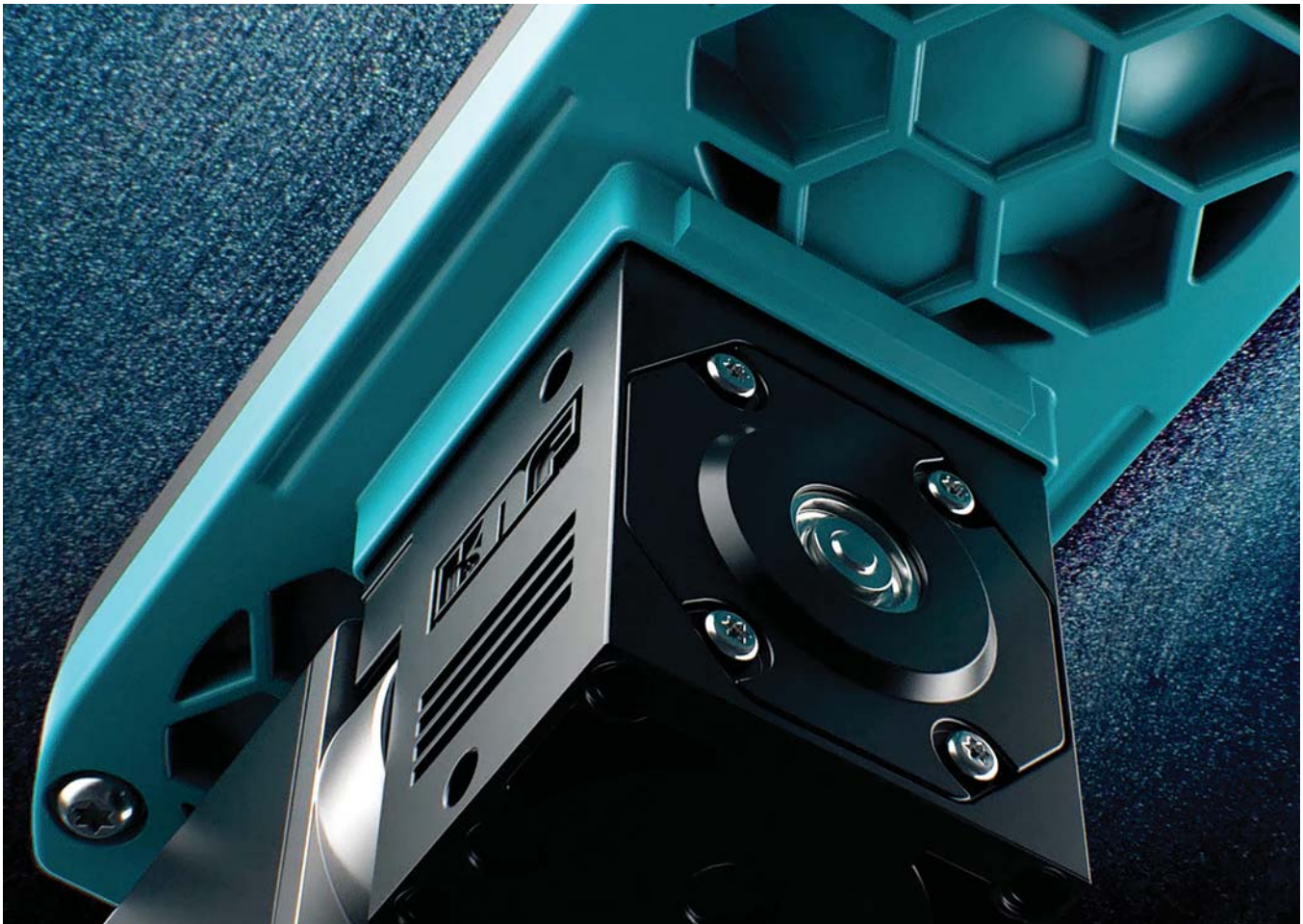
As MIT professor Wojciech Matusik writes in this month's issue, the emergence of artificial intelligence (AI) and machine learning will change the way researchers conduct experiments and develop innovations.

"We're on the cusp of a revolution in designing and manufacturing products," Matusik writes.

Where does this leave the Spencer Silvers of the world? In a different role, but one that is no less crucial to the process. Jesse Coors-Blankenship, senior vice president of Technology for PTC, offered this thought: "These developments will shift the role of the engineer to curating parameters and test conditions, and then choosing the best design from a range of permutations generated by AI.

"Eventually even the design-selection process will require AI assistance, as the sheer range of generated solutions outpaces the engineer's ability to sort through them," Coors-Blankenship added. "Liberated from the tedious trial and error of refining their designs, engineers can focus on *what* their design needs to accomplish rather than *how* the design will be realized."

Luck can be defined as when opportunity meets preparation. Silver earned 37 patents in his 3M career, so if the temptation is to think of Post-It Notes as lucky, it was luck borne of hard work and talent. If the future of innovation will be better realized by AI, it still will be fueled by innovation that is more intuitive than artificial. md



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News

AI MAKES A DEEP IMPRESSION on Industrial Manufacturing

A survey confirms AI adoption gained traction with industrial manufacturers over the course of the pandemic.

From design to process planning and production, manufacturers will be looking to advanced technologies such as artificial intelligence (AI) to step up resilience planning.

This finding was reinforced over the course of the past year, according to a KPMG survey, "Thriving in an AI World," which solicited feedback from seven industries.

According to the survey, 49% of industrial manufacturing business leaders reported that AI is fully functional at scale within their organization, and 61% of industrial business leaders noted that an increase in productivity is its greatest potential benefit.

Business leaders also reported that AI is at least moderately functional in their organizations, including those in industrial manufacturing (93%), financial services (84%), technology (83%), retail (81%), life sciences (77 %), healthcare (67%) and government (61%).

The Big Takeaway

The survey's historic finding, according to David Neely, managing director, Intelligent Information, KPMG, was that the reported adoption rate was highest of all industries in industrial manufacturing.

David Neely, managing director, Intelligent Information, KPMG.

"It runs a little bit contrary to what we would have expected based on some of the interactions we've had with clients in this space," Neely said. The industrial manufacturing (IM) sector was the most mature at using these technologies, but revealed the highest levels of angst when it came to employing AI technologies from a security, privacy and regulatory standpoint.

He further explained that AI adoption in industrial manufacturing is observed along two realms. Firstly, IM adoption of technology automation has been concentrated in the back office for routine, value-added activities, where enabling efficiencies, productivity and cost reduction are key drivers.

Secondly, IM has for many years been a leader at incorporating AI technologies on the product side—for technology going into self-driving vehicles, aircraft, aerospace and defense products. IM has lagged when it comes to implementing AI technologies into business functions, Neely said.

For Roy Mathews, managing director, Data and Analytics, KPMG, IM can be further classified into three buckets: smart factories, smart products and smart office. "Smart office is the area in which industrial manufacturing is lagging," he said. "But smart factories and smart products are the areas that are natural to IM, given the proliferation of

Roy Mathews, managing director, Data and Analytics, KPMG.

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Industry 4.0 initiatives. There is an incentive to automate. AI is a huge catalyst for Industry 4.0."

There is a natural tendency to adapt AI for factory settings, said Mathews. The data associated with AI in IM environments is generally structured. Sensors capture structured data from equipment, which is easy to process and enable, he said. This is unlike financial services or healthcare, where there's a lot of unstructured data.

Defining AI

For the study, AI was defined as any type of solution that generates insights from data or from patterns. The definition also extended the definition to automating tasks, which would include such concepts as machine learning, cognitive computing and robotic process automation.

A further classification would be to think of AI as those technologies that emulate human decision making. "Contrast this to technologies that emulate human activities—which is more in the realm of process automation or robotic automation," said Neely.

There has since been a huge shift to initiatives moving into mainstream and production mode.

Other Findings

1. 61% of industrial manufacturing business leaders say that an increase in productivity is the greatest potential benefit of AI adoption, and most (95%) agree that AI technology would make their company run more efficiently.

2. According to industrial manufacturing business leaders, in the next two years, AI technology will have varying impacts and will experience growth dependent on industry needs:

- 21% for product design, development and engineering
- 21% for maintenance operations
- 15% for production/assembly

Mathews said that leveraging AI to gain efficiencies across maintenance, operations, product design and engineering, and supply chain will be integral to building enterprise resilience.

Neely agreed. "That's going to be increasingly important in the future, given the learnings of the COVID-19 disruption," he said. "Companies are looking closely at how they build resilient supply chains and how they'll recover from disruptions and brand disruption on a global scale.

> "The use of AI over the last decade has generally been experimental, but in recent years we have started to see a move from experimental stage to a production at scale mode."

Experimental to Mainstream

While AI is native to technology companies such as Google and Apple, the rest of the industry is now adapting it and making it part of the business function, said Mathews.

"The use of AI over the last decade has generally been experimental, but in recent years we have started to see a move from experimental stage to a production at scale mode," he explained. Prior to that, organizations would embark only on innovation-related initiatives until they had a proof of concept, noted Mathews.

"Whereas those problems were historically tackled from a mathematical modeling and optimization standpoint, new AI technologies provide a more sophisticated means for analyzing data, looking at alternatives and optimizing in an even more powerful and sophisticated way," he concluded. md

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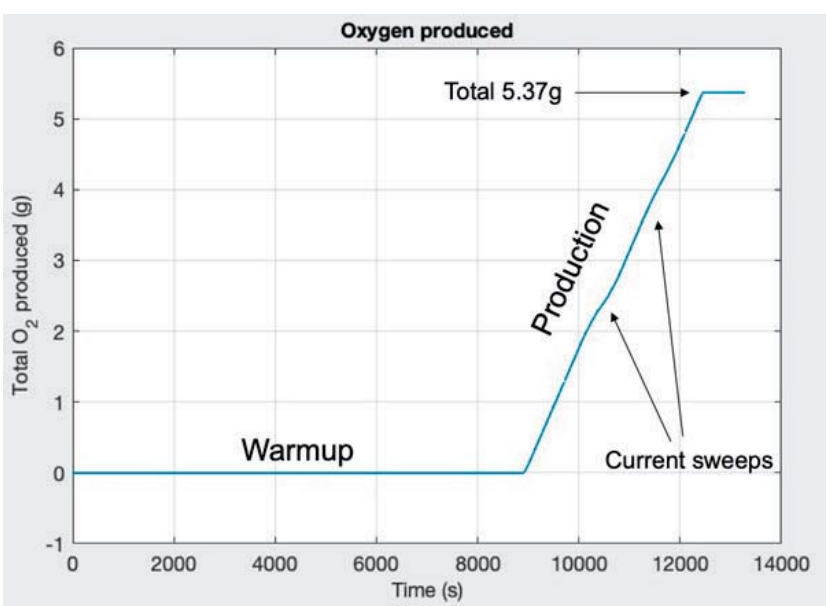
NASA ROVER Extracts Oxygen from Martian Atmosphere

NASA RECENTLY TESTED its "Mars oxygen in-situ resource utilization experiment" on board the Perseverance Mars rover. This toaster-sized device converts the CO_2-rich Martian atmosphere into oxygen, as well as carbon dioxide as a waste product.

Moxie heats the incoming atmosphere to about 1,470°F (800°C) to carry out the extraction. This means it had to be made of heat-resistant materials, such as 3D-printed nickel alloy parts, which heat and cool the gases flowing through them. It also has a layer of a lightweight aerogel for insulation to retain the heat inside the device. A thin gold coating on Moxie's surface reflects infrared heat, keeping it from radiating outward and potentially damaging other parts of Perseverance.

Technicians at NASA's Jet Propulsion Laboratory lower the Mars oxygen in-situ resource utilization experiment (Moxie) into the belly of the Perseverance rover. *(NASA/JPL-Caltech)*



After warming up for two hours, Moxie began producing oxygen at about six grams per hour. After an hour of operation, about 5.4 grams of oxygen were produced, enough to keep a person alive for about 10 minutes of normal activity. *(MIT Haystack Observatory)*

In its first test, Moxie created about five grams of oxygen, enough to keep an astronaut alive for about 10 minutes. Moxie will undergo eight more tests which fall into three phases. The first-phase tests will check out and characterize Moxie's performance; the second phase looks at its performance in varying atmospheric conditions, such as different times of day and seasons; and in the third-phase tests, NASA will push the envelope and try new operating modes and scenarios, such comparing operations at three or more different temperatures. By the end of the testing, NASA expects Moxie will demonstrate its targeted production rate of extracting 10 grams of oxygen per hour.

If Moxie meets NASA expectations, the technology it is based on could be used to supply future Mars explorers with oxygen to breathe and with a major proponent of the rocket fuel they will need to return to Earth.

To burn fuel, the returning rocket must have more oxygen by weight. Getting four astronauts off the Martian surface and to an orbiting return spaceship, for example, would require approximately 15,000 lb of rocket fuel and 55,000 lb of oxygen. In comparison, the four astronauts living and working on Mars would require just 2,200 lb of oxygen to breathe.

The alternative to using Moxie-type technology to get oxygen on Mars would be to carry about 60,000 lb of it on the trip from Earth to Mars. It would be more efficient and less costly to carry a 2,000-lb Moxie-based O2 extractor that could supply that same oxygen. ■

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A SHRIMP-INSPIRED CAMERA Helps Detect Tumors

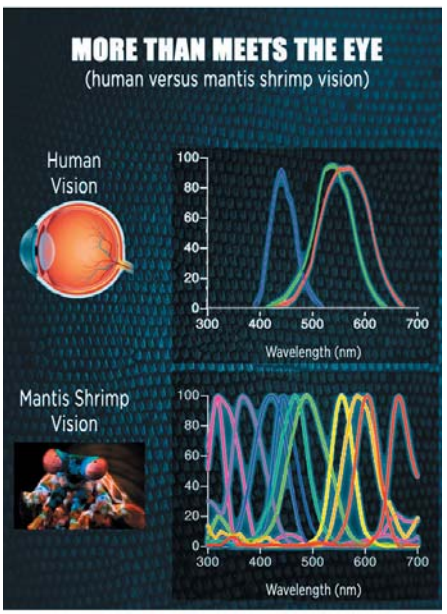
ENGINEERS AT THE University of Illinois took a clue from the mantis shrimp when they developed a camera for helping surgeons identify tumors in patients. The shrimp's eyes can discern up to 12 different colors, including some in the IR range, thanks to stacks of light-sensitive cells that make up the sensing part of the shrimp's eyes. Humans, on the other hand, can only perceive combinations of three colors—red, green and blue—using the single layer of light-sensing cells lining the retina.

To partially replicate the shrimp's visual capabilities, the engineering team combined semiconductors and optical filters to build a camera that can capture the three colors of visible light doctors would normally see, as well as three colors of invisible near-infrared light they cannot.

The camera is used during tumor-removal surgery on patients who have been injected with tumor-targeted probes. The probes seek out tumors and accumulate in their cancerous tissues. They also emit near-IR light, which the new compact camera can detect and display to surgeons.

"The combination of the bioinspired camera and tumor-targeting drugs will ensure that surgeons leave no cancer cells behind in the patient's body," says Goran Kondov, a professor and chief surgeon who used the camera on a patient. "This additional set of eyes will help prevent recurrence of the disease, providing patients a quicker and easier path to recovery. And the device can potentially be manufactured at low cost since it is so simple, making it accessible to hospitals around the world."

The engineering team is now adapting the camera to mount on endoscopic probes, letting minimally invasive tumor surgery be done in other hospitals. ■



The human eye perceives only three colors: red, green and blue. The mantis shrimp uses stacks of light-sensitive cells at the tip of its eye to "see" up to 12 colors. *(Steven Drake/Beckman Institute for Advanced Science and Technology)*

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RESEARCHERS EFFICIENTLY Turn Wood into Ethanol

RESEARCH TEAMS AT Lawrence Berkeley and Sandia National Laboratories have jointly develop a streamlined and efficient process for converting woody plant matter, such as forest overgrowth and agricultural waste—material that is currently burned either intentionally or unintentionally—into liquid biofuel. Until now, wood has been difficult to chemically break down.

The teams found that commercially available enzymes, which are nontoxic, can be combined with a specially engineered strain of yeast along with wood in a single container or "pot," to make ethanol. Using a single reactor lets the process use less water and energy. The work is the first-ever end-to-end process for ethanol production from woody biomass featuring both high conversion efficiency and a simple one-pot configuration.

Technological and economic analysis helped the teams identify the improvements needed make ethanol from the new production process at $3 per gasoline gallon equivalent.

The process presents several opportunities. "Removing woody biomass from forests, such as overgrown pines of the Sierra, and from agricultural areas such as almond orchards of California's Central Valley, we can address several problems at once: disastrous wildfires in fire-prone states, air pollution hazards from controlled burning of crop residues and our dependence on fossil fuels," says Lalitendu Das, a postdoc fellow at Sandi and the Joint BioEnergy Institute (JBEI). "On top of that, we would significantly reduce the amount of carbon added to the atmosphere and create new jobs in the bioenergy industry."

Ethanol is already used as an emissions-reducing additive in conventional gasoline, typically constituting about 10% of the gas used in cars and trucks in the U.S.

Ethanol derived from plant biomass can also be used to make more complex diesel and jet fuels, which are helping decarbonize the difficult-to-electrify aviation and freight sectors. Currently, the most common source of bio-based ethanol are corn kernels, a starchy material much easier to break down chemically, but which takes land, water and other resources to produce.

A researcher at Berkeley Lab prepares woody biomass to be broken down into fermentable sugars. *(Berkeley Lab)*

The teams found that woody biomass can be efficiently broken down and converted into advanced biofuels in a process that is cost-competitive with starch-based corn ethanol. The process can also turnout "drop-in" biofuels chemically identical to compounds already in gasoline and diesel fuel.

One benefit of the new process is that it would reduce the amount of dry wood that accumulates over the years and increases the risks of wildfires. "According to a recent report, by 2050 there will be 38 million tons of dry woody biomass available each year, making it an exceptionally abundant carbon source for biofuel production," says Carolina Barcelos, an engineer at Berkeley Lab's Advanced Biofuels and Bioproducts Process Development Unit.

The next steps in this effort are to develop, design and deploy the technology at the pilot scale, which is defined as a process that converts one ton of biomass per day. The Berkeley Lab teams are working with Aemetis, a renewable fuel and biochemicals company that wants to commercialize the technology and launch it at larger scales once the pilot phase is complete. ■

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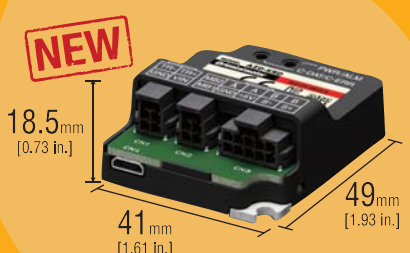

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RESEARCHERS DEVELOP the Whitest Paint Ever

TO SAVE ENERGY, engineers at Purdue University have developed a paint that is whiter than any other, which means it reflects more light. Putting it on roofs and sides of buildings will keep them cool and reduce the need for air conditioning.

"If you covered a roof about 1,000 square feet with it, you could get the 10 kilowatts of colling power, which is more than the central air conditioners found in most houses," says Xiulin Ruan, a mechanical engineering professor at Purdue.

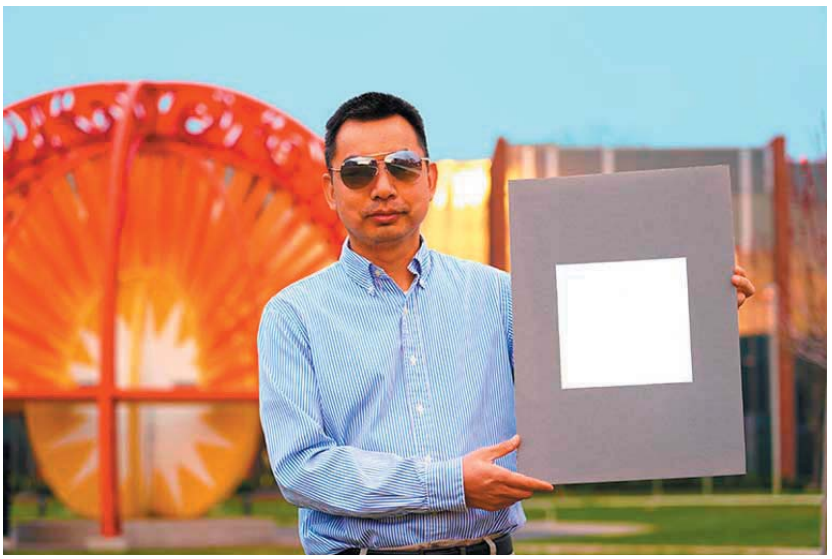
The new paint reflects up to 98.1% of visible sunlight and also repels infrared heat. When painted on a surface, it can make it cooler than the surrounding air. Typical commercial white paints get warmer rather than cooler. Paints on the market designed to reject heat reflect only 80% to 90% of sunlight and can't make surfaces cooler than their surroundings.

In tests, the paint kept surfaces 19°F cooler than their ambient surroundings at night. It also cooled surfaces 8°F lower than the surroundings under strong noontime sunlight. The paint's solar reflectance is so effective, it even worked in the middle of winter. During an outdoor test with ambient temperature of 43°F, the paint lowered the test sample temperature by 18°F.

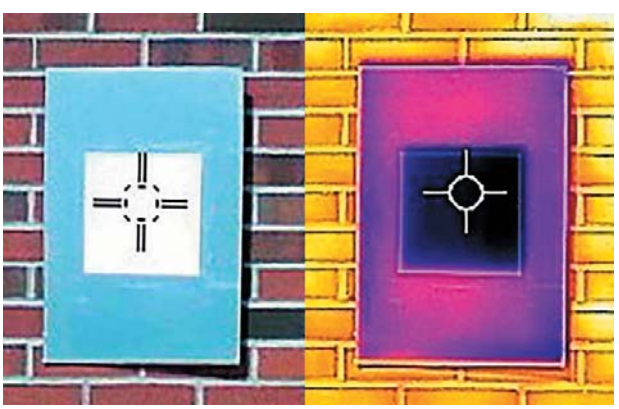
The new ultra-white paint seems to be on the opposite end of the spectrum as Vantablack, a coating that has been dubbed "the blackest black." Vantablack, was invented by Surrey NanoSystems; it absorbs up to 99.9% of visible light.

The key to the new coating's ability is its high concentrations of barium sulfate, a chemical used to make photo paper and cosmetics white.

"We looked at various commercial products—basically anything that's white," says Xiangyu Li, a postdoctoral who worked on this project as a Purdue Ph.D. student in Ruan's lab. "We found that barium sulfate can make things really, really reflective, which means that they're really, really white."



Xiulin Ruan, a Purdue University professor of mechanical engineering, holds a sample of the whitest paint on record. *(Purdue University/Jared Pike)*



An infrared image (right) shows how a sample of the whitest white paint (left) cools the board below ambient temperature, something not even commercial "heat rejecting" paints can do. *(Purdue University/ Joseph Peoples)*

The team also used a range of different-sized barium sulfate particles. Including large to small particles let the paint scatter and reflect a wider range of light frequencies found in sunlight.

The team could've made the paint even whiter, but then it would be less useful as paint. "Although a higher barium-sulfate particle concentration is better for making something white, you can't increase the concentration too much," says Li. "The higher the concentration, the easier it is for the paint to break or peel off."

This white paint is the result of six years of research, building on attempts going back to the 1970s to develop radiative cooling paint as a feasible alternative to traditional air conditioners.

Ruan's lab had considered more than 100 different materials, narrowed them down to 10 and tested about 50 different formulations for each material. Their previous ultra-white paint was made of calcium carbonate, a compound commonly found in rocks and seashells.

The researchers predict that their new ultra-white paint should be able to withstand outdoor conditions. It should also be easy to make, as it was made using a technique compatible with commercial paint fabrication. ■

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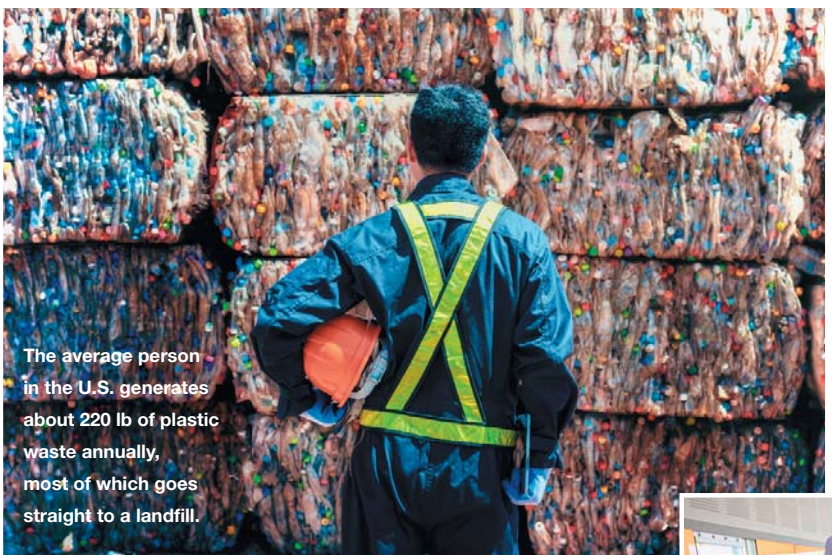

The average person in the U.S. generates about 220 lb of plastic waste annually, most of which goes straight to a landfill.

A TEAM OF researchers at Lawrence Berkeley National Laboratory has been studying large-scale production of a new plastic, poly(diketoenamine). It has all the useful properties of traditional plastics but, unlike traditional plastics, PDKs can be recycled indefinitely with no loss in quality. The team found that PDK-based plastic could quickly become commercially competitive with conventional plastics, and the products will get less expensive and more sustainable as time goes on.

The problem with traditional plastics is that so far, more than 8.3 billion tons of them have been produced, and the vast majority of it has ended up in landfills or being burned in waste incineration plants. Only a small proportion of plastics are recycled "mechanically," meaning they are melted down and re-shaped into new products. Unfortunately, this technique is limited because plastic resins are mixed with many different additives for different textures, colors, and capabilities, such as pigments, heat stabilizers and flame retardants.

So, when many different plastics are melted down together, the plastic polymers get mixed with many potentially incompatible additives, resulting in a new plastic with much lower quality than those made using virgin resin from raw materials. As such, less than 10% of plastic is mechanically recycled more than once, and recycled plastic usually must contain a significant amount of virgin resin to compensate for the dip in quality.

PDK plastics sidestep this problem by using resin polymers that easily break down into individual monomers when mixed with an acid. The monomers can then be separated from any additives and collected to make new plastics without any losing any performance or quality. The team's earlier research shows that this "chemical recycling" uses little energy and creates few CO2 emissions. It can also be repeated indefinitely, creating a completely circular material lifecycle unlike the current one, which is essentially a one-way ticket to waste.

"The next step is to determine how much it will cost to scale it up, what the affect will be on energy use and emissions, and how to get there from where we are today," says Brett Helms, a staff scientist at Berkeley Lab.

Recycled PDKs are already drawing interest from companies sourcing plastics. The Berkley team has been conducting market research and meeting with industry people and have determined that the best initial application for PDKs are markets where manufacturers will get their products back at the end of their lifespan, such as the auto industry (through trade-ins and take-backs) and consumer electronics (through e-waste programs). These companies can then reap the benefits of 100% recyclable PDKs, namely sustainable branding and long-term savings. Plus, some countries plan to charge significant fees on plastic products made of non-recycled materials. That should give companies a strong incentive to move away from virgin resins and drive the demand for recycled plastics.

Brett Helms, foreground, pictured at work in the Molecular Foundry developing PDK and the processes to make it. *(Thor Swift/Berkeley Lab)*

The team is also working on way to improve the process by using microbe-made precursors. The process currently uses industrial chemicals but was initially designed with microbes in mind. This would let nearly the entire polymer be made from plant material fermented by engineered microbes.

PDK technology is available for licensing and collaboration. If interested, please contact Berkeley Lab's Intellectual Property Office. ■

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The PLC BREAKS OUT

AT A GLANCE:

- As end-users take advantage of more capable PLCs, they must also consider security.
- By increasing the overall computing power of PLCs, controller vendors have made room for additional capabilities.
- Improvements in computing power have created a sophisticated PLC that can synchronize servo drives or control complex process loops while transmitting data and supporting an HMI.

A new architecture takes advantage of technological advances to boost performance.

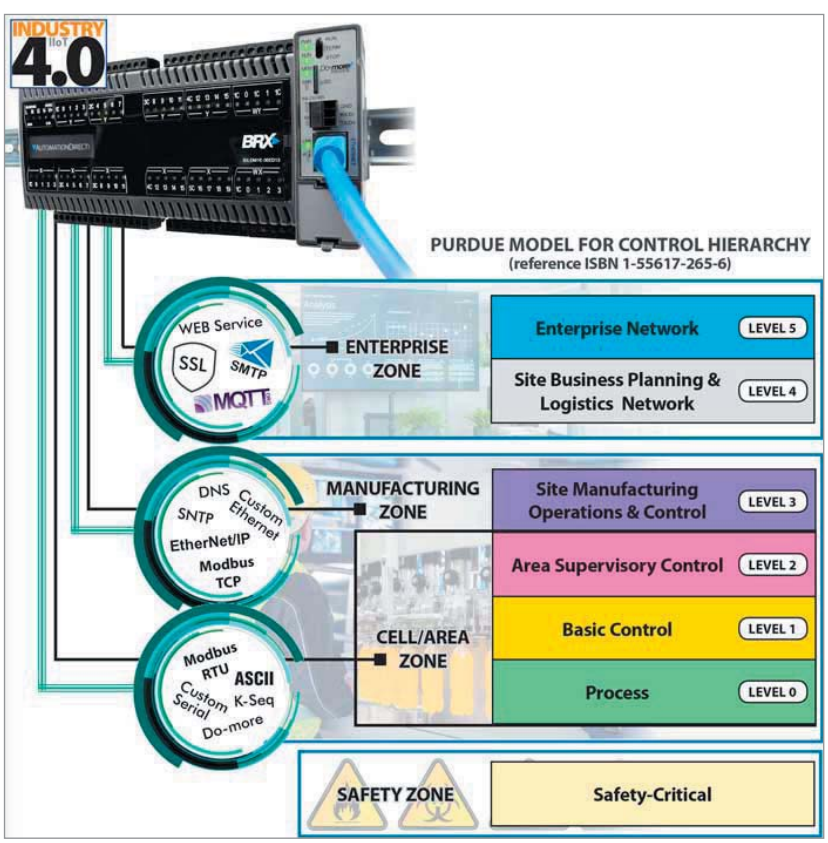
Anyone who has served in the military or even a large company understands the concept of hierarchy—it identifies who's in charge, the chain of command and how each individual fits in that structure. Some people find security in the structure, while others with ambition can feel stifled. Similar situations apply in industrial automation. A hierarchical structure defines what type of equipment goes where, and what actions are supposed to happen at each level. This approach is explained in detail by the Purdue Enterprise Reference Architecture *(Fig. 1)*.

It puts process and field devices at the bottom, control equipment in the middle and enterprise information technology (IT) systems at the top. Operational technology (OT), with its PLCs, generally exists at the basic control level where they interface with field devices, execute control loops and control motion. When there is a need to send data to higher-level systems, it must be passed up the chain of command, moving from layer to layer.

This situation has two major faults:

- It calls for a lot of developer effort and computing resource overhead with multiple communication protocols.
- It does not recognize or utilize the growing capabilities of today's generation of PLCs.

Classic industrial automation architectures represent concepts and equipment limitations of the 1990s. PLCs of that era were less powerful and therefore had to be specialized and focused to perform specific high-speed control functions. Higher-level systems were required to provide more advanced data-processing capability. But moving data between the lowest and highest levels called for a significant effort.



1. The Purdue Architecture delineates clearly defined layers, reflecting older thinking based on available technologies.

Users generated custom code configurations to select, arrange and manage data. A lot of parts and programming were frequently involved: PLCs, gateways, PCs, software packages, network configuration and supporting code. Even when data connectivity could be patched together, it was often at the expense of security. Traditionally, PLCs had few (if any) cybersecurity provisions, especially for internet-connected systems.

Change and Improvements

Much has changed in the industrial space over the past few decades. One issue is that overhead remains a problem. Plants want flatter and less-complex control systems for processes and machines. The concept of having so many layers of specialized equipment is wasteful, but can be streamlined with more versatile controllers capable of performing multiple overlapping roles. Older PLCs could not handle their high-speed requirements while being distracted by other data management functions.

Improvements in computing power *(Fig. 2)* mean today's PLCs can now synchronize servo drives or control complex process loops while transmitting data and supporting a human-machine interface (HMI). A sophisticated PLC can straddle more than one level.

Second, as just noted, PLCs have come a long way—but adoption of all improvements is not uniform across vendors. Some companies have decided that traditional structures are safe and elected to remain within those constraints, even though limited communication capabilities makes integration with up- and downstream equipment difficult. Synchronization is still possible, but it is complex to implement and requires additional overhead.

By putting technological improvements to work and increasing the overall computing power of their PLCs to handle basic functions with far less sweat, some vendors have made room for additional capabilities. For example, by including a longer list of communication protocol options, a PLC can bridge over intermediate network layers and reduce the complexity of interfacing with the enterprise. Even a relatively simple PLC can operate in an environment dominated by equipment from a different vendor. Additionally, it can communicate with IT-centric assets using a representational state transfer application programming interface (REST API) or secure message queuing telemetry transport (MQTT/S) over wired or wireless networks. This is a far cry from older PLCs that only speak MODBUS.

2. Some modern PLCs also incorporate advanced data handling features and communications protocols so they can easily interface OT field data with IT enterprise systems.

This ability can extend even farther with IoT connectivity direct to the cloud. Even a small or medium PLC may be certified to have native connectivity to Microsoft's Azure Platform. Certification assures users that the device is tested to work with the Azure infrastructure and provides clear documentation about how to connect. Azure offers many industrial IoT capabilities to help users visualize and optimize their operations, including:

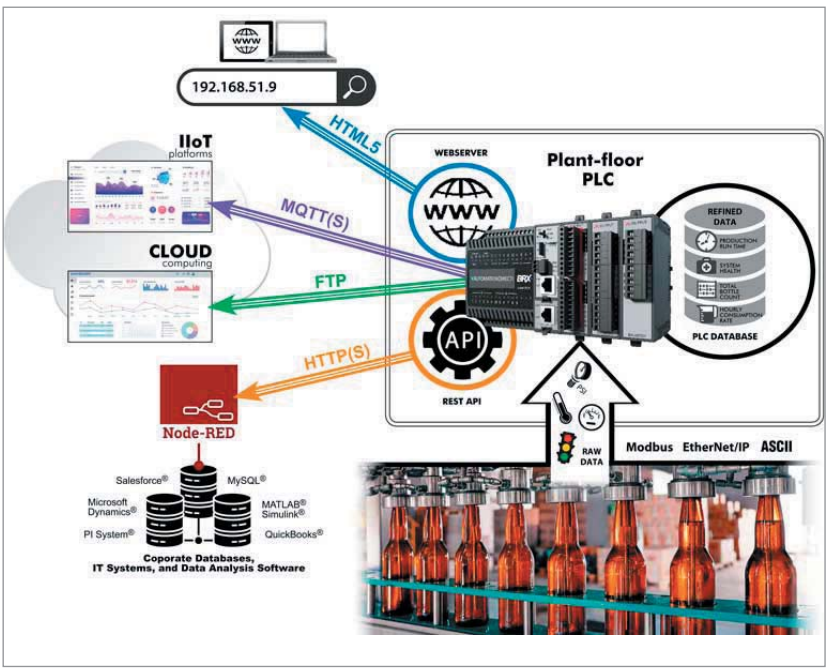
- Cosmos DB for data storage
- Power Apps for easily building low-code solutions
- Web and mobile visualization
- Machine learning and analytics to build advanced predictive models

Consider this situation: A PLC must pass data upstream to a corporate network for advanced processing. Using the traditional approach, it moves via the chain through all the layers, possibly converted to a different protocol a time or two, and ultimately reaches its destination. The alternative is an Azure-certified PLC able to interface with an Azure IoT hub without the need of a gateway: a direct connection, less complex and with far less overhead.

Applying the Standards

Some of the most popular serial and Ethernet protocols for OT purposes include ASCII, Modbus RTU, K-Seq, Modbus TCP and EtherNet/IP. On the other hand, IT systems use protocols like SNTP DNS, MQTT, SMTP, SSL and web services. A PLC bundling these capabilities together becomes a bridge from OT to IT, creating many ways to connect new and legacy factory floor equipment to today's enterprise systems.

When all data integration elements are built-in and reside natively in a PLC, setup is much faster. IT users typically prefer open-source solutions because they are already familiar with



3. AutomationDirect BRX Series PLCs include several data connectivity options, and each is a Microsoft Azure Certified Device.

this approach, rather than specialized environments common to industrial products.

When these technologies are available, users can select from a range of options based on process requirements *(Fig. 3)*. They can:

- Store data in the PLC and forward it to other systems using FTP
- Present information as web pages hosted by an internal web server
- Expose data to external clients with a REST API
- Communicate data to other systems using MQTT over TLS

The last of these options, MQTT, has risen to become a popular standard for PLC-to-cloud communications. The PLC in the field initiates conversations as outbound messages to a centralized broker, which can be on premises but is most often in the cloud. This enables two-way communications while avoiding firewall and IT management issues which would occur with many types of inbound communications.

MQTT communications are responsive, but at the same time can withstand network and communication outages commonly found at edge locations. A PLC using MQTT is ideal for transmitting data to an IIoT platform located on a cloud computing service like Microsoft Azure. Users can access the data with enterprise or mobile clients, or they can create other applications to use this PLC-sourced MQTT data.

Security and Flexibility

Improved PLC connectivity unfortunately leads to greater cybersecurity risks. Therefore, new PLCs must include built-in security features, such as:

- Closed by default to requests from the outside world
- On-board storage of username and password credentials managed by OT personnel
- IP whitelisting to control which external clients are allowed to communicate with the PLC
- Secure communication over TLS when possible

When all data integration elements are built-in and reside natively in a PLC, setup is much faster. IT users typically prefer open-source solutions because they are already familiar with this approach, rather than specialized environments common to industrial products.

As end-users take advantage of more capable PLCs, they should ensure that these security capabilities are available and are configured properly.

Yesterday's PLCs and other industrial automation products were largely incapable of advanced computing tasks that users want and need today, because they were specialized and limited in terms of data handling. The processing power incorporated in today's OT digital devices provides greater capabilities for supporting IoT and analytical endeavors at the enterprise level and in the cloud. Merging proven OT-based technology with carefully coordinated IT-friendly communications and security results in a potent PLC combination. Modern PLCs can connect directly to the cloud, making it easy to break out of traditional restrictions. md

DAMON PURVIS is the PLC product manager at AutomationDirect.com. He has more than 22 years of industrial automation experience. Previous roles have included designing and deploying automated solutions in a variety of industries and managing product development of manufacturing data management and business intelligence applications.

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The New Era of MACHINE CONTROL

Assess five key areas when reviewing the modern platform.

AT A GLANCE:

- The goal is to allow the PLC to be continually upgraded like a smartphone instead of being doomed to obsolescence.
- Controller manufacturers have created their own app stores to provide links for design and operational software to customers.
- A new generation of machine controllers allows designers to leverage open architecture tools to drive manufacturing innovation.

The PLC—the programmable logic controller, or automation controller—has been the central tool used to drive advances in automation efficiency, productivity and flexibility for several decades. Automation machine controllers have evolved through several generations of hardware and software, taking advantage of advances in processor power, sophistication and high-speed, Ethernet-based automation protocols to drive increases in automation throughput and productivity.

Until recently, machine controller architectures—both hardware and software—evolved somewhat in isolation from the broader computing and IT platforms that have transformed the globe. However, a new generation of modern machine controllers is revolutionizing the industry, providing technology that offers a whole new kind of openness and ease of use, while still supporting the complex functionality that current and future automation systems demand.

"Old vs. New": Limitations of Prior Controller Platforms

Prior generations of machine controllers made effective use of advances in processor technology and communication interfaces to provide support for even faster automation control requirements. They also provided other functionality, such as increased use of sensors and vision systems. However, a significant limitation of these systems was the way that controller technology developed in isolation from broader trends in the world of IT.

The broader IT world has an open software architecture, unlike many controller platforms. Today's smartphones provide the perfect model. Smartphone operating systems provide the foundation for an unending array of specialized programs and apps that are easily downloaded and intuitive to use. This openness and interoperability have enabled constant creativity for outside developers to enhance smartphone functionality.

In contrast, controller technology has continued to be much more closed, thereby limiting the ability of automation OEMs to have long-term flexibility and control of their systems. For example: If a packaging systems OEM wants to develop a new generation of machines, it is typically forced to make an early judgment in the design process about which controller family to use.

A new generation of machine controllers is emerging, allowing the automation community to leverage the openness and sophistication of these new tools to drive manufacturing innovation. *(Bosch Rexroth)*

From that point on, that family of machines is wedded to that controller platform and how the supplier supports the controller over time. Because of these architecture constraints, it could be very difficult to switch to a different platform or alternative controller: Each controller uses a different operating system or proprietary software, making it more difficult and expensive to offer the same machine with options for a different machine controller.

Because the software architecture of these proprietary controllers has been so tightly controlled, the platform often did not support newly emerging capabilities or applications. Automation OEMs were limited in their ability to support new applications, particularly for functionality sought after in Industry 4.0 manufacturing operations.

If a manufacturer wanted to be able to monitor and collect machine performance data from all its machines plantwide and cleanly link up that data through cloud applications for real-time analysis and long-term systems management, that kind of functionality often had to be specially developed through custom drivers and specialized communications.

However, a new generation of machine controllers is emerging to overcome these limitations and free the automation community to leverage the openness and sophistication of these new tools to drive manufacturing innovation.

Openness: Key Traits of New Machine Controllers

Today's state-of-the-art machine controllers are rapidly moving away from the closed, proprietary architectures of prior systems. Here are five key traits that machine builders and automation end-users should consider when assessing different platforms.

1. Apps-based architecture. One of the most significant differences between past and current machine controller platforms is how open and app-based the most advanced of them have become. Nowadays, software development accounts for more than half of the value creation in automation engineering. For machine manufacturers and end-customers, efficient engineering and straightforward application programming offer a considerable potential for savings and degree of freedom.

The most obvious model for this approach is the smartphone, with highly stable, robust operating systems incorporating features such as encrypted data layers that enable multiple automation apps to communicate and share information with each other.

In modern machine controllers, the open software architecture with flexible app technology lets OEMs select the apps

that they need or use any open-source software. They can use software they developed themselves on the open platform and use their expert automation and controls knowledge to create machine-specific apps in whatever popular programming language fits their needs.

Leading controller manufacturers such as Bosch Rexroth are even creating "app stores" where compatible apps for specialized machine functions, such as vision inspections systems or predictive maintenance tools developed by companies that specialize in that kind of software, can be downloaded for use—a further example of the smartphone model.

2. Hardware. The performance demands placed on this new generation of controllers requires top-notch hardware. There are controller providers who are launching Linux-based multicore processors with the speed and sophistication to support the most demanding requirements.

Multicore processors provide a critical advantage in the app-driven architecture: Controllers are now being asked to handle a much wider range of functions simultaneous to the core automation, I/O and motion sequence control of the machine. No matter how powerful, a single processor handling 64 axes of deterministic motion control as well as supporting data collection and other app functions is likely to bog down.

Some controller suppliers offer a wide range of controller options. Bosch Rexroth's ctrlX CORE control can be deployed as a standard cabinet-mounted controller, either as part of an industrial PC or in a distributed, drive-based controller solution. *(Bosch Rexroth)*

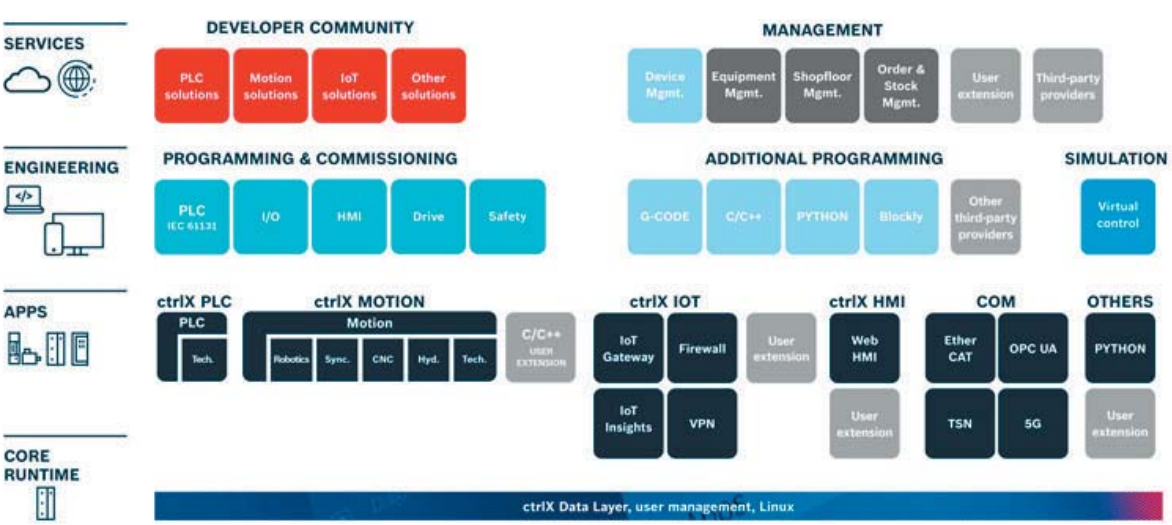
With a multicore processor, one core can be dedicated just to machine control, while another core supports leading-edge apps like machine learning or database maintenance. The use of Linux as the foundation for the operating system makes sense because it is a proven, open-source platform that has millions of developers updating and enhancing its capabilities.

There are versions of Linux that have been developed to support real-time, high-speed processing in other applications and have demonstrated reliable, robust performance, making it eminently suitable for use in the most demanding automation applications in combination with the multicore processor architecture.

3. Connectivity. The need for open and fast communications capabilities is every bit as important as the advances in software architecture and hardware performance. The automation industry has made great strides toward the use of high-speed, Ethernet-based bus architectures that promise greater openness and interoperability.

The newest controllers are rapidly promoting support for the EtherCAT protocol, which is being adopted as a de facto standard bus in demanding industries such as semiconductor fabrication. EtherCAT also has the advantage of being more motion-centric, a valuable asset for automation applications.

However, it's important to assess whether a controller line is open to supporting other popular protocols such as Sercos, EtherNet/IP or PROFINET. In addition, there is growing support for emerging protocols such as OPC-UA and Time-Sensitive Networking (TSN); machine controllers equipped with an open architecture to support these options besides EtherCAT can provide a valuable, future-proof solution.



There are significant advantages to selecting a machine controller that's part of a larger automation portfolio, like Bosch Rexroth's ctrlX AUTOMATION platform. Such systems are engineered to communicate and work efficiently. *(Bosch Rexroth)*

4. Stable and scalable. In the past, controller portfolios would often be restrictive in how scalable they were. To use that platform across the entire machine, automation OEMs were sometimes forced to select controllers with more features and power than a given machine axis or set of axes needed.

Smart scalability is a key advantage of the new generation of open machine controllers, with base platforms that can be scaled up with additional app functionality as needed. Instead of having dozens or hundreds of different controllers with specific functionality determined by hardware, the core architecture lets the automation OEM scale as needed.

Many of the leading-edge controllers provide powerful tools to let the OEM periodically access the controller's core to provide software updates, patches and revisions—exactly the same way most major business applications and PC programs are supported.

In addition, some controller suppliers offer a wider range of controller options. A single control can be deployed as a standard cabinet-mounted controller as part of an industrial PC or in a distributed, drive-based controller solution. The same control, with the same OS and interfaces, can even make it possible to implement hybrid solutions combining drive-integrated and cabinet-based controller platforms on a single machine, without requiring specialized knowledge or different programming capabilities.

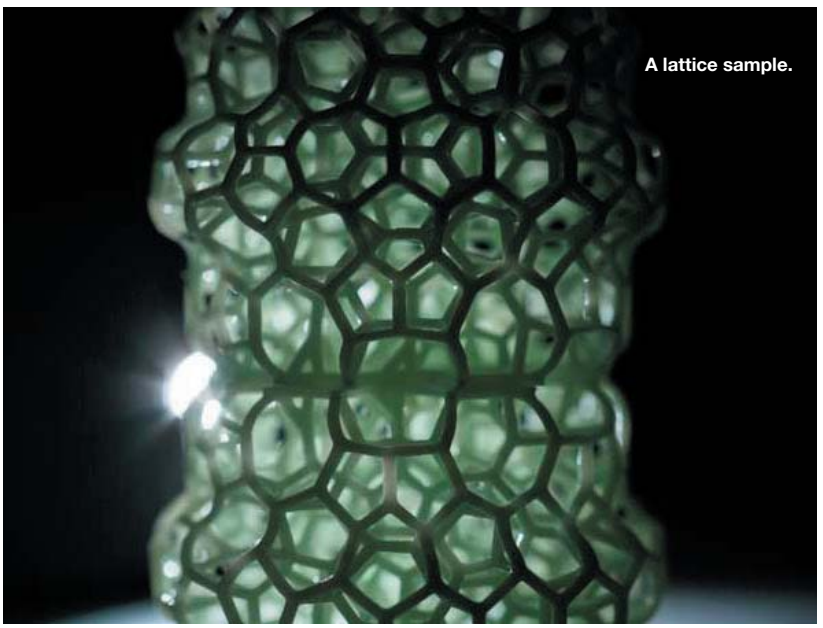
5. The total automation platform. While the industry has plenty of companies that focus almost exclusively on supplying PLCs or motion control drives, there are significant advantages to selecting a machine controller that is part of a larger automation portfolio, all designed and engineered to communicate and work together with the highest degree of efficiency and versatility. Key elements of a complete automation platform, including drives, HMIs, I/O and programming platforms that share common hardware, firmware and software, can significantly simplify and save engineering time and resources.

In these total platforms, system functions seamlessly complement each other and can also be extended by apps and third-party hardware and software thanks to the absolute openness of the system. Superior connectivity is supported with virtually all relevant automation protocols, as well as offering freedom in the choice of development environment and programming language.

The "new" machine controller, responding to the needs of Industry 4.0, will deliver the openness, app-driven ease of use and flexibility that will soon make it possible for automation builders to think of their PLC like a smartphone for automation instead of a component destined for obsolescence. md

REHANA BEGG | Senior Editor

Lattice Design Enables 3D-Printed Nasal Swab Production



A lattice sample.

A 3D printing company uses its lattice technology to help resolve the national shortage of nasopharyngeal testing swabs during the pandemic.

AT A GLANCE:

- A national shortage of nasopharyngeal testing swabs motivated the additive manufacturing community to demonstrate its ability "to design fast, trade fast and put it into production very fast."
- Hardik Kabaria, director of software engineering, Carbon, developed a viable swab prototype within a couple of hours.

- Carbon Design Engine, a lattice design generator, is being democratized so users can pay back through feedback.

Manufacturing disruptions due to stay-at-home orders last year exposed weaknesses in the supply chain that brought manufacturing to a standstill. In the middle of the mayhem, manufacturing communities banded together to bridge gaps in resilience strategies. Some would turn to additive manufacturing for tactical measures in meeting supply chain resilience.

Consider the nasopharyngeal swab shortage. Consisting of a plastic shaft and a swab head that is typically covered with an absorbing material such as cotton, polyester or nylon, these narrow sticks were in short supply and held up coronavirus testing. It would take both ingenuity and the experience of working with lattice technology to propel a new swab design to market and remedy the scarcity.

"In 3D printing we always think about different ways that the technology we have can benefit not just the society, but help people create parts at the right time, when it's needed," said Hardik Kabaria, director of software engineering for the 3D printing technology company Carbon.

But it wasn't until the news of the swab shortage was in circulation that the 3D community jumped in, acknowledged Kabaria, who viewed the situation as a challenge that 3D printing technology should be able to solve. "This is what we have imagined our technology to be useful for," he said.

The nasal swab was not an item 3D technology would conventionally print, pointed out Kabaria, because they are relatively cheap and easy to manufacture by conventional methods. The 3D printing intervention was needed, he said, because "the supply chain broke."

For Kabaria, the medical device shortage created the "right problem statement" and was an incentive for the additive manufacturing community to demonstrate that it was able "to design fast, trade fast and put it into production very fast."

At a conceptual level, Kabaria was motivated to apply his knowledge and the technology Carbon had developed. And once a directive from higher up landed in his inbox, it was all he needed to go ahead and look up how swabs are designed, figure out what it is made of and to consider whether Carbon's lattice design concept could be applied.

Lattice Design

Additive manufacturers use lattice structures—two or three-dimensional

micro-architectures made up of nodes and struts—to design products. They are used across the body of an object and have been used across the 3D printing domain for achieving mechanical stability or stiffness. Lattice design offers the advantage of reducing weight while retaining structural integrity, as well as an ability to defy the constraints of traditional manufacturing, often in favor of higher-performing products with excellent shock absorption and impact protection.

The use of lattice design isn't new. Look to civil engineering for historical examples, where support systems for bridges are based on uninterrupted, crisscrossed diagonals that form overlapping loadbearing triangles, known as trusses.

Until now, pointed out Kabaria, lattice design has not been used widely, or at a mesoscale, in a way that it might be conventionally associated with helmets, saddles, shoes or even swabs. "However, 3D printing is a backbone that can enable it," he asserted. Kabaria's doctoral research in mechanics and computation at Stanford University was directed toward building a robust, efficient and automatic mesh generation tool for two- and three-dimensional geometries.

Carbon's Digital Light Synthesis (DLS) technology, for instance, is used in bicycle saddles. It enables the saddle to rebound quickly, giving riders the experience of having a suspension built into the saddle. The lattice can achieve a mechanical response—which is not only different, as Kabaria explained, but more superior than traditional foam applications.

Swab Test

"Using lattice design concepts, we could create a cage of lattice, such that whenever the swab is inside the nasal cavity, one may rotate it and it would be able to capture the biological sample that is needed," said Kabaria.

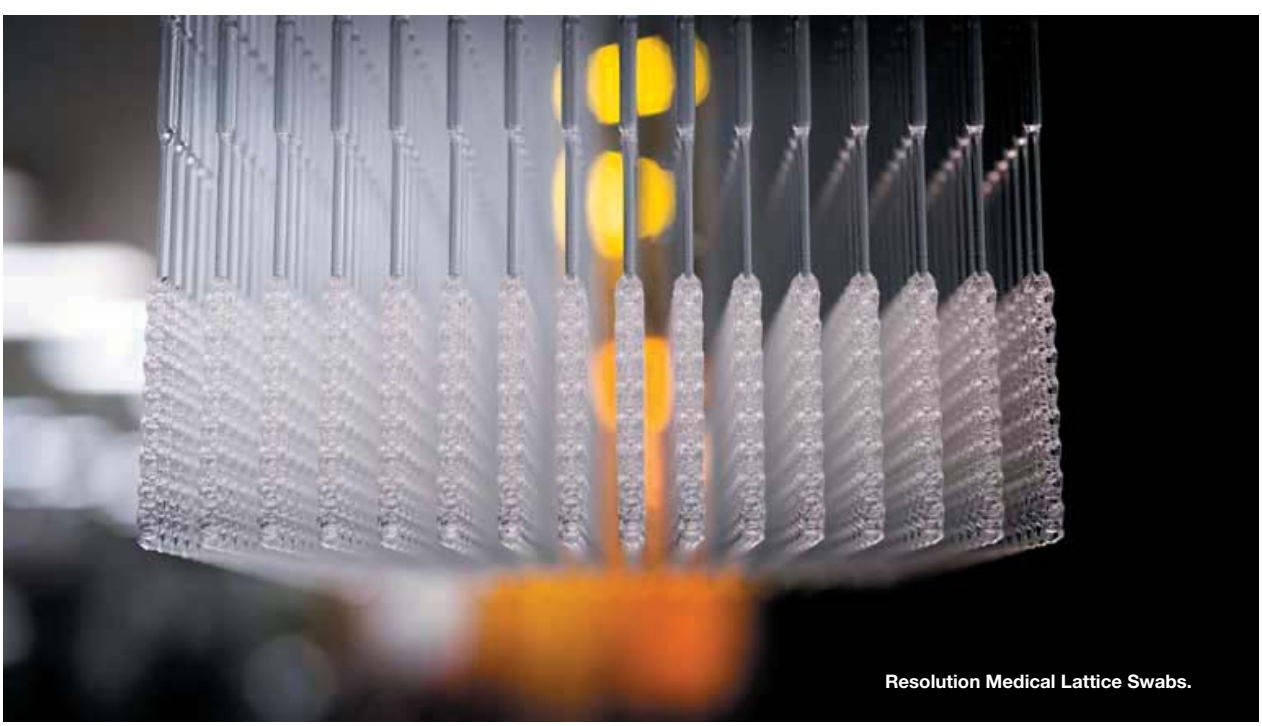
Not only would he be able to put his theory to the test using Carbon's Design Engine computational design software, but once the design and performance requirements of a medical swab were applied to the program, he was able to deliver a viable design within two hours. His team printed a prototype that same day. "This tells you how fast the cycle can be, from a product conceptualization to choosing the material and printing it on a printer the same day," Kabaria said.

Over the course of the following three weeks Carbon's design team, in consultation with its medical devices partner Resolution Medical—an FDA-registered *in vitro* diagnostic and medical device manufacturer—would iterate the design. The finalized, colorless Resolution Medical Swab had a unique dome tip and consists of a soft lattice cage around a flexible helical core, which allows the swab to more easily conform to the organic pathway of the nasal cavity. It was constructed from KeySplint Soft Clear material.

The first shipments of the swabs were submitted for clinical assessment at Stanford University and Beth Israel and Deaconess Medical Center in Boston to prove that the lattice-based design was performing at the same level as the golden standard, said Kabaria.

Accelerating Design Cycles

Kabaria would never have guessed that the swab would garner his employer a spot on the Top 10 list of *Fast Company*'s "Most Innovative Companies" (March/April 2021).



Resolution Medical Lattice Swabs.

Nor could he have imagined that he would engineer a nasal swab to help stem a national medical supply shortage during the pandemic. Resolution Medical was able to scale capacity to print more than 1 million swabs per week using Carbon's printers.

"It shows that if you can print locally and design very fast, even a large clinical study can happen in a very short amount of time," reflected Kabaria. "Of course, there was pressure from the shortage, but that allowed Resolution Medical and Carbon to put this swab in the market for clinical institutions to purchase and use, along with the right clinical data within 20 days."

Earlier this year, Carbon announced that its subscribers would have access to its Carbon Design Engine software. The system automates the process of creating performance-oriented lattices—a time-saver for design engineers.

This step toward democratizing the software, Kabaria said, will help relieve a bottleneck. Carbon's team of mechanical engineers uses the tool to help customers. However, they are limited by the number of queries they can assist at any given time. Making the software available to companies that own Carbon printers will allow customers to explore their own ideas.

The software application can be accessed through the cloud. It is built around five structures, each offering unique mechanical behaviors, such as the ability to plot for stiffness-to-mass ratio, long stress plateau for memory foam or nonlinear mechanical response. The application also helps users select parameters based on volume production. Once the user uploads a part, the platform automatically populates the lattice, while at the same time taking on the burden of the algorithmic work and computational geometry.

Working with CCM, an official licensee of on-ice hockey equipment for the National Hockey League (NHL), Carbon used Design Engine to produce custom Super Tacks X helmets. "Each helmet is unique to the player who wears the helmet," said Kabaria. "We used the same tool to automatically generate a design specific to a particular head shape, without any human intervention."

The Super Tacks X helmet, crafted with the Carbon DLS 3D printing process, replaces foam padding with the NEST Tech lattice for increased breathability, comfort and protection. *(Carbon)*

Carbon

> **"We used the same tool to automatically generate a design specific to a particular head shape, without any human intervention."**

Similarly, opening the platform to design engineers in Carbon's ecosystem will enable users to find new applications that can be taken from design to production, said Kabaria. It allows users to be innovative while being collaborative and providing feedback.

For Kabaria, therein lies the lightbulb moment. The value for Carbon is the insight gained from design engineers. The idea is to keep adding computational power to generate complex shapes quickly across different industries. "From consumer products, automotive components to medical devices," said Kabaria, "the universe of parts that we can affect is pretty wide." md

WATCH THE *Machine Design Insider Interview* **with Ellen Kullman, CEO of Carbon, at** *https://machinedesign.com/21163484.*

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THANIEL SMITH | Manager of Application Engineering, Thomson Industries, Inc.
IAN MILLER | National Services Business Development Manager, Motion Canada

GETTING UP TO SPEED

Understanding ball screw potential and limitations.

The ability to operate consistently at higher speeds is why motion system designers often specify ball screws over lead screws. However, ball screws have speed limitations of their own. Understanding those will help you optimize ball screw assembly performance in applications ranging from small laboratory fluid pumps to large overhead gantries and high-performance machinery.

Ball Screw Basics

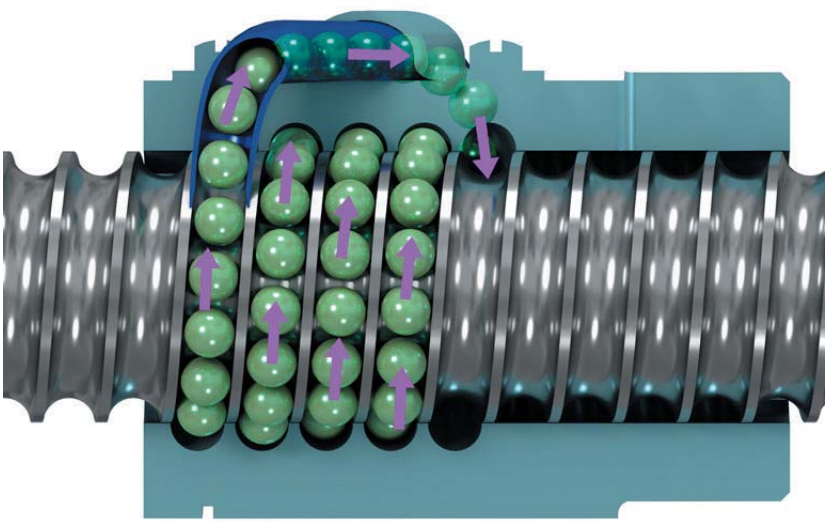
A ball screw assembly consists of a screw and a nut with recirculating ball bearings. The connection between the screw and the nut is made by ball bearings, which roll in the matching ball forms within the nut and screw shaft. This distributes forces over many bearings, giving a relatively low load per ball and a low coefficient of friction, contributing to higher speed operation capability *(Fig. 1)*.

The screw and nut usually have unique maximum RPM limits, so selecting the most effective ball screw assembly requires attention to both.

Ball Screw Design Features

Primary screw shaft design features impacting maximum RPM are end mounting, screw lead and screw diameter.

Every ball screw has a natural frequency at which it vibrates excessively, which is known as its critical speed. When the application speed aligns with the critical speed, the screw vibrates in harmony *(Fig. 2)*. Imbalances inherent in the screw then resonate with it, causing excessive bending, bowing, vibration and, eventually, failure.

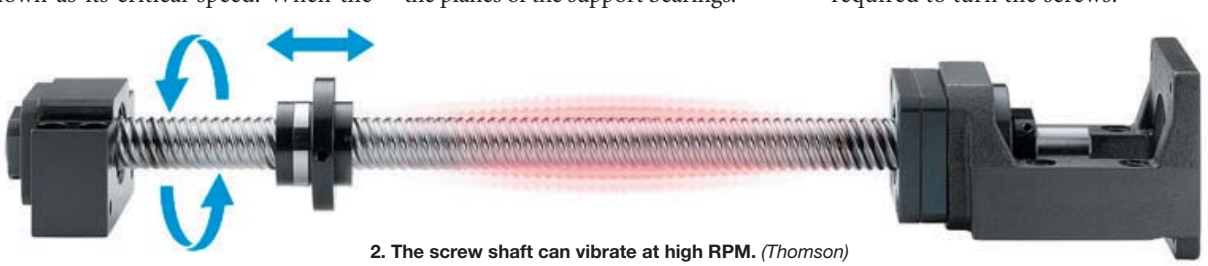


1. Ball screws have a low coefficient of friction because the load is distributed across multiple bearings, which recirculate while the shaft turns. *(Thomson)*

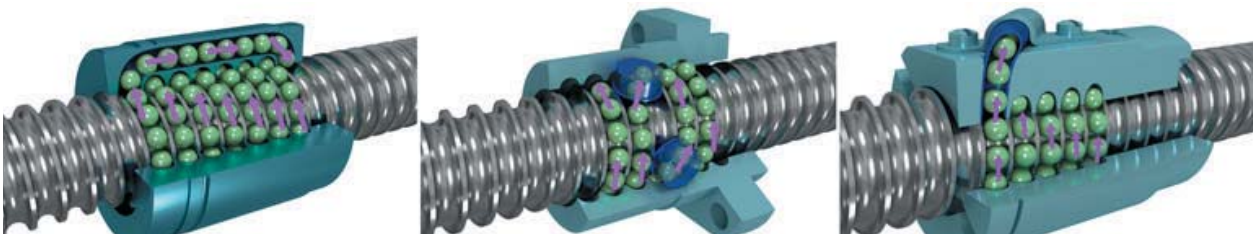
End mounting. Mounting options include fixing it at one end in a thrust bearing, supporting it at both ends in floating bearings, fixing it at one end while supporting it at the other end in a floating bearing, or fixing it at both ends in thrust bearings. The highest speeds are attainable when ball screws are fixed at both ends. The fixed ends resist bending moment loads so the ball screw tries to remain perpendicular to the planes of the support bearings.

However, fixing at both ends can be more expensive and difficult to install than the other mounting options. When fixed at both ends, the distance between support blocks is not adjustable and can make aligning the mounting holes a challenge.

Screw lead. Higher leads will increase the linear speed by moving the nut along the screw faster, assuming constant input speed. When comparing two screws with different leads of a constant linear speed, the higher lead will decrease the input motor speed. Higher leads do, however, increase the torque required to turn the screws.



2. The screw shaft can vibrate at high RPM. *(Thomson)*



3. A comparison of ball return systems (from left to right): internal, button and external. *(Thomson)*

Screw diameter. Larger-diameter screws increase the load capacity and the maximum RPM rating. Smaller diameter long screws will have a lower RPM. With the same lead, the larger diameter screw will have a higher speed rating.

What Limits Maximum RPM?

The ball nut maximum RPM is limited by the speed of the ball bearings circulating through the ball nut. Exceeding the ball nut maximum RPM may result in permanent damage to the ball re-circulation components. The ball bearings may break out of or jam the return system, potentially resulting in the unit's complete failure.

There are three major types of returns systems: internal, button and external *(Fig. 3)*. The purpose of the returns is to provide re-circulation of the ball bearings in the nut. The return system design affects the nut's speed limitations.

The external return systems typically utilize a small finger that extends into the ball groove to deflect the ball into the return path. At high speeds, this finger can flex from the ball bearings hitting it and eventually break off. The button and internal designs are generally more robust and typically can operate at higher speeds than the external return system.

Optimized for Speed

A system optimized for speed above all else would likely require the following:

- Fixed end supports for the screw assembly
- Higher leads to increase linear speed
- Large-diameter screws to increase the load capacity and the RPM rating
- Internal return systems for the ball nuts

The maximum speed for a 1-in. diameter screw like this one will vary greatly depending on length—ranging from 2,938 RPM at 36 in. and 184 RPM at 144 in. (rated at 80% of its critical speed, simple supports). Values can be referenced in the Machinery Handbook. *(Motion)*

The ball nut maximum RPM is limited by the speed of the ball bearings circulating through the ball nut.

However, many other factors come into play, including load characteristics, positional accuracy, repeatability, required life expectancy, dimensional constraints, input power requirements, environmental conditions and available budget.

The impact of most factors affecting speed can be calculated. Ball screw manufacturers typically recommend maximum speeds for their products and provide tools that will help you precisely measure the physical tradeoffs. md

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MORE INFORMATION ABOUT Motion Industries can be found at *www.motion.com/machinedesign*.

MATTHEW DURACK | General Manager and VP of Engineering, Tekmill
SEBASTIAN BARAN | Sales Engineer, Festo

Redesigning a Test-Tube Handler for Robot-Based COVID Testing

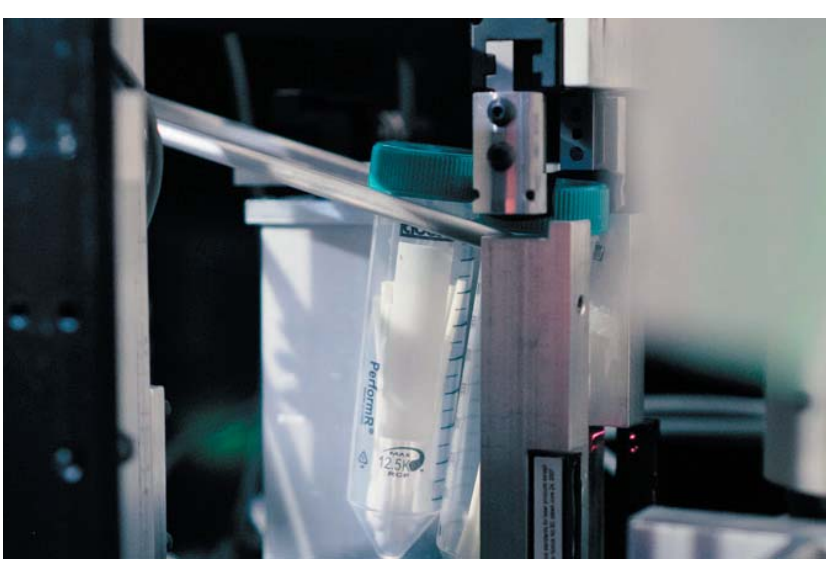
The updated machine can handle 100,000 tests per day.

When the COVID-19 pandemic struck last year, the demand for fast and accurate testing of patients' nasal-swab samples skyrocketed, with some labs going from needing 10,000 swabs checked daily to more than 100,000. To meet that rising demand, engineers at Tekmill and Festo redesigned one of Tekmill's automated robotic machines that handles 50-ml test tubes of agricultural samples and places them in a rack while they waited to be tested. They coupled the updated machine with a new approach to testing to come up with a system that could handle 100,000 samples per day.

Up until this time, a patient's nasal swab would be sealed in a test tube for processing at a screening laboratory, where it underwent the Center for Disease Control's (CDC) protocols for reverse transcription quantitative polymerase chain reaction (RT-qPCR) testing. At the lab, the test tube's cap is removed, reagents are added, and the samples undergo a series of lab processes that determine whether the swab is positive or negative for COVID-19.

Designers knew the one-sample-per-test-tube approach needed to be changed to get to high-volume testing. Not only does the one-swab approach create a mountain of backlog when demand rises so steeply, it eats up incredible amounts of consumables—reagent, test tubes and caps—which are costly and

The Tekmill CTF-COV was designed to speed testing of patients' samples to check for COVID-19.



A test tube is positioned for having its cap removed. Several COVID-19 test swabs are in the tube, part of the pool processing approach.

quickly became hard to come by in such large volumes.

To sidestep these hurdles, labs adopted pool processing. In this approach swabs from several patients are placed in a single test tube and processed as a single diagnostic sample. If the multi-swab test tube—say, a group of 10 people—is negative, no action is required and they are all counted as negative. If, on the other hand, the tube tests positive, then only those 10 individuals need to go through the more expensive but useful rapid testing that identifies positive results in under 30 min.

Handling 10,000 test tubes per day is significantly easier than handling 100,000 tubes, but it is still a challenge for labs. To streamline the process further, automation and robotics needed to be applied.

Using the example of 10 swabs per test tube, 10,000 tubes can be analyzed per day, effectively screening 100,000 people for COVID-19 daily. Pool processing also cuts the use of consumables by about 90%. Handling 10,000 test tubes per day is significantly easier than handling 100,000 tubes, but it is still a challenge for labs. To streamline the process further, automation and robotics needed to be applied. This is where Tekmill's and Festo's expertise was brought to bear.

Tekmill, a contract design and fabrication company located at the University of Illinois in Research Park, had already developed an automated 50-ml conical centrifuge tube handler for decapping, adding reagent, recapping and placing the 50-ml tubes into a standard test-tube rack of 24 tubes. It freed up skilled lab workers who would otherwise spend hours manually taking caps off, pipetting reagent, placing caps back on and then racking thousands of 50-ml tubes.

The machine was reliable and fast, with a throughput of over five tubes per minute. It delivered reagents with an accuracy of ±3% error for volumes less than 3 ml. The device included a temperature-controlled reagent compartment, quick change-and-clean features, a peristaltic-based pump for sterility and accuracy, and a display screen-based user interface.

The Festo EXCM mini-gantry robot's gripper (background) is about to lower itself and grip the cap as the test tube is rotated. The small footprint of the gantry made it well suited for ensuring the overall machine was compact for lab use.

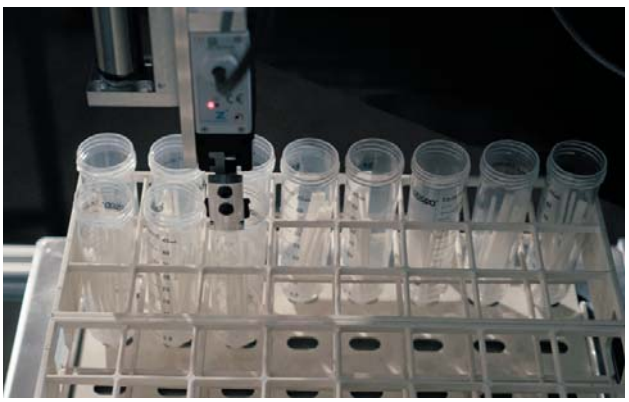
The automated machine was compact and could be easily wheeled to where it was needed. It was also flexible, thanks to the EXCM mini-gantry robot from Festo, a global company that designs electrical and pneumatic automation equipment.

The gantry robot raised the cap as the test tube was spun, lowered the cap as the tube rotated the opposite way after filling and then placed the test tube in the rack. The robot could easily be reprogramed as conditions changed.

The first step in pooled testing is decapping the tubes and accurately adding reagent. The Tekmill machine could already do this, but not at the targeted rate of 10,000 tubes per day. With support from Festo, Tekmill electrical and mechanical engineers began a rapid redesign to revamp the machine's robotic gantry.

One of the first tasks was to redesign the cap handling. In the original machine, a test tube was rotated while the Z-axis on the mini-gantry robot used its parallel gripper to hold the cap as it came off the test tube, and later held and lowered it as the tube swiveled closed. After the redesign, the robot no longer removed the cap, added reagents and then put the cap back on. Instead, it removed the cap, dropped it into a newly added disposal bin and then added reagent.

Although machine vision and barcode reading and tracking were not required



The gantry robot provides the speed and precision needed to handle 10,000 test tubes per day.

on the original redesign of the machine, Tekmill engineers wisely planned for this upgrade should it ever be needed. This pre-planning saved time and effort when a vision subsystem and barcode reading were added to the pooled testing machine to track samples and lower the risk of errors. Fluid handling in the original machine migrated seamlessly to the new one, including the benefits of keeping the reagent sterile by using a peristaltic pump.

Take a look at Tekmill's robotic sample tube handler in action: *https://youtu.be/89b-AUBl8F4*

During testing of the new machine, dubbed the COF-CTV, it was noted that some tubes arriving to be capped were over-torqued to the point that the caps could not be removed without damaging them. Tekmill installed torque sensors to identify over-torquing. When offending tubes are encountered, the mini gantry moves them to a bin designated for manual opening. This preserves the integrity of the 10 samples in the offending tube while maintaining the speed of the other tubes through the unit.

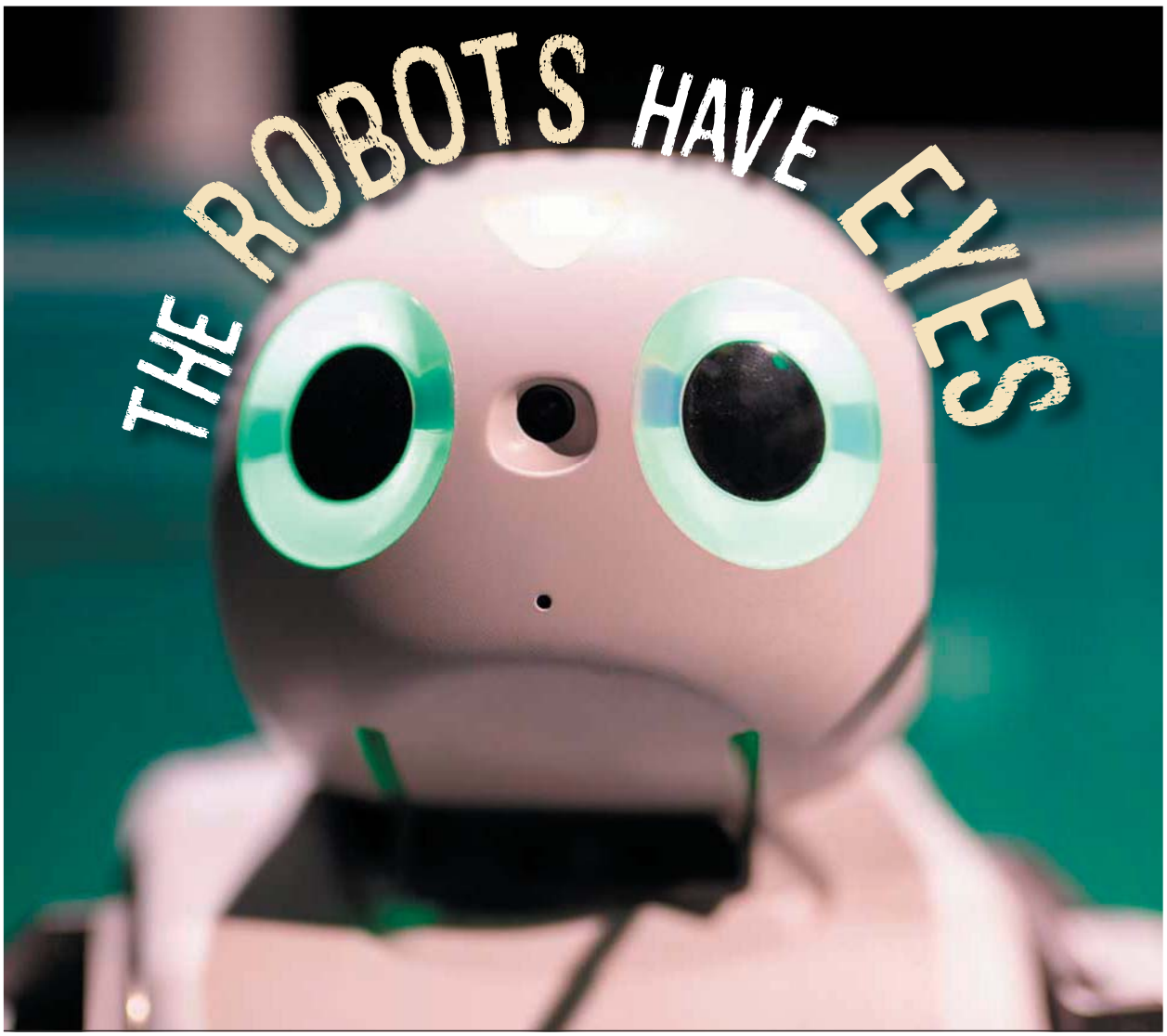
Tekmill engineers also increased the per-load capacity to more than 400 test tubes, which means it only needs to be loaded once per hour, an efficient use of lab staff. The flexibility of the EXCM mini-gantry robot made this transition in speed and quantity a matter of programming. Overall, the upgrades increased throughput from old to new machine by about 20%.

Running around the clock, each CTF-COV tube-handler makes it possible to process 100,000 COVID-19 tests per day using pool testing, a clear demonstration of the power of robotics to increase throughput in today's automated labs.

Take a look at Tekmill's robotic sample tube handler in action here: *https://youtu.be/89b-AUBl8F4.* md

ASSAF EDEN | Director of Product Management, Bright Machines

THE ROBOTS HAVE EYES



Alexander Oganezov | Dreamstime

Machine vision is growing at an astronomical rate—and transforming manufacturing in the process.

Machine vision as a category is growing rapidly; the 3D machine vision market is expected to double in size during the next six years, and today, the technology is a vital component of most modern automation solutions.

There are many factors contributing to the increased adoption of this technology in a manufacturing context. First, demand for automation solutions in general has increased as manufacturers continue to grapple with labor shortages. Second, the cost has decreased dramatically—when cameras, sensors, robotics and processing power are inexpensive, they can be applied to more solutions.

Technology performance also is increasing, giving machine vision systems the ability to process large amounts of information in a fraction of a second. Finally, advanced artificial intelligence and machine learning algorithms are making the data collected from machine vision even more valuable, and manufacturers are realizing the power of those insights.

But what exactly is machine vision, and how can it be incorporated into automation solutions to produce better outcomes?

Giving Robots Eyes *and* a Brain

A vision system typically includes a series of disparate parts, including cameras, lenses, lighting sources, robotic components, processing computers and application-specific software.

The cameras are of course the "eyes" in this system—there are many types of cameras in use for machine vision, and each camera can be assigned for different application needs. There are also differences in how cameras are configured within an automation solution.

Static cameras are placed in a fixed position, have a more bird's-eye view of the process unfolding below and can be used in scenarios where speed is imperative. There are also dynamic cameras, which are positioned on the end of the robot arm and much closer to the process, thereby delivering higher accuracy.

Computing power is also an important aspect of the vision system—essentially, the "brain" that helps the eyes conduct their work. The computation resources required for machine vision that leverage machine learning algorithms will be different than those needed for traditional machine vision applications. Many companies offer software libraries for implementing vision capabilities.

Some capabilities are designed for application users; others are intended for use by software programmers. Regardless, it's software that gives machine vision advanced capabilities that have dramatic impact for manufacturers, with programs to control tasks and the ability to feedback valuable insights from the line.

Machine Vision Applications

The concept of replacing basic human capabilities with a vision-guided solution is gaining steam, as vision for assembly lines can be used in an increasing range of applications and processes.

A typical "electronics in a box" assembly process provides one example. This is a product category that spans many shapes and sizes and is relevant across a number of industries (including but not limited to medical equipment, power tools and home appliances). The assembly process for these hardware components consists of placing the electronics, such as a circuit board, into the housing, or box.

Many of the assembly steps involved in electronics in a box assembly can benefit from the use of machine vision because of the precision required.

Inspection. Machine vision can be used to inspect all top and bottom cover components as they enter the assembly line, looking for defects such as cracks in the metal—if these components are in poor condition, it can lead to quality issues for the assembled unit. With machine vision, cracks are detected quickly, and if they are larger than a specified size, the component is automatically rejected. In addition to cracks, color variations can also be inspected; a color camera can identify discoloration damages and reject faulty units.

Product tracking. Required in the automotive and healthcare industries, product tracking is used during the entire manufacturing process. So usually, the first vision task for circuit boards during the assembly processes is to read the product label, serial number or barcode. The product label identifies the specific unit so it can then be tracked throughout the entire assembly process.

The label location can be pre-defined and the vision system is used to read the label and communicate its findings to other factory systems. Applying labels is a common requirement in assembly lines and another perfect use case for machine vision, which can detect any obstacles on the surface and ensure perfect placement.

Installation. Adding components to a circuit board can require vision capabilities both for quality control and for positioning. As an example, for a varistor that needs to be added to a circuit board, machine vision would first inspect the varistor to verify that both legs are straight and not damaged. Vision can also inspect the varistor's identification to confirm it's the correct part, and the varistor's orientation for proper assembly on the circuit board.

Finally, vision capabilities can identify the correct location on the circuit board where the varistor will be installed and soldered in place. During the soldering process, vision is used to monitor conditions such as the wetting area, lead lengths, solder balls, contact angles and solder fill.

Machine vision also aids in similar processes that require consistency and precision, like thermal paste dispensation application and metal shield insertion. Dispensing sealant is another example; a vision system can reference the expected path and compare it to the achieved result.

Final assembly. Fastening methods, such as screwdriving, also are frequently used to assemble products. This process can be more consistent with a vision system. Machine vision can be used to identify the screw hole and to navigate the robot with the screwdriver accurately to the specified location. Once complete, a vision system can verify that the screw has been fastened properly. If there is more than one screw, the vision system can be used to navigate to additional holes and implement the screwing process as many times as needed.

Machine vision can also be useful in component feeding, guiding detailed part assembly, part sorting and closed-loop activities such as DIMM card insertion using force feedback control (any process where human inputs are not needed, and the system is designed to achieve known outcomes).

The ROI of Machine Vision

To achieve next-generation automation and fully realize the benefits of the technology, machine vision on an assembly line isn't just "nice to have"—it's vital. This technology enables diverse capabilities for inspection, robot navigation and quality control, and the use cases for machine vision are continuing to expand in scope and complexity as the technology continues to evolve.

That translates to tremendous potential for manufacturers, as vision solutions for automated lines can improve production capacity, production stability and production yield. As both the hardware and the algorithms involved with machine vision continue to improve, so does the ROI for manufacturers who invest in these solutions. md

How do Japan's machine tools and material manufacturers remain ahead of the competition?

Leader Roundtable

	What sets you apart from your competitors?	What is the main challenge/goal for your company or industry?
 **YOSHIHARU INABA,** **Chairman, FANUC**	"We are the pioneers of automation and robotization for manufacturing sites. Throughout our years of operation, we have developed a unique set of skills based on experience. This accumulation of expertise allows us to advance and progress in a tough competitive environment. Our technical expertise is coupled with the preciseness of Japanese manufacturing."	"Relying on automation processes and robots will be one of the solutions to answer our decreasing workforce and aging population. However, this solution is clearly not limited to Japan for it will be applicable to the entire world. Our industry is focused on developing robots that can help human beings. The idea is to have machines, robots and such, do the heavy and monotonous labor, while humans focus on precise and unique work."
 **NAOTAKA KONDO,** **President, Toyo Tanso Co., Ltd.**	"Our products have attracted attention because we can express the full potential of isotropic graphite. Our graphite has many applications because of its excellent properties: it is stronger than conventional graphite; resistant to extreme temperatures, has excellent electrical conductivity; it is also stable and lightweight. One of the products we developed is CNovel, which is used for many kinds of batteries, particularly fuel cells."	"With technological advances, semiconductors are now used for the development of nano-scale devices. Consequently, the demand for accuracy and precision has drastically increased, and machining processes played a central role in achieving this level of precision. At TOYO TANSO, we supply materials critical to the production and adequate-functioning of these next-generation machining systems."
 **AKIHIRO NIKKAKU,** **President, Toray Industries INC.**	"We are continuously striving to improve our carbon fiber technologies by producing more resilient and stronger material. Among all the firms in the world, I think Toray is the one that has most continued to pursue excellence in carbon fiber technology. Various emerging carbon manufacturers are able to produce materials at the level of T700 today, however, we have already gone beyond that and successfully developed the 'T1100' in 2014."	"When it comes to carbon fibres, they were first developed by Professor Shindo, in 1961, and we were also involved in that process. It was only in 1971 that we were able to effectively produce carbon fiber material. We've taken around 60 years to develop this technology and it is still undergoing intensive research today. Toray's R&D efforts can be crystallized in the philosophy of 'never giving up,' 'never feeling defeated' and persistently pursuing R&D."
 **HIROJI GOTO,** **President & CEO, NS TOOL**	"We were the pioneer of the smallest end mill available on the market with a size of 0.01mm. We focus on putting efforts into our high-precision machines in creating miniaturized components at a nano level, where other companies do not have the capability of doing so – this is our competitive advantage. We have high expectations and put a lot of effort and investment into pursuing research and development."	"We want to contribute to even bigger development in this field and continue to be the pioneer in high-precision measurements. We invested 1.4 billion yen to build our new R&D facilities to further develop our technology. The building itself is a vibration proof building that is designed to support the R&D environment for making high-precision tools, as you need to ensure that there are no external vibration factors."
 **YOSHIO WATANABE,** **President, YAMAWA**	"We have engineers who design and develop our machines and engineers who operate the software. This is to ensure we have what is needed to develop the best production system to create high-precision and high-quality products. Furthermore, our machines are researched and developed to perform well in producing at a fast rate."	"Our market is focusing deeply on high-precision processing only. In that case, we believe that our company can strive further in the high-precision industry as our strategy moving forward. Infrastructure is getting bigger each day, and we believe that it has high potential for growth. Our company is competent in supplying tools and equipment for infrastructure."

NS TOOL: micro-machining for macro impact in hi-tech fields

NS TOOL Core Line

■ Crafting tomorrow's industries by pioneering miniaturization in high-precision machining.

With increasing demands for higher-quality, lighter-weight and miniaturized components in automotives, electronics and ICT, many top companies turn to the high-precision processing technology developed by NS TOOL.

In the face of increasing competition from China, NS TOOL has set itself apart by focusing on high-quality and following the trends of miniaturization, which led the company to develop the world's smallest end mill, at a size of 0.01mm, back in 2005. Since its launch, this cutting tool has increased steadily in terms of numbers of users, which include high-end manufacturers of smartphones and sensors.

"Our principle and philosophy strongly highlight the importance of making these kinds of tools and machines a reality, so we can make it possible for industry to move further towards miniaturization," explains president, Hiroji Goto.

Micro milling on a human hair

NS TOOL sees ample opportunity in developing end mills that will be used in the manufacture of the latest technologies, such as electronic vehicles, 5G, advanced semi-conductors and sensor technologies for AI and IoT. The company has thus recently made a JPY 1.3bn investment in its R&D facilities to further develop its technologies.

"We are focusing on our high-precision machines to create miniaturized components at a micro level," says Mr. Goto. "We aim to contribute to even bigger development in this field and continue as the pioneer in high-precision machining."

NS TOOL

www.ns-tool.com/en/

Leading Japanese Tier-2 supplier makes decisive push into EV components

■ Leveraging its long-standing experience working with major brands, such as AISIN, ADVICS, BOSCH and HITACHI, Kurota is developing state-of-the-art components for electronic and hybrid vehicles.

With almost a century of history in innovation, Kurota began its engagement with the Japanese automobile industry in its nascent post-war period. Ever since then, the company has progressed in line with the advancements of the automotive industry, supplying high-performing aluminium brake pistons and engine components to leading Japanese, European and American clients.

TOSHIHIRO KURODA,
President, KUROTA

Today, as the industry undergoes its most profound transformation with environmental concerns and regulations spurring demand for greener vehicles, Kurota has put forward a range of components suited for the hybrid and electric vehicles (EVs) that will be the prominent fixtures on the roads of tomorrow.

Aluminium brake pistons

"In the field of brake components, we can still supply our existing products to EV makers and the production of our aluminium brake pistons for EVs and hybrids has increased in recent years," explains president, Toshihiro Kuroda.

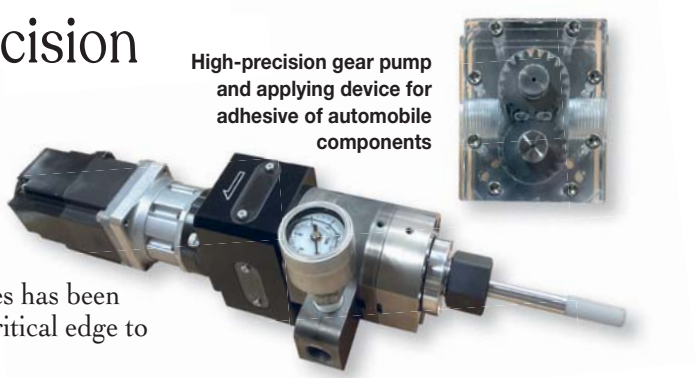
"A new area of product development is in electric pumps for EVs. We are currently producing shafts for electric pumps. As they are used in the cooling system of inverters, these components require a high level of accuracy and reliability. With the EV era coming sooner than expected, we are exploring various options, focusing on new fields where we can utilize our strength and technologies."

Responding to the rapidly changing demands of the industry will remain key for Kurota moving forward. As it looks towards its 100th anniversary in 2025, the company's main goal is to further become a reliable manufacturer on the global market as a supplier of high-quality automotive parts. "Thanks to our status as a tier two supplier trusted by brand names, including AISIN, ADVICS, BOSCH and HITACHI, we are in a good position to achieve that goal," concludes Mr. Kuroda.

CHALLENGE THE NEAR FUTURE.
KUROTA
www.kurota.com/e/

Kyowa FineTech: high-precision processing technologies that meet our customer's demands

■ The firm's eco-friendly solution for lithium batteries has been developed in reaction to market needs, providing a critical edge to compete in new sectors of industry.



High-precision gear pump and applying device for adhesive of automobile components

As the trends of global manufacturing evolve – an industry which is perpetually tasked with innovating to meet society's modern challenges – Japan and its army of SMEs that characterize the sector is leading from the front.

MUNEYUKI HASHIMOTO,
President,
Kyowa FineTech

Kyowa FineTech, which manufactures machines based on finding solutions to the world's environmental problems, is one such fine example. "We start off by knowing what the problem is in the market and propose machines to tackle those issues," explains the company's president, Muneyuki Hashimoto. "Lithium batteries are one issue that we have successfully managed to overcome. This type of battery has holes that leak solvents as pollutants. We came up with a pioneering solution in making solvent adsorption equipment to be able to inspect and adsorb the solvents to create a more eco-friendly environment."

An increasing utilization of batteries in manufacturing is for electric vehicles, a rapidly growing market defined by the need for sustainability, and so one that Kyowa's adsorption equipment is primed for.

"Electric vehicles are a promising trend in the industry," says Mr. Hashimoto. "Like many other industries, the automobile industry needs the utilization of technology. Therefore, it is a huge opportunity to enter these markets with our advanced technology, for example our high-precision gear pump, and compete in the new sectors of industry."

kyowa
fine-tech co.,Ltd.
www.kyowa-ft.co.jp/en/

NISSEI supplies you with technology, not the locking bolt itself

■ Rolling a low-cost, anti-loosening bolt "PLBv2" at last! This practical and effective bolt does not rely on friction.

TOSHINAKA SHINBUTSU,
President, NISSEI

We might think there are no technical improvements left to be made on a bolt, but let's think again: what about the problem of loosening? It is a fact of mechanical life that bolts loosen. Many techniques for keeping bolts tight have appeared. From the point of view of practical usage, cost effectiveness, and the ability to truly prevent loosening, making better bolts is an old but new problem. Nissei invites you to look at their fresh solution, PLBv2. PLBv2 (Perfect Lock Bolt, version 2) relies on double nuts and multiple threads rolled onto a single shaft.

For fasteners such as bolts, loosening is the enemy. The need for periodic tightening and problems arising when bolts need to be replaced or re-used are common. In the battle against loosening, many solutions have been attempted—all, until now, have been mediocre. Relying on friction to prevent bolts from loosening is not good enough. A mechanical solution built into the structure of the bolts is what is needed.

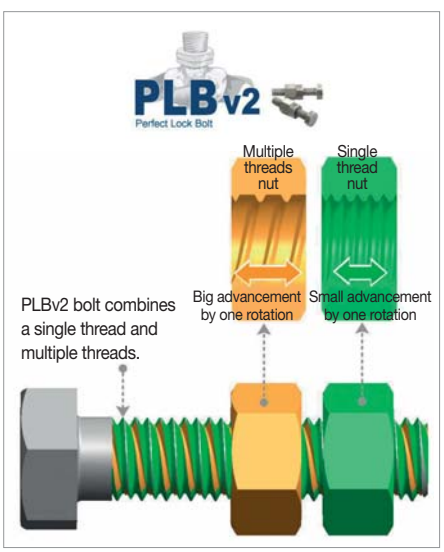
Principle and Features of PLBv2

Here is one mechanical method to protect against loosening. Roll the lead of each bolt with two different threads, then add one nut to follow each thread. Because the lead that the inner nut follows is longer than the one for the outer nut, when vibration inevitably makes the nuts start to rotate loose, the inner nut will be blocked by the outer nut. This is because the lead followed by the outer nut is more closely-packed, and so the outer nut must rotate more slowly. This is mechanical blocking.

Manufacturing method

How to mass produce bolts with two separate and distinct threads? It cannot be done reliably by cutting threads into the bolt shaft, but it can be done with thread rolling. Nissei, an innovative maker of rolling machinery located in Yamanashi Prefecture in Japan, has tackled this problem to produce uniform and reliable bolts that cannot be loosened by normal vibration: PLBv2.

Machines that could make dies capable of rolling a complicated pattern were not readily available when we started our Perfect Lock Bolt project. In 2018, we completed round dies, then in 2019 flat dies, developing new techniques one after the other. We envisioned planetary dies as the means to this end. All in all, it has taken 15 years to reach the level at which our machines can roll two kinds of threads—simultaneously—on one anti-loosening bolt.



PLBv2 bolt combines a single thread and multiple threads. Threading of PLBv2 requires specialty dies made by NISSEI. The dies can be used on an ordinary thread rolling machine. The dies can roll PLBv2 in one action.

Can be rolled with your company's existing equipment

The anti-loosening bolt that Nissei has developed and named PLBv2 has been tested and conforms to international standard ISO16130. For the specified vibration criterion relative residual clamp force of 2000 cycles, other companies' products received a rating of "acceptable loss of clamp force", which in ISO16130 terms means they perform adequately from 40% to, at best, 85% of the time. PLBv2 is rated ISO16130 "Good self-locking behavior", meaning performance is good 93% of the time.

A major value of PLBv2, above and beyond its anti-loosening properties, is practicality in actual use. By tightening the outer nut, the inner nut is also tightened. Both bolts, one action. With ordinary double nuts, each nut has to be tightened individually. With PLBv2, the inner nut follows the outer nut naturally. It is like having to fasten only one nut instead of two. No PLBv2-specific tools are required, ordinary tools do the job. Ease and practicality in usage are additional advantages of PLBv2.

The process of rolling bolts with thread rolling machines is advantageous to bolt makers. In other, more ordinary processes, after cold forging, heat treatment processing is recommended. The same processes are applied to PLBv2 with the same system. There is no need to buy new systems when you have the license. The threads can be rolled simultaneously on existing thread rolling machines, provided they are equipped with PLBv2-specific dies made by Nissei. "Being able to roll these bolts on machines already in place is a big advantage," says Shuichi Amano, chief engineer/engineering director at Nissei. "It's a competitive cost advantage to get a better bolt from existing equipment."

Shape your dream
NISSEI

www.nisseiweb.co.jp/e/index.php
contact: **plb_bolt@nisseiweb.co.jp**

READ: custom-made solutions for high-precision manufacturing

■ A cutting-edge leader, READ uses AI and Big Data to enhance the quality of its products and services.

Amid increasing regional competition in the field of precision processing, Japanese companies will keep a competitive edge through a strict adherence to *monozukuri* (Japanese craftsmanship) and *kaizen* (continuous improvement), particularly in the field of high-precision machinery, where READ remains at the cutting edge.

YOSUKE NABEYA, President of READ

"Japan excels in precision machinery and that is where the strengths of *monozukuri* and *kaizen* come to life," argues READ president, Yosuke Nabeya. "In our case, we produce original products and technology that only we are able to manufacture. Our focus depends on our ability to continue drawing the strengths of *monozukuri* and what role we can provide to the world."

Drawing on its superior and unique technology cultivated over the past five decades, READ manufactures high-precision processing, grinding and cutting tools. Having gained the highest trust and reputation among clients in Japan, the company aims to go global as it also looks to penetrate new industries, such as medical, semiconductors, automotive and solar panels.

"We utilize and develop our technology based on the ability of our company to create the hard blades and grinding tools designed for processing materials that are difficult to machine. Therefore, we have been focusing on such difficult materials used in other new fields," explains Mr. Nabeya.

"We would like to improve ourselves together not only with our conventional partners but also international partners. If there are companies whom we can collaborate with in any of these new industries, we are willing to provide our technological expertise to such companies and establish fruitful relationships with them."

Harnessing the power of AI and Big Data in its manufacturing processes, READ will continue to make high-quality products for the industry needs of tomorrow.

READ Co.,Ltd.
www.read.co.jp/englishver/

Ogura Jewel Industry: more than a century of experience in jewel processing

■ Ogura's high-precision micro-machining technology is a cut above the competition.

Beyond their aesthetic use in jewelry, diamonds, rubies and sapphires are widely employed in an ever-increasing number of industrial applications due to their excellent mechanical, optical, physical and chemical properties. However, these extremely hard-yet-brittle materials can be difficult to cut and shape, which is why the most high-precision machinery and technology is required to process these precious jewels.

Vitrified bond diamond wheels

For more than a century, Ogura Jewel Industry Co. Ltd. has been the leader in precision machining and technology for the processing of diamonds, rubies, sapphires, as well as other brittle materials such as zirconia ceramics, platinum, titanium, tungsten, 18-karat gold and various cemented carbides.

Combining its century-old dedication to the Japanese craftsmanship tradition with its advanced micro-machining and nanometer technology, Ogura is the reputed partner of choice for high-demanding clients operating in a wide range of sectors, including machine tools, semiconductors, telecommunications and automotives.

As an example, Ogura has been a pioneer in the business of the hole drilling process (which is utilized as a wire guide for Electrical Discharge Machining), coating dies for magnet wires, and nozzles for water jets. In response to the shifting trends in customer demands, the company also provides the rotating axis (bearing) for the watt-meter.

Coil winding nozzles & Enameling dies

Drawing on its prowess for innovation and working in close collaboration with its clients, Ogura will continue to develop market-leading solutions in response to the latest industry demands.

INDUSTRIAL JEWELS OGURA
www.ogura-indus.co.jp/en/

Tsukiboshi: "We focus on our people and their mental brilliance, as well as a *monozukuri* that is environmentally friendly"

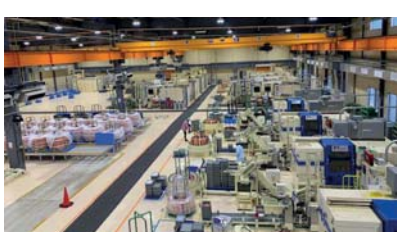
■ In building a strong corporate culture with its employees and in turn providing its automotive customers with high-quality products, Tsukiboshi aims to differentiate itself by engendering strong values of *monozukuri* and sustainability.

With Japanese companies continuing to face stiff price competition from elsewhere in the east Asian region, the country's SME manufacturers – particularly in the highly competitive market for industrial parts and products – continue to set themselves apart through the uniquely Japanese characteristics of *monozukuri*.

"With respect to prices, China, Taiwan and South Korea are increasing their competitiveness with mass production. Nevertheless, the strength of small-and-medium-sized Japanese enterprises in the manufacturing industry is their ability to pay keen attention to customer needs. We differentiate ourselves in quality by fully understanding our customers' purpose of use and developing a suitable product," says Wataru Uchimoto, President of Tsukiboshi Manufacturing Co. Ltd.

"Our passion for *monozukuri* is based on the deep-rooted culture of our employees. Each Tsukiboshi employee strives to create superior products, and we as a company desire to integrate what each employee has created to provide a superior service for our customers. That is the starting point of *monozukuri*."

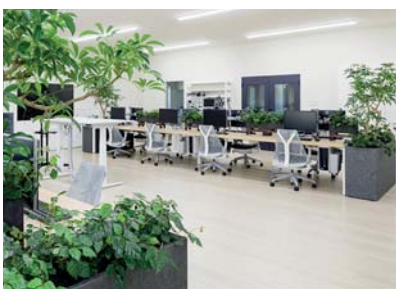
Founded in 1947, Tsukiboshi employs a unique manufacturing method to produce



WATARU UCHIMOTO, President

high-quality bolts, nuts, rivets, and washers for the automotive sector. This includes bespoke designs it creates through the forging process, which provides additional value to its final products. "By providing our customers with products made by machinery built in-house, we are not only differentiating ourselves from other companies, but also engendering this strong attachment toward *monozukuri* in our employees," explains Mr. Uchimoto.

By 2025, the global high-precision industry expects to reach a value of $300 billion, with the automotive sector to contribute approximately $65 billion, largely driven by a fast-accelerating transition to electric vehicles (EVs) worldwide. For a company whose internal combustion engine-related products currently provide roughly 70% of its output for the automotive sector, this irreversible EV trend is a strong motivator not only to innovate and adapt the business strategy accordingly, but also employ an increased focus on sustainability across the board.



"With the trend toward EVs, we are focusing our energy on the development of new EV-related products, with emphasis on safety parts," says Mr. Uchimoto. "For this we are contemplating a layout for our new factory presently undergoing construction that is scheduled to be completed next year. According to that layout, in-plant physical distribution will be reduced by approximately 40%, helping to vastly improve the sustainability of our operations."

This will only help further differentiate Tsukiboshi from its low-cost, mass-producing regional competitors, says Mr. Uchimoto. "We focus on the people who are manufacturing the products and their mental brilliance, as well as *monozukuri* that is environmentally friendly."

Z-PRO

Ultimate Machining Taps

快作

Recommended to high performance machining use.

Coated taps for through hole

VUPO

Spiral Pointed Taps

Coated taps for blind hole

VUSP

Spiral Fluted Taps

Think threads with YAMAWA

https://www.yamawa.com/en/

TRANSPORT CONTROL

The mechatronic eXtended Transport System (XTS) now includes an application-specific HMI control for visualization of dynamic product transport. The XTS technology already supported collision-free motion with movers working independently or in groups and delivering dynamic, high-precision positioning on customer-specific track geometries. The new HMI software extension generates matching visualizations from an existing XTS track configuration with just one mouse click. The generated XTS HMI Control is automatically linked with all necessary parameters from the user's application and can directly display the current positions of all movers within the system. The solution consists of three levels and readily combines with other HMI Controls, or even with animated images, as required. This means that users can create highly realistic representations of complete systems with minimal effort.

BECKHOFF AUTOMATION LLC, www.beckhoff.com

ETHERNET SWITCH

The SX5E-HU085B 8-port unmanaged industrial Ethernet switch provides many managed switch features to support the rapidly expanding quantity of Ethernet, IoT and IIoT devices used in critical and challenging commercial and industrial locations. No software configuration is needed, and flexible installation options make this an economical yet high-performance solution. This switch operates at 10 and 100 Mb/s, with auto negotiation of speed and full or half duplex mode, and every port automatically detects and adjusts for straight-through or crossover cable connections.

IDEC CORPORATION, us.idec.com/SX5E-8port

INDUSTRIAL ROBOTS

The 6-axis IRB 1300 industrial robot includes new protection elements that enable it to be used in tough industrial applications and contamination-free production processes, opening new opportunities for increased productivity, improved product quality and reduced cycle times in a variety of industries including electronics assembly, automotive and metals fabrication. Originally launched in 2020, the IRB 1300 is now available in IP67, Foundry Plus 2 and cleanroom ISO 4 versions. This will expand its use in tough environments, with high levels of liquids and dust. This is achieved by preventing intrusion by sealing all electrical components, which enables a variety of processes in multiple industries.

ABB ROBOTICS & DISCRETE AUTOMATION, go.abb/robotics

ROTARY ENCODERS

The IXARC high-precision magnetic absolute rotary encoders are now available with a BiSS-C interface. Encoders with this interface are ideal for commutation and position feedback on BLDC servo motors and are also an excellent fit for motion control applications, such as medical equipment. They feature robust design, 17-bit resolution and excellent dynamic response (up to 12,000 RPM). Multiturn variants feature a 32-bit rotation measurement range (over two billion revolutions). The rotation counter is self-powered, using Wiegand energy-harvesting technology, eliminating the need for backup batteries or gear drive systems.

POSITAL, www.posital.com

SAFETY LASER SCANNERS

Safety laser scanners offer an ingenious, cost-effective way to protect an entire area. This can be a static application such as a robot cell or the area surrounding a moving device such as an AGV. They are ideal for providing safe access to potentially dangerous locations or areas. These laser area scanners are configurable and feature a 275-deg. viewing window that allows for several user-defined zones of protection. I/O and dust filtering are other options configurable through the unit.

AUTOMATIONDIRECT, https://www.automationdirect.com/safety-laser-scanners

LINEAR MOTION BEARINGS

Slide Ways are non-recirculating linear motion bearings used primarily in optical and measurement equipment where high-precision movement is required. The SV style consists of two roller cages with precision rollers in a cross arrangement and four rails with V-shaped raceways. The SVW has one rail with V-shaped grooves on both sides and 2 SV rails. The catalog contains all dimensions, drawings and ratings necessary for specific applications. 3D CAD is available.

NB CORPORATION OF AMERICA, www.nbcorporation.com

CARLO GAVAZZI, www.GavazziOnline.com

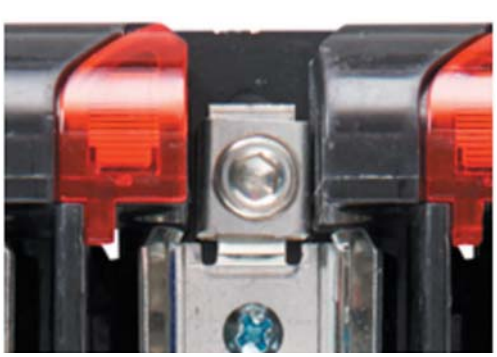
ON/OFF CURRENT SENSOR

The EISH Series of On/Off current sensors can detect current as low as 200 mA AC and up to 60 Amps AC, making it optimal for applications in a variety of markets including HVAC, water treatment, data centers, tunnel/airport lighting and other areas of critical infrastructure. The EISH Series features a space-saving and versatile housing which can be either DIN rail- or panel-mounted. It has a built-in current transformer with a solid state normally open output. A 12 mm through hole easily accepts insulated wire. The EISH Series is self-powered from the input current, making it simple and cost-effective.

FUSE BLOCK HEX SCREWS

Hex-screw head options for the 60-A LFR and LFT series of fuse blocks are ideal for manufacturing automation, helping OEMs simplify the tightening process for their components to reduce assembly errors. The hex-screw 60-A fuse blocks accommodate a wide range of existing mounting configurations and feature a snap-to-release DIN-rail mounting for easier installations, as well as reinforced fuse clips for increased reliability.

LITTELFUSE, Littelfuse.com/FuseBlocks



HYDRAULIC HOSES

The MEGASys MXT with XtraTuff Plus cover (MXT-XTP) is a universally applicable hydraulic hose featuring patent-pending wire-braid technology. MXT-XTP offers compact size, light weight, flexibility and high performance with added durability from the XtraTuff Plus (XTP) cover. MXT-XTP is suitable for the most demanding fluid power challenges across a broad array of industries and applications, including construction and mining, material handling, machining and metal processing, injection molding and other stationary machinery, agriculture and forestry, aerial lifts, and more.

GATES, www.gates.com/mxt

PRESSURE INSTRUMENTS

The new Cerabar and Deltabar pressure and differential pressure instruments feature a Bluetooth interface for easier operation, as well as improved efficiency in regulatory control, safety and other systems. Heartbeat Technology creates the data basis for predictive maintenance and allows the instruments' functionality to be verified without process interruption. Intuitive operation is now provided via the SmartBlue app, which includes guided operating sequences for parameterization and commissioning of the pressure sensor, bridging distances of up to 50 ft. Thus, even measuring points that are difficult to reach or in hazardous areas are easy to maintain, even if they are only integrated into the process via a 4–20mA interface.

ENDRESS+HAUSER, www.us.endress.com

Machine Design

AUGUST 2021 ISSUE PREVIEW

Cover Story
The Monthly focus:
Mobility Design

Applications.
Putting ideas to work:
Cobots lend a hand, as humans the strategy

Trends. The cutting edge ideas in design:
Cloud computing: Who needs it, and why?

Product Digest. Innovations and design trends:
Materials and fastening

Design U: Design
The cloud brought down to earth

Ad Close:
7/2/2021

Materials Due:
7/12/2021

AD INDEX

STEPHEN J. MRAZ | Senior Editor

Predicting Wind Power Costs for the Next 30 Years

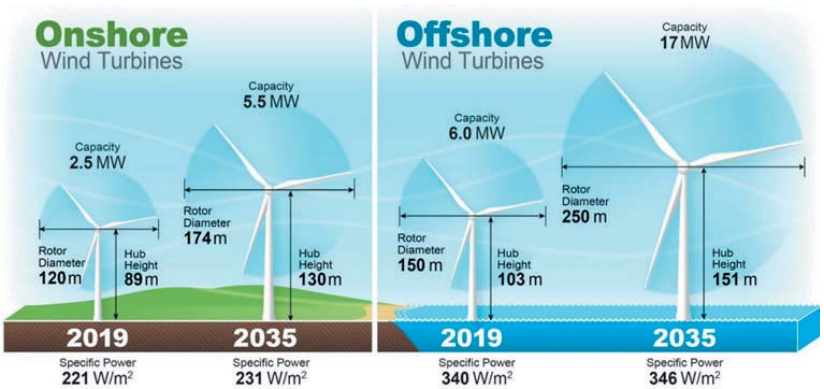
Wind power companies will see levelized cost of energy drop by 17% to 35% by 2035 and 37% to 49% by 2050, driven by bigger and more efficient turbines, lower capital and operating costs, and other advancements, according to a survey of 140 wind-power industry observers taken by researchers at Lawrence Berkeley National Laboratory.

The survey also looked at levelized energy costs across three types of wind-power plants: onshore (land-based), fixed-bottom offshore and floating offshore. There are greater absolute reductions (and more uncertainty) in the levelized energy costs for offshore wind compared with onshore wind, and a narrowing gap between fixed-bottom and floating offshore wind, according to the survey. Still, predicted future costs for all three types are half what a similar 2015 survey predicted.

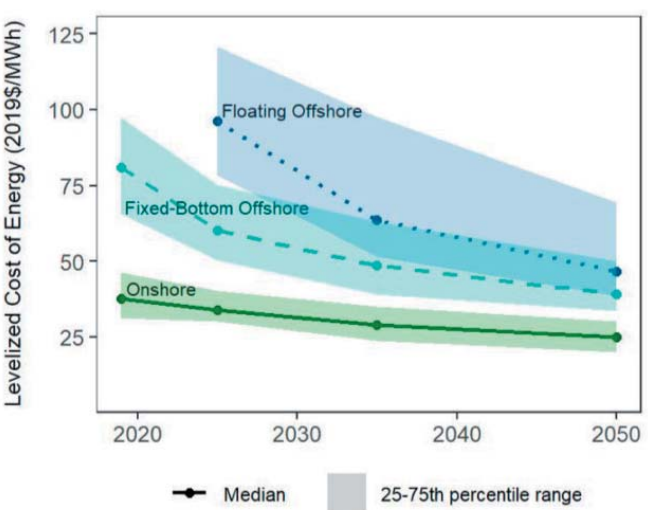
The federal government is trying to "maximize offshore wind potential" and identifies wind power as a key component of the nation's efforts against climate change. Wind power could play an important role in reaching net zero carbon emissions by mid-century.

Five key factors affect the levelized cost of energy: upfront capital cost, ongoing operating costs, capacity factor, project design life and cost of financing. Experts anticipate continued improvements across all these factors.

A key driver in these improvements is turbine size, according to the survey. For onshore wind, growth is expected not only in generator ratings (to an average of 5.5 MW in 2035, up from 2.5 MW in 2019), but also in two other factors that increase capacity—rotor diameters and hub heights.



These illustrations show the changes in dimensions and capacities for onshore and offshore wind turbines.



A survey of wind-power industry observers predicts substantial cost reductions for onshore, fixed-bottom offshore and floating offshore wind power, but there is considerable uncertainty in those future costs.

Offshore wind turbines are expected to grow to an average of 17 MW in 2035, up from 6 MW in 2019. Floating offshore wind is predicted to gain market share, going from its current pre-commercial state to account for 25% of new offshore wind projects by 2035.

The survey indicates that cost reductions have accelerated in recent years, faster than previously predicted by most forecasters and faster than historical rates of decline.

"All else being equal, these trends will let wind play a larger role in global energy supply than previously thought while facilitating energy-sector decarbonization," says Joachim Seel, a researcher at Berkeley Lab. "Analysts, investors, planners and policymakers should avoid outdated assumptions and forecasts." At the same time, as documented in the survey, uncertainties in the magnitude of future cost reduction are significant, illustrating the importance of including this uncertainty in modeling, as well as in policy, planning, investment and research decisions. md

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