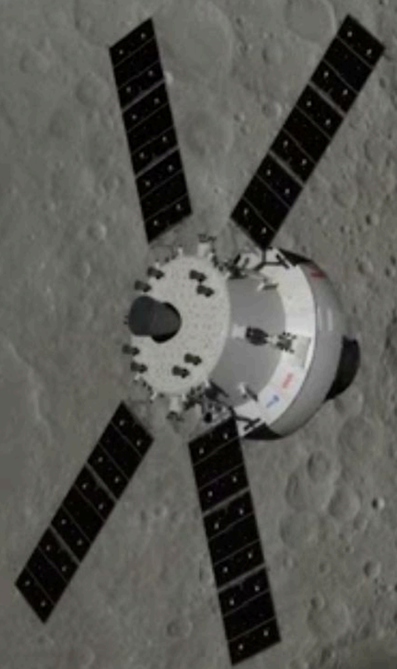
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January 2025

MOON ON THE HORIZON



NASA's ambitious Artemis program aims to land astronauts on the lunar surface. The engineering is out of this world.

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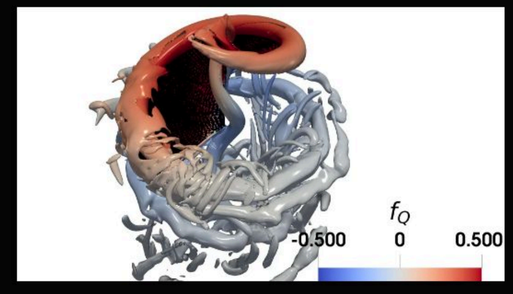
ALSO IN THIS ISSUE:



IN PURSUIT OF GREEN STEEL



FREE-PISTON STIRLING ENGINES



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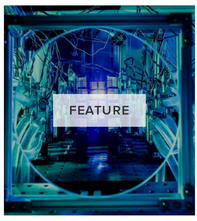


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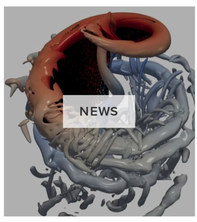


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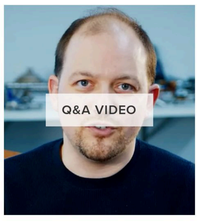


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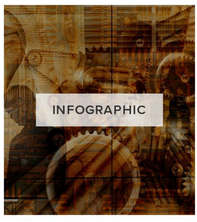


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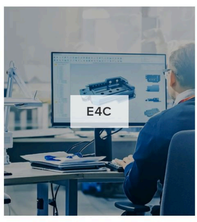


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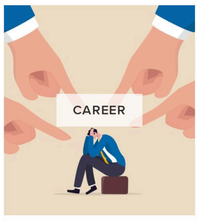


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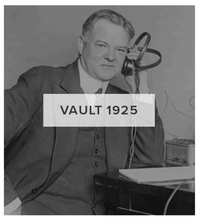


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MECHANICAL ENGINEERING

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Start Here

See what's in this issue

I AM A CHILD OF THE MOON RACE, the competition between the United States and the Soviet Union to land the first humans on another celestial body (and by extension, prove which socioeconomic system was superior). And space was a constant theme of my childhood, ranging from the full-color articles of the Apollo missions that filled *National Geographic* to the plywood and 2x4 lunar lander my dad built for my brother and me to play in.

Even after the U.S. stopped going to the moon in 1972, the expectation space exploration wasn't at an end, but simply at the end of the beginning.

It's taken more than half a century, but humanity seems poised to start the next chapter of space exploration with the Artemis missions set to start as early as 2026. (Without a Kennedy-style deadline imposed on the program, the timeline keeps getting extended.) The first crewed mission will simply orbit the moon, but we could see a human walking on the lunar surface as soon as 2027.

Of course, the astronauts are just the visible point of a giant army of engineers, scientists, and technicians who are designing and building the rockets and capsules. Senior Editor Louise Poirier spent the better part of a year talking to them and the result is **the cover story this month, "Artemis Transcends Apollo."**



Engine nozzles and the heat shield for the Artemis II European Service Module, which will provide the power necessary to propel Orion on a trip around the Moon. Photo: NASA

Poirier's feature is just one of a slew of great articles I am proud to present to you. For instance, author and science writer Lina Zeldovich looked at **the future of the steel industry**, which is developing new technologies for reducing or even eliminating its carbon dioxide emissions. Imagine using high-powered lasers to melt iron ore.

Elsewhere, our staff and freelance writers are exploring the frontiers of engineering, from **developing a Stirling engine for microscale nuclear reactors** to **extracting lithium from water used in hydraulic fracturing in Appalachia** to **gaining a better understanding of how athletes pick up new skills**. We interviewed **Ratnak Sok of Waseda University in Tokyo about the future of the internal combustion engine** and **roboticist Stephen Indyk about creating tools to be used by rovers on Mars**. And because everything old could become new again, we check out the work of engineers who are **testing whether Leonardo da Vinci's famous aerial screw design could be a better propeller for drones**.

Our Cathy Cecere took advantage of our new digital format to create an interactive story about **the salary premium engineers get for learning specific skills**. And be sure to check out our monthly Big Quiz; this month, we **test your knowledge of the 1960s and 1970s Moon Race**.

And there's so much more, including links to selected ASME podcasts on the righthand side of this page and other material throughout this issue. We're just starting to scratch the surface of everything we can provide for you in this new, all-digital format.

Much as I was when I was a starry-eyed youth, I can't wait to see what the future holds in store.

—Jeffrey Winters, editor in chief

There's more to ASME than the magazine. Be sure to check out these features.

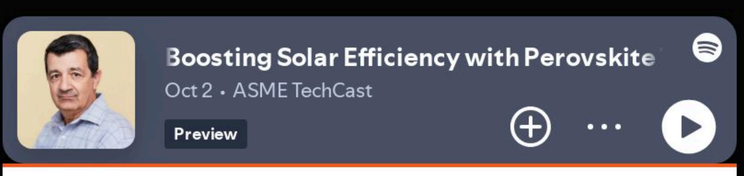
ASME TechCast

Some of our most recent episodes include:



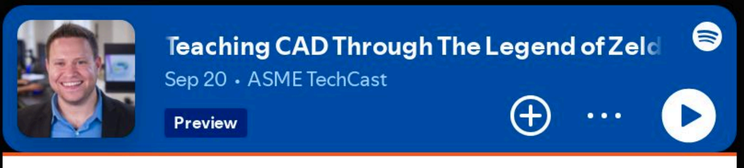
WHAT EMPLOYERS WANT

Gabriella Coloyan Fleming and Abdulrahman Alsharif discuss the skills students need to move from higher education into their engineering careers.



BOOSTING SOLAR EFFICIENCY WITH PEROVSKITE TECH

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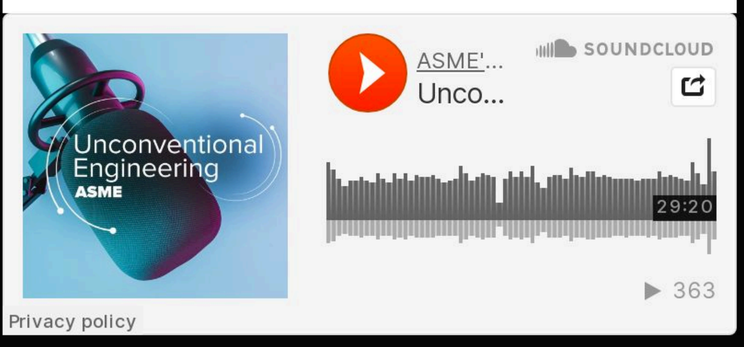


TEACHING CAD THROUGH THE LEGEND OF ZELDA

University of Maryland professor Ryan Sochol created a syllabus around a popular video game to teach machine design and CAD software.

ASME UNCONVENTIONAL ENGINEERING

Join ASME CEO Thomas Costabile and STEM educator Jay Flores as they talk with some of the most exciting names in engineering. Recent episodes include interviews with spacecraft systems engineer Joan Melendez-Misner and Jeff Perry, author of "The Intentional Engineer." **Check out the podcast landing page to hear them all.**



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Artemis Transcends Apollo

The Artemis mission is set for takeoff, with new lunar exploration and discovery missions right around the corner, propelled by incredible feats of engineering.

By Louise Poirier

MECHANICAL ENGINEERING

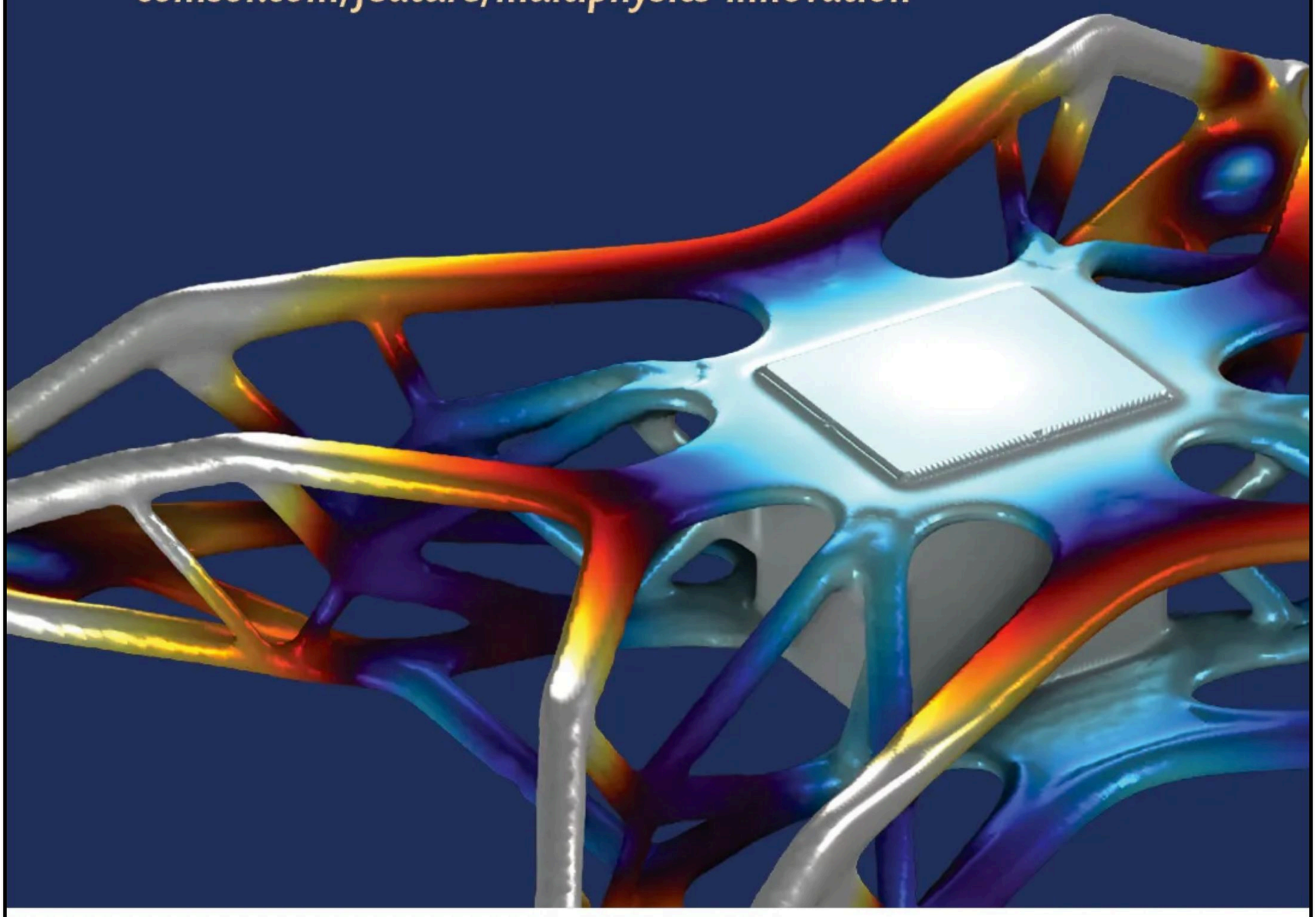
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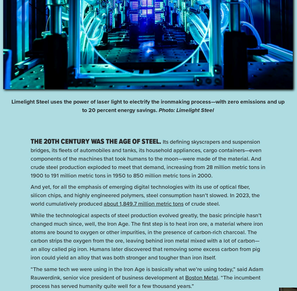
COMSOL

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IN PURSUIT OF GREEN STEEL

From hydrogen to electrolysis to lasers, innovators are devising new processes to decarbonize the crucial alloy humanity can't live without.

Written by ***Lina Zeldovich***



Limelight Steel uses the power of laser light to electrify the ironmaking process—with zero emissions and up to 20 percent energy savings. ***Photo: Limelight Steel***

THE 20TH CENTURY WAS THE AGE OF STEEL. Its defining skyscrapers and suspension bridges, its fleets of automobiles and tanks, its household appliances, cargo containers—even components of the machines that took humans to the moon—were made of the material. And crude steel production exploded to meet that demand, increasing from 28 million metric tons in 1900 to 191 million metric tons in 1950 to 850 million metric tons in 2000.

And yet, for all the emphasis of emerging digital technologies with its use of optical fiber, silicon chips, and highly engineered polymers, steel consumption hasn't slowed. In 2023, the world cumulatively produced about 1,849.7 million metric tons of crude steel.

While the technological aspects of steel production evolved greatly, the basic principle hasn't changed much since, well, the Iron Age. The first step is to heat iron ore, a material where iron atoms are bound to oxygen or other impurities, in the presence of carbon-rich charcoal. The carbon strips the oxygen from the ore, leaving behind iron metal mixed with a lot of carbon—an alloy called pig iron. Humans later discovered that removing some excess carbon from pig iron could yield an alloy that was both stronger and tougher than iron itself.

"The same tech we were using in the Iron Age is basically what we're using today," said Adam Rauwerdink, senior vice president of business development at Boston Metal. "The incumbent process has served humanity quite well for a few thousand years."

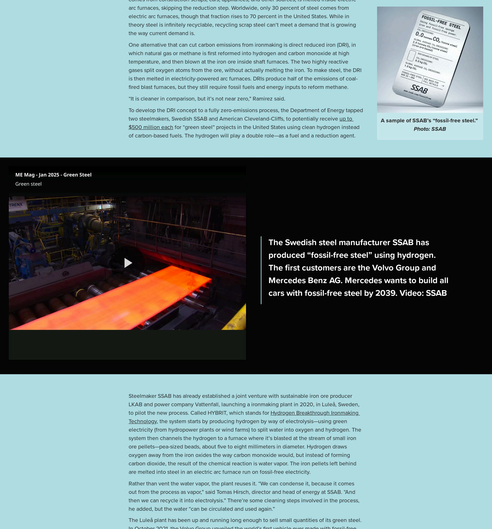
Carbon—in the form of charcoal or coke, a fuel made from heating coal or petroleum in a low-oxygen environment—has been essential for steelmaking from the beginning, but it has only been recently that the emissions from blast furnaces have drawn attention from engineers. According to the International Energy Agency, the production of one ton of steel creates 1.8 tons of carbon dioxide emissions. The steel industry as a whole is responsible for producing anywhere from 7 percent to 11 percent of the world's carbon emissions. The exact figure depends on what you include, explained Hilary Lewis, steel director at Industrious Labs, an environmental organization that works to develop more sustainable steel production technology. "The 11 percent includes methane emissions to make coke from coal," Lewis said.

Those carbon emissions were part of the big run-up in steel production from 1900 and today, but they are no longer sustainable. That's why efforts to "greenify" the industry are underway. Across the world, steelmakers are exploring alternative methods of turning iron into steel with ambitious goals of drastically reducing greenhouse gas emissions—as close to zero as possible.

In March 2024, the U.S. Department of Energy announced $6 billion to decarbonize energy-intensive industries, steelmaking being one of them. The goal is to develop a way to strip oxygen from iron ore without relying on the carbon sources that have sustained the industry for millennia.



Workers transport equipment past a semi-industrial electrolytic cell, behind, a device that uses electric current to produce liquid iron, at Boston Metal's Woburn, Mass., facility. ***Photo: Boston Metal***



REDUCES

Ancient steelmaking was a small-batch effort. In the Industrial Age, steelmaking advanced through the use of blast furnaces to melt the iron ore, coke, and limestone (to remove impurities from the ore) while blasting in hot air. "Those run on coal, they blow tons and tons of coal, and they run on coal today," said Kaitlyn Ramirez at RMI, (formerly Rocky Mountain Institute), a think tank that works to decarbonize the global energy system. "This traditional steelmaking with the blast furnace is very emission-intensive, as well as producing many other pollutants that impact air quality," Ramirez said.

While blast furnaces start with iron ore, a lot of steel today is recycled and remelted, a process which requires less energy and emits fewer greenhouse gases. The recycled steel, which comes from construction scraps, cars, appliances, and other sources, is melted inside electric arc furnaces, skipping the reduction step. Worldwide, only 30 percent of steel comes from electric arc furnaces, though that fraction rises to 70 percent in the United States. While in theory steel is infinitely recyclable, recycling scrap steel can't meet a demand that is growing the way current demand is.

One alternative that can cut carbon emissions from ironmaking is direct reduced iron (DRI), in which natural gas or methane is first reformed into hydrogen and carbon monoxide at high temperature, and then blown at the iron ore inside shaft furnaces. The two highly reactive gases split oxygen atoms from the ore, without actually melting the iron. To make steel, the DRI is then melted in electricity-powered arc furnaces. DRIs produce half of the emissions of coal-fired blast furnaces, but they still require fossil fuels and energy inputs to reform methane.

"It is cleaner in comparison, but it's not near zero," Ramirez said.

To develop the DRI concept to a fully zero-emissions process, the Department of Energy tapped two steelmakers, Swedish SSAB and American Cleveland-Cliffs, to potentially receive up to $500 million each for "green steel" projects in the United States using clean hydrogen instead of carbon-based fuels. The hydrogen will play a double role—as a fuel and a reduction agent.



A sample of SSAB's "fossil-free steel." ***Photo: SSAB***

ME Mag - Jan 2025 - Green Steel
Green steel



Steelmaker SSAB has already established a joint venture with sustainable iron ore producer LKAB and power company Vattenfall, launching a ironmaking plant in 2020, in Luleå, Sweden, to pilot the new process. Called HYBRIT, which stands for Hydrogen Breakthrough Ironmaking Technology, the system starts by producing hydrogen by way of electrolysis—using green electricity (from hydropower plants or wind farms) to split water into oxygen and hydrogen. The system then channels the hydrogen to a furnace where it's blasted at the stream of small iron ore pellets—pea-sized beads, about five to eight millimeters in diameter. Hydrogen draws oxygen away from the iron oxides the way carbon monoxide would, but instead of forming carbon dioxide, the result of the chemical reaction is water vapor. The iron pellets left behind are melted into steel in an electric arc furnace run on fossil-free electricity.

Rather than vent the water vapor, the plant reuses it. "We can condense it, because it comes out from the process as vapor," said Tomas Hirsch, director and head of energy at SSAB. "And then we can recycle it into electrolysis." There're some cleaning steps involved in the process, he added, but the water "can be circulated and used again."

The Luleå plant has been up and running long enough to sell small quantities of its green steel. In October 2021, the Volvo Group unveiled the world's first vehicle ever made with fossil-free steel—an autonomous electric dumper, which contains more than three metric tons of HYBRIT steel. Demand is surging, and SSAB is selling every ounce of what the little pilot plant produces —and it can't make it fast enough. An industrial-scale HYBRIT plant in Gällivare, Sweden, which is projected to start operating in 2027, will help meet the demand. With the grant from the U.S. Department of Energy, SSAB will also build a similar HYBRIT plant in Mississippi.

Cleveland-Cliff is in negotiations with the Department of Energy for a grant to add a green steel plant in its current location in Middletown, Ohio, installing a hydrogen-ready, flex-fuel DRI plant and two 120-MW electric melting furnaces. According to a press statement, "The facility will have the flexibility to be fueled by natural gas, which would reduce current ironmaking carbon intensity by over 50 percent; a mix of natural gas and clean hydrogen; or clean hydrogen, which would reduce current ironmaking carbon intensity by over 90 percent."

DISSOLVED

While hydrogen is made via electrolysis, it's not the only possible product—or pathway to green steel. A spinoff from MIT called Boston Metal uses molten oxide electrolysis (MOE). The process requires two electrodes. The positively charged anode is built from an inert alloy of chrome and iron that can withstand high temperatures and oxygen without corroding. The negatively charged cathode is the molten metal itself, which accumulates on the bottom of the chamber called the MOE cell.

In between there's a liquid electrolyte comprised of primarily iron oxide and other oxides that can be present in the iron ore, such as magnesium or aluminum.

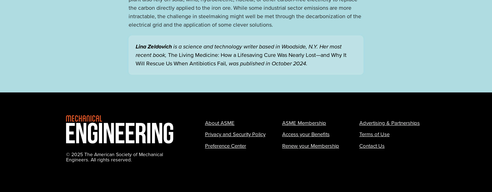
"We're doing electrolysis on iron ore," Rauwerdink of Boston Metal explained. "So, we're using the power of the electrons to do what historically would have been done with the carbon atom."

When electricity runs between the anode and cathode, heating the mix to nearly 3,000 °F, the oxygen atoms break off, yielding liquid iron at the bottom, which can be gathered.

"As you add the iron ore, it dissolves into the electrolyte," Rauwerdink said. "And then at certain intervals, you will do what's called tapping. You physically drill into the cell, and you'll pull out a pool of some of the molten metal. Then you plug that hole shut and the process continues." The only byproduct of the reaction is oxygen; no greenhouse gases are produced.

Boston Metal's method can work not only for steel, but for other metals, too.

The company, which has already raised over $250 million, is currently building its first plant in Brazil to extract niobium and tantalum from the waste products of tin mining. For steel, Boston Metal plans to license the technology to steelmakers or to iron ore miners.



This candle holder is the first object crafted from "fossil-free steel" produced at SSAB's HYBRIT steel mill. ***Photos: SSAB***

ILLUMINATED

Electricity isn't the only carbon-free power source that can break iron and oxygen bonds. Lasers, which emit a coherent beam of energy-carrying photons, can do so too. That's the concept that Olivia Dippo, co-founder of Limelight Steel, came up with while working on her doctorate in material science and engineering at University of California, San Diego.

"We were using a couple of different types of lasers to heat materials and 3D-print objects with it," Dippo said. "And I started thinking about what other technologies can we apply this to."

Her collaborator, also a doctoral student then, thought the steel industry could use some lasers.

It's an unexpected turn. While lasers have a fearsome reputation in science fiction, for decades, experts viewed lasers as inefficient tools that belonged to academic labs rather than industry. But that has changed as the technology came of age, Dippo said.

"Lasers are powerful, they're becoming more efficient, and they can operate on a lot of different material systems that I think people haven't necessarily thought of before."

Although Limelight Steel has received $2.9 million from the U.S. Department of Energy, the company is still in the research and development stage and is operating at small scale.

"We are in the tens of grams range right now," Dippo said, but the company has very ambitious goals and is already erecting a facility in Oakland, Calif. "We're building a pilot which will be in the 100 tons a year range, and then we'll build a demonstration plant, and then we'll be at commercial scale, probably by 2030."

The industrial plant will have a continuous feeding mechanism channeling the iron ore into the reactor and taping the liquid iron out as it melts. Dippo estimated that the method can cut about 70 percent of emissions.

Of course, those emissions reductions depend on a supply of zero-carbon electricity to run the lasers. The electrolysis cells deployed by Boston Metal or the hydrogen used in the HYBRIT plant also rely on solar, wind, hydroelectric, nuclear, or other carbon-free electricity to replace the carbon directly applied to the iron ore. While some industrial sector emissions are more intractable, the challenge in steelmaking might well be met through the decarbonization of the electrical grid and the application of some clever solutions.

__Lina Zeldovich__ is a science and technology writer based in Woodside, N.Y. Her most recent book, The Living Medicine: How a Lifesaving Cure Was Nearly Lost—and Why It Will Rescue Us When Antibiotics Fail, *was published in October 2024.*

MECHANICAL ENGINEERING

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RETURN OF THE FREE-PISTON STIRLING ENGINE

Researchers at the University of New Mexico demonstrate that the elegant mechanical engine is well suited for nuclear microreactor applications.

Written by ***Kayt Sukel***



Minghui Chen (right) and student Phat Doan (left) working on the high-temperature, high-pressure helium test facility for testing Stirling engines.

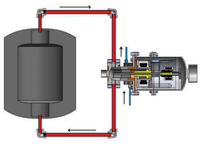
WHEN ROBERT STIRLING INVENTED his namesake engine in the early 1800s, he built it in hopes of replacing the steam engine. Ironically, its unique design, which converts heat energy to mechanical energy, was largely used to power low-energy freezers for much of its early life. The development of a free-piston Stirling engine (FPSE) in the 1960s, which used free floating pistons to support energy conversion, made it possible for the engine to do much more than previously thought. The National Aeronautics and Space Administration (NASA) understood its potential to help power space travel. One such free-piston Stirling power converter system has been in continuous (and maintenance-free) use at NASA's Glenn Research Center for more than 14 years.

Researchers from the University of New Mexico's Department of Nuclear Engineering see new potential for this type of power system in microreactor applications. UNM assistant professor Minghui Chen said its compact design and high efficiencies make it an ideal candidate to support small nuclear reactors that can be used in a variety of different energy applications, including working as part of the electrical grid.

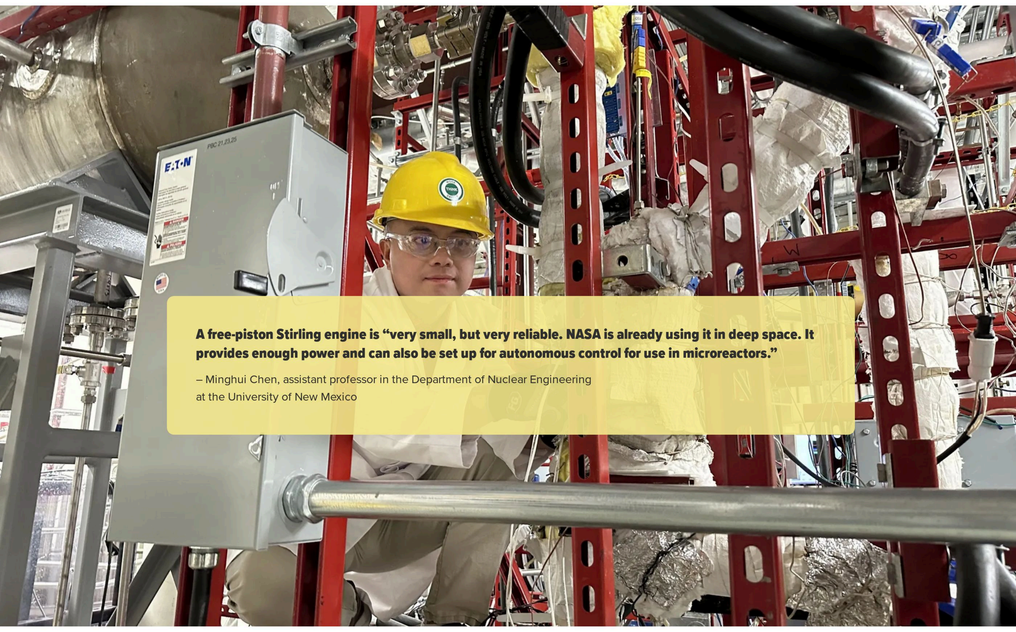
The team reported its findings in the paper, "Design and Analysis of a Free-Piston Stirling Engine for Microreactor Applications," published in the *Journal of Nuclear Engineering and Radiation Science*.

"It's very small, but very reliable," Chen said. "NASA is already using it in deep space. It provides enough power and can also be set up for autonomous control for use in microreactors. It makes it an excellent choice for these applications."

To test its feasibility, Phat Doan, a doctoral student in the Nuclear Engineer program, analyzed the design of a 20-kilowatt (kWe) FPSE using MATLAB to determine its efficiency and output. He and Chen discovered that their proposed FPSE had 21.7 percent efficiency with a total output power of 20.7 kWe. Chen said Doan spent a great deal of time using different models to do the calculations to make sure the design was sound. They were pleased to show that it is, but Chen said they have more work ahead to scale up the model for actual use in a microreactor setting.



Schematic of an FPSE connected to the microreactor loop.



A free-piston Stirling engine is "very small, but very reliable. NASA is already using it in deep space. It provides enough power and can also be set up for autonomous control for use in microreactors."

– Minghui Chen, assistant professor in the Department of Nuclear Engineering at the University of New Mexico



The research team, Left to Right Phat Doan, Anutam Bairagi, Braden Foderaro, Minghui Chen, Bao Nyugen, Alexandra Martinez, and Yuqi Liu.

"Now, [Doan] is working on putting in more accurate modeling capabilities for testing. We are working on high-temperature and high-pressure helium experiment testing. We are also doing shakedown testing to test the instrumentation," he explained. "But our current results are for one unit, about 20 kWe. If we wanted to have an output of 1 megawatt electrical, we are talking about putting about 50 units together. We cannot do that right now—but it is possible, with some design changes, we can upgrade the power in a single unit to 500 kWe in the future."

To that end, the team is also looking at ways to make targeted improvements to the FPSE system. While Doan's calculations demonstrated its current design is efficient, compact, and reliable, the team is looking at potentially replacing the heat exchanger for heat flux and developing a more robust foil for the regenerator. The team is relying on simulation tools to help them "optimize the configuration," Chen said.

"It could be serial or parallel configuration of different engines in our new microreactor—we need to see how we can get it to have very high efficiency when it is coupled with the real microreactor," he said.

In the meantime, Chen hopes that others will see the strong potential of this mechanical workforce for future microreactor applications.

"It's an excellent choice," he said. "It can be plug and play, ready for microreactor applications. And for those interested in these potential applications, our testing code and models are open source. Any scholar or student can use this code to do their own research in this area."

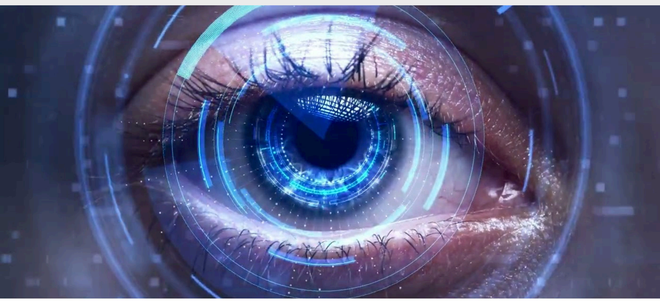
Kayt Sukel *is a technology writer and author in Houston.*

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THE EYES HAVE IT?

New research from the University of Florida suggests that vision may play an important role in helping people learn new motor skills.

Written by ***Kayt Sukel***





WE ALL KNOW THAT PERSON—the one who can naturally swing a golf club, pick up the latest TikTok dance, or successfully balance in a new yoga pose with little to no effort. It would be all too easy to say that individual is gifted with extra flexibility or perhaps some unique muscular capabilities. But a new study from Daniel Ferris, a professor of biomedical engineering at the University of Florida, and his former doctoral student, Noelle Jacobsen, suggests that those who can learn new movements quickly may be gaining that advantage from the brain—particularly the visual cortex, a region of the brain responsible for vision.

"There's a lot of variability in how fast people can pick up new motor skills or adapt to new environments," said Jacobsen, who is now a postdoctoral researcher at Imperial College London. "Adaptation, in particular, is something we all have to do in our daily lives. Without thinking about it, most of us can walk in a new pair of shoes, cautiously move across a patch of ice, or learn to rollerblade. We were interested in trying to figure out what our brains are doing while we are doing this kind of adapting."

To that end, Ferris and Jacobsen monitored the brain activity of study participants using high density electroencephalography (EEG) as they walked on a special treadmill with two belts moving at different speeds. The task was fairly simple: Participants just had to walk on the treadmill, finding a way to adapt their normal gait in order to manage the split belt and speeds. Unsurprisingly, just as you might see in dance class or on the pickleball court, some people could quickly adjust to this new type of walking to the order of about a minute. Others took a little longer to get the hang of it, about four times longer on average.



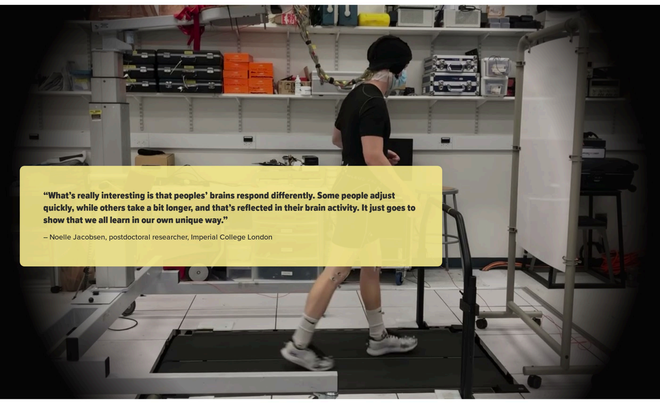
It took up to 2.5 hours for researchers to set up the electroencephalography (EEG) system and prepare each participant before an experiment.
Photo by Noelle Jacobsen

"Everyone in the study was a neurotypical young adult. We subgrouped them by how fast they could adapt to the new way of walking and then looked at their brain activity as they did it," Jacobsen said. "We found differences in the visual cortex, as well as posterior parietal cortex between the fast learners and slow learners."

The visual cortex is responsible for perceiving and processing visual information from the outside world, while the posterior parietal cortex has been linked to activities like planning movements and spatial awareness. The researchers also noticed a difference in anterior cingulate cortex activity, which has been associated with error correction.

Jacobsen said the research group did not anticipate seeing differences in visual cortex—it was a bit of a surprise—and what exactly it means is up for interpretation.

"It's clear that vision is important and certainly, there are studies to show that if you have worse visual ability, you will have worse gait stability, especially in older adults," she said. "We know that vision is important for balance and walking stability in general so it may be that fast and slow adapters have slightly different learning strategies that use vision in different ways as they figure out how to adapt."



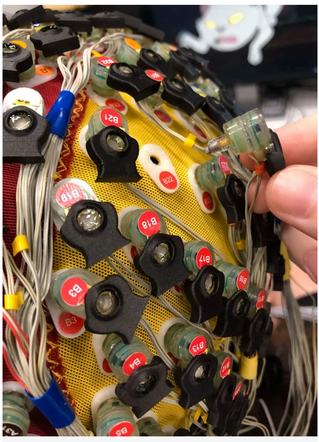
"What's really interesting is that peoples' brains respond differently. Some people adjust quickly, while others take a bit longer, and that's reflected in their brain activity. It just goes to show that we all learn in our own unique way."

-- Noelle Jacobsen, postdoctoral researcher, Imperial College London

But that does not necessarily mean that vision by itself is helping you learn new movements. In fact, in a previous study, Ferris and colleagues demonstrated that using strobe training glasses to briefly interrupt visual input can help people learn how to walk on a balance beam faster.

"These glasses, which temporarily block out your vision for a couple of seconds, can speed up how fast you can learn to balance and walk," she said. "So, the visual cortex activation we see might not mean that people are using vision more. It may be that they are suppressing it and relying on other sensory information in order to learn the new skill faster."

These studies open up some exciting new research questions into the exact role that vision plays in learning or adjusting motor skills, but also exciting possibilities for gait rehabilitation after an injury or stroke, Jacobsen said.



Close-up of a dual-electrode EEG system, showing a primary electrode that faces the scalp to measure brain signals and a secondary electrode facing outward to detect movement noise.
Photo by Noelle Jacobsen

"What's really interesting is that peoples' brains respond differently. Some people adjust quickly, while others take a bit longer, and that's reflected in their brain activity. It just goes to show that we all learn in our own unique way," she said. "If we can start to understand what kind of activity patterns are normal, you can tailor treatments to strengthen those brain areas, even perhaps leading to more personalized approaches in athletic training and rehabilitation."

Such insights could also help support the development of performance-enhancing wearable devices.

"One of the coolest things about this research is how mobile brain imaging lets us see what our brains are doing in real time during everyday activities," Jacobsen continued. "As we learn more about what the brain is doing, exploring the different areas involved with real-world activities, we can use that information to create new types of devices that might be able to enhance athletic training or help with balance training in older adults."

Kayt Sukel *is a technology writer and author in Houston.*

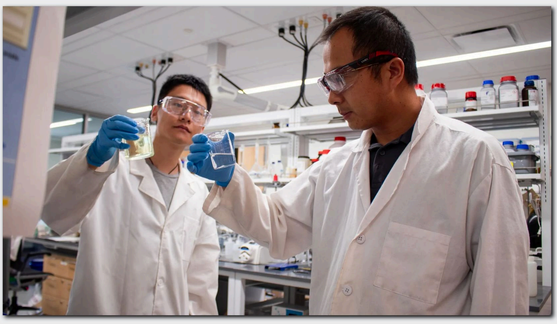


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PULLING LITHIUM FROM FRACKING WATER

A new approach to extract lithium from produced water could help mitigate growing demand for the strategically important material.

Written by ***Nicole Imeson***



(From left) Graduate student Peidong Liu and mining and minerals engineering associate professor Wencai Zhang analyze water samples in the lab. ***Photo by Hailey Wade for Virginia Tech.***



Engineers from EQT Corporation help Wencai Zhang collect produced water samples for laboratory testing. Photo courtesy of Wencai Zhang.

AS THE USE OF ELECTRIC VEHICLES and other green energy solutions have increased, so has the demand for lithium, a metal vital to producing the high-power rechargeable batteries at the heart of these technologies. Lithium mining, however, is expensive and environmentally unfriendly. However, researchers at Virginia Tech's Department of Mining and Minerals Engineering have optimized an extraction process that would draw lithium and other critical minerals from produced water, a derivative of oil and gas production.

Produced water is injected into underground reserves to enhance recovery of petroleum products or to remove heat from the process. Until now, lower concentrations of lithium, which would need significant refinement to become battery-grade quality, and its cost per pound have discouraged more widespread produced water extraction efforts. However, by refining the process to efficiently extract lower concentrations and remove more contaminants, this research is showing potential for large-scale industrial implementation.

A MEMBRANE BOOST

Traditional methods for lithium extraction rely on evaporative brine processing and hard rock mining. In the evaporative process, workers pump high-lithium brine into large ponds for solar evaporation. As the water evaporates, the brine becomes concentrated with lithium, sodium, and other minerals. Common in South America, this method consumes vast amounts of land, water, and time. Hard rock mining involves removing large sections of earth and processing the material to separate lithium from other minerals. This energy-intensive process requires land clearing as well.

The cost- and resource-heavy nature of traditional methods makes them unsuitable for low-concentration lithium sources such as produced water. But the Virginia Tech team's breakthrough in lithium extraction from produced water offers a promising alternative.

The process to separate lithium ions from solutions relies on an ion exchange membrane enhanced by an aluminum-based adsorbent for better lithium extraction. Aluminum-based adsorbents have gained success in industrial applications due to their strength and durability across multiple cycles, allowing for repeated use while maintaining effectiveness in attracting lithium ions. This newer method works faster, uses less water, and reduces environmental impact compared to traditional approaches, making it ideal for extracting lithium from lower concentration produced water.

For its five-phase approach, the Virginia Tech team modified a lithium/aluminum layered double hydroxide (Li/Al-LDH) resin membrane by enlarging the pores to increase the surface area and adding functional groups to enhance lithium-ion attraction while preserving the structural integrity of the Li/Al-LDH.

"Chemical modification increased the material's adsorption capacity and physical modification produced a hierarchical porous structure, which expanded surface area and pore diameter to boost adsorption further," explained Wencai Zhang, associate professor at the Department of Mining and Minerals Engineering at Virginia Tech.

The first phase removes solid particles while retaining critical minerals. The second phase uses selective precipitation followed by further refining to produce high-purity non-lithium critical mineral products. The third phase uses an efficient resin membrane to attract and separate lithium ions from the solution. Ion exchange minimizes environmental impact, requiring less water and space compared to other lithium mining methods. Benchtop continuous lithium extraction and battery-grade lithium compound production will be carried out at Austin Elements, an industrial partner of Zhang's team with lithium extraction and purification expertise.

In phase four, carbon mineralization is used to fix carbon dioxide and remove alkaline earth metals from the solution. Carbon dioxide is then added to bond with the minerals, forming solid carbonates, which can then be filtered out of the solution. In phase five, which is still under development, the team is aiming to reduce salinity and eliminate the remaining contaminants through Phyto-microbial treatment, using genetically modified plants with enhanced purification traits.



Transport trucks line up to unload produced water. Photo courtesy of Wencai Zhang.



> **"For critical mineral recovery from secondary sources, we considered low concentrations and how to implement the technology in the industry. Some technologies are advanced but costly, driving up the final product's cost per pound."**
>
> Wencai Zhang, associate professor in the Department of Mining and Minerals Engineering at Virginia Tech

A NEW SOURCE

Produced water cycles through multiple stages before being stored in deep reservoirs or evaporation ponds. Its contents vary by well or process, but most consider it industrial waste. Additives used in oil and gas extraction, along with hydrocarbons and minerals from the ground, make the water brackish or saline, rich in lithium, strontium, chlorine, bromine, phosphorus, and other minerals.

"For critical mineral recovery from secondary sources, we considered low concentrations and how to implement the technology in the industry. Some technologies are advanced but costly, driving up the final product's cost per pound," Zhang explained.

The average lithium concentration of produced water from the Marcellus Shale area of the Appalachian Basin—spanning New York state, Pennsylvania, Ohio, and West Virginia—measured around 95 parts per million (PPM), though areas varied. The Duvernay Formation in Alberta, Canada averaged 43 PPM, while the Gongxian shale gas well in the Sichuan Basin, China measured 33 PPM. The Virginia Tech team's technology increased the effectiveness of lithium extraction at concentrations as low as 50 PPM. However, the researchers aim to push the limit down to just a few PPM.

While further processing could make the produced water safe for drinking, this research effort "targeted irrigation water, which has a lower quality requirement compared with drinking water," Zhang said. Irrigation water typically comes from groundwater wells, rivers, or lakes, which also serve as drinking water sources. Recycling and improving produced water for irrigation would ease the demand on these sources, preserving them more for potable use.

By optimizing the ion exchange process and focusing on low lithium concentrations, the Virginia Tech team has created a more cost-effective and environmentally friendly solution that has the potential to transform produced water from industrial waste into a valuable resource for both irrigation and critical mineral recovery.

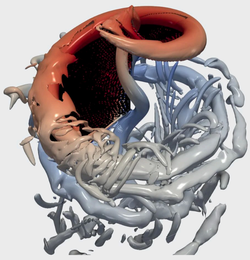
Nicole Imeson *is an engineer and writer in Calgary,Alta.*

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BUZZ KILLER

Drone noise annoys. To soften it, a group of Johns Hopkins researchers turned to the rotor design of a true Renaissance man.

Written by ***Michael Abrams***



The boundary of vortices around a helical screw-type propeller.

FOR HOMEOWNERS, PICNICKERS, AND PRIVACY ENTHUSIASTS, the buzz of a drone is an annoyance. For the military, that sound is worse—it's a dead giveaway. "Even a small drone makes a lot of noise," said Rajat Mittal, a professor of mechanical engineering at Johns Hopkins University in Baltimore. "Once you start thinking about delivering a 10-pound Amazon delivery or something, you can imagine the kind of noise that these drones are going to make."

With a grant from the Army Research Office, Mittal and a Johns Hopkins team that included Jung-Hee Seo, an associate research professor of mechanical engineering, and Suryansh Prakhar, a mechanical engineering doctoral student, set out to mitigate the whine of these quadcopters.

They first turned to airborne products of evolution for inspiration. Flying insects of roughly the same size can make wildly different amounts of noise. The mosquito, for instance, is famous for its annoying buzz, to the point of having children's books written about it.

"But from a same-size fruit fly, you will not be able to hear the noise from their wings," Mittal said. "The wings of fruit flies have a much larger area than the wings of, for instance, mosquitoes, and because they have larger area wings, they actually flap them at a lower frequency."

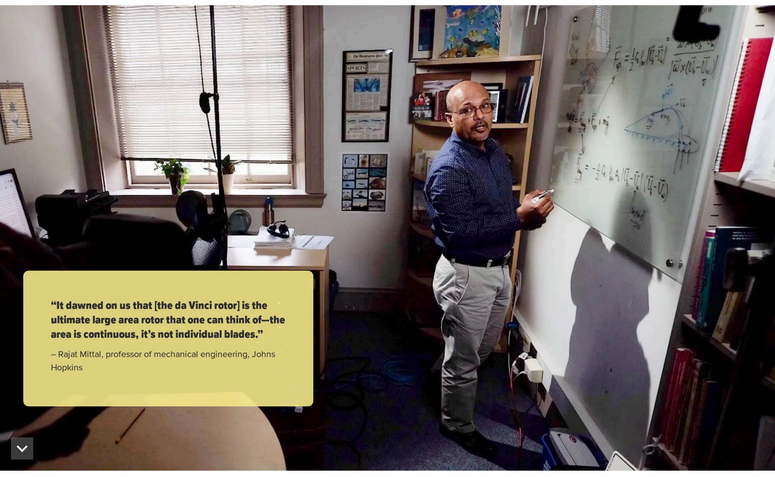
Mittal and his team conjectured that if they could increase the area of a drone's rotor, they would generate more lift per revolution per minute (RPM), allowing for a reduction in RPM and ultimately slashing noise as well. So, for the purposes of noise reduction, they assumed that the larger the rotor, the better.

This insight led them to the design of a Renaissance artist and polymath.

Sometime in the 1480s, Leonardo da Vinci sketched out a concept for a flying contraption in his notebooks. His "aerial screw" looks like one-and-a-half turns of a corkscrew—essentially an uninterrupted spiral rotor.



A model based on a 1480s sketch of an aerial screw by Leonardo da Vinci.



"It dawned on us that [the da Vinci rotor] is the ultimate large area rotor that one can think of—the area is continuous, it's not individual blades."

– Rajat Mittal, professor of mechanical engineering, Johns Hopkins

"It dawned on us that this is the ultimate large area rotor that one can think of—the area is continuous, it's not individual blades," Mittal said. "If our hypothesis is correct, then the da Vinci rotor should produce less noise."

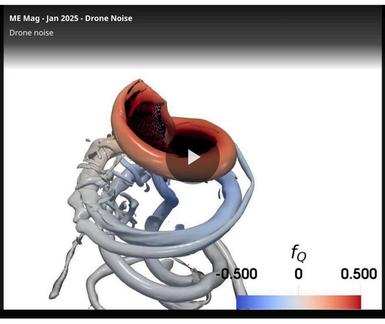
To prove it, the researchers decided to make a 3D model of the screw and run it through a few virtual paces. Thankfully, that didn't require extrapolating from the tiny centuries-old sketch drawn by the painter/scientist/engineer/architect. Researchers at the University of Maryland had already created a da Vinci aerial-screw-powered drone two years before, so the Johns Hopkins team used its design to create its own for simulation.

Running the simulations was data heavy business. "Each of these simulations runs on about 256 parallel processors—and they run for many days," Mittal said. "If I were to just kind of back extrapolate Moore's law to 15 years ago, it would probably take many months to run a single simulation."

In the end, all that processing proved the team's hunch correct. They showed that for the same amount of lift generated by a two-bladed rotor, they are able to rotate the da Vinci rotor at a much lower RPM. "Because of that and because of the continuous distribution of the blade area, we are able to reduce the overall acoustic noise for a given amount of lift," Mittal said.

What's more, the extra area required no additional power. "It turns out that this change in the shape of the rotor seemingly gives us both a reduction in the noise and a reduction in the power consumption," he said. That's a crucial assist for an application where battery weight is so limited.

The noise of a conventional two-bladed rotor comes from the turbulence spilling off the tips of the rotors. In simulation, the aerial screw created much less chaos, turning the air in long "smoothish fingers." But that's not to say that the da Vinci corkscrew is a piece of unimprovable perfection—for noise or for lift. The dimensions and materials of an aerial screw rotor are sure to be tweaked in the future for greater efficiency and noise reduction.



This animation depicts the boundary of swirling air currents (vortices) around a propeller, color-coding each vortex based on measurements to visualize which flows generate the most upward lift force keeping the propeller aloft, enabling detailed study of propeller physics.

Even so, it's remarkable that the Renaissance design, out of the box, showed an improvement over contemporary ones. In fact, da Vinci seems to have understood that a single turn of a corkscrew would not produce enough lift and that a multiple-turn corkscrew would end up pushing too much air down on itself. "He was kind of brilliant," Mittal said. "He doesn't have five corkscrews or half a corkscrew—he has one full circle and a half. I think intuitively he might have understood that too few is not good and too many is not good either."

The next step is to refine the model to try to further reduce the sound the rotor makes. The team is currently working with the Indian Institute of Technology Delhi to explore using a larger overall rotor area and lower RPM.

The end product will be a corkscrew that can replace the rotors of any drone. "We don't want to rebuild an entire drone," Mittal said. "All we want to do is replace the rotors of an existing drone, because then we don't have to worry about controls."

After that, the drones of the world will be able to do what they do a little more surreptitiously.

Michael Abrams *is a technology writer in Westfield, N.J.*

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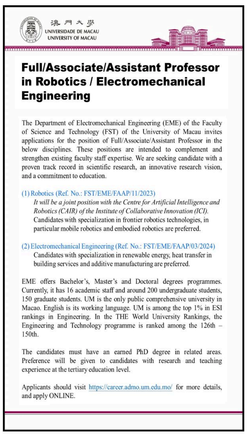
MEMBER SPOTLIGHT



RATNAK SOK

This ASME Forward Ambassador is improving ICE and EV sustainability and viability.

Written by ***Cathy Cecere***



澳門大學
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UNIVERSITY OF MACAU

Full/Associate/Assistant Professor in Robotics / Electromechanical Engineering

The Department of Electromechanical Engineering (EME) of the Faculty of Science and Technology (FST) of the University of Macau invites applications for the position of Full/Associate/Assistant Professor in the below disciplines. These positions are intended to complement and strengthen existing faculty staff expertise. We are seeking candidate with a proven track record in scientific research, an innovative research vision, and a commitment to education.

(1) Robotics (Ref. No.: FST/EME/FAAP/11/2023)
It will be a joint position with the Centre for Artificial Intelligence and Robotics (CAIR) of the Institute of Collaborative Innovation (ICI).
Candidates with specialization in frontier robotics technologies, in particular mobile robotics and embodied robotics are preferred.

(2) Electromechanical Engineering (Ref. No.: FST/EME/FAAP/03/2024)
Candidates with specialization in renewable energy, heat transfer in building services and additive manufacturing are preferred.

EME offers Bachelor's, Master's and Doctoral degrees programmes. Currently, it has 16 academic staff and around 200 undergraduate students, 150 graduate students. UM is the only public comprehensive university in Macao. English is its working language. UM is among the top 1% in ESI rankings in Engineering. In the THE World University Rankings, the Engineering and Technology programme is ranked among the 126th – 150th.

The candidates must have an earned PhD degree in related areas. Preference will be given to candidates with research and teaching experience at the tertiary education level.

Applicants should visit https://career.admo.um.edu.mo/ for more details, and apply ONLINE.

ELECTRIC VEHICLES (EVS) ARE GREAT, but "they're not the only solution to get us to carbon neutrality," declared Ratnak Sok, associate professor at the Research Organization for Next Generation Vehicles at Waseda University in Tokyo. Sok's expertise, encompassing electrified vehicles, thermal engineering, CFD, and the internal combustion engine (ICE), has led him to believe in "multi-pathway approach" to meeting the challenge of climate change.

Sok is part of an elite group of global researchers who help promote the ASME's work with ICE—he is an ICE Forward Ambassador. The carbon neutrality targets set by the countries and governments of the world are critical, ambitious, and difficult, Sok said, concluding, "We cannot rely only on battery electric vehicles. Currently, about 95 percent of the vehicles in the world run on internal combustion engines. So why not continue to develop the engine to make it better?"

EFFICIENCY IS KEY

The world is looking toward e-fuels, ammonia, or hydrogen, to gain a better carbon dioxide advantage faster, he explained. And you can reach your goals "without changing much when it comes to engine, hardware, or current infrastructure," Sok concluded. This is mainly because when you consider the life cycle of batteries, for example, "raw material refinery and battery manufacturing still use energy from fossil fuel."

There are countries where EVs are a very good match, he explained. "For countries like Norway or Iceland, it's perfect. EVs make sense in those countries because in those nations' energy comes 98 percent from renewables." There are challenges including "enough charging stations" to serve these automobiles and how expensive these EVs are to the ordinary consumer. So costly, in fact, that "most consumers cannot afford them," he explained.

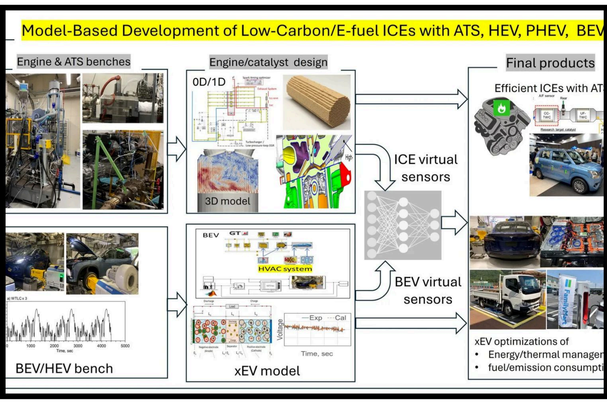
And finally, passenger cars are not the only means of transportation that need to be transformed. "You have to electrify other transportation sectors," he explained. This includes heavy duty trucks, off-road, marine, railway, agricultural, and other machinery. "These segments are hard to electrify," Sok explained.

VIRTUAL SENSORS

Regardless of the engine type, whether an ICE or an EV, the need to be more efficient is key. Physical sensors are commonly used to record performance data of ICEs, for example for online feedback control and calibration. But they're prone to diagnostic and increased development costs. Lookup tables are commonly used in conventional calibration and feedback control; however, the table parameters increase with the advancement of ICE technologies under transient operations. Consequently, the calibration and control systems are time-consuming.



Ratnak Sok (front right) joins 2024 Waseda University graduates and lead researcher Jin Kusaka (front center). Photo: Waseda Mobility Group



ASME ICE Forward Ambassador Ratnak Sok has developed a virtual diesel engine and virtual sensors to provide an onboard feedback control system that predicts the combustion, performance, and emission of internal combustion engine using neural networks and image processing.

That is where the use of virtual sensors comes into play. One big advantage of digital sensors over the physical kind is durability. "When you put a physical sensor in an engine, you run the vehicle for several years. Those sensors age. And overtime they get damaged by extreme conditions such as, for example, very high speed or high load driving," he explained.

Sok's work includes developing novel virtual sensors to address these issues by predicting the combustion, performance, and emission of ICEs using neural networks and image processing/translation. The novel sensors are targeted for onboard feedback control systems under transient driving.

To make the scheme work Sok and his team needed to first devise a virtual diesel engine (VDE) and calibrate it against experimental data taken from a production 2.2 L turbocharged diesel engine. The VDE was used to generate teaching data such as indicated torque, fuel consumption, engine brake thermal efficiency, maximum pressure rise rate, NOx, and CO_2 emissions. Next, Sok's team developed virtual sensors using five machine learning regressors.

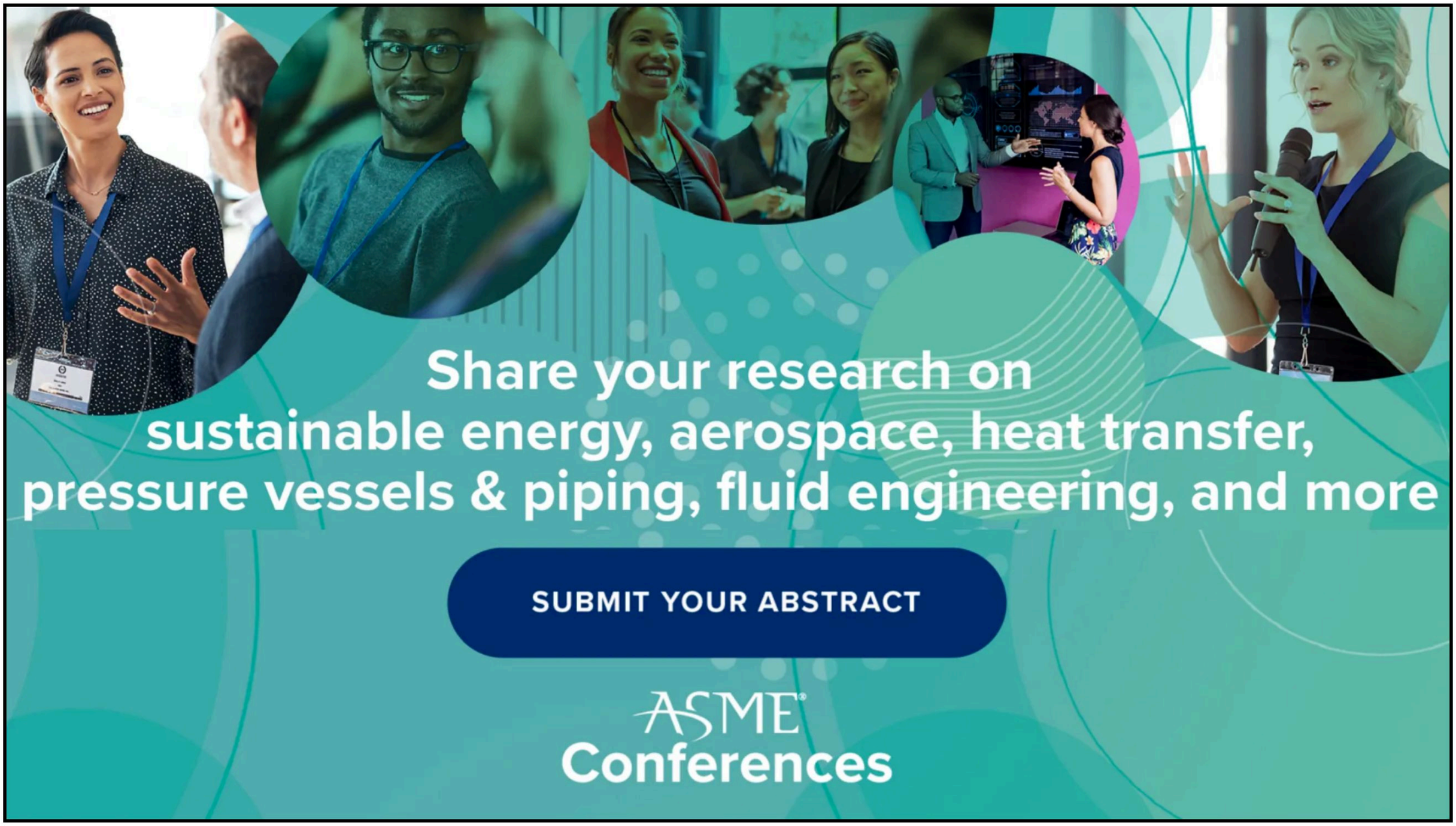
"When you use digital sensors with AI you are able to make advancements much quicker," Sok concluded. The downside of virtual sensors are, however, that AI needs a lot of data. And further, original equipment manufacturer (OEM) data needed to build an accurate model is very difficult to obtain because of confidentiality

Sok plans to extend the scope of his research to compare the predicted and desired rate of heat release using the feedback system. This feedback system will then be used to control the injection pattern, which could yield optimal fuel economy and better emissions of any type of advanced ICEs (fueled by either gasoline, diesel, e-fuel, or hydrogen). According to Sok, this will pave the way for a fast feedback control system and reduced engine calibration and control costs. The same virtual sensing can also be applied to predict dynamic battery responses too. He added that he plans to apply artificial intelligence or machine learning applications to predict EV performance in his upcoming collaborative projects with OEMs, too.

Cathy Cecere *is the membership content program manager.*

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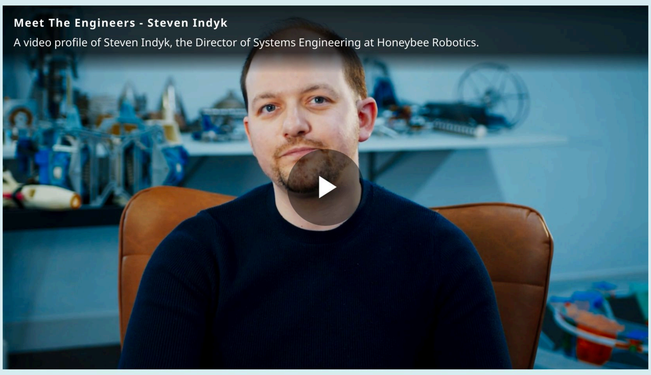


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Q&A // VIDEO

MEET STEVEN INDYK, AEROSPACE ROBOTICIST

It's easy to figure out what you don't like. The only way to discover what you are passionate about is to sample everything.



Steve Indyk describes his work as a systems engineer for space missions.

[Video Transcript]

A COMMON DAY FOR ME at Honeybee Robotics is usually working on a variety of different projects. It's not one project all the time. It's usually one or two larger projects and then a slew of smaller ones, sometimes developing large space missions and sometimes developing smaller mechanisms and components that can go to space and endure different rigorous environments. I work with a lot of our internal folks leading engineering development projects as a systems engineer, and I also work external with our customers to help design and develop what sort of instruments and systems they would like in space.

I was always inspired by the traditional space program, and really it's the opportunities that companies and the government have allowed to happen. Everything we do is built on previous engineers, previous scientists, previous space exploration capabilities, and everything we have today is incremental or really big leaps forward. There's a lot of good NASA missions that have been created in the past 10, 20 years. And today, even more excitingly, there's a lot more commercial interest and commercial companies that are doing really great things in space.

One of the most surprising things I learned as an engineer is the value of your writing and communication skills. Going through undergrad and grad as an engineer, it's very easy to latch on to the science and the math concepts, but communicating with your peers, communicating with other organizations, written communication, these are all critical skills that you know, the earlier you learn and feel very comfortable with, the further they'll carry you in your career.

Advice I would give to somebody coming up in the aerospace industry, or wanting to work in the aerospace industry would definitely be try all the different things that you can. I think it's very easy for any student to understand and figure out what they don't like, but it's very hard to figure out what you do like. And the only way to discover that is by trying all the different things, all the different topics, read all the different literature, try all the different experiments, put yourself out there, risk what sort of activities and really discover what you're really interested in and passionate about.

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USC Viterbi
School of Engineering

ASSOCIATE PROFESSOR OR FULL PROFESSOR RANK
DEPARTMENT OF AEROSPACE AND MECHANICAL ENGINEERING

The University of Southern California invites applications for multiple tenured positions at the Associate Professor or full Professor rank in the Department of Aerospace and Mechanical Engineering (AME) in the USC Viterbi School of Engineering. Candidates must have demonstrated research excellence with external funding and sustained commitment to the discipline. An earned doctorate in Aerospace Engineering, Mechanical Engineering, or a closely related field, is required. Exceptional candidates may be considered for a chaired professorship. The USC Viterbi School is committed to increasing the diversity of our faculty and welcomes applications from women; persons of African, Hispanic and Native American descent; veterans; and persons with disabilities. Outstanding senior applicants who have demonstrated academic excellence and leadership, and whose past activities document a commitment to issues involving the advancement of women in science and engineering may be also considered for the Lloyd Armstrong, Jr. Endowed Chair, which is supported by USC's Women in Science and Engineering (WiSE) Program endowment.

Our department's search this year aligns with USC's $1 billion Frontiers of Computing initiative, the largest, most comprehensive academic initiative in the university's history. The initiative has already resulted in the creation of the USC School of Advanced Computing. It is expected that successful candidates will be affiliated with this new school. While applicants from all research fields will be considered, priority will be given to those whose research aligns with one or more of the following affinity areas: (i) Computational Science and Engineering; (ii) Sustainability and Computing; and/or (iii) Computational Medicine and Health. Applicants are required to incorporate into their research and teaching statements at least one page that clearly describes how their research and teaching interests and accomplishments align with at least one of these affinity areas. Applications that do not address the affinity area(s) in their statements will be considered incomplete and will not move forward in the selection process.

Positions are available starting August 16, 2025. Candidates should apply at **https://ame.usc.edu/facultypositions**. Application materials must include a cover letter, a curriculum vitae, statements of research and teaching interests (each up to 2 pages) and contact information for at least three references. Applicants are encouraged to include a succinct statement on fostering an environment of diversity and inclusion.

The USC Viterbi School of Engineering is among the top-tier engineering schools in the world. It counts 213 full-time, tenure-track faculty members. Faculty engage in interdisciplinary research through the School's research centers, including the Information Sciences Institute, the Institute for Creative Technologies, the Department of Homeland Security's first University Center of Excellence (CREATE), the National Center for Metropolitan Transportation Research (METRANS), the Center for Artificial Intelligence in Society (CAIS), and the Center for Advanced Manufacturing (CAM). The School is affiliated with the USC Stevens Center for Innovation. Our research expenditures typically exceed $177 million annually.

The annual base salary range for the following faculty ranks in this posting are:

• Associate Professor $136,000 - $165,000

• Full Professor: $174,000 - $236,000

When extending an offer of employment, the University of Southern California considers factors such as (but not limited to) the scope of responsibilities of the position, the candidate's work experience, education/training, key skills, internal peer equity, federal, state.

USC is an equal opportunity, affirmative action employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, protected veteran status, disability, or any other characteristic protected by law or USC policy. USC will consider for employment all qualified applicants with criminal histories in a manner consistent with the requirements of the Los Angeles Fair Chance Initiative for Hiring ordinance.

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INFOGRAPHIC

Do Students Learn What Industry Needs?

Engineering faculties decide what knowledge and abilities their graduates have to launch their careers. However, new engineers often end up with skills that don't match employer expectations.

EXPLORE

MECHANICAL ENGINEERING

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WHEN UNIVERSITY FACULTY PLAN COURSES offered to engineering students, they don't always consider what employers need from newly minted mechanical engineers. Based on this premise, research scientist Gabriella Coloyan Fleming joined Michelle Klopfer, Andrew Katz, and David Knight to examine over 26,000 job descriptions (including 4,962 for mechanical engineers), looking at the specific professional and technical skills listed as requirements.

Their paper, “What engineering employers want: An analysis of technical and professional skills in engineering job advertisements” in the *Journal of Engineering Education*, not only revealed which professional and technical skills industry employers sought, but also uncovered which skills offered a premium to those who can say they held them.

The research team decided to mine job ads with the idea that there possibly was “a gap between what schools do to prepare students and what engineers actually do in the engineering industry,” said Fleming, who is now a researcher in the Department of Engineering Education at Virginia Tech in Blacksburg. Fleming saw this in her own job search experience. “I was considering technical engineering jobs in industry,” she said. “There was a gap between the skills that I had and the skills that employers required. I'm hoping that this research can help future students not have the same experience I did.”



CLOSE OVERLAY

Professional Skills in Demand

The research team found that employers believe graduates from well-reputed programs “have satisfactory technical skills” and “job-specific technical skills can be learned on the job.” Employers give more weight to professional or “soft” skills. To identify the professional skills most relevant to engineering occupations, the team used the O*NET Skills database and identified 20 that ranged from “listening” and “writing,” to more complex skills as “problem solving.” Even though professional skills are very commonly listed in job advertisements, “students are only really indirectly taught them,” Fleming said. For example, although the word teamwork is in 72 percent of mechanical engineering bachelor's level job ads, the skill is not directly taught.

Teaching professional skills can be difficult, Fleming conceded. “Professors might believe putting students in teams will teach them how to be a good team member and leader. But that’s making a big assumption,” she said.

Source: “What engineering employers want: An analysis of technical and professional skills in engineering job advertisements,” February 2024, issue of the *Journal of Engineering Education*.



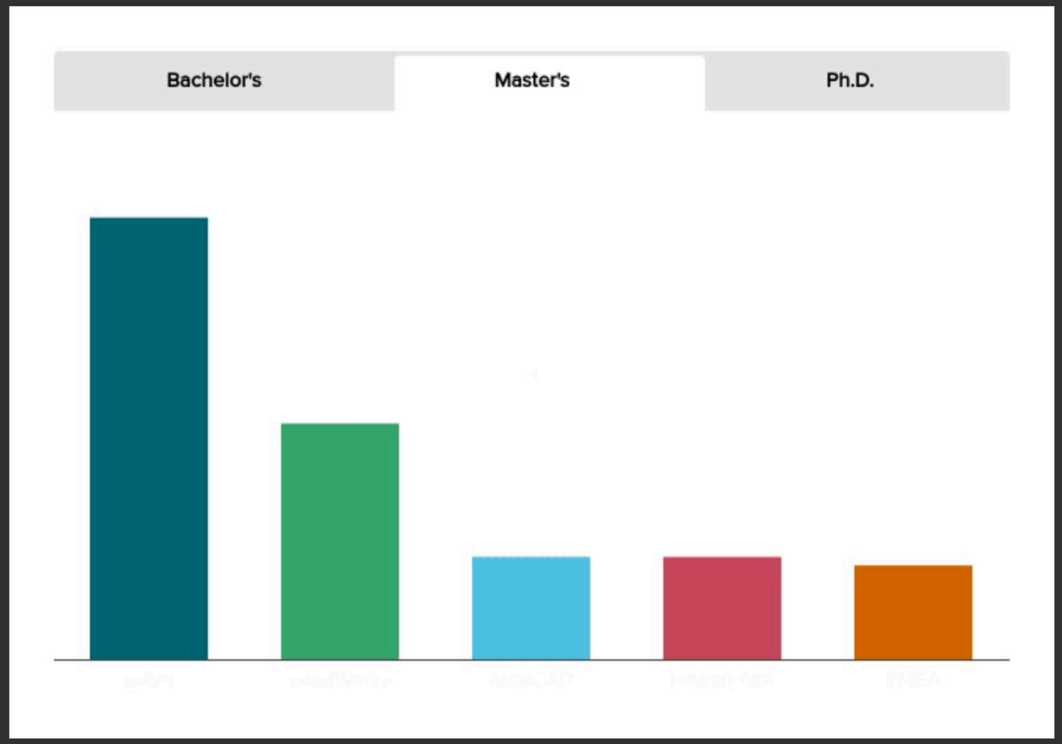
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The Most-Desired Technical Skills

The gap between the technical skills needed to work as a mechanical engineer and what was taught in school is often a function of what was covered but not needed. Fleming gives the example of the software package MATLAB. “Universities put a lot of emphasis on MATLAB. That’s what’s taught in a lot of classes. But it’s really in a minority of job advertisements for mechanical engineers,” she said.

Looking specifically at the northeast region of the U.S., the researchers reported that the “top technical skills mechanical engineering employers desire are design, manufacturing, controls, and materials.”

Source: “What engineering employers want: An analysis of technical and professional skills in engineering job advertisements,” February 2024, issue of the *Journal of Engineering Education*.



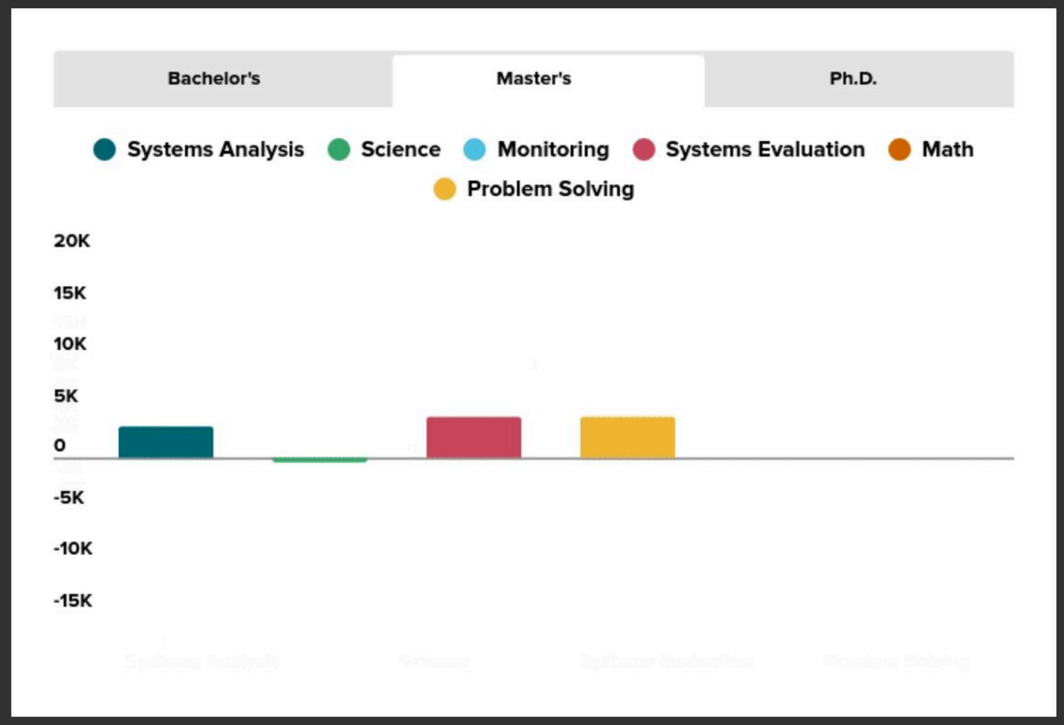
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Which Skills Pay Off?

The report considers the connections among salary data, education level, engineering discipline, and the skills listed within each job advertisement. So while the report highlighted which skills were most commonly sought from a frequency perspective, it also offered the "value proposition" of hiring a future employee with specific skills. To understand which skills are the most financially valued, the researchers introduced the concept of "skill premiums."

To do this, they calculated salary levels for advertised positions contained each skill and compared them to those that did not require the skill. This provided a "skill premium" for each category. "We hope these findings can bring new empirical support to conversations about engineering curricular choices that programs and students might make as they consider alignment with workforce demands," the team commented.

Source: "What engineering employers want: An analysis of technical and professional skills in engineering job advertisements," February 2024, issue of the *Journal of Engineering Education*.



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Which Technical Skills Should You Learn?

To understand what this research means for a technical skill, for bachelor's level jobs across disciplines, for example, that listed Python in the skills or descriptions category had a median salary of $94,250, as compared with a median salary of $79,500 for advertisement that did not specify Python. So, in this case, the “skill premium” would be $14,750 for Python. A negative skill premium indicates that the median salary for a job with a given skill is lower than the median salary for a job without that skill. The researchers also found that specific engineering disciplines had specific software preferences. For example, SolidWorks appeared frequently in job advertisements for mechanical engineering.

Source: “What engineering employers want: An analysis of technical and professional skills in engineering job advertisements,” February 2024, issue of the *Journal of Engineering Education*.



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ENGINEERING FOR CHANGE

Sustainable Manufacturing Needs Simulation

Ansys's Pepi Maksimovic discusses the way digital twins and other simulation technologies can help factories cut waste and improve energy efficiency.

Written by ***Rob Goodier***



To Pepi Maksimovic, director of application engineering at Ansys, the engineering simulation software company, the global manufacturing industry is a heat-wasting carbon emitter with wide targets for improvement. For Maksimovic, that viewpoint is just part of her job: She leads a technical team that helps customers improve their efficiency, reduce emissions, and, in some cases, design new technologies needed for a low-carbon future.

A handful of statistics paint the picture. Pumps, compressors, heat exchangers, mixers, furnaces, and other equipment are energy pits contributing to an industry that wastes about 65 percent as unused heat. Most of the emissions are in chemical manufacturing and refineries, and about half of the energy powering the manufacturing industry is derived from natural gas. The energy, the manufacturing machinery, and the processes within each plant can be transformed and optimized, Maksimovic said. Some already have been.

On February 4th, Maksimovic will share insights from her work in a fireside chat on the main stage at Informa's Sustainable Manufacturing Expo in Anaheim, California. In conversation with Chris Cantrell, ASME's Senior Managing Director of Standards and Engineering Service, Maksimovic will discuss digital innovation and rigorous standards that support companies as they assess, validate, and scale sustainable manufacturing initiatives.

In advance of that conversation, Maksimovic discussed the role of engineering simulation software in building a sustainable manufacturing industry.

ME: Let's start with the problem. How urgent is it to improve the manufacturing industry?

Pepi Maksimovic: The timelines to hit the net-zero emission target by 2050 and meet the Paris Accord are tight. We have only two or three decades, pretty much, to act.

A lot of the technologies that are currently employed in the manufacturing environment have been around for decades or a century-plus. They're mature, but we're still finding areas to improve and refine and make them better. To achieve decarbonization goals, however, requires not only continuing to improve upon existing technologies but also the development, maturation, scale-up, and deployment of totally new solutions in a relatively short period of time.

We don't have another 100 years to refine and improve. The pace of innovation must be accelerated. And that's where engineering simulation comes in.

ME: Starting with the big picture, how can engineering simulation software help?

Maksimovic: It's multi-fold. Let's begin from the standpoint of environmental impact and efficiency. A factory or plant deploys equipment like pumps, compressors, heat exchangers, mixers, furnaces, heaters, etc. Every single piece of equipment consumes energy and adds to the carbon emissions created by the manufacturing process. It's all cumulative. Simulation software can optimize the design and performance of the equipment for energy efficiency and emissions reduction.

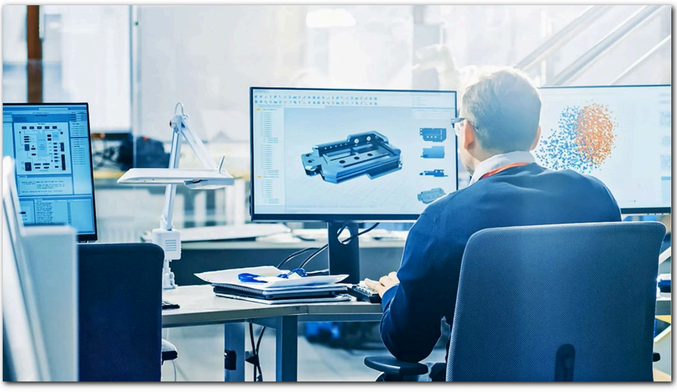
Studies show that about 80 percent of the carbon footprint of a product—including manufacturing equipment—is locked in the materials it is made of and how it is manufactured. Simulation can help guide materials selection as well manufacturing techniques for improved sustainability.

Next let's look at operational efficiency. Simulations can improve efficiency by reducing scrap rates, commissioning time, and down time and providing the ability to make operational decisions in real time.

For example, monitoring a manufacturing process to make changes as needed is typically done by installing sensors, followed by collecting and processing sensor data. By using simulation and creating so-called digital twins, an operator can put virtual sensors anywhere and extract data from wherever they want. The available data is collected from both physical data simulations. The information is greatly enriched and operators can act on the data almost instantaneously. To maximize efficiency, they can adjust the feed rate or change the RPM of a certain machine, for example, to control the yield and quality of the product, maximize the throughput and all the usual measures of manufacturing efficiency.

Digital twins are also used to improve energy efficiencies. In short, a variety of use cases can come into play.

Finally, simulation has a critical role in advancing innovations in zero- and low-carbon energy solutions such as nuclear, hydrogen, and others needed to decarbonize the manufacturing sector.



"Simulation enriches and accelerates the ideation process. It spurs creativity. Once people start using it, the light bulbs turn on in their heads, and they want to use more of it." — Pepi Maksimovic, director of application engineering at Ansys. ***Photo: courtesy of Ansys***

ME: Can you share examples of companies that have benefitted using simulation software?

Maksimovic: Simulation software is used in all manufacturing industries: aerospace, automotive, materials, food, pharmaceuticals, semiconductor manufacturing, etc.

Plants that process materials are energy-intensive and operate around the clock. Process interruptions and unplanned downtime are costly, so optimization is critical, both from a financial and environmental standpoint. One glass manufacturer was able to reduce scrap by 30 percent by deploying virtual monitors in their production lines.

In another example, Verbund, a leading producer of in Austria, used digital twins for predictive maintenance and was able to save over $100,000 per year per turbine by avoiding unnecessary downtimes. Scaled across 100-plus plants in operation and the savings are significant.

Another energy company, TotalEnergy, was able to achieve 2 percent improvement in operations and save millions of dollars per year per refinery using digital twins.

Simulation is used to virtually model the myriad of processes that occur in manufacturing as feed materials are transformed into products. Those include heating and cooling, melting and solidification, combustion, ventilation, mixing, separation, forming, molding, casting, quenching, machining, joining, dipping and coating, crushing, conveying, packaging, additive manufacturing, visual inspection, and others.

ME: What are some of the obstacles to adopting tools like simulation software to improve sustainability?

Maksimovic: None that are unsurmountable or complicated. One is not being familiar with simulation. Some smaller or more traditional manufacturing companies are just not used to using simulation technology or digital engineering.

ME: Is it hard to learn to use the software? Is training an issue?

Maksimovic: That's not really an obstacle nowadays. Simulation tools have become fairly straightforward to learn and use; user experience has come a long way compared to 20-30 years ago when it tended to be reserved for Ph.D.s and deep subject matter experts. Modern simulation tools have become more intuitive.

ME: Are there other obstacles?

Maksimovic: Perhaps computational power. The relative cost of computing has gone down, but the complexity of the problems tackled with simulation increases as the capabilities of the software develop. Which is why high-performance computing, GPU computing, and cloud computing are commonly leveraged for speed and scale.

ME: What are some of the ways simulations can influence the engineering design process?

Maksimovic: Simulation enriches and accelerates the ideation process. It spurs creativity. Once people start using it, the light bulbs turn on in their heads, and they want to use more of it. Simulation helps people drive all these engineering changes. They innovate. They get new ideas. That's where you start seeing a lot of ideas rapidly fire up. And that breaks down the resistance to the tools.

See Pepi Maksimovic in conversation with Chris Cantrell at the Sustainable Manufacturing Expo in Anaheim, Calif., February 4th at 1:15-2PM Pacific Time.

ROB GOODIER *is News Editor at Engineering for Change, a community working to prepare the international technical workforce to improve life for people and the planet. ASME is a founding partner of E4C.*

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COLUMN // PATENT

When to Disclose an Invention

Patent law makes the U.S. a first-to-file system, but exceptions abound.

Written by ***Kirk Teska***

Patent law is established to protect intellectual property, and it works best when the rules are roughly the same everywhere. In 2011, as part of a harmonization effort, the United States changed from a first-to-invent to a first-to-file (a patent application) regime primarily because that's the system of almost every other country.

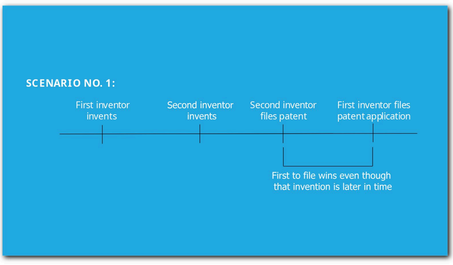
The first-to-invent system in place for many years did produce some fights among competing inventors for a given patent—fights governed by a set of byzantine rules—but usually the first patent application filer prevailed. That meant the U.S. was a de facto first-to-file system anyway especially since these fights were few and far between. Think about it: What are the odds two inventors invent almost exactly the same thing at the same time?

The American Invents Act that implemented the first-to-file system solved a problem that didn't really exist.

The weird part of the regime change was the U.S. kept its "one year grace period" system which almost no other country has. So much for harmonization. In the U.S., an inventor can invent something, publicly disclose it, sell it, whatever, and still file a valid patent application up to a year later. But, to make the one-year grace period system work in the new first-to-file system, you have to allow a first-in-time inventor but second-in-time patent application filer to prevail against a first-in-time patent application filer in certain scenarios. So, the patent laws allow the second-in-time filer, if he publicly discloses the invention before the first-in-time filer files his patent application, to not have that patent application knock out the first inventor's second-in-time patent application.

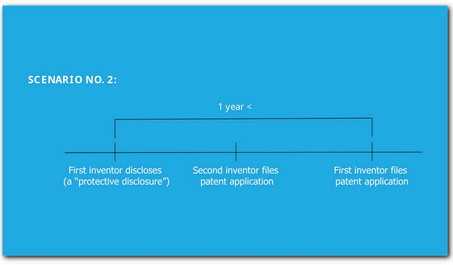
For any sadomasochists out there who want to dive deeper into this, it's all in 35 United States Code section 102. Beware: there are five subsections, 11 sub-subsections, and even a few sub-sub-subsections. If there is a more poorly written law in our books, I've not seen it. My patent law students seem to like my crude but easy to memorize summary: Absent theft or some bizarre fact pattern, the first patent application filer wins unless the first inventor, second patent application filer discloses before the second inventor files (and then also files within a year after the disclosure). These two charts may help.

Scenario 1 represents the first-to-file regime where the first filed patent application wins even though that invention was second in time over the first inventor's invention. An exemption to that rule is shown in the next scenario.



Scenario 2 shows how, under the one-year grace period system, since the first inventor disclosed the invention before the second inventor filed a patent application, the second inventor's first-to-file patent application does not count against the first inventor's second-in-time patent application. Here, in contrast to scenario 1, the second filer prevails. The second scenario involves a "protective disclosure" by the first inventor who disclosed the invention before the other inventor filed a patent application. The earlier disclosure protects the second filed patent application against the first filed patent application so long as the discloser complies with the one-year grace period and follows up with a patent application within a year of the disclosure.

Let's now look at one more scenario:

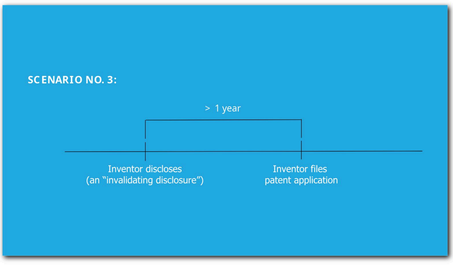


In this scenario, the one-year grace period does not help the inventor because the inventor disclosed the invention and more than one year later filed a patent application that will be held invalid. Thus, scenario 3 involves an "invalidating disclosure."

So far, so good except for one little problem: Recently, the Patent Court ruled protective disclosures in scenario 2 do not mean the same thing as invalidating disclosures in scenario 3. For example, a private ("secret") sale of a product incorporating an invention would count as an invalidating disclosure under scenario 3 but not as protective disclosure under scenario 2. The same would probably be true of a secret process used to manufacture a product that was then sold—which would count as an invalidating disclosure (as to both the process and the product) but probably not a protective disclosure as to the process.

The reason is invalidating disclosures and protective disclosures involve different policy considerations.

The policy under scenario 2 is to protect an inventor who publicly discloses an invention from patent application filers who beat the inventor in the race to the Patent Office. The policy under scenario 3 is to prevent an inventor from commercializing an invention and then waiting too long to file a patent application even when, in the commercialization effort, no one learns about the nature or details of the invention.



Does it matter? Maybe, because certain patent strategies could be adversely affected. IBM and others, for example, engage in invention pledge programs where they publish and disclose technologies they decide not to patent to protect themselves from later patent application filers attempting to protect the same technology. Also, some companies publish first and then wait a year to file a patent application to take full advantage of the one-year grace period (enabling further research and development and making sure the invention really has market value) to protect themselves from others who file a patent application before they do.

Given the Court's recent ruling, some of these strategies may need revamping.

> **"Absent theft or some bizarre fact pattern, the first patent application filer wins unless the first inventor, second patent application filer discloses before the second inventor files (and then also files within a year after the disclosure)."**

For an invalidating disclosure, the actual invention might never be known to others (such as the sale of a product embodying invention even if the sale is private), public use of the invention (even though the public never sees its details), and even an offer for sale of a product embodying the invention. For a valid protective public disclosure, the publication, sale, or use must involve the public's actual knowledge of the details of the invention. Thus, a scientific article describing the invention works for both an invalidating disclosure and a protective disclosure while showing a gizmo (but not its internal workings) at a trade show constitutes an invalidating disclosure but not a protective disclosure.

Until this case was decided, many people thought that what works for an invalidating disclosure also works for a protective disclosure. That's not true anymore. Maybe a patent strategy that predates even the change to the first-to-file regime may again be invoked: file early and often.

KIRK TESKA *is the managing partner of Iandiorio, Teska and Coleman, LLP, an adjunct professor at Suffolk Law, and the author of two books:* Patent Savvy for Managers *(NOLO) and* Patent Project Management *(ASME Press).*

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COLUMN // HISTORY

A Singular Sensation

Mechanical engineers and metallurgists sought to improve gas turbine blades by eliminating grain boundaries.

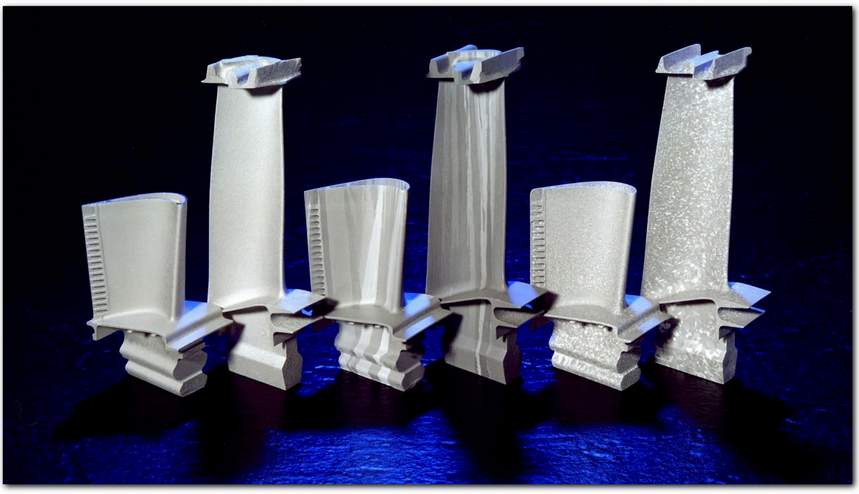
Written by ***Lee S. Langston***

Conventionally cast gas turbine airfoils are polycrystalline, consisting of a three-dimensional mosaic of small, metallic, equiaxed crystals, or "grains," formed during solidification in the casting mold. Each equiaxed grain has a different orientation of its crystal lattice from its neighbors'. Resulting crystal lattice misalignments form interfaces called grain boundaries.

These grain boundaries are not innocuous. Life-limiting events—such as intergranular cavitation, void formation, increased chemical activity, and slippage under stress loading—happen at grain boundaries. These conditions can lead to creep, shorten cyclic strain life, and decrease overall ductility. Corrosion and cracks also start at grain boundaries. In short, physical activities initiated at superalloy grain boundaries greatly shorten turbine vane and blade life, and lead to lowered turbine temperatures with a concurrent decrease in engine performance.

Over 60 years ago, a small group of mechanical engineers and metallurgists at Pratt & Whitney, one of Connecticut's jet engine manufacturers, audaciously set out to totally eliminate grain boundaries in superalloy turbine airfoil blades and vanes in their gas turbines. The goal was to develop a casting process that would produce one, single crystal of very large size.

Gas turbine technology history shows that game changers like the single-crystal (SX) program typically entail 30 years or more. The 10-year Pratt & Whitney SX targeted group success is thus worthy of a study in itself.



Turbine blades (first stage, short; second or third stage, taller) are acid etched to show grain structure. Pair at left is single crystal; center, directionally solidified; right, equiaxed.

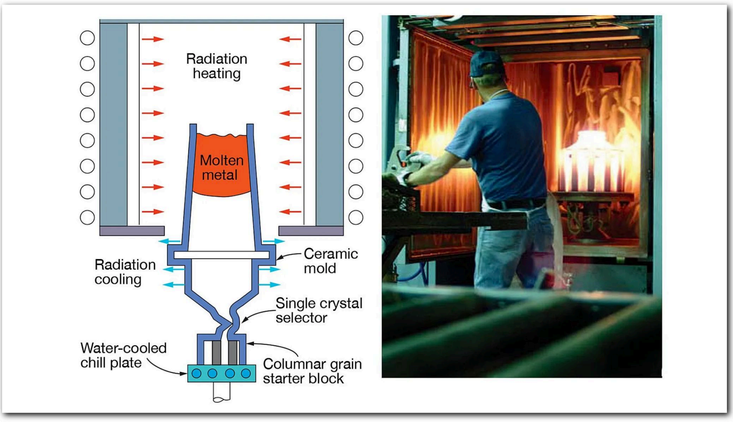
INCREASING EFFICIENCY

Gas turbine thermal efficiency increases with greater temperatures of the gas flow exiting the combustor and entering the work-producing component: the turbine. Turbine inlet temperatures in the gas path of modern high-performance jet engines can exceed 3,000 °F, while non-aviation gas turbines operate at an upper limit of 2,700 °F.

In high temperature regions of the turbine, special high melting point nickel-base superalloy blades and vanes are used, which retain strength and resist hot corrosion at extreme temperatures. These superalloys, when conventionally vacuum cast, soften and melt at temperatures between 2,200 °F and 2,500 °F. This means blades and vanes closest to the combustor may be operating in gas path temperatures far exceeding their melting point and must be cooled to acceptable service temperature (typically eight-to-nine-tenths of the melting temperature) to maintain integrity.

Thus, turbine airfoils subjected to the hottest gas flows take the form of elaborate superalloy investment castings to accommodate the intricate internal passages and surface hole patterns necessary to channel and direct cooling air (bled from the compressor) within and over exterior surfaces of the superalloy airfoil structure. To eliminate the deleterious effects of impurities, investment casting is carried out in vacuum chambers.

A unique turbine blade/vane casting process was developed, based on maintaining strict control of one-dimension spanwise heat transfer in the ceramic mold to a chill plate, to solidify the molten superalloy. A key part of the process was the invention of a mold helical "pigtail" passage that served to start the single crystal solidification.



Single-crystal blades are made by a process like that shown in the simplified sketch at left. A vacuum furnace is opened after casting a cluster of single-crystal gas-turbine blades in a ceramic mold (right). Note the chill plate beneath the mold.

The making of a SX turbine airfoil starts with carefully controlled mold temperature distributions to ensure transient heat transfer in one dimension only, to a water-cooled chill plate that supports the mold. Columnar crystals form at the knurled chill plate surface in a mold chamber called the "starter." The upper surface of the starter narrows to the opening of a vertically mounted helical channel called the "pigtail," which ends at the blade root. The pigtail admits only a few columnar crystals from the starter.

Crystal orientations grow at different rates into the liquid metal in the pigtail, with one orientation growing the fastest. Thus, with ample coils, only one crystal emerges from the pigtail into the blade root, to start the SX structure of the airfoil itself.

Starting in the late 1960s with a very focused single-crystal (SX) turbine blade program, Pratt & Whitney was able to successfully put them into a production jet engine, going from concept to manufacture product within 10 years. The effort was led by former MIT faculty member, Maurice "Bud" Shank, and directional solidification metallurgy expert, Frank VerSynder.

In gas turbine use, SX turbine airfoils have proven to have as much as nine times more relative life in terms of creep strength and thermal fatigue resistance, and over three times more relative life for corrosion resistance, when compared to equiaxed crystal counterparts. By eliminating grain boundaries, SX airfoils have longer thermal and fatigue life, are more corrosion resistant, can be cast with thinner wall—meaning less material and less weight—and have a higher melting point temperature.

These improvements all contribute to higher gas turbine thermal efficiencies in jet engines. In larger electric power and land-based gas turbines (with some airfoil lengths up to 45 centimeters, with each finish casting weighing as much as 15 kilograms) SX airfoils offer corrosion resistance, as well as higher thermal efficiencies.

Lee S. Langston *is professor emeritus in the mechanical engineering department at the University of Connecticut at Storrs.*

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CAREER FOCUS

Removing the Toxins from Company Culture

High-achieving businesses embrace purposeful company cultures in which leaders help employees feel valued, heard, and engaged. Not every company is like that.

Written by ***Robin Flanigan***



THERE'S A DIFFERENCE BETWEEN an unhealthy work environment and a toxic one, but both can lead to burnout, an all-too-common condition among both engineers and their superiors.

Forty-six percent of engineers and 34 percent of executives report teamwide burnout, according to the *2024 State of Engineering Management Report* by engineering management platform Jellyfish.

That may mean low or no energy, feeling continuously distracted, or having trouble finding purpose in what used to be meaningful work.

"The environment matters more today than it ever has," said Peter C. Atherton, P.E., president and founder of ActionsProve, LLC, and author of *Reversing Burnout: How to Immediately Engage Top Talent and Grow!* "It's different than it was just 10 years ago. We are in a new era."

While about two-thirds of Atherton's clients are high-achieving engineering and architecture firms, roughly one-third of them are in crisis, struggling with one or more aspects of their business or organization. That often includes chronic and unsuccessfully managed stress.

In the past, many workers felt lucky just to have a job. Today, Atherton said, top-talented employees who have many options and other organizations reaching out to them these days—particularly since Covid, when many aspects of the workforce changed—expect leaders to create a culture focused on much more than logistical progress.

"Are we working in an environment where it's not draining all the time—where it's getting the best out of us and not just the most out of us?" asked Atherton, who addressed this question in his newest book, *Next-Level Leadership: How to Build and Leverage Your Essential Team Success Ecosystem*.

Currently, there is more work to be done than people available to do it—a pervasive situation throughout the U.S. economy but particularly acute in the engineering trades, Atherton said. That has led to an inflection point, he said, where a more purposeful company culture in which leaders help employees feel valued, heard, engaged, and able to contribute to their own and their organizations' successes can make all the difference.

"We've just gotten busy again, and in some cases, we've taken our eye off that aspect of what Covid taught us," Atherton said.

He recommended responding to the situation specifically, and to organizational and team design generally, the way engineers would approach bridge design—thinking about how the columns, beams, and cables, with their compressive and tensile forces, work together in harmony.

"There's a tension and a pressure that just needs to be understood and balanced and ultimately leveraged," he said. "It allows us to get to new places, overcome something that otherwise would be dangerous or impassable."



> **"Designing a culture has to be done explicitly and with intentionality."**
>
> Peter C. Atherton, P.E., president and founder of ActionsProve, LLC

Atherton's tips for some ways to go about this include:

Get some rest and manage your time wisely. Try not to bring work problems, tensions, and pressures home. And if you get stuck on a problem in the middle of a workday, give your brain a break and take a walk in nature, if possible. This allows space for new perspectives and possible solutions. "We're smart people and we work for smart people," he said. "We might be able to make some adjustments by managing our own time and stress."

Seek out support. Talking to a peer group, therapist, coach, or mentor may help preserve your sanity, as well as help "gain the language, competence, and confidence to have a conversation with your supervisor" about making a shift of some sort, he said.

Talk about a potential shift. Let your supervisor know how you're feeling, while being proactively and thoughtfully engaging. Atherton suggested asking, "Is there a way we can make some adjustments?" and "Is this going to last forever?" Most of the time, he noted, supervisors are unaware of these feelings and appreciate being given the chance to modify what isn't working well. But don't expect your supervisor to solve things alone. "Let's be professional, let's be human, and let's have a real discussion about this, because that's what creates respect and clarity," he said.

Shift teams. Sometimes conversations don't change things. Atherton cited one of Gallup's most famous leadership research breakthroughs showing that 70 percent of the variance between the highest-engaged teams and persistently disengaged teams comes down to the manager. "So, you could be in an incredible organization with a great executive culture, but you just need to change groups," he said.

Take time off and make a plan. This may be necessary to think about how best to move forward, because even if you can tolerate an unhealthy workplace for a while, "it eventually will beat down even the best people," Atherton said. Just keep in mind that the world will continue to evolve. "Are you going to evolve with it? If you take a time-out, for how long and what will you do? Because at some point you need to move forward," he added.

Leave if needed. Thriving cultures at work don't happen by accident, and this is especially true for those that last a long time, Atherton pointed out. "Designing a culture has to be done explicitly and with intentionality. If that's not the case at your workplace, and your mental health is suffering, it may be time to look for opportunities elsewhere where the culture better aligns," he said.

Robin Flanigan *is an independent writer in Rochester, N.Y.*

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TECHNOLOGY FOCUS

Robotics and Automation

A roundup of recent advances in engineering technology.
In this issue, a look at breakthroughs and commercialization of robots.

ROBOTS IN THE FIELDS

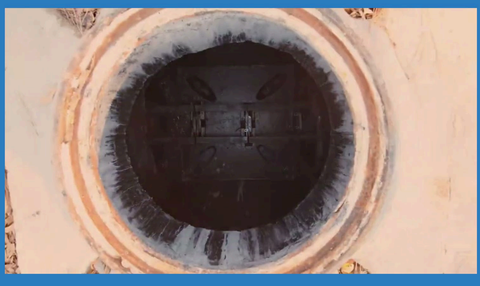
Farming operations, which feature repetitive work in challenging conditions, seem ripe for an infusion of automated help. That insight has driven investment in startups operating in the agricultural robotics space. FarmDroid, the manufacturer of field-ready robotic systems based in Vejen, Denmark, announced in October 2024 that it had obtained 10.5 million euros in capital to help fund its expansion into global markets.

FarmDroid announced in July 2024 that it had 500 robots in use in 23 countries, including limited deployments in California, Michigan, and Oregon, where they seeded and weeded crops. The company's FD20, which was demonstrated this past growing season, is a solar-powered field robot that uses GPS to mark the position of each plant at seeding and subsequently performs both inter-row and intra-row weed control.

Because the FD20 can target individual weeds with a micro-spray system, FarmDroid says its robots can reduce the overall volume of pesticide use.

FarmDroid isn't the only robotics company operating in agriculture. Harvest CROO Robotics in Tampa, Fla., has developed an AI-enabled system for identifying and plucking ripe strawberries. And France's Naio Technologies has deployed two different models specialized for tending to vines in wine-growing regions.





AUTOMATED CARHOPS

Some drive-in diners of the 1950s featured roller-skating waitresses who brought orders out to parked cars. While nostalgia-soaked patrons might love to see the return of this service, Austin, Tex.-based Pipedream Labs is offering the next best thing. In November 2024, it announced the launch of its robotic food-delivery system, which uses underground robots to shuttle food orders from the kitchen to customers.

According to Canon Reeves, co-founder and chief technology officer of Pipedream, many restaurants and grocery stores face a challenge when it comes to fulfilling pickup orders. The labor and logistics of running orders out to waiting vehicles can be daunting. The ultimate delivery system would be something akin to teleportation, he told *The Robot Report*.

Pipedream hasn't cracked that, but they have developed a system than relies on a network of buried tubes, similar to the pneumatic tubes used in bank drive-through windows.

In late 2023, Pipedream demoed a system in Peachtree Corners, Ga., that extended a network of tubes nearly one mile long to connect restaurants and stores in the shopping center to a set of kiosks in the parking lot. Orders were loaded onto bins that rode atop small autonomous vehicles through the tube network.

The newest system, located at a fast-food restaurant at an undisclosed location in Texas, took less than a week to build across the restaurant's parking lot. Reeves said he wanted to reduce the build time to less than three days.

Reeves was quoted by *The Robot Report*, laying out the company's ultimate vision as part of a door-to-door delivery system. "We believe in this world where our system can hand off to other systems," he said. "You can image this system getting it close to your neighborhood, and maybe a sidewalk robot finished that last 100 feet to your doorstep."

DO INDOOR ROBOTS NEED LEVELS OF AUTONOMY?

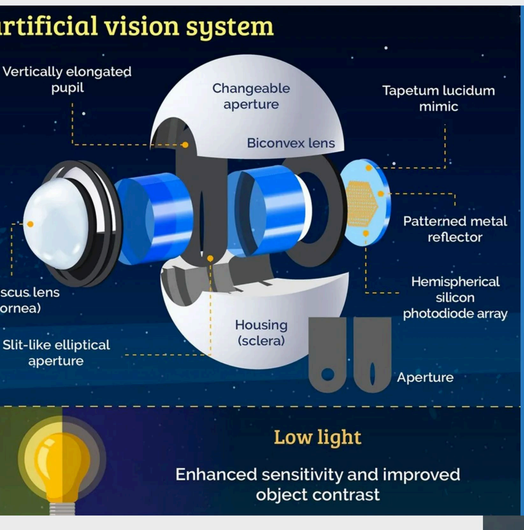
Some 10 years ago, the Society of Automotive Engineers unveiled a set of categories for differentiating between levels of "self-driving" for autonomous automobiles, with Level 5 being the as-yet-unachieved gold standard for a car that can get around with no human driver.

Autonomous indoor robots generally don't have backup drivers the way robo-taxis do. Recently Relay Robotics, the Campbell, Calif.-based maker of hospital and hotel delivery robots proposed a set of autonomy levels for helping potential buyers better understand what autonomous robots can—and can't—do. A blog post written by engineers working for the company laid out a set of standard terminology.

"Relay robots in particular, are being deployed in busy hospitals and hotels across the world. However, unlike automated driving, there is currently no widely adopted standard for levels of autonomous navigation for indoor robots," wrote Sonali Deshpande, senior navigation engineer, and Jim Slater, robot systems architect. "Our objective is to present such a framework."

The five-level categorization is determined by installation complexity, the ability to navigate social situations or changing environments, and the potential to move between floors within a building. Robots that can operate only along paths that are defined by paint or buried wires, say, would be Level 1, while "Level 5 robots are robots that could navigate in all indoor environments on par with human skill, as well as do so in a completely new environment without detailed prebuilt maps and a manually intensive installation process," the engineers wrote.





CAT'S EYES FOR AUTONOMOUS ROBOTS

The vertical-slit pupil of a cat's eyes serves a purpose. During the day, they reduce glare, while at night, the pupils widen to allow light to hit a reflective layer to boost vision in the dark.

Now, a group of researchers in South Korea have taken inspiration from cat's eyes to produce a new advanced vision system for robots.

The system includes a slit-like aperture that filters excess light to help focus on key objects. A reflective layer much like the one in a cat's eye improves visibility in low-light conditions.

The researchers said the system allowed enhanced object detection and recognition capabilities.

"Robotic cameras often struggle to spot objects in busy or camouflaged backgrounds, especially when lighting conditions change," said Young Min Song from Gwangju Institute of Science and Technology in a press statement. "Our design solves this by letting robots blur out unnecessary details and focus on important objects."

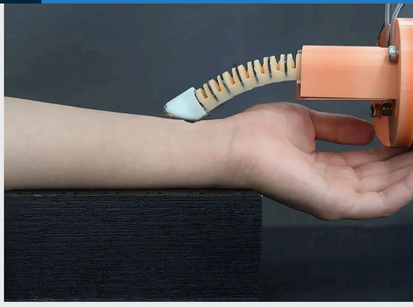
One advantage of the vision system is that it relies on the design of the lens rather than on heavy computer processing, making it more energy efficient than conventional vision systems.

ROBOTIC FINGER CAN TAKE A PULSE

Building a robotic sense of touch is still in the beginning stages, but researchers at the University of Science and Technology of China in Hefei report developing a finger that is sensitive enough to conduct routine medical exams such as taking a pulse or checking for abnormal lumps.

While lack of sensitivity is a concern with existing robotic fingers, a larger worry for patients is safety. Hard robotic fingers could be seen as potentially harmful if they poked vigorously. Fingers made from softer material have not been able to sense physical properties of the body well enough for diagnoses.

The researchers reported that the simple, soft finger they developed has conductive fiber coils with two parts—a coil wound on each air chamber of the device's bending actuators (the parts that enable it to move) and a twisted liquid metal fiber mounted at the fingertip. Signals from these coils told the researchers how much the finger bent as it touched an object and how much force it applied.



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ASME NEWS

New Support for Hydrogen in ASME Piping Standard

A roundup of recent Society events.

PRCI PROVIDES GUIDANCE FOR THE ADDITION OF HYDROGEN PIPELINE REQUIREMENTS

The Emerging Fuels Institute of the Pipeline Research Council International (PRCI) has completed a Consensus Engineering Requirement (CER) project to translate and update the pipeline language from the ASME B31.12 Hydrogen Pipelines Standard to establish a new exception chapter for hydrogen pipelines in the ASME B31.8 Gas Transmission and Distribution Piping Systems Standard.

The comprehensive, practical guide supports fit-for-purpose projects and helps maintain pipeline safety. The final report with the proposed language and project details and a corresponding webinar are now available for free on the PRCI website.

“This change will result in a more efficient application of clear, consensus-based hydrogen rules for piping systems by consolidating these rules into the standards that are most often used by our industry partners,” said Chris Cantrell, ASME’s senior managing director of standards and engineering services.

More than 200 individuals from ASME, PRCI, and the broader pipeline community reviewed the project and provided comments as the project progressed. Moving forward, the PRCI project team will support the ASME B31.8 Hydrogen Task Group in presenting the proposed language in the CER for review and approval through a consensus process by the ASME B31.8 and B31 Standards committees for inclusion in the 2026 edition of B31.8.





ADRIAN BEJAN RECEIVES ASME MEDAL

Adrian Bejan, the J.A. Jones Distinguished Professor of Mechanical Engineering at Duke University in Durham, N.C., has been awarded the 2024 ASME Medal. Established in 1920, the award is the highest honor that the Society can bestow and recognizes “eminently distinguished engineering achievement.”

Bejan received the medal at ASME’s International Mechanical Engineering Congress & Exposition in Portland, Ore. He is honored for unprecedented creativity, breadth, and permanent impact on engineering; for developments in the new science of energy, motion, form, and evolution; and for building bridges to design in biological, geophysical, and sociological systems.

An eminent scholar in his field, Bejan earned B.S., M.S., and Ph.D. degrees at the Massachusetts Institute of Technology in 1971, 1972, and 1975, respectively. He is credited with several groundbreaking developments. He unified thermodynamics with heat transfer, fluid dynamics, and the science of form (i.e., flow configuration, image, design), as a counterweight to the doctrine of reductionism; discovered, taught, and applied the Constructal Law of evolution in nature; and brought together biologists, physicists, engineers, sociologists, philosophers, economists, managers, and athletes with creative books for the public, including *Design in Nature* (2012), *The Physics of Life* (2016), *Freedom and Evolution* (2020), and *Time and Beauty* (2022).

ASME President Susan Ipri-Brown honors Adrian Bejan with the 2024 ASME Medal. *Photo: Andrea Lonas*

E-FEST CAREERS 2024: INNOVATING THE FUTURE

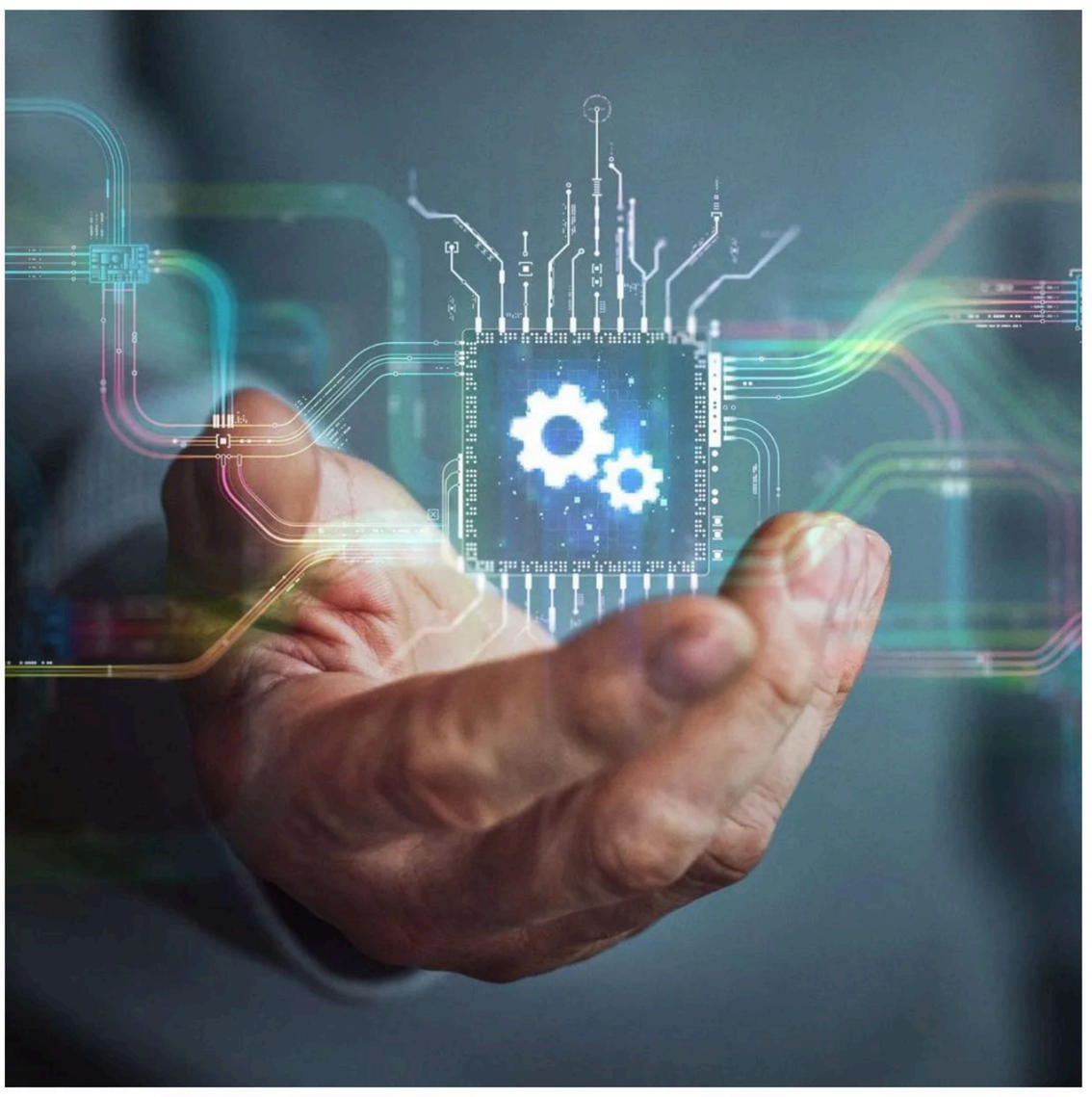
Through live and on-demand sessions, E-Fest Careers 2024 offered thousands of students and young professionals a place to learn, engage, and network.

Thousands of students and early career engineers from around the world attended ASME E-Fest Careers in September 2024. The digital event combined career and professional development sessions, a scavenger hunt, networking, and other activities. The live and on-demand sessions focused on "Innovating the Future: AI and Mechanical Engineering Synergy” featuring topics that included sustainability in robotics and automation, AI in aerospace, and women in engineering.

Palaniyappan Kailasam, director at Prolotek Technologies, presented “Importance of Dimensional Management in the Engineering Profession,” where he explored how precise dimensional control is crucial for ensuring product quality, functionality, and cost-effectiveness in engineering projects. Kailasam explained that when an individual pursues a career in dimensional engineering in manufacturing their work includes design, prototype development, and automated assembly that may have to consider parts made by separate suppliers.

Four women came together for “Women in Engineering,” a panel discussion that took on the challenge of successfully building and navigating in an engineering career. Vidhya Sriram, managing partner of PS power controls, addressed the question of core technical knowledge and how important it was to build a career in engineering. “Once you have technical knowledge,” she said, “and once you know more than those [who you are working with], then you will be better able to command respect.”

Mechanical engineering and the role engineers take in sustainability took center stage in the session, “Sustainability in Robotics and Automation”. In this session Sourav Karmakar, founder and CEO, Infinos Tech, explored the intersection of sustainability, robotics, and industry. The economy, carbon dioxide emissions, robotics, manufacturing, and carbon neutrality “is all connected,” Karmakar explained. He covered solar sails, actuators, and other ingenious methods that allow robots to move in a more sustainable way.



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BIG QUIZ

All About the Moon Race

The last time we went to the moon, it was a scramble of national pride and cutting-edge engineering. Test your knowledge of this era in space exploration—and join the leaderboard to see where you stack up.

Today, the dividing line in space travel is private enterprise versus government sponsorship. But in the 1960s, two nations—the United States and the Soviet Union—put their reputations on the line to see which one could land a human traveler on the lunar surface. In this month's Big Quiz, we test how much you remember about that era, when eyes of the world rested on the work of engineers.

Big Quiz: All About the Moon Race

Page 1 of 10

1. Everyone knows Neil Armstrong was the first person to step on the Moon. Who was the last person (so far) to step on the Moon, on December 14, 1972?

- ◯ Frank Borman
- ◯ Walter Schirra
- ◯ Gene Cernan
- ◯ Harrison Schmitt

Next

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VAULT

Elimination of National Waste

A famed technologist-turned-public citizen trained his engineering eye to a booming American economy and found areas in need of optimization in this article first published in January 1925.

Written by ***Herbert Hoover,*** *U.S. Secretary of Commerce*



IN COOPERATION WITH COMMERCE and industry to advance productivity, the U.S. Government, through the Department of Commerce, has developed a definite constructive national program for the elimination of waste in our economic system. The need is plain. The American standard of living is the product of high wages to producers and low prices to consumers. The road to national progress lies in increasing real wages through proportionately lower prices. The one and only way is to improve methods and processes and to eliminate waste. Regulation and laws are of but minor effect on these fundamental things.

There are wastes which arise from widespread unemployment during depressions and from speculation and overproduction in booms; wastes attributable to labor turnover and the stress of labor conflicts; wastes due to intermittent and seasonal production, as in the coal and construction industries; vast wastes from strictures in commerce due to inadequate transportation, such as the lack of sufficient terminals; wastes caused by excessive variations in products; wastes in materials arising from lack of efficient processes; wastes by fire; and wastes in human life.

Against these and other wastes, the Department of Commerce has for the past three years developed an increasingly definite program.

Unemployment. The First National Conference on Unemployment, called in 1921, produced successful relief measures, and demonstrated that exhaustive investigations should be made of the whole problem. A committee of businessmen, labor leaders, economists, and engineers collaborated in this study, and this report did much to curb the beginnings of a dangerous boom in the spring of 1923.



Secretary of Labor James J. Davis (left) and Herbert Hoover attended a 1921 labor conference on unemployment. Photo: Library of Congress

Seasonal Construction. A committee reporting on this showed conclusively that custom, not climate, is mainly responsible for the ups and downs in building, and that these evils are largely unnecessary and can be eliminated. For most types of construction it is now possible to build the year round in the United States.

The value of yearly construction in this country is over five billion dollars. If building falls off, there is always a slackening in many other lines of industry, resulting in unemployment, decreased purchasing power of employees, and further depression.

Important action has now been taken in many communities in changing leasing dates and in other devices to induce more regularity to construction.

Bituminous Coal Industry. Investigation revealed the high instability of this industry and the fact that it was functioning at great material loss. Due to the war and to periods of profiteering, far too many mines had been developed and placed in operation.

The primary remedies needed in this industry were better transportation, reduction of seasonal character of industry, summer storage of coal, and industrial peace. Through an application of these, the industry is now on the road to stabilization.

In this industry, the past year, as compared with the year 1920, shows a saving to the consumer of about one billion dollars, which must be reflected in decreasing costs of production in every avenue of industry and commerce.



President Calvin Coolidge (center) stood with Herbert Hoover and other attendees at the 1924 National Conference Utilization of Forest Products Summary, held at the National Museum in Washington, D. C. Photo: Library of Congress

Superpower. Engineering science has brought us to the threshold of a new era in the development of electric power. This era promises great reductions in power cost and wide expansion of its use. Fundamentally, this new stage of progress is due to the perfection of high voltage, longer transmission, and more perfect mechanical development in generation of power.

The Northeastern Superpower Committee, with its engineering subcommittee, reported in April, 1924, dealing with the major steps necessary to bring about the technical development required, and already a number of these steps have been undertaken by the various power systems throughout this area.

Purchasing Specifications. The war showed that the faultiness of specifications used in Federal purchases resulted in great waste of public funds.

The Federal Specifications Board was established to take the multitude of specifications in hand, and the manufacturers are being brought into consultation to make sure that the industrial and commercial setting of a given specification is right from the point of view of the practical producer. In this manner a complete revision of Government specifications is under way, 210 such standard specifications having been prepared up to the present time.



One of the new technologies promoted by the Department of Commerce under Hoover (second from left) was delivery of mail via airplane. Photo: National Archives

A specific saving is in the wearing parts in automobiles, and a computation made by manufacturers shows that the benefit to the public automobile user through the longer life amounts to a saving of at least fifteen million dollars a year.

Improvement in Technical Processes. Many of the small manufacturers who cannot afford to establish the laboratory and research staff necessary for consideration of broad problems now use the Bureau of Standards in researches into the elimination of waste in industrial processes.

Instances of such researches of public interest are reduction of losses in the baking of Japan ware and in the installation of an optical-glass industry.

Simplified Practice. A large field in the elimination of waste lies in the direction of simplified nomenclature, grades, and variations in dimensions of industrial products. The Division of Simplified Practice, established in 1921, serves as a centralizing agency in bringing together producers, distributors, and consumers for the purpose of assisting these interests in their mutual efforts to eliminate waste in production and distribution.

Herbert Hoover, *31st president of the United States, was U.S. Secretary of Commerce from 1921 to 1928. Prior to that he was a mining engineer and served as the director of the U.S. Food Administration during World War I.*

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Looking ahead

Here's what we have planned for the February issue.

Managing the New Engineering Workforce

Gen Z is entering the workforce, and the influx is creating generational clashes with established managers. We look at how to defuse the tensions.

What Makes E-Bikes Run?

Suddenly, it seems electric bicycles are everywhere on city streets. Their overnight success is the culmination of a decade of engineering advances in battery packs and electric motors.

Also: Teaching self-driving cars how to drift into turns, implantable sensors that can fight against opioid abuse, a quiz about Roman engineering, and how to write an impactful cover letter.



Coming in June

Our 2025 Watch List will spotlight early career engineers making an impact in their industry … and the world at large. If there's an engineer you think we should learn more about, let us know at this link.
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ASME helps the global engineering community develop solutions to real world challenges. Founded in 1880 as the American Society of Mechanical Engineers, ASME is a not-for-profit professional organization that enables collaboration, knowledge sharing, and skill development across all engineering disciplines, while promoting the vital role of the engineer in society. ASME codes and standards, publications, conferences, continuing education, and professional development programs provide a foundation for advancing technical knowledge and a safer world. In 2020, ASME formed the International Society of Interdisciplinary Engineers (ISIE) II & III LLC, a new for-profit subsidiary to house business ventures that will bring new and innovative products, services, and technologies to the engineering community.

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