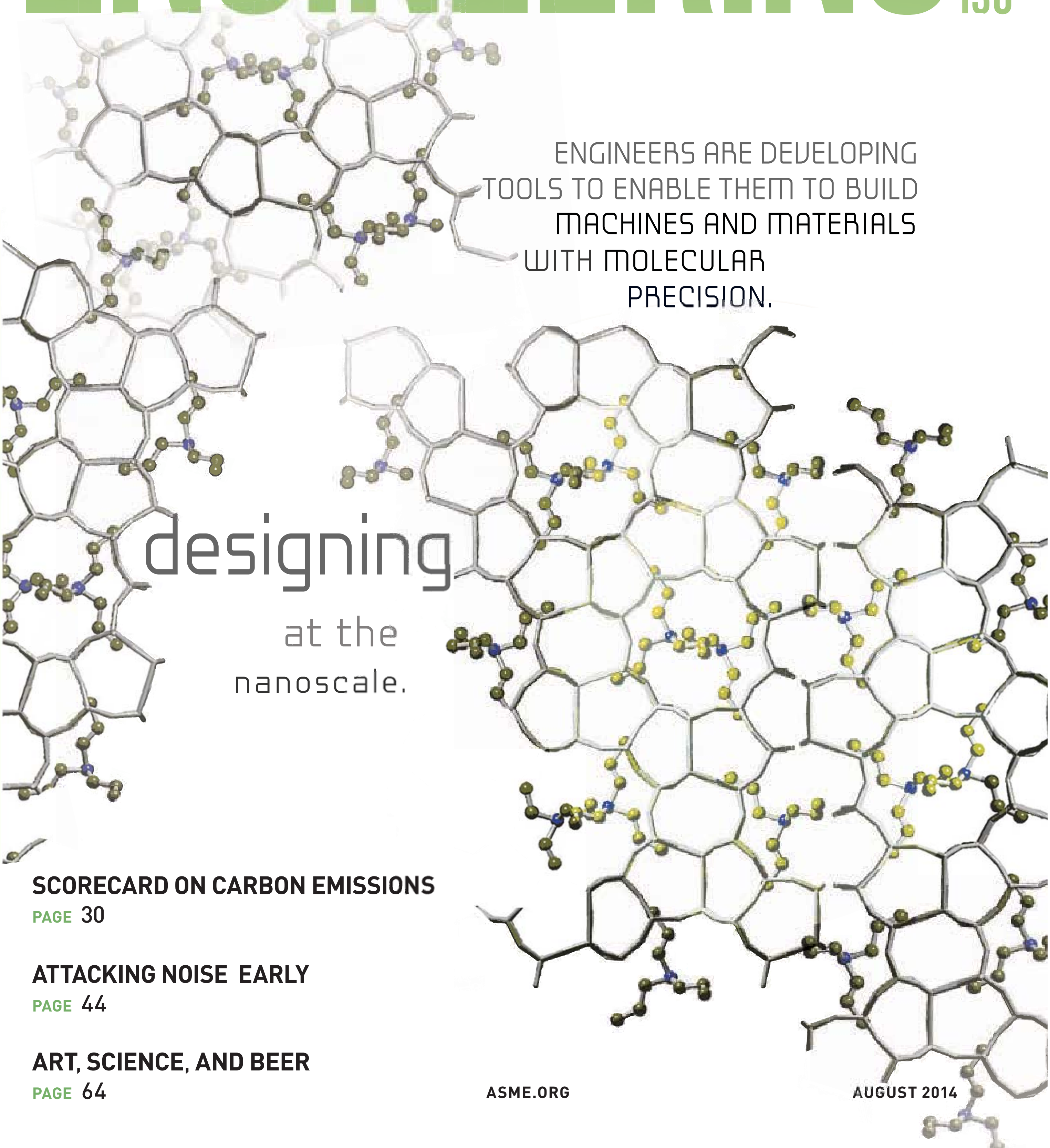
MECHANICAL
ENGINEERING
Technology that moves the world
THE MAGAZINE OF ASME
No. 08
136



ENGINEERS ARE DEVELOPING TOOLS TO ENABLE THEM TO BUILD MACHINES AND MATERIALS WITH MOLECULAR PRECISION.

designing at the nanoscale.

What do these outstanding individuals have in common?

They are all part of UB's Department of Mechanical and Aerospace Engineering, School of Engineering and Applied Sciences

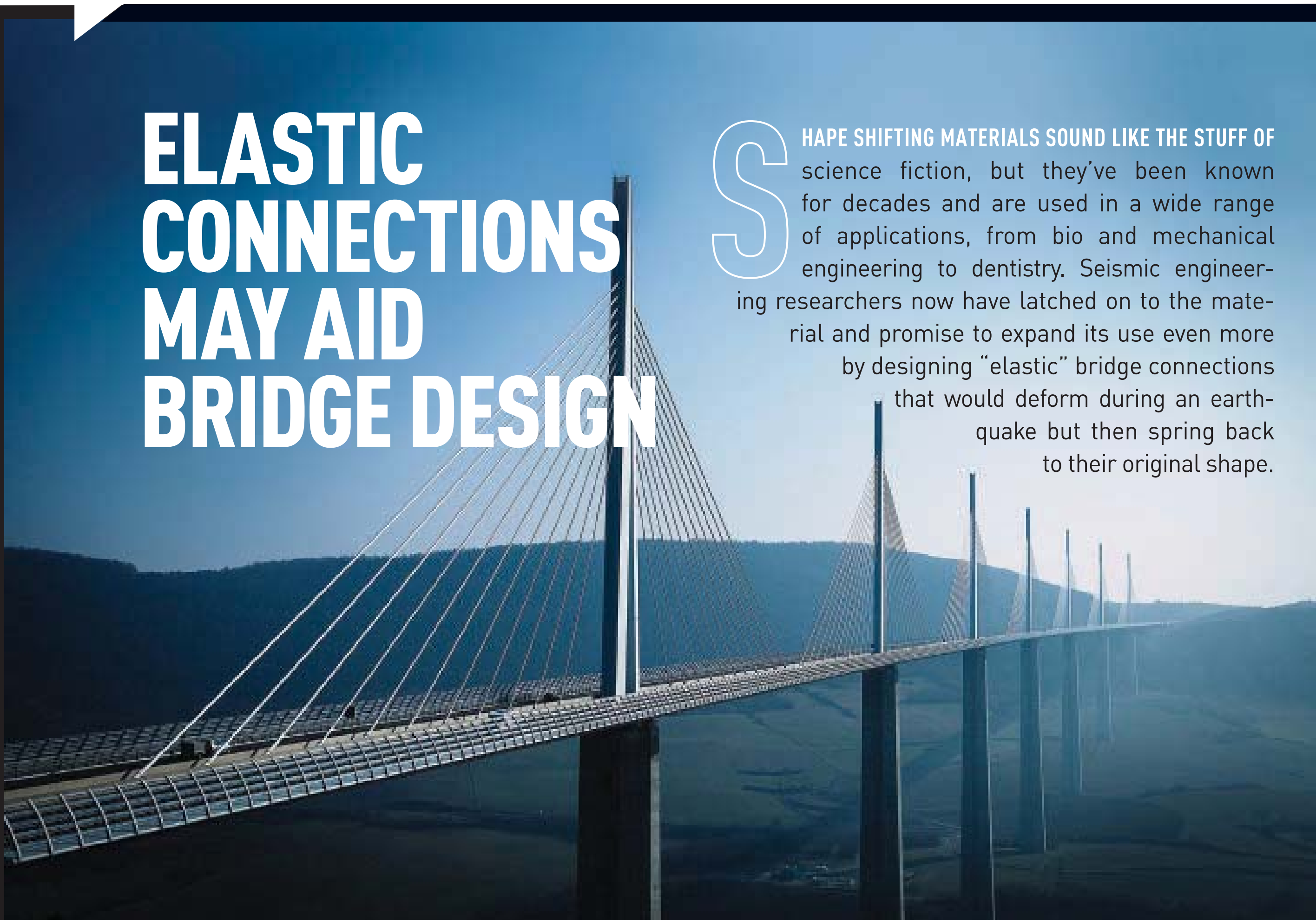
A proud host sponsor of the
2014 ASME Advanced Design and Manufacturing Impact Forum

School of Engineering and Applied Sciences

University at Buffalo *The State University of New York*

208 Davis Hall, Buffalo, NY 14260

(716) 645-2771 | ub-seas@buffalo.edu | www.eng.buffalo.edu



ELASTIC CONNECTIONS MAY AID BRIDGE DESIGN

SHAPE SHIFTING MATERIALS SOUND LIKE THE STUFF OF science fiction, but they've been known for decades and are used in a wide range of applications, from bio and mechanical engineering to dentistry. Seismic engineering researchers now have latched on to the material and promise to expand its use even more by designing "elastic" bridge connections that would deform during an earthquake but then spring back to their original shape.

NEXT MONTH ON ASME.ORG

3-D SCANS UNLOCK MYSTERIES

Using advanced 3-D laser scanning technology, structural engineer Steve Burrows and specialists from the University of Arkansas Center for Advanced Spatial Technologies scan and digitally analyze three of the world's landmark structures to unlock engineering mysteries.

PODCAST: 3-D PRINTING SPARE PARTS IN SPACE

Jason Dunn, the CTO of Made in Space, a space manufacturing company that has partnered with NASA to launch the first 3-D printer to space, discusses the challenges of 3-D printing in microgravity.

EFFICIENT AS A CLAM

Partnering with Bluefin Robotics, MIT assistant professor Amos Winter has created RoboClam, an underwater robot inspired by the razor clam.

MAKING A DIFFERENCE

The first White House Maker Faire, held June 18, provided a boost to STEM education and the entrepreneurs of the "Maker Movement."

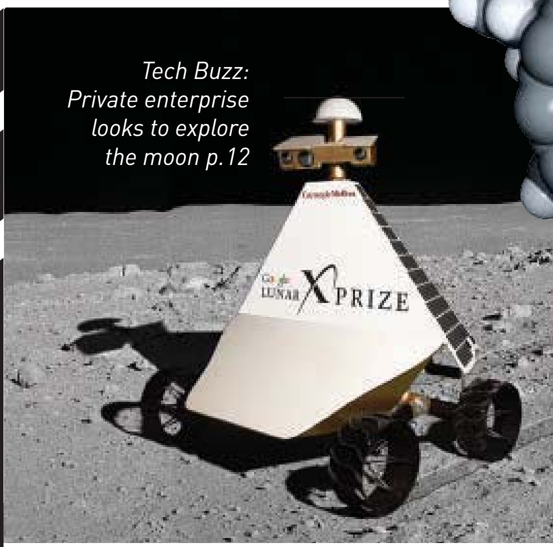
VIDEO: BILL NYE TOUTS WOMEN IN SCIENCE

Bill Nye, CEO of the Planetary Society, talks about the importance of STEM and the need for more women in science and engineering.

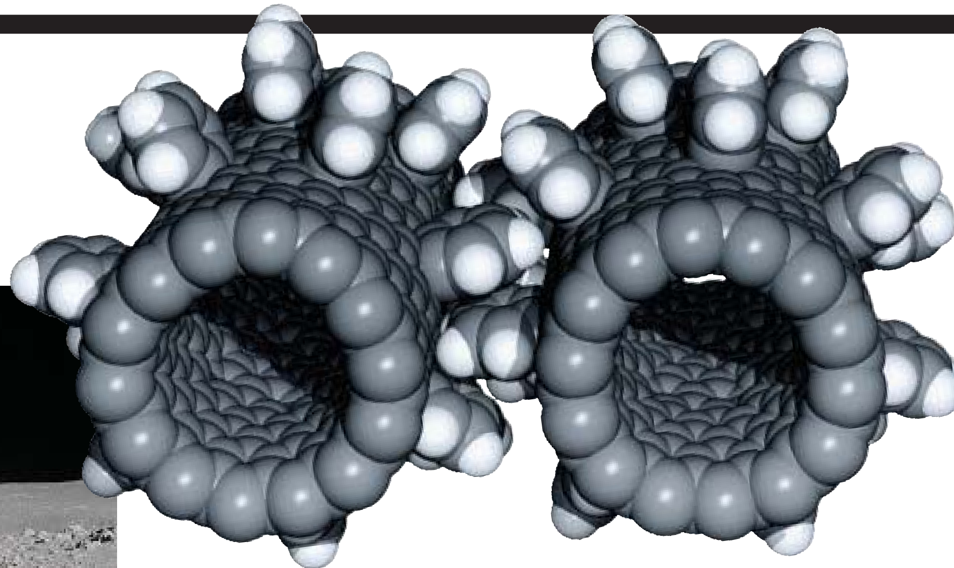
For these articles and other content, visit **asme.org.**

CONTENTS

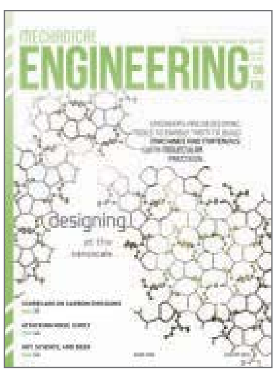
08 136

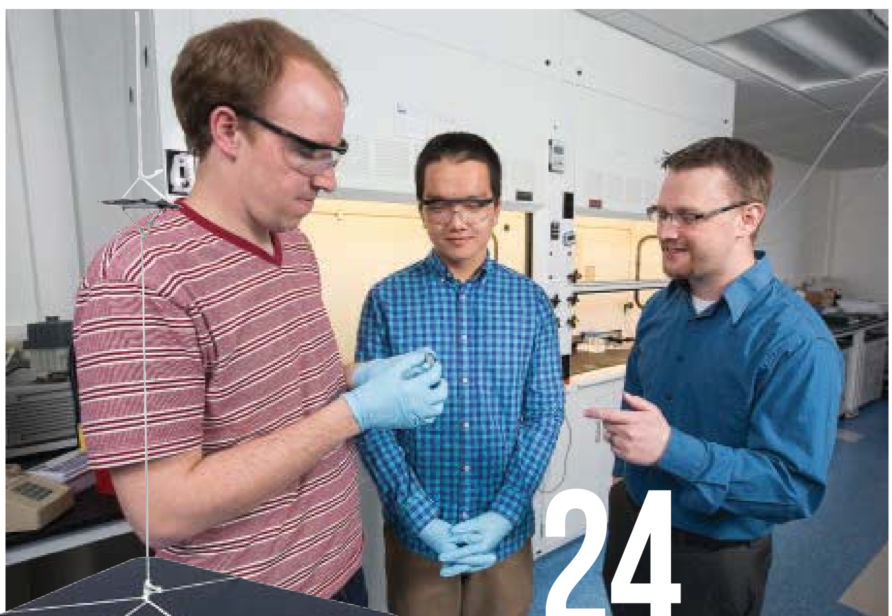


Tech Buzz: Private enterprise looks to explore the moon p.12



ON THE COVER





ASME
SETTING THE STANDARD

THE QUIET FOREFRONT

Consumer electronics makers are putting acoustical analysis into the hands of the design engineers to get noise out of products earlier.

BY JEAN THILMANY

ASME NEWS

J. Robert Sims is confirmed as the new President of ASME, and the Society recommends changes to China's manufacturers.

INSIDE

ART, SCIENCE, AND BEER

Input Output: The line from engineering to brewing is more direct than some may think. BY JEAN THILMANY

MECHANICAL ENGINEERING // THE MAGAZINE OF ASME

Contact *Mechanical Engineering*

Mechanical Engineering
Two Park Avenue, New York, NY 10016
212.591.7783; fax 212.591.7841
memag@asme.org

Published since 1880 by the American Society of Mechanical Engineers (ASME). Mechanical Engineering identifies emerging technologies and trends and provides a perspective on the role of engineering and technology advances in the world and on our lives. Opinions expressed in Mechanical Engineering do not necessarily reflect the views of ASME.

Give me the place to stand, and I shall move the earth — Archimedes

ASME offices

Headquarters
Two Park Avenue, New York, NY 10016
212.591.7722; fax 212.591.7674

Customer Sales & Service
22 Law Drive, Fairfield, NJ 07007
[illegible]
In U.S. toll-free 800 THE ASME
International [illegible]
e-mail customercare@asme.org

Washington Center 1828 L Street, N.W., Suite 810
Washington, DC 20036-5104
202.785.3756

Int'l Gas Turbine Institute [illegible]
[illegible]
http://igti.asme.org

Int'l Petroleum Technology Institute
[illegible]
asme-ipti.org

Europe Office [illegible]
[illegible]

Asia Pacific LLC [illegible]
[illegible]

India Office [illegible]
[illegible]

BPA WORLDWIDE
ENERGY STAR PARTNER
ASSOCIATION MEDIA & PUBLISHING

For reprints, contact [illegible]
[illegible]

asme.org
on.fb.me/MEMAGAZINE
memagazineblog.org

Mechanical Engineering (ISSN 0025-6501) is published monthly by The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990. Periodicals postage paid at New York, N.Y., and additional mailing offices. POSTMASTER: Send address changes to Mechanical Engineering, c/o The American Society of Mechanical Engineers, 22 Law Drive, Box 2300, Fairfield, NJ 07007-2300. [illegible]

John G. Falcioni
Editor-in-Chief

ADVANCED MATERIALS FOR GAMES OF ALL SIZES

Not too distant from the collection of smiley, sad, angry, and other round-faced emoticons on your smartphone or IM dashboard is an image of the iconic black-and-white-patched soccer ball. But even if you're one to use these hackneyed little critters in e-mails and texts, chances are you probably never even realized the soccer ball was there, let alone think to use it.

I admit to inserting the ball into text messages a few times in the past weeks as my team, the Albiceleste, kept me on the edge of my seat during the quadrennial FIFA World Cup that ended last month. As it turns out, the real black-and-white soccer ball, with its 32 panels comprising 12 black pentagons and 20 white hexagons stitched together, isn't as ubiquitous as one might think, at least not in international competition.

The German company Adidas, maker of the official ball of Fédération Internationale de Football Association (FIFA) sanctioned tournaments, has designed five different soccer balls for international play—none of them had black pentagons and white hexagons. Remarkably, the traditional soccer ball has not been used in the World Cup since the tournament was played in West Germany in 1974. The search for the optimal soccer ball for use in the highly fêted World Cup has included the Tango, the Azteca, the Questra, and the much maligned Jabulani, which was used four years ago in South Africa. This year, for the World Cup in Brazil, Adidas created Brazuca.

Each new ball is engineered with material advances to make the sphere more aerodynamic, more waterproof, and easier to control. If the goal (no pun intended) of ball technology is to make play more competitive, then the Brazuca can lay claim to being a huge success. Pundits (yours truly included) say this year's World Cup was one of the best in recent history.

The Brazuca, along with many other soccer balls, it turns out, is made in Sialkot, a town in the northeast region of Pakistan recognized as the soccer ball capital of the world. Before China got involved a few years ago, seven out of 10 soccer balls in the world were made in Sialkot and factories there produced more than 60 million soccer balls a year. Now it's down to about 40 million. The Brazuca is produced at an Adidas factory where 40 percent of the workforce is comprised of women—no small feat in Pakistan. The ball has six patches that are glued together, not stitched. This makes these soccer balls, according to Adidas, the most aerodynamic ever made.

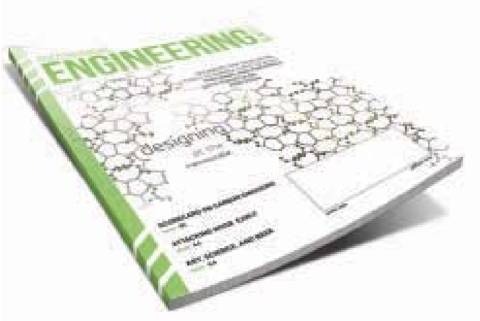
Testing included smashing it against a wall at 45 mph, dredging it in water to ensure it wouldn't absorb moisture, and baking it at 130 °F for seven days so that it stood up to the heat of the Amazon, where some of the games were played this year. Wind tunnel tests showed that unlike the Jabulani, which was made in China and tended to change directions in flight when it was kicked, the Brazuca remained stable.

Our cover story this month focuses on advances in material design for different types of applications—nano, meso, micro, and macro scale manufacturing processes. The work is being conducted by the Georgia Institute of Technology's Multiscale Systems Engineering Research Group.

I'm wondering whether the researchers from Georgia Tech will manufacture a high-end soccer ball for those exciting nano foosball games I like to watch. ☺ **ME**

FEEDBACK

What has been the most critical technological improvement in sports? Email me. ***falcionij@asme.org***




" I get what I need to keep my line running, when I need it.
It's great to be an engineer."

JUNE 2014

Reader Baker pins industrial decline on CEO greed.

One reader explains the decline of U.S. manufacturing. Two more talk climate. And another remembers the two meanings of "cheap."

WHY THE RUST BELT RUSTED

To the Editor: Concerning the editorial in the June 2014 issue of *Mechanical Engineering,* the reasons for the manufacturing collapse in America are not nearly so complex as you state and are not well documented, since the facts would shed light on the ownership class in America.

At one time manufacturing employees were respected in most industries and treated as an asset. They were paid a decent wage and were protected by safety rules and our environment was protected, at least in theory, by rules against gross pollution. The 1980s brought on a new environment in industry where managers were largely business trained (MBAs). Unfortunately, a significant number looked at the wages being paid to American workers and the cost of safety and environmental regulations and decided that these monies were better going to the bottom line of their companies. Stock owners could care less what happened to workers as long as the profits kept coming in.

The first step was to move work to cheaper parts of America, as you point out, but the grand plan was to move the work and entire industries to Asia. A few visits to China convinced many managers that the Chinese would do anything for very low wages and the safety and environmental issues were nonexistent there. So moves to China and other Southeast Asia countries began and the "Rust Belt" ensued. MBA schools jumped on the bandwagon teaching students and managers from industry the basics of giving away our economy.

The reversal of this, if it happens, is due to hard lessons being learned by industry managers and the costs associated with shipping materials, work-in-process, and finished goods to Asia and back to America. What I am saying is that most of the problem is the greed of CEOs and CFOs rather than other hard-to-control forces at work.

James W. Baker, *Elkton, Md.*

UNSETTLED SCIENCE

To the Editor: Steve Cohen's recent letter concerning climate change (June 2014) really bothers me. His claim that, since 97 percent of the climate change (notice, it is no longer global warming) papers say that it is caused by man, then "the science is, in fact, settled" is really irrelevant.

I suggest that everyone read Bill Bryson's excellent book: *A Short History of Nearly Everything*. This book has a recurring theme—current scientific "experts" do not like to be challenged, especially by anyone whom they consider to be an outsider, and will go to great lengths to quiet and even demonize any challengers.

I believe that is exactly what is going on in the field of climatology today. Those who would challenge today's position of the 97 percent are being demonized.

Science is rarely, if ever, settled. If it had been, then I would think that doctors would still be regularly using leeches.

Tom Parrish, *Tullahoma, Tenn.*

RESEARCH CHALLENGE

To the Editor: I enjoyed reading the Bill Nye comments and would like to challenge the readers/engineers to do some research by obtaining a heat transfer book. They could read chapters such as "Gas Radiation" and "Solar Radiation" in *Heat Transfer* by J.P. Holman or "Radiation Emission and Absorption by Gases" and "Solar Radiation" in *Heat Transfer* by Frank M. White.

Readers should also obtain dew point data around the world and a psychometric chart, which can be found in ASHRAE Handbooks. I will be waiting to hear their comments.

Linman Bjerken, *Downey, Calif.*

WHO ARE WE TO SAY?

To the Editor: In his letter "Peak and Repeak" (May 2014) Mr. Peekna asserts that ASME should "take the lead in abandoning phrases such as 'oil production,' 'gas production,' and 'production' of any other mineral. Because such phrases are not true and are also loaded, in being politically misleading."

In the first place, why should ASME get involved in changing common industry terminology for that sake of political sensitivities? Use of those terms is not and never has been "political." These terms are used throughout the oil and gas industry and have been for over a century. They are applied not only to the activity at the wellhead, but also to several stages of additional processing downstream. For instance, natural gas liquids are "produced" in a gas plant. It is commonly understood that oil and gas are not somehow manufactured underground.

We as engineers have better things to do than to waste our time and energy in tweaking common vernacular to better suit an individual's political preferences. Perhaps the lead in this effort would better be taken by a political organization, because to utilize a recognized technical, supposedly non-political organization such as ASME, would be truly misleading.

Dan Norman, *Canyon, Texas*

GLOBALLY SHODDY

To the Editor: I bought a lawnmower made by a U.S. manufacturer with an engine made by a reputable U.S. company. I won't comment on the replacement of durable steel parts in the mower by short-lived plastic. I'm used to that by now.

When it came time to change the oil in the engine I got a shock—no drain plug. According to the manual, I was expected to turn the lawnmower upside down and drain the oil through the fill port. I had to sit down, and for the first time in my life I was ashamed of my mechanical engineering profession: a short-cut like that to save a few bucks in manufacturing.

This brings me to comment on globalization and the consequent global competition. Back when we saw the Japanese as our top competitor it forced us to take a hard look at quality and make improvements—overall, a good outcome.

Now that cheap manufacturers are the competition, the goal is cheap (and I refer to both meanings: inexpensive and shoddy). We are told that cheap goods are the benefit we all get from globalization. The lawnmower is just one of the products that have made me long for the time when I could afford fewer things, but they were designed well, performed well, and lasted.

Larry Simmons, *Portland, Ore.*

FEEDBACK

Send us your letters and comments via hard copy or e-mail memag@asme.org (use subject line "Letters and Comments"). Please include full name, address and phone number. We reserve the right to edit for clarity, style, and length. We regret that unpublished letters cannot be acknowledged or returned.

UNDERWATER ROBOTS GET TOUCHY-FEELY

Remotely controlled robots can go where humans cannot. Underwater, they can clear biohazards, disarm mines, help in the exploration of gas and oil, or conduct environmentally sensitive research.

WHETHER IT IS DISASSEMBLING A WEAPON or muscling closed a valve, these jobs are all things people would do with their hands. Now a University of Washington startup aims to give operators of underwater robots this same sense of touch.

The company, BluHaptics, was founded by three UW professors, electrical engineer Howard Chizeck, commercialization fellow and research associate Fredrik Ryden, and applied physicist Andy Stewart.

BluHaptics wants to build robots that can do complex tasks more naturally. Like all haptics systems, sensors in robot grippers and effectors deliver force feedback through the handle of a controller. The sensory information can help operators avoid objects and guide the robot through a task.

"The sense of human touch is key to human dexterity," Ryden said. "If you don't think so, just look at what happens when people lacking a sense of touch try to tie their shoe laces."

A control system that anticipates contact lies at the heart of the robot's haptic capabilities. As the robot closes in on a target, non-contact sensors, such as lasers and sonar, ping the structures around them. This creates a cloud of points that the software fuses into a video map of the environment. Users can rotate and manipulate the map, like a 3-D CAD image, to plot how they will navigate the robot to the target.

They can also surround objects with 'virtual fixtures,' essentially force fields that constrain spatial motion. The simplest virtual fixture acts like a virtual straightedge, helping operators move the robot in a straight line. When the operator deviates from this path, the fixture sends force feedback to the joystick or haptic controller to resist the motion and guide the robotic arm back into the proper alignment.

Virtual fixtures can also prevent operators from crashing robots into objects they want to avoid. This helps them navigate the robot through a complex environment, such as the pipelines under an offshore platform, while minimizing unintended damage. Like their physical counterparts, virtual fixtures could guide a robotic welder to a subsea pipe while keeping it away from sensitive valves.

Ryden and Chizeck did not set out to build underwater robots. Instead, in 2010, they began working on a haptics system for a surgical robot under development in Chizeck's Biorobotics Lab. They saw that they could apply many of their surgical innovations to underwater robotic control.

BluHaptics now seeks to build on its first robot, which combines its proprietary control technology with an out-of-the-box robotic manipulator. For example, it is working with companies that already deploy subsea robots to develop templates of common underwater tasks into its software. This will make it easier for less experienced operators to manage the robots effectively.

Ryden is also building a new interface that fuses data from several sensors into a single head-mounted display. It will enable robot pilots and supervising engineers to collaborate more closely on complex subsea tasks, and put their new sense of touch to better use. **ME**

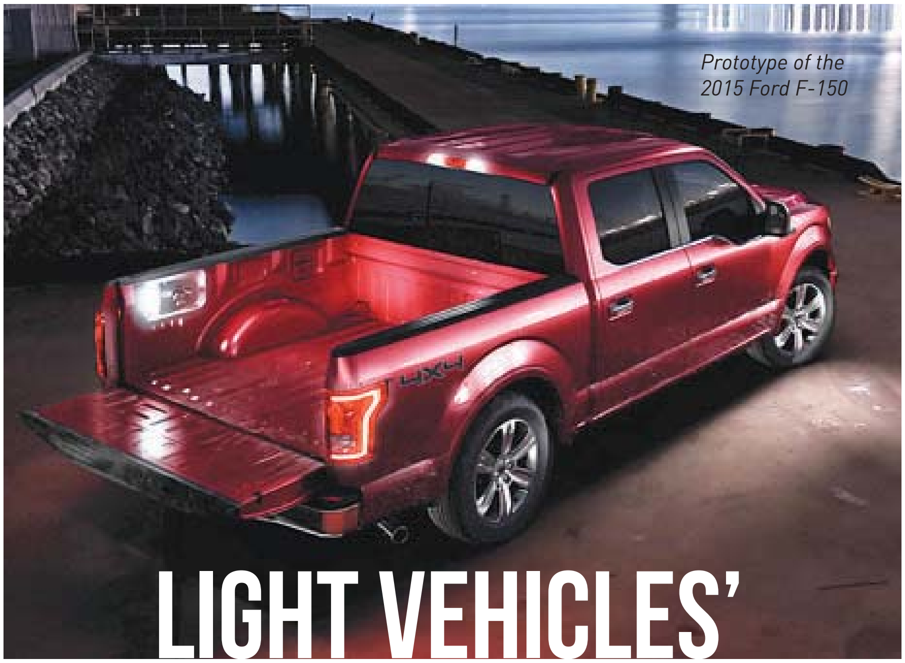
JAMES PERO

QUICK FACTS:

WHAT IT IS: Haptic-feedback system for underwater robots.

DEVELOPER: BluHaptics.

HOW IT WORKS: Laser and sonar data create a virtual force field to help the operator stay away from critical areas.



Prototype of the 2015 Ford F-150

LIGHT VEHICLES' LIGHTWEIGHT FUTURE

PICK-UP TRUCKS ARE MARKETED BASED ON THEIR TOUGHNESS. But over the coming decade, they are going to have to become more efficient as well: fuel economy standards are scheduled to rise sharply for light trucks. To meet these standards, automakers are going to switch over to aluminum bodies for their trucks, according to a recent survey by the consulting firm Drucker Worldwide.

By 2025, Drucker reports, aluminum will comprise more than 75 percent of pickup truck body and closure parts.

Other segments of the vehicle fleet will see increases in aluminum use as well. According to the survey, by 2025, 85 percent of hoods, 46 percent of car doors, and 18 percent of complete auto bodies will be made of aluminum, and the average weight savings per vehicle will be 175 pounds.

Less than 1 percent of vehicles today have complete aluminum bodies.

Total aluminum content in vehicles is forecast to reach 10 billion pounds in North America by 2025. The global total will be 35 billion pounds, making the auto industry perhaps the largest global market for aluminum.

Aluminum use in the North American auto industry reached 5.4 billion pounds in 2012.

Drucker's report, *2015 North American Light Vehicle Aluminum Content Study*, was commissioned by the Aluminum Association. For the report, the consultancy surveyed all major North American automakers.

Truck makers are already moving toward aluminum, the survey reports. Ford's F-150, one of the most popular vehicles in the United States, will have an aluminum body beginning in model year 2015. Each truck will have more than 1,000 pounds of aluminum content, which will save more than 700 pounds in weight over the current model. By 2016, Drucker said, Ford will be producing 850,000 of these aluminum-body trucks each year. **ME**

JEFFREY WINTERS

VOLUNTARY INTERNET TRANSPARENCY

MANY PEOPLE FEEL COMFORTABLE conducting financial transactions on the web. As more data moves online, concern over its inadvertent misuse by people authorized to access it has been growing. On the other hand, increasing the restrictions on access could undermine useful data sharing.

A group of researchers at Massachusetts Institute of Technology believe the solution may be transparency rather than obscurity.

The researchers, who worked with the founder of the World Wide Web, Tim Berners-Lee, are in the Decentralized Information Group at MIT's Computer Science and Artificial Intelligence Laboratory. They're developing a protocol they call HTTP with Accountability, or HTTPA, which they said would automatically monitor the transmission of private data and allow the data owner to examine how it's being used.

The group's role is to develop new technologies that exploit web protocols like HTTP, XML, and CSS, said Oshani Seneviratne, an MIT graduate student in electrical engineering and computer science.

According to Lalana Kagal, a principal research scientist at the lab, HTTPA would assign each item of private data its own uniform resource identifier.

Remote access to a web server would be controlled much the way it is now, through passwords and encryption. But every time the server transmitted a piece of sensitive data, it would also send a description of the restrictions on the data's use. And it would log the transaction, using only the identifier, somewhere in a network of encrypted, special-purpose servers, Kagal added.

HTTPA would be voluntary. It would be up to software developers to adhere to its specifications when designing their systems. But HTTPA compliance could become a selling point for companies offering services that handle private data, Seneviratne said.

"It's not that difficult to transform an existing website into an HTTPA-aware website," Seneviratne said. "On every HTTP request, the server should say, 'OK, here are the usage restrictions for this resource,' and log the transaction." ■

BACK TO THE MOON

A STRONG CONTENDER FOR THE GOOGLE LUNAR X PRIZE, which offers $20 million to the first private group that lands a spacecraft on the moon, successfully travels more than 500 meters, and transmits high definition images and video, is moving closer to its goal of a moon landing. If all stars align, Pittsburgh-based startup Astrobotic will land its lunar vehicle on the moon in October 2015.

'We are looking good for October 2015. We have a launch vehicle and have lined up payloads," says Astrobotic's CEO John Thornton, a mechanical engineer from Carnegie Mellon University. The company recently tested a rocket launching and landing in the Mojave Desert using its hazard-detection system, which uses cameras and lasers to guide the lander towards a safe touchdown.

"That's the closest we can get to the moon landing here on earth," says Thornton, adding that one of the biggest challenges is doing an autonomous landing on the surface of the moon. "We use a scene-matching algorithm, which is basically looking at the images seen below the lander and matching those up to onboard maps to identify where we are in terms of landing."

As Astrobotic's chief engineer, Thornton led the build of the Griffin lander. Almost the size of a car with a mass of 525 kg, Griffin uses a laser scanner to determine if there are any rocks or craters that can interfere with the landing. The lander is also equipped with advanced navigation software. Radio time-of-flight and Doppler provide the lander with the primary means for navigation during cruise while sun sensors and the star tracker enable attitude determination.

When approaching the moon, cameras register the spacecraft to lunar terrain for precision landing and laser sensors construct 3-D surface models of the intended landing zone to detect slopes and hazards and determine a safe landing spot. "We compile the sensor feedback and match it with onboard maps to land our spacecraft accurately on the moon," Thornton says. Ramps mounted on the top of the deck enable rover egress, and four legs provide stability and shock absorption as the lander touches down.

Part of the X Prize requirement is to traverse 500 meters on the moon and send images and video. Astrobotic's Red Rover is being developed for that. The pyramidal shape of the 80 kg rover regulates heat during hot lunar days, and its batteries survive and hold charge at cryogenic temperatures, enabling the rover to hibernate through two-week lunar nights and resume activities the next day. Red Rover is also *continued on page 14»*

GLOBAL

CHINESE WATER COMPANY HAS BIG INTERNATIONAL PLANS

A water company based in China, Beijing Enterprises Water Group Ltd., plans to invest as much as $1.6 billion in overseas markets in five years, according to a senior executive.

In June, the Hong Kong-listed water plants operator, which is a subsidiary of the state-owned Beijing Enterprises Holdings Limited, opened its international headquarters operation, BEWG International Pte. Ltd., in Singapore.

According to a report carried by Xinhua, Zhang Zhenpeng, managing director of BEWG International, discussed the company's activities in a speech during Singapore International Water Week.

BEWG International will be an umbrella firm to operate the group's current and potential investments in markets outside the Chinese mainland. Those investments are estimated to be as much as $1.6 billion U.S.

BEWG operates more than 300 water plants and water treatment facilities, with a combined capacity of about 20 million tons per day, Xinhua reported. It has a presence in most provinces of the China mainland, and also in Indonesia, Malaysia, and Portugal.

According to Zhang, the company has so far invested about $480 million since it started expanding into the overseas markets in 2009. "The water industry leaders from China are gradually coming to be able to compete against the multinationals, as they accumulated the experience and technological expertise through their past ten or 20 years of fast growth, and they have the capital, too," he said.

The company is bidding to build and operate a facility in Singapore to treat polluted water to produce clean water. Most of the water will be available for industries with special requirements, and some of the purified water will also be put into reservoirs.

Southeast Asia is an important market for the company, which has interests that include a $320 million project in Malaysia. ■

TABLETS THAT CAN

To disinfect a bucket of dirty water before drinking, villagers in areas without clean drinking water may one day simply drop in a ceramic tablet.

It works by releasing silver nanoparticles into water at a controlled rate, killing the microscopic creatures that cause disease, according to its manufacturer, PureMadi, a not-for-profit founded at the University of Virginia.

PureMadi plans to manufacture the tablets, called MadiDrops, at rural South African factories, where it already makes ceramic water filters. The drops could cost the equivalent of $5, depending on the region, said Beeta Ehdaie, a doctoral candidate in civil and environmental engineering at the university in Charlottesville. She leads the development of MadiDrop.

"The MadiDrop is working just as well, if not better, than what we see with ceramic filter performance," Ehdaie said.

MadiDrop doesn't remove sediment, chemicals, or other contaminants, but it may destroy most or all of the disease-causing microbes in drinking water.

Ehdaie and her team developed MadiDrop during research at PureMadi, which has production facilities in Limpopo Province, South Africa, where it makes ceramic, ionic filters coated with ionic silver.

MadiDrops, top, use silver particles to disinfect water. Women, left, use PureMadi's other product, ceramic water filters.
Photos: Rachel Schmidt, UVA.

continued from page 12 »

BACK TO THE MOON

equipped with a pair of stereo cameras and a camera with a telephoto lens. It navigates, detects obstacles, and captures 3-D video footage and maps.

According to Thornton, the rover's first spot on the surface of the moon will be the Lacus Mortis, which translates to the Lake of Death. "The reason we want to go there is because of the unique skylights that exist only on the moon—100 m deep and across. If you get to the bottom, there are underground caves that could be a potential destination for future human missions to the moon because if you are underground, you're protected from micrometeorites, cosmic radiation, and other hazards on the lunar surface," he says. "Our lander will be landing next to that and our rover will drive and explore the pit, which will be the first time anyone has seen it this close."

The Google Lunar X Prize competition is the first time in history that start-ups and universities are competing with nations to land on the moon. Spun out of Carnegie Mellon University's Robotics Institute in 2008, Astrobotic has grown to a team of 14 that's composed of mechanical, electrical, robotics, and software engineers. "It takes all disciplines to land on the moon," Thornton says.

"WE COMPILE THE SENSOR FEEDBACK AND MATCH IT WITH ONBOARD MAPS TO LAND OUR SPACECRAFT ACCURATELY ON THE MOON."

John Thornton, CEO, Astrobotic

Astrobotic has signed a deal with SpaceX to launch its lunar lander on a Falcon 9 rocket in October 2015 and recently also formed a partnership with NASA for the development of robotic lunar landing capability. "Once we are close to the moon, we drop into lunar orbit and descend. We will be dropping payloads on the way. We are able to carry 270 kg of other payloads, so we are offering that for sale and already have dozens of customers around the world who are interested in our moon mission," Thornton says.

There are several future lunar missions scheduled or proposed by various nations or organizations, but the challenge is considerable. Out of 33 teams that initially registered for the Lunar X Prize, only 18 remain in the running. According to Thornton, Astrobotic is leading. "We are one of the only teams with a launch vehicle contract," he says. "We are selling payloads and also have a strong partnership with NASA. We have built prototypes, are doing testing, and have our rover ready to go." ME

CHITRA SETHI, ASME.ORG

CLEAN WATER

To make the filters porous, sawdust is mixed into the clay. When the clay is fired in the kiln, the sawdust burns out, leaving space for water to drip through. The filter pores are coated with a solution of silver nanoparticles, which act as a disinfectant.

The robotic zebrafish under study in Maurizio Porfini's lab at the Polytechnic Institute of New York University move their tails

The ceramic MadiDrops have pores that contain a silver or copper particles.

The idea for the tablets arose during research into better ways to manufacture the filters and the silver nanoparticles painted onto them.

"In the lab, we experimented with different methods of applying silver to the ceramic. We found a novel way that would be cheaper and requires fewer steps," Ehdaie said. "In the process we had a eureka moment where we realized that if we make it into the shape of a tablet or a disk, the silver can release at a controlled rate and that would serve as a water purifier."

The performance data from field studies in rural South African communities are not yet published. The researchers don't want to give details until after publication, but Ehdaie said the drops have disinfectant rates comparable to those of the filters. **ME**

ENGINEERINGFORCHANGE.ORG

HOW APPROPRIATE?

Development engineers shouldn't automatically **prefer locally made goods over imports.**

Ask a dozen professionals working in global development, and you'll likely get a dozen (or more) definitions of "appropriate technology." There is a rough consensus, however, that one should consider whether the technology is small scale, energy efficient, environmentally sound, labor intensive, controlled by the community, and maintained locally before it earns the label "appropriate."

As a member of the ASME Appropriate Solutions Evaluation Program Steering Committee, I've had a chance to hear and consider these views. I've found that this definition has often led to the interpretation that manufactured goods imported into the country are inappropriate. The possibility that the relative benefits of an imported product could be greater than a locally produced alternative is not often critically considered.

Which is more appropriate—locally produced, low-cost chlorine that employs local residents in production, or a manufactured, imported filter? Easy choice? What if you learn that the epidemiology literature strongly supports the use of filters instead of chlorine in improving health?

Going further, do we support locally produced filters at higher overall cost, or imported filters that have strict quality control standards and can be mass produced to maximize impact?

Which, then, is truly more appropriate?

Or what about a locally produced stove built with local clays, but with an emission profile that's no different from an open fire? Is that more appropriate than a cleaner, imported Chinese stove? Is a 500-watt solar panel really more appropriate than a similarly priced 2,000-watt diesel generator that's part of a pre-existing supply chain?

The pitfalls of a strict definition of appropriate technology can arise when rigorous, multidisciplinary trade evaluations are neglected. While the local stove or filter may check 9 of 10 boxes for "appropriate technology," it fails on the fundamental purpose of that technology—to improve health. Recognizing this requires a respect for public health, business, policy, and engineering expertise simultaneously.

THE PITFALLS OF A STRICT DEFINITION OF APPROPRIATE TECHNOLOGY ARISE WHEN RIGOROUS EVALUATIONS ARE NEGLECTED.

The strict interpretation of appropriate technology can, effectively, be somewhat paternalistic: "What we have is too fancy for you, so we're going to teach you how to build a version out of sticks and mud."

A caricature of this accidental tension looks like this: The public health folks think the engineering is "solved" and that what matters is behavior change. The entrepreneurs think the mark is missed if you don't charge people for a product. The engineers, meanwhile, are baffled by all the touchy-feely. And the public policy folks wonder how to manage unfunded mandates.

My team has weighed these considerations with our own program in Rwanda. Through a partnership between the for-profit company DelAgua Health and the Rwanda Ministry of Health, imported household water filters and cookstoves will be distributed this summer to about half a million people. The program will earn revenue from the generation of carbon credits under the United Nations, and will be evaluated by a team of researchers led by the London School of Hygiene and Tropical Medicine.

Our priorities when designing this program were primarily to target a health improvement, starting with the leading causes of illness among children, diarrhea and pneumonia. So we evaluated which technologies could most cost-effectively reduce drinking water contamination and indoor air pollution.

Secondly, which technologies were most likely to be adopted by households? Which technologies were eligible for carbon finance? Which technologies were durable, and could be maintained by a team of technicians under our employ? We reached consensus around importing water filters that exceed the World Health Organization "highly protective" rating, and improved wood fuel cookstoves that would most easily be adopted by communities while still reducing emissions. Engineering, public policy, climate change, and public health can all work together. ME

EVAN THOMAS is an assistant professor of mechanical engineering at Portland State University, COO of DelAgua Health, and CEO of SweetSense Inc.

NON-STICK HEAT TRANSFER: PTFE

PTFE tubing has been approved by the ASME Section VIII pressure vessel code for use in flue gas heat exchanger systems in fossil fuel power plants. This is the first plastic material adopted by the Section VIII, Division 1 of the Code, and only the second non-metallic material to be approved. Graphite was approved several years ago. The PTFE approval advances technology to reduce sulfur dioxide emissions and increase efficiency of power plants and waste incineration plants.

The PTFE tubing has been approved for use in heat exchanger systems in which recovered heat is used to partially preheat boiler feed water. Preheating results in less fuel being burned, which in turn reduces carbon dioxide emissions. In addition, sulfur oxide emissions can be reduced by as much as 50 percent, reducing acid rain potential in the environment.

This technology for PTFE tubing in a flue gas cooler has been successfully demonstrated for more than 10 years in Europe. ASME approval was given in March 2014, allowing the use of the technology in North America. The PTFE used is a pure unreinforced polymer with considerable testing and quality assurance mandated by the new Code rules, giving it high reliability and a long service life. In the U.S. alone there are more than 50 gigawatts of installed coal—and lignite—fired power plants which could benefit from using PTFE flue gas coolers.

Recently a fluoropolymer tubed flue gas cooler was installed in Saskatchewan, Canada, for use in a power plant that burns high-sulfur lignite. It was approved for use via a provincial waiver because it could not be ASME certified. With Code approval for this material, the need for special waivers will be eliminated and the potential for widespread usage is made easier.

The first PTFE heat exchanger was installed in 1985 in a coal-fired power plant in Schwandorf, Germany, and that unit reduced SO_2 emissions by 90 percent. In 1991, after 200,000 hours of successful experience with that unit, further units were installed at the same plant. Other units were installed a few years later in several other power plants in Germany and the Czech Republic.

In a 2010 installation in Belchatow, Poland, for a lignite-fueled power plant, efficiency was improved from 41.4 to 42 percent, increasing the generating capacity from 797 MW to 845 MW and saving 31 MW of energy in each line. Additionally, the installation reduced carbon emissions by 100,000 metric tons per year.

The heat exchanger installed at a coal-fired power plant at Siekierki, Poland, uses arrays of PTFE tubes. According to the company, the tubes have been in service for two years and have shown no sign of corrosion from hot flue gases.

Photo: Wallstein Ingenieur GmbH, Recklinghausen, Germany

Another installation, at a lignite-fueled power plant in Ledvice, Poland, in 2011, efficiency was calculated to be improved by 0.3 percent, increasing the generating capacity from 655 MW to 660 MW with a corresponding reduction of carbon emissions by 78,000 metric tons per year. Also, the use of pre-heated boiler feed water was calculated to save an additional 13 MW.

An advantage of PTFE tubes is that they are better able to resist the corrosive effects of sulfur oxides, which form sulfuric acid when condensed. In the past, high nickel alloy tubes have been used in such units but had limited lifespans of up to only two years, due to the high temperatures and acid concentrations encountered in flue gas systems. In Europe, PTFE tubes have been shown to resist corrosion and have a lifetime at least five times that of high alloy tubes.

PTFE tubes have nonstick surface properties, and as a result, they don't allow fly ash and dust from flue gas to build up. Units are usually equipped with water spray nozzles that are intended to wash the fly ash off the tubes. With metal tubes this has proven to be very difficult and the tubes typically become fouled, reducing heat transfer and accelerating corrosion because the tubes run hotter. With PTFE, water sprays are very effective at preventing fly ash buildup and at maintaining acceptable heat transfer rates. Better heat transfer helps maintain the increase in efficiency of the power plant and the reduction in sulfur dioxide emissions.

Typical heat exchanger modules used in power plants have a surface area of approximately 18,836 square feet (1,750 m^2) and are approximately 6.5 feet (2 m) square by 44 feet (13.5 m) overall length with 1,800

APPROVED FOR PLANT EXHAUST

U-shaped tubes installed per bundle. A typical power plant of 600-800 MW may have 5 to 10 modules installed.

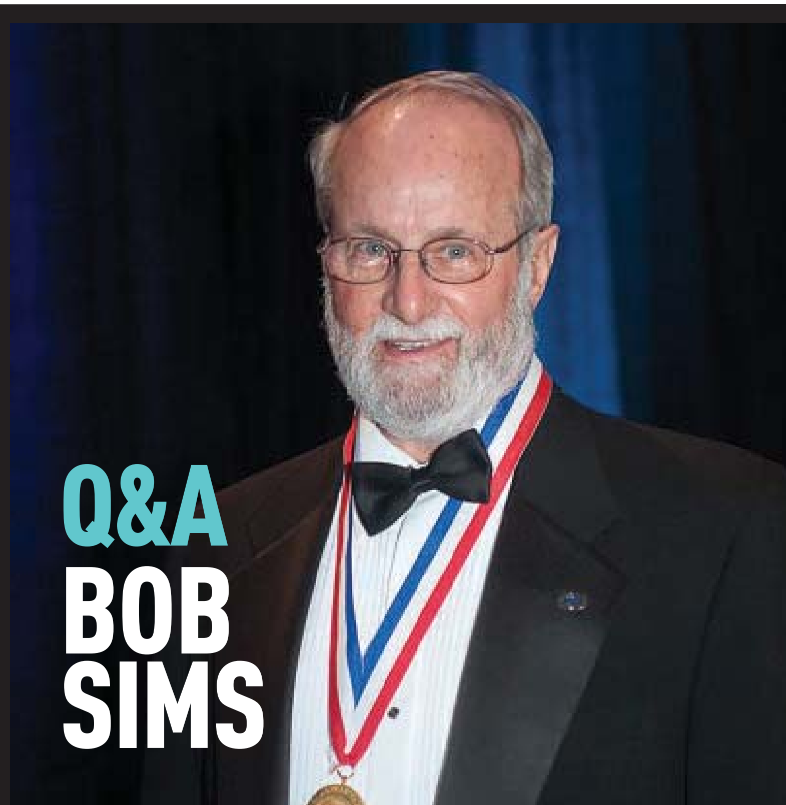
The recent ASME approval of PTFE tubes was based on approval of Code Case 2795 for Section VIII, Division 1 of the Boiler and Pressure Vessel Code. A Code Case is a modification to the Code rules to allow new materials or new rules to be approved for a very narrowly focused application until it can be brought into the Code on a permanent basis. A Code Case was needed because the PTFE tubes are installed in a very low-pressure housing which is not Code certified, so they become the true pressure boundary against the retained water pressure inside, of up to 116 psig (0.8 MPa).

The action on this Code Case began in early 2013 and was approved by the Standards committee and the Board on Pressure Technology Codes and Standards in March 2014.

An 858 MW-rated generating unit being built at a lignite-fired power station in Belchatów, Poland, is expected to have a high efficiency rating, around 42 percent. The unit will include two flue gas coolers, equipped with heat exchangers using a PTFE pressure hose system.

ASME does not endorse any particular manufacturer or product. The Code Case is based on generic ASTM specifications and testing, which can be used to evaluate PTFE resin or tubing from any supplier. ME

BERNARD F. SHELLEY is a pressure vessel consultant for DuPont, and the writer of the Code Case.



Q&A BOB SIMS

NAMED ASME PRESIDENT AT JUNE'S ANNUAL meeting, J. Robert Sims, a senior engineering fellow with Becht Engineering Co. Inc., will succeed Madiha El Mehelmy Kotb in his new role.

Bob Sims is an authority in risk-based technologies, high-pressure equipment, mechanical integrity evaluation, and fitness-for-service analysis, including brittle fracture analysis. He worked at Exxon for over 30 years. As a pressure equipment specialist for the last 10 years, Sims was responsibile for standards and for improving equipment integrity.

An ASME member for over 30 years, Sims has served on the Board of Governors from 2010 to 2013 and as senior vice president for Standards and Certification from 2005 to 2008.

ME: Why did you become an engineer?

B.S: From an early age I wanted to be an engineer. Some of my earliest memories are of building things like model airplanes and contraptions using Erector sets. I also experimented with electronics, such as old radios, when I was in grammar school. I've always been interested in how things work, particularly mechanical things like cars.

ME: What's one lesson, of many, learned over your career?

B.S: My engineering career has involved working in many areas, which taught me the importance of both a multidisciplinary approach and lifelong learning. My early assignments with Exxon involved the design, construction, and startup of pilot plants for experimental refining and chemical processes. That involved mechanical, chemical, and electrical engineering as well as instrumentation and control systems. I also designed equipment used to test the properties of things as diverse as lubricating oils and tires, as well as a demonstration plant for a new process to produce plastic film.

ME: Tell us about your ASME involvement up to this point?

B.S: Although I'd been active in the ASME student section in college, I hadn't remained active until about 15 years after I graduated, when I got the assignment to design the high-pressure equipment for the new polyethylene plant.

I found that ASME provided many valuable resources for quickly getting up to speed in the highly specialized high-pressure equipment field.

In particular, the Pressure Vessels and Piping Division sponsored technical sessions in this area. At one of the sessions, several folks recommended that ASME publish codes and standards covering high-pressure equipment. I volunteered to join several code committees and eventually chaired the committees that drafted standards for high-pressure piping and pressure vessels. That led to involvement in other standards committees and to roles on various supervisory codes and standards committees.

ME: Tell us a little about your plans as ASME president?

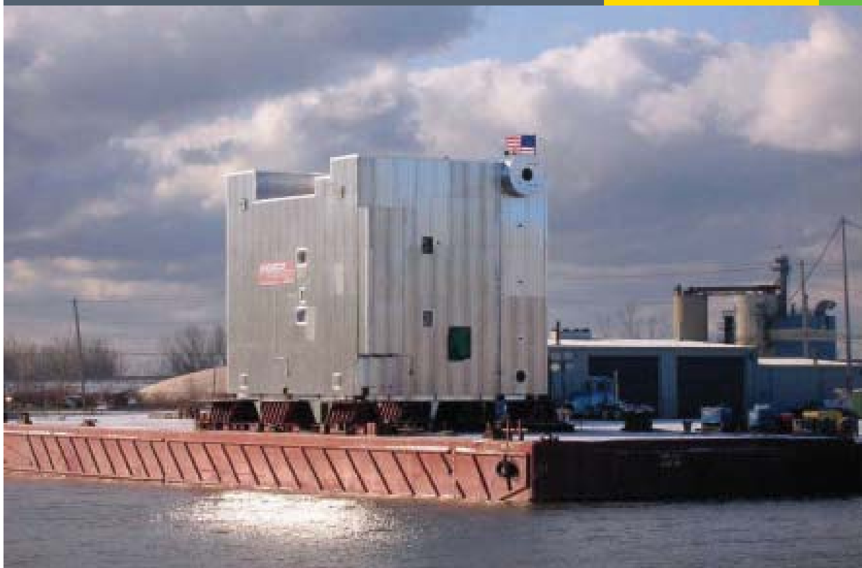
B.S: I want to be an advocate for the continued growth of ASME in fulfilling our Pathway 2025 mission set by the Board of Governors. The organization is increasingly more responsive to the needs of engineers and of society worldwide, and I want to help facilitate that development. I want to make sure we're all in agreement on how to fulfill our mission.

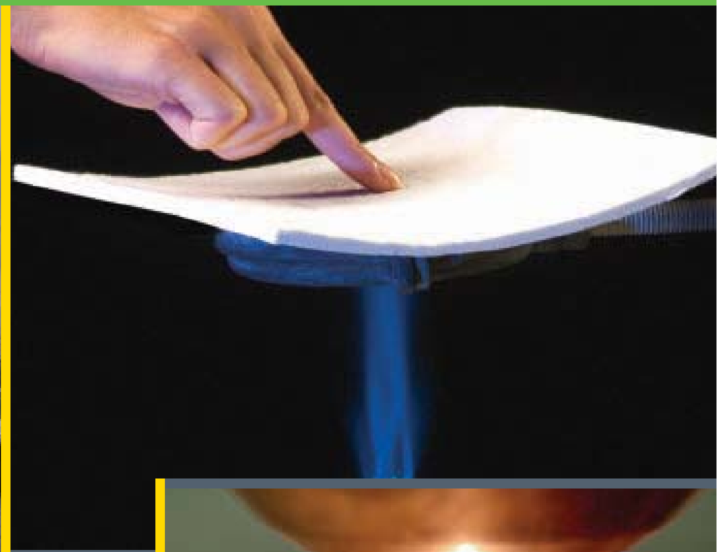
One of my particular areas of emphasis is energy. ASME should have a stronger voice in providing the facts about energy choices. We need all of our energy sources, plus some that haven't yet been developed, to meet the world's energy needs. Reliable, low-cost energy is essential for improving the standard of living of people worldwide.

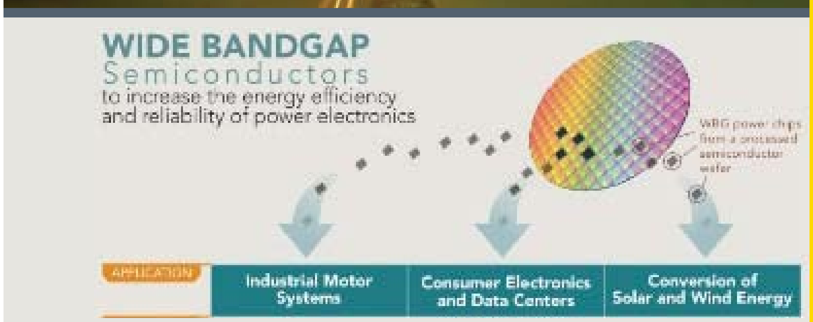
We need to consider all the energy sources we have available and consider all the environmental impacts of what we do. Making those difficult choices requires we have all the data available and ASME is uniquely positioned to provide the data and information needed. We need to put the data in a form accessible to decision makers.

ME: What's something few people know about you?

B.S: I enjoy driving exotic sports cars. Since I can't afford to buy one, I've taken advantage of several opportunities provided by car clubs to drive some of these cars on racetracks. I've even driven a Formula 1 car on a track in New York State. The engineering that goes into these cars is amazing. I enjoy exercising them to their limits. **ME**







SAVE THE DATE

American Energy & Manufacturing Competitiveness Summit

September 17, 2014

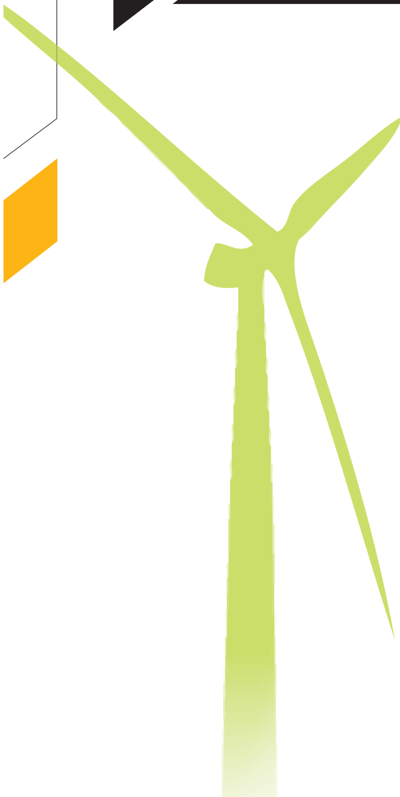
Washington, DC

www.aemcsummit.compete.org

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ADVANCED MANUFACTURING OFFICE

http://energy.gov/eere/amo/advanced-manufacturing-office



WIND TURBINE ENERGY

Wind turbines produce energy with almost no emissions but they do have an environmental impact. A recent study has quantified that impact.

Its authors found the greatest energy expenditure usually happens during a turbine's manufacture, but that energy expended in those processes is usually paid back within about six months of turbine operation.

Two researchers at the Oregon State University in Corvallis examined the life cycle environmental impact of two 2-megawatt wind turbines that would become part of a wind park under consideration in the U.S. Pacific Northwest.

Wind turbines are frequently touted as the answer to sustainable electricity production especially if coupled to high-capacity storage for times when it is impractical to operate them.

Lifecycle costs and environmental impact in terms of energy use and emissions brought about through manufacturing, installation, maintenance, and end-of-life processing are often cited in discussions for and against turbines, but hard data is lacking, according to Karl Haapala, an assistant professor in the School of Mechanical, Industrial, and Manufacturing Engineering at the university. Haapala carried out the research with Preedanood Prempreeda, a mechanical and industrial engineering student at the university.

"But forms of energy generation require the conversion of natural resource inputs, which are attendant with environmental impacts and costs that must be quantified to make appropriate

SENSOR CENTER AIMS

SEVERAL ENTITIES IN FLORIDA HAVE launched a program to build an industry-led consortium devoted to smart sensors in an effort to bring jobs back to the state.

The University of Central Florida is working with Osceola County and the Florida High Tech Corridor Council to establish the Florida Advanced Manufacturing Research Center, a research and incubation facility focused on universal smart sensors.

The center will be built on 20 acres owned by Osceola County near the intersection of U.S. 192 and Florida's Turnpike.

According to the university's president, John Hitt, advanced smart sensors stand to shape the future of automobiles, surgical devices, home appliances, and a host of other devices.

The world smart sensors market is projected to reach $7.8 billion by next year,

PAYBACK

energy system development decisions," Haapala said.

The two set out to broaden the discussion by carrying out a lifecycle assessment of two 2-megawatt wind turbines to identify their net environmental impact in terms of production and use.

A lifecycle assessment takes into account sourcing of raw materials, transport, manufacturing, installation, and maintenance through a wind turbine's expected two decades of useful life. It also considers the impacts of recycling and disposal at end of life, Haapala said.

They also analyzed energy payback based on cumulative energy demand and the energy produced by the wind turbines over 20 years.

They found that the majority of predicted environmental impacts would be caused by materials production and manufacturing processes.

Even in a worst-case scenario, lifetime energy requirements for each turbine would be negated within one year of operation. So for the following 19 years, each turbine would, in effect, power more than 500 households without consuming electricity generated by conventional energy sources, Haapala said. ■

TO RECLAIM LOST JOBS

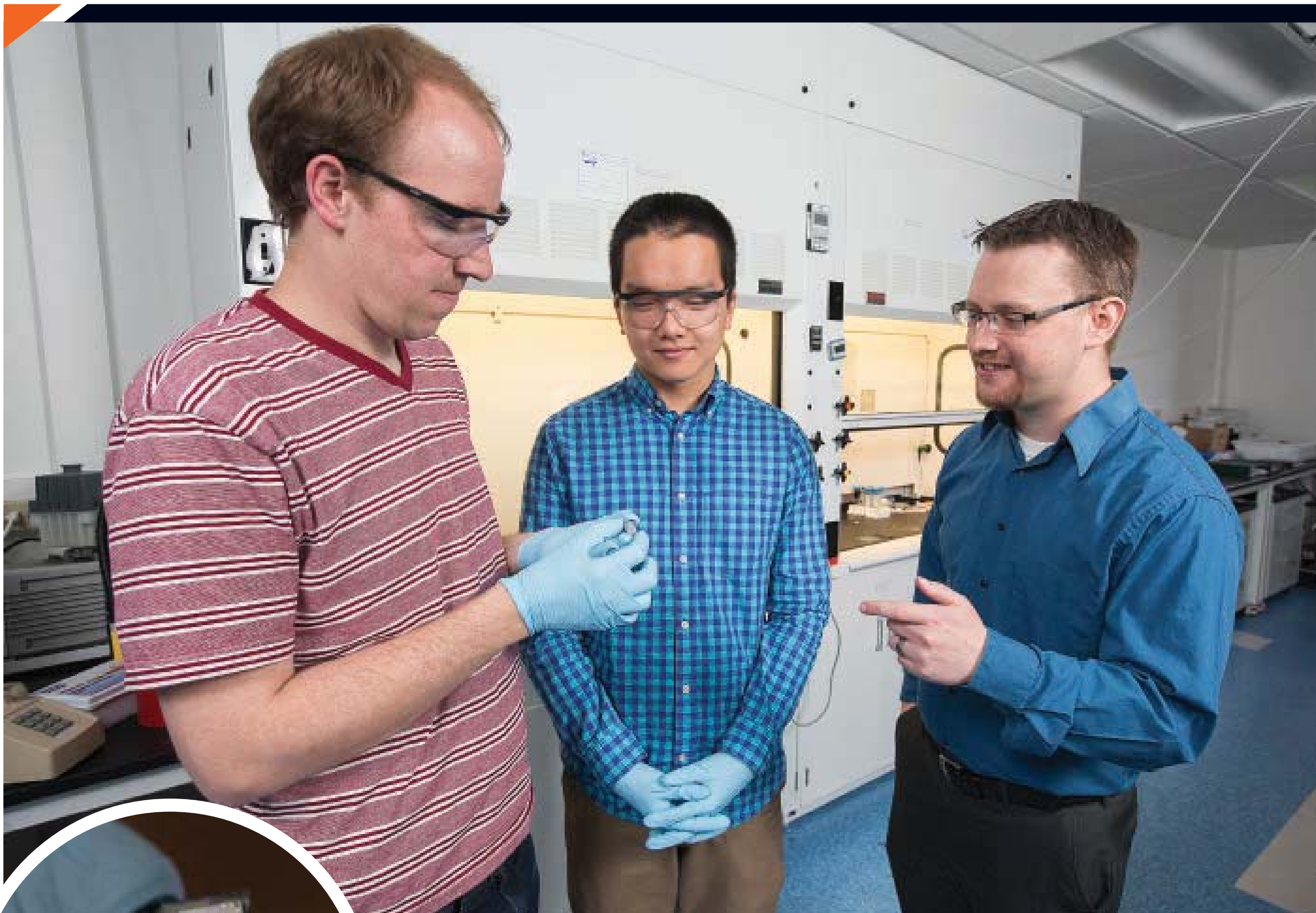
according to analysis firm Global Industry Analysts Inc.

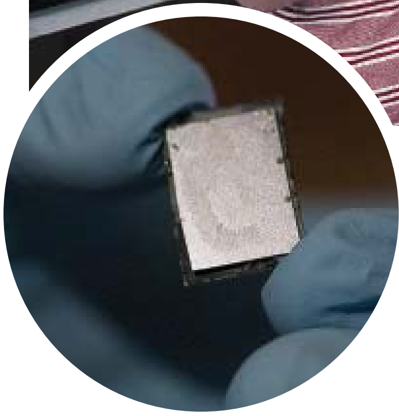
Researchers at the University of Central Florida have developed sensors capable of a range of applications—from detecting hydrogen and specific chemicals in the air to reading oxygen in the blood—and are also creating the materials that will enable sensors to be integrated into ever-smaller computer chips, Hitt said.

The sensor center comes at a time when Florida is losing manufacturing jobs and could help revive that sector. A June report from the Brookings Institution said that Florida has lost 75,000 manufacturing jobs since 2007.

The Florida High Tech Corridor Council is a regional economic development initiative of the University of Central Florida, the University of South Florida, and the University of Florida. The council's mission is to support high tech industry and innovation. ■

THE SENSOR CENTER COMES AT A TIME WHEN FLORIDA IS LOSING JOBS IN MANUFACTURING AND COULD HELP REVIVE THAT SECTOR.





BATTERIES BEGONE

Portable devices need a mobile power supply, and right now that means batteries. But in laboratories around the country, researchers are working to develop other methods for powering miniature electronics.

Andrew Westover, left, John Tian, center, and Cary Pint look at a supercapacitor built in their lab. The insert shows a close-up view of the power source.

ELECTRICITY ON BOARD

THE LAB Nanomaterials and Energy Devices Laboratory, Vanderbilt University, Nashville, Tenn.; led by Cary Pint, assistant professor of mechanical engineering.

THE OBJECTIVE Design of energy storage platforms that can be integrated into technology to replace fossil fuels.

THE DEVELOPMENT A supercapacitor that becomes part of the system it powers.

The Nanomaterials and Energy Devices Laboratory at Vanderbilt University has developed a load-bearing supercapacitor that can be integrated with its surroundings, and simultaneously act as the power source and a structural element of devices that it powers.

The lab's device stores electricity by assembling electrically charged ions on the surface of a porous material instead of storing it in chemical reactions as batteries do.

This supercapacitor may allow for a future in which energy is a part of systems themselves, like a laptop with a casing that serves as its battery, an electric car powered by energy stored in its chassis, or a home where the dry wall and siding store the electricity that runs the lights and appliances, said mechanical engineer Cary Pint, who directs the lab.

The device can stand up to these tough surroundings, he added.

"These devices demonstrate that it's possible to create materials that can store and discharge significant amounts of electricity while they are subject to realistic static loads and dynamic forces, such as vibrations or impacts," Pint said.

The structural supercapacitor stores

and releases electrical charge while subject to stresses or pressures up to 44 pounds per square inch and vibrational accelerations greater than 80 g, according to Andrew Westover, a graduate student in the lab who helped design the device.

The supercapacitor, which looks like a small, gray, wafer, consists of silicon electrodes that have been chemically treated to possess nanoscale pores on their inner surfaces.

Then they're coated with a protective ultrathin graphene-like layer of carbon. Sandwiched between the two electrodes is a polymer film that acts as a reservoir of charged ions.

When the electrodes are pressed together, the polymer oozes into the tiny pores in much the same way melted cheese soaks into the nooks and crannies of artisan bread during the making of a toasted sandwich. When the polymer cools and solidifies, it forms an extremely strong mechanical bond, Westover said.

"The biggest problem with designing load-bearing supercaps is preventing them from delaminating," he said. "Combining nanoporous material with the polymer electrolyte bonds the layers together tighter than superglue."

The supercapacitor could become part of laptop's shell to create a self-charging device.

RECHARGEABLE MEDICINE

THE LAB Stanford Integrated Biomedical Systems, Stanford University; Ada Poon, principal investigator.

THE OBJECTIVE To build engineering platforms for electronics integrated with the human body.

THE DEVELOPMENT A wireless system to beam energy to small chips in implanted devices.

This minuscule medical device, at right, could be implanted within a patient and recharged as needed by a power source held outside the patient's body.

Stanford Integrated Biomedical Systems has devised a new way to power implantable electronic devices smaller than a grain of rice. The method could eliminate batteries and recharging systems for medical devices.

The implanted devices can be powered or recharged by holding a power source about the size of a credit card outside the body, above the device, according to Ada Poon, who led the development project. The recharger uses about the same amount of power as a cell phone to transmit energy.

The method could power a new generation of programmable microimplants, including drug delivery systems to apply medicines directly to affected areas, Poon said.

The crux of the discovery involves a new way to control electromagnetic waves inside the body. Up to now, Poon said, electromagnetic waves in everyday use have been divided into two types: far-field and near-field waves.

Far-field waves, like those broadcast from radio towers, can travel over long distances. But when they encounter biological tissue, they either reflect off the body harmlessly or get absorbed by the skin as heat, she said.

Some current medical devices, like hearing implants, use near-field waves, Poon said, but they can transfer power only over short distances, limiting their usefulness deep inside the body.

Poon took advantage of the fact that waves travel differently when they come into contact with different materials such as air, water, or biological tissue. She designed a power source that generated a special type of near-field wave. When this special wave moved from air to skin, it changed its characteristics in a way that enabled it to propagate.

She called this new method mid-field wireless transfer and has shown it can power and recharge the implantable devices.

The lab is preparing the system for testing in humans. ME

MIXED VIEWS ON CARBON CURBS

An Environmental Protection Agency official ran into criticism in front of a House committee hearing over the agency's proposed rules to curb carbon dioxide emissions.

Across Washington at a Senate hearing, four former EPA administrators who served under Republican presidents urged carbon emissions controls.

Before the House Energy and Power Subcommittee received testimony from Janet McCabe, EPA's acting assistant administrator for the office of air and radiation, subcommittee chairman Ed Whitfield (R-KY) and colleagues criticized the EPA's proposed rule, and questioned the agency's authority to regulate carbon emissions.

In his opening remarks, Whitfield called the 600-page regulation "unprecedented." He said the prevailing opinion among members of the committee is that the rules are unworkable and would be ineffective in curbing climate change.

Meanwhile, a Senate Environment and Public Works subcommittee held a hearing on "Climate Change: The Need to Act Now." The witnesses included four former EPA administrators who were appointed by Republican Presidents: William Ruckelshaus served as the first EPA Administrator under Richard Nixon and then again under Ronald Reagan; Lee Thomas also served under Reagan; William Reilly served under George H.W. Bush; and Christine Todd Whitman served under George W. Bush.

The four testified about the need to control carbon emissions to avoid the most calamitous impacts of climate change, such as rising sea levels, dangerous heat waves, and economic disruption.

According to Ruckelshaus, "Several months ago, after talking with one another, the four former EPA administrators sitting in front of you found we were convinced by the overwhelming verdict of scientists that the earth was warming and that we humans were the only controllable contributor to this phenomenon," he said. "Given those facts, we all signed an op-ed piece that recommended that America get serious about reducing our contribution to changing the world's climate rather than simply sitting back and accepting the avoidable consequences."

LISTEN TO THE HOUSE HEARING AT http://1.usa.gov/1sbRFtv. **THE SENATE'S HEARING IS ARCHIVED AT** http://1.usa.gov/UALQa9.

COMMERCE DEPARTMENT NAMES MANUFACTURING COMMUNITIES

IN A BID TO SUPPORT MANUFACTURING ACTIVITIES across the country, the U.S. Department of Commerce has named the first 12 Manufacturing Communities, under a new program to help communities attract and expand private investment in the manufacturing sector and increase exports.

The Manufacturing Communities Partnership initiative, led by the Commerce Department, is designed to accelerate the resurgence of manufacturing in communities nationwide.

In order to earn the designation, communities had to demonstrate the significance of manufacturing already present in their region and develop strategies to make investments in six areas: workforce and training, advanced research, infrastructure and site development, supply chain support, trade and international investment, and operational improvement and capital access.

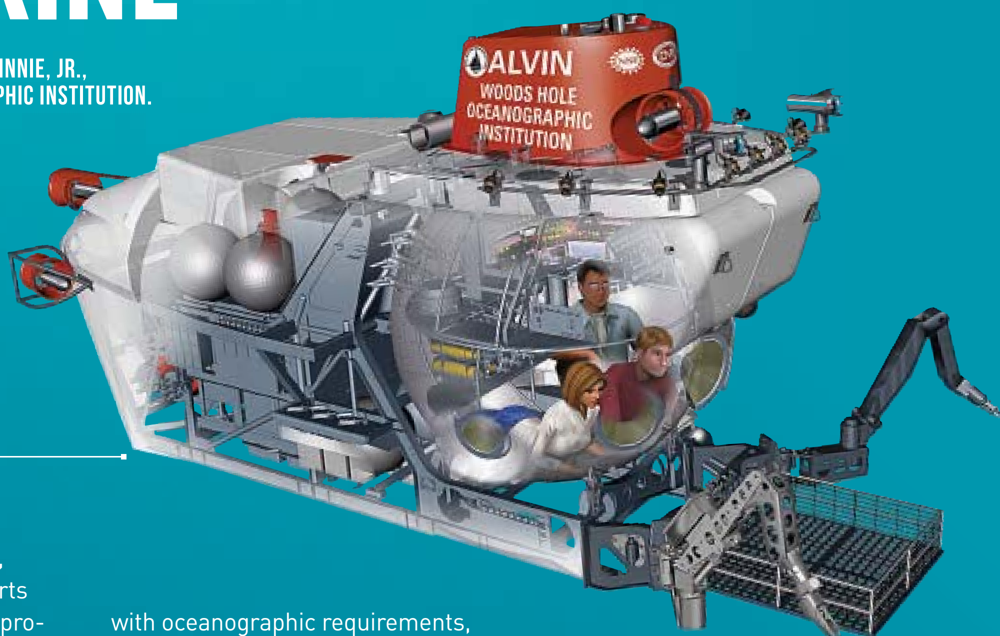
For more information on IMCP, visit
http://www.eda.gov/challenges/imcp/index.htm

Manufacturing Community	*Lead Organization*
Southwest Alabama	*University of South Alabama*
Southern California	*University of Southern California Center for Economic Development*
Northwest Georgia	*Northwest Georgia Regional Commission*
Chicago metro region	*Cook County Bureau of Economic Development*
South Kansas	*Wichita State University*
Greater Portland region in Maine	*Greater Portland Council of Governments*
Southeastern Michigan	*Wayne County Economic Development Growth Engine*
New York Finger Lakes region	*City of Rochester*
Southwestern Ohio Aerospace Region	*City of Cincinnati*
Tennessee Valley Sound region	*University of Tennessee*
Milwaukee 7 region	*Redevelopment Authority of the City of Milwaukee*

ALVIN: OCEAN RESEARCH SUBMARINE

BY JOSEPH B. WALSH AND WILLIAM O. RAINNIE, JR., ENGINEERS AT WOODS HOLE OCEANOGRAPHIC INSTITUTION.

A new submersible, capable of taking oceanographers into depths greater than a mile, was launched 50 years ago.



In spite of the attraction of the undersea world, until recently, technology (excepting the efforts of Barton in the nineteen thirties) provided means to bring man to depths less than perhaps 500 feet below the surface.... The need for a manned submersible has been apparent at the Woods Hole Oceanographic Institution (WHOI) where oceanographers from widely differing disciplines want a vehicle which can be used as an underwater laboratory. The opportunity for constructing such a vehicle was provided in the spring of 1962 when funds were made available by the U.S. Navy, Office of Naval Research. The problem at WHOI then became that of deciding what type of submersible would best serve the needs of the oceanographers. The specifications for *Alvin*, a two-man submarine capable of going to a depth of 6,000 feet emerged from discussions in which various possibilities were compared with oceanographic requirements, technical and financial reality, and, above all, the necessity for safe operation....

An operating depth of 6,000 feet was chosen as the least possible value satisfying the needs of the WHOI scientists. This depth capability opens to exploration about one sixth of the area of the bottom of the oceans and neighboring seas, including the continental shelves, part of the continental and island slopes, and many sea mounts. This upper 6,000-foot layer of the ocean includes much of the life of the ocean as well as the region where variables such as current, temperature, and sound velocity, of interest to the physical oceanographer, are most active. A collapse depth of 10,800 feet was specified, resulting in a safety factor of 1.8. ME

LOOKING BACK

ABOUT THE VAULT

Alvin, which is now the longest-serving deep-sea submersible, was the subject of an article in the August 1964 issue.

EVER DEEPER

Alvin has been through some upgrades since 1964. Originally designed for a depth of 6,000 feet, it can now withstand depths to 4,500 meters—greater than 14,700 feet. Another upgrade in the near future is expected to prepare the submersible for dives to 6,500 meters, more than three times its original depth rating.

Above: An illustration by E. Paul Oberlander for WHOI of Alvin *today.*

The U.S. has a goal to reduce greenhouse gas emissions by **30 percent**. Where do we stand today?

BY THE NUMBERS: TAKING INVENTORY OF CARBON EMISSIONS

The U.S. Environmental Protection Agency announced a proposed set of regulations in June that would work to reduce annual greenhouse gas emissions from existing power plants by 30 percent by 2030. That's part of a larger program of fuel efficiency and other measures designed to bring economy-wide emission levels down 17 percent from a 2005 baseline by 2020.

Power plant emissions of greenhouse gases—mostly carbon dioxide that is created by the burning of fossil fuels—are the focus of these new regulations for good reason. Thermal generating stations that burn coal, natural gas, or fuel oil vented more than 2,000 million metric tons of carbon dioxide into the atmosphere in 2012. That's more than 30 percent of the 6,525 million metric tons that were emitted by the entire economy, according to EPA figures published earlier this year. (The net emissions are almost 1,000 million metric tons less than this because of carbon sinks, which have grown through forestry activities and land use changes.)

> Since 2005, the nation has reduced emissions by **728 million metric tons**, though those reductions have not been distributed evenly.

The second largest source of emissions is burning petroleum—gasoline, diesel, jet fuel, and so on—to power transportation. This sector is also subject to regulations that are designed to improve efficiency; by model year 2016, the corporate average fuel economy for vehicles sold in the U.S. will increase to 39 miles per gallon for cars and 30 mpg for light trucks. Most automakers who sell cars in the American market have agreed to make additional improvements, to 54.5 miles per gallon for cars and light-duty trucks by model year 2025. This is better than double what the CAFE standard was as recently as 2008.

These measures should continue trends that have pushed the U.S. off the track of ever-increasing greenhouse gas emissions. Since 2005, the nation has reduced emissions by 728 million metric tons, though those reductions have not been distributed evenly. Coal-fired power plants, gasoline-powered light trucks, and industrial combustion of oil and coal have seen major cuts; gasoline use in passenger cars, and natural gas combustion for industry and electricity generation have seen increased emissions. Those last increases are likely net reductions as gas has supplanted more carbon-intensive coal and oil in many cases.

Even so, the total greenhouse gas emissions from fossil fuel combustion account for more than 5,000 million metric tons, and while the scheduled cuts are more than just a shave, they won't come close to what will be needed to reduce the pace of increase of carbon dioxide in the atmosphere. To do that will require much more effort in many more countries over a longer period of time. **ME**

JEFFREY WINTERS

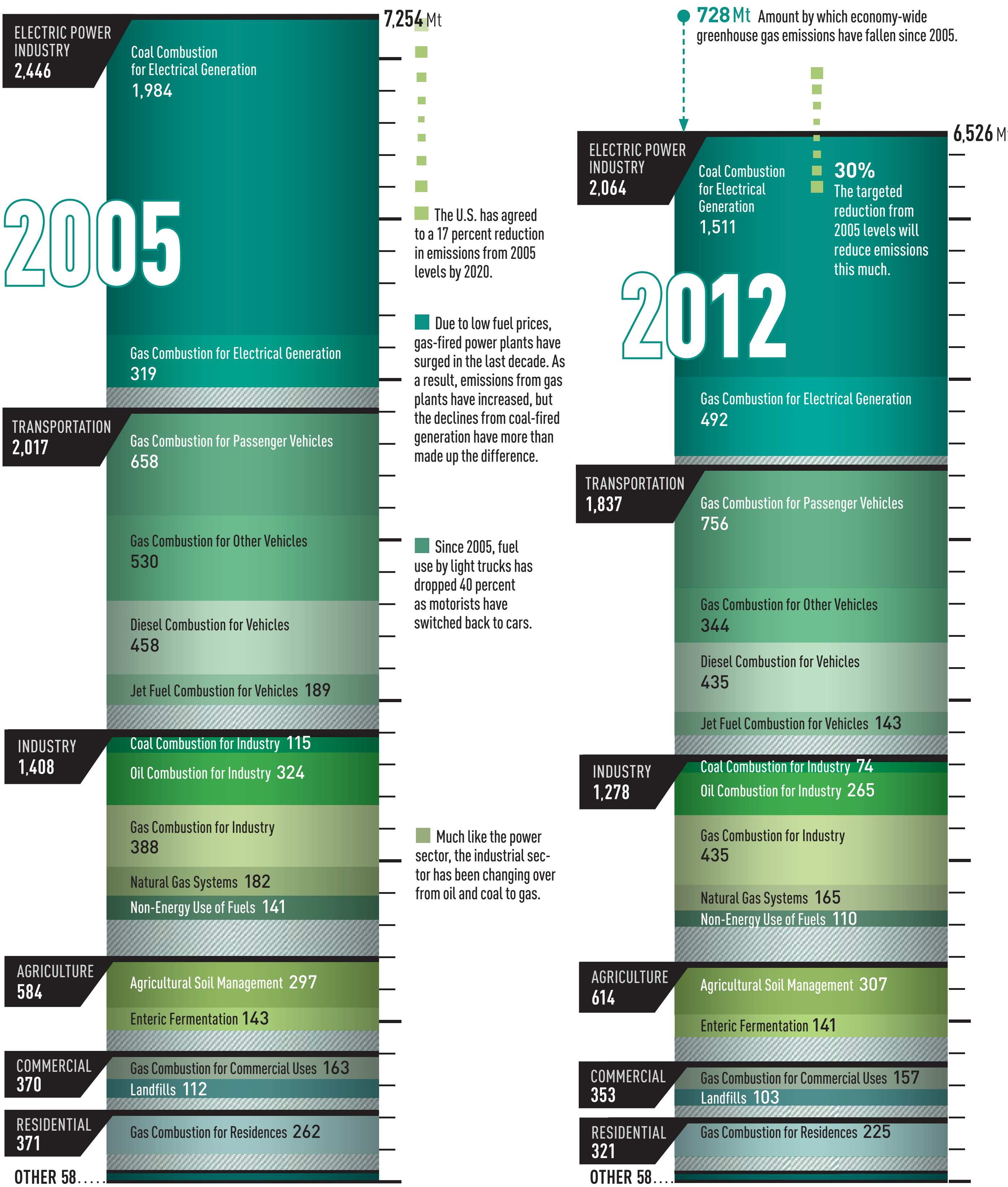
GRAPH 01

U.S. GREENHOUSE GAS INVENTORY

SOURCE: *U.S. Environmental Protection Agency*

SOURCE: EPA

U.S. GREENHOUSE GAS EMISSIONS / IN MILLIONS OF METRIC TONS (Mt)



CAD AT THE NANO SCALE

RESEARCH AT GEORGIA TECH SEEKS TO GIVE ENGINEERS THE ABILITY TO CUSTOMIZE MATERIALS AS THEY DESIGN.

BY YAN WANG

THE TIME HAS COME FOR ENGINEERS TO BE ABLE TO **CUSTOMIZE THEIR MATERIAL EXACTLY TO THE PIECE THEY'RE DESIGNING.**

As the advent of flexible electronics attests, the materials with which things are made are at the root of today's product innovations.

The Georgia Institute of Technology's Multiscale Systems Engineering Research Group, where I'm a faculty member, is working to integrate the modeling and simulation features of today's CAD with materials design capability. These integrated features would be available at the nano, meso, micro, and macro scales, which we call multiscale CAD.

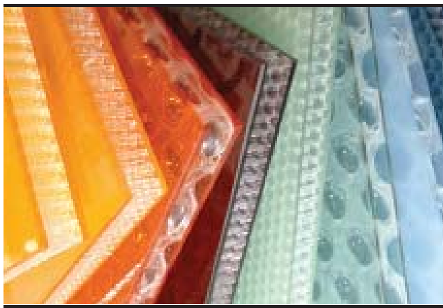
Integration would allow engineers to create customized materials (that is, materials that contain pores or voids, or super alloys that have coexisting phases) to meet their needs while performing structural and shape design at the macro scale.

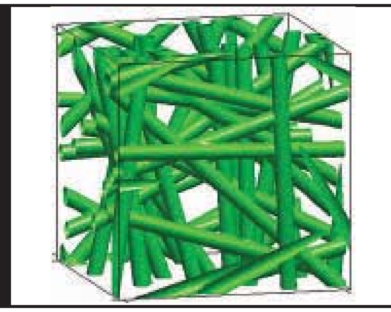
Similar to the conventional CAD as the first tool for virtual prototyping, the primary function of multiscale CAD is to allow the efficient construction and interactive modification of geometric models for microstructures. Existing boundary-representation-based parametric modeling approaches have become inefficient in model construction at

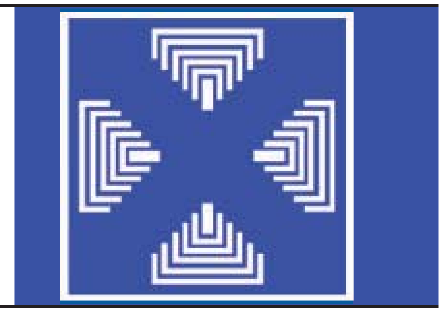
CUSTOMIZING MATERIALS: CAD systems of the future may be able to model synthetic materials on the order of ultra-porous zeolite. At right, part of the current materials browser in Autodesk Inventor.

nano and meso scales where geometry and topology are highly complex. New modeling and representation techniques are thus needed and this is the goal of our research.

In future CAD systems, engineers will be able to zoom in to specify material morphology and distributions. They'll be able to combine material design at the nano or micro scales, with geometrical and topological design at the macro scale to optimize the product's performance.







MODELING SUBJECTS: Engineers would be able to design and model materials including, fom left, polymers, fibrous porous media, silicon, graphene, or textiles.
At far right, a schematic of ionized physical vapor deposition, a nanoscale manufacturing process.

In this way, design engineers will be able to customize materials to their design in much the same way they select and change part geometries today. They'll be able to simulate the product with the selected geometries and materials in place. These would be available in an all-in-one package so engineers could create specific materials while they are designing a new product.

What we're envisioning is to allow engineers to define their own materials rather than use those already discovered.

NEW MATERIALS' FUTURE

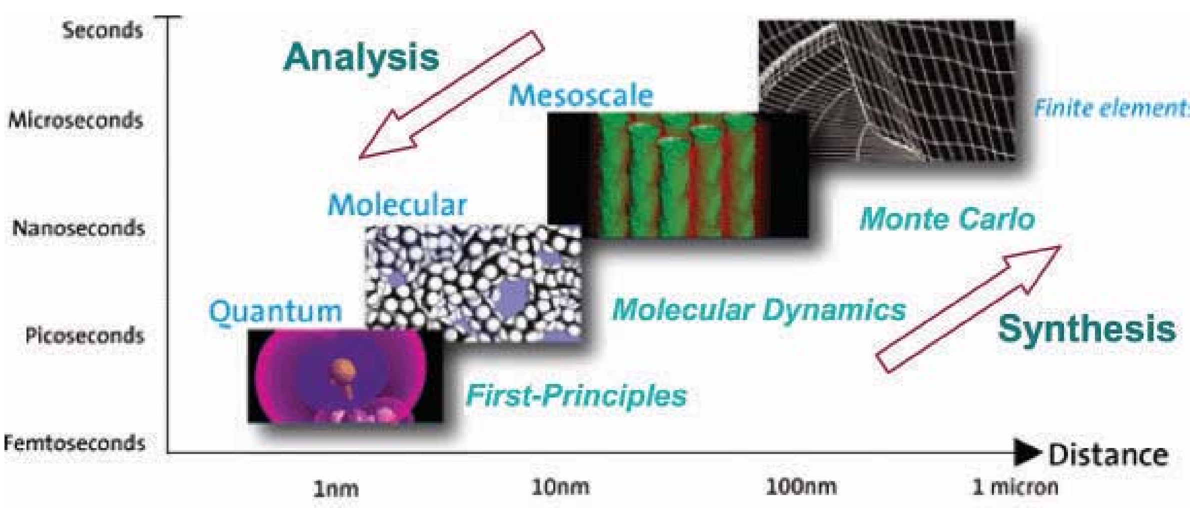
As it stands now, there's a divide between materials creation and product design. Bringing them together within the same system will allow for all kinds of new material properties and structures that currently haven't been used in the engineered world.

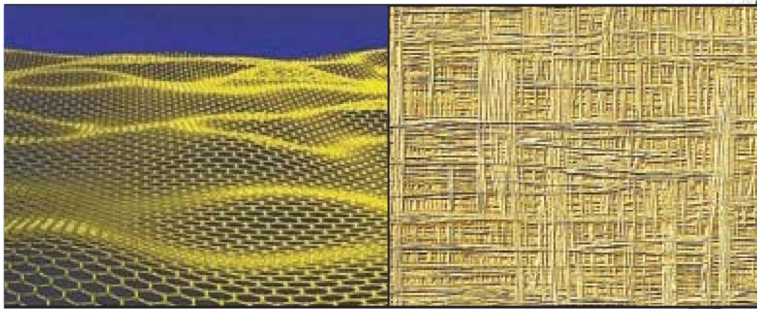
Integrating those two functions would allow engineers to customize and design material properties on any portion of their CAD design by simply zooming into the specific region, specifying material compositions, designing atomic or crystalline configurations, and simulating material performance within the product to ensure it will work as needed. If it doesn't, engineers can redesign the material, the part, or both, and test again.

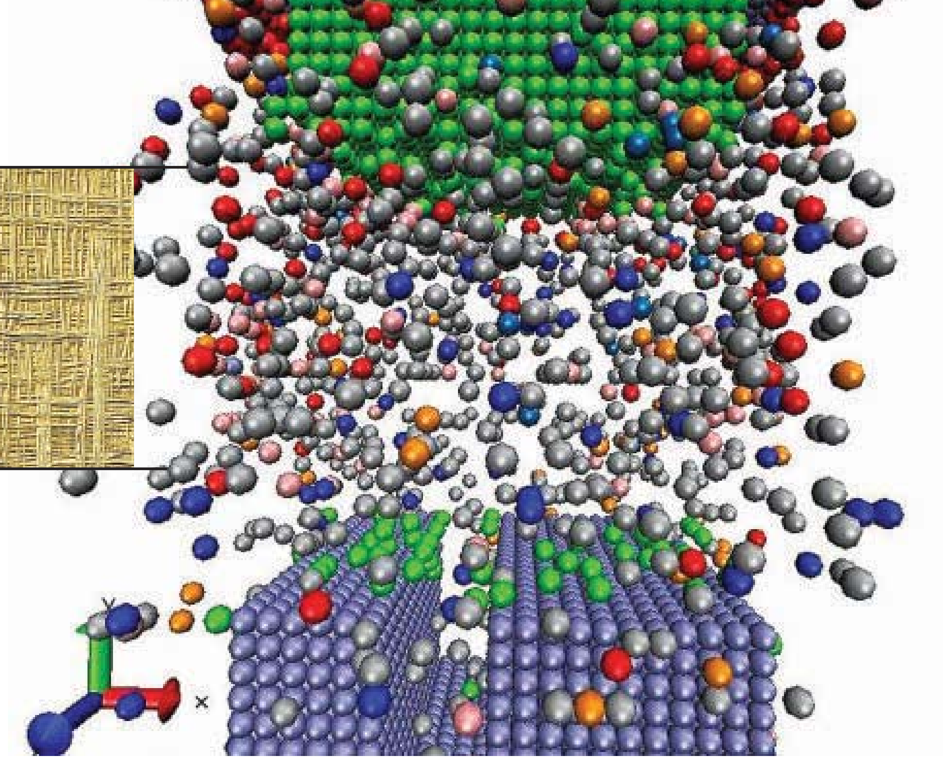
This is of interest because design decisions made at the microscopic level determine a material's properties, which, in turn, determine product behavior.

In today's CAD-enabled design processes, design engineers select available materials from databases. They select the materials they deem best suited to their products' specifications and their designs.

The conventional material selection approach that design engineers usually take is based on the isolated databases that were built without the input of problem-specific needs. Such a one-directional approach to discover, devise, and deploy new materials has a long development cycle and is not cost-effective. Even the materials science and engineer-







ing community has realized that this "lack of design" approach limits the rapid advancement of engineering materials.

To discover new materials, scientists run many experiments. In a process that is analogous to baking a cake, various ingredients are mixed and processing conditions are tried based on scientists' own experiences. If a cake is too hard or if it falls, a baker will tinker with the recipe, and materials scientists have had a similar practice.

It's only after materials scientists discover a new material through these experiment-driven approaches that product engineers consider how it can be best used within an engineered product. They also enter the new material into the materials database used by CAD designers today.

So from an engineering design perspective, discovery is not design. Design starts with asking the question: "What are the problems I have and what are the materials I need to solve it?"

The existing product development process doesn't integrate material design for the product into CAD. Say a mechanical engineer wants to design a vehicle from design specifications that call for the car to be light but strong. Currently, the engineer can only play around with different geometric shapes and topologies within the CAD design.

Materials are given. They can only be selected from the existing materials database.

Therefore, the available "degrees of freedom" that design engineers control to optimize the performance of products are restricted to the geometry and topology offered within CAD systems. The addition of material properties in the design space would offer design engineers more degrees of freedom. Customizable materials would provide extra flexibility to realize increasingly intricate product functionality.

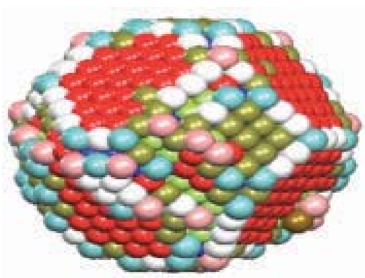
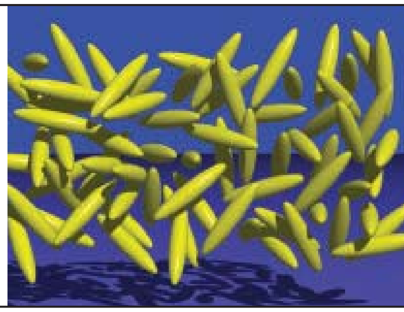
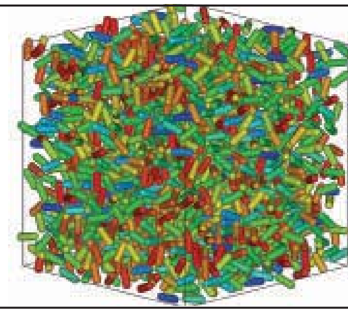
In other words, materials selection should be replaced by materials design to better meet customers' requirements in realizing modern products.

AS IT STANDS NOW, THERE'S A DIVIDE BETWEEN MATERIALS CREATION AND PRODUCT DESIGN.

BRINGING THEM TOGETHER WITHIN THE SAME SYSTEM WILL ALLOW FOR ALL KINDS OF NEW MATERIAL PROPERTIES AND STRUCTURES THAT CURRENTLY HAVEN'T BEEN USED IN THE ENGINEERED WORLD.

MATERIALS ARE GIVEN. THEY CAN ONLY BE SELECTED FROM THE EXISTING MATERIALS DATABASE.

MATERIALS IN THE LIBRARY: Contemporary CAD systems let engineers specify materials from a range of choices, but do not zoom in for the design of materials with special features on the nano or mesoscale.

CLOSE-UP VIEWS: From left, a gold nanoparticle, a liquid crystal, a Monte Carlo simulation of particles in an isotropic stage, a synthetic zeolite crystal, and transis-

COMPUTE INSTEAD OF EXPERIMENT

Simulation software tools would also be used to analyze the material at multiple scales. The engineer could use them to compute the physical properties instead of experiment. The tools can quickly answer questions to verify the design; for example, what is the modulus of elasticity of the newly designed material? This mechanical property can be directly calculated and predicted from material configurations done at the atomic scale.

Nano scale materials simulation can predict mechanical, thermal, optical, and electrical properties for some particular atomistic structure. The calculated properties from nano scale simulations can be plugged into traditional FEA for overall structure analysis. So it's kind of a chain reaction of calculations. Computation allows engineers to predict material properties and use those numbers to run FEA at the macro scale.

The value of a multiscale CAD environment lies in knowledge shared and used across disciplines. Do mechanical engineers have to learn more about materials in order to use multiscale CAD in the future? No. In fact, today's engineers don't have to know all details of how to formulate and solve differential equations behind FEA and CFD software in order to run simulations.

Similarly, our goal is to develop integrated software tools that will allow engineers to design materials in the same way they run FEA analyses, without the need of knowing all chemistry and physics behind them. We aim for software tools that simulate materials and predict their properties by simple mouse clicks.

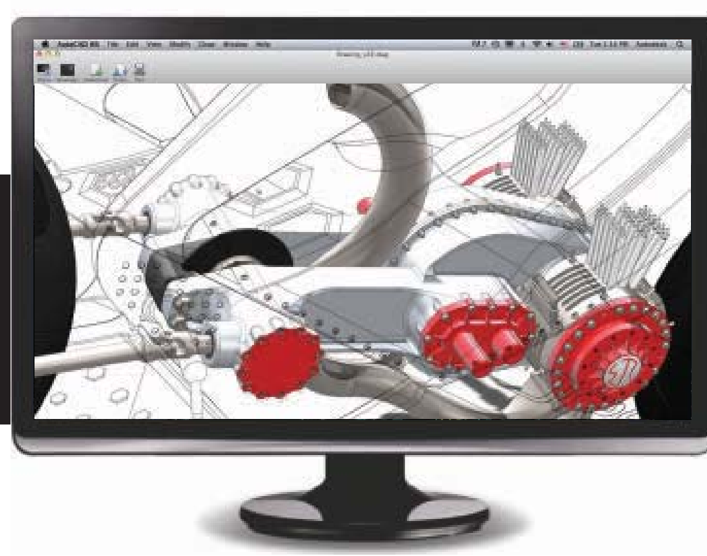
We began working on this concept a few years ago. One challenge has been how to allow computers to represent shapes and structures at the nano or meso scales, which are much more complex than the structures at the macro level, as currently done in CAD. We are also working on a new area called computer-aided nanomanufacturing that can predict whether or not the design of nanostructures and nanomaterials are manufacturable.

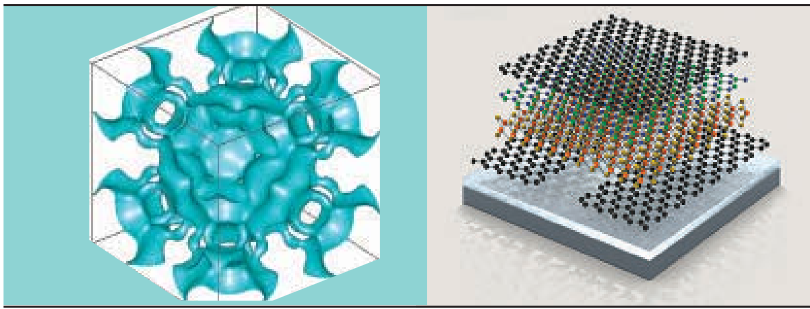
RADICALLY DIFFERENT SHAPES

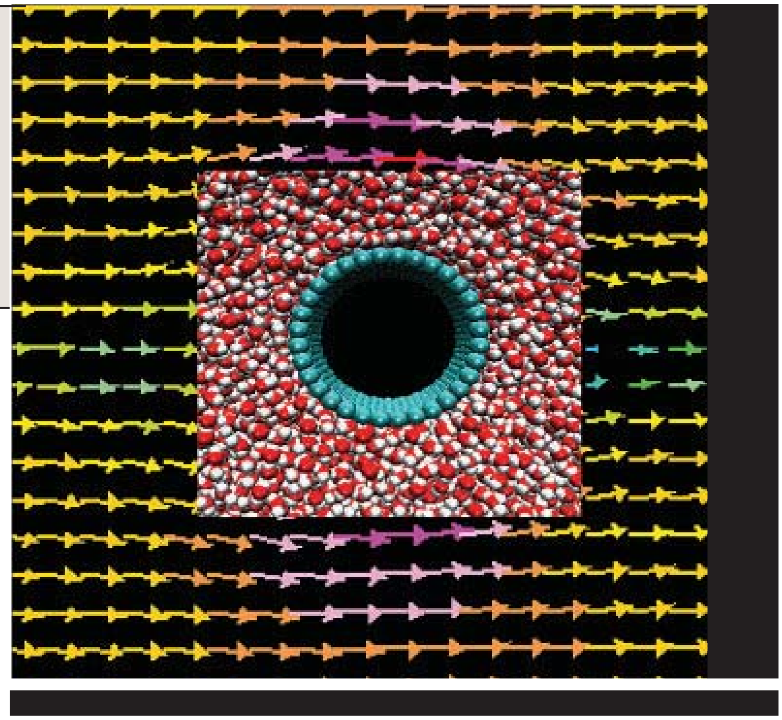
Offering the capability of designing materials in CAD requires the representation of many different kinds of shapes. Compared to the geometries at the nano scale or in nature, traditionally used geometries in engineering design are very simple and mostly flat, such as buildings, chairs, and computers, because that's what the current CAD can do today.

Natural shapes, like sea urchin, and kale, and geometries at nano scales, like zeolite, and polymer, are very complex. Part of our effort is to see how we can present these atomic configurations and porous structures by computer.









tors made of 2-D materials. At far right, a bio nanosensor.

WE AIM FOR SOFTWARE TOOLS THAT SIMULATE MATERIALS AND PREDICT THEIR PROPERTIES BY SIMPLE MOUSE CLICKS.

The engineer using the nano CAD software would first design the complex shapes interactively, simulate properties of the design, and optimize toward the need. The engineer could then apply the designed material in the macro scale simulation using FEA software.

The multiscale CAD would also allow engineers to design better functional materials, such as state-change materials. Examples of these materials, used for their state transformation properties every day, include batteries for energy storage, DVDs for information storage, and shape-memory alloys for orthopedic surgery. Charged and discharged batteries are two states of the material, as are burned and erased DVDs, and deformations of shape-memory alloys.

For instance, erasable DVDs depend on special materials with certain optical properties. When a laser pulse burns them, the materials change between transparent and non-transparent. This optical property change is used to store the binary information of zero or one.

The designer of DVD materials needs to decide the speed of burning and the amount of energy required to finish the state transformation. Atomistic simulation can be used to predict the required energy for the transformation. The designer can determine the material compositions and atomic configurations best suited to meet target performance.

The geometric modeling of microstructures that make up material is still in its infancy. The efficiency and controllability of complex and porous shapes are the most important research topics for the interactive modeling and design of microstructures. ME

YAN WANG is an assistant professor of the Woodruff School of Mechanical Engineering at the Georgia Institute of Technology in Atlanta, and a faculty member at the institution's Multiscale Systems Engineering Research Group.

DESIGN ON A NEW SCALE:
Just as current CAD software models parts and assemblies, future systems may be able to zoom in and model materials on the molecular level to give them novel properties specifically suited to a given product.

MORE THAN 30 YEARS AGO, ENGINEER **K. ERIC DREXLER** STARTED WORKING ON THE CONCEPT OF **NANOSCALE MACHINERY** AND **MANUFACTURING**.

He recently spoke with *Mechanical Engineering* associate editor Jean Thilmany about the present state and future prospects of this most advanced form of manufacturing.

AT ITS HEART, atomically precise nanomechanical engineering—the building of machines and factories on the scale of large molecules—is mechanical engineering writ small.

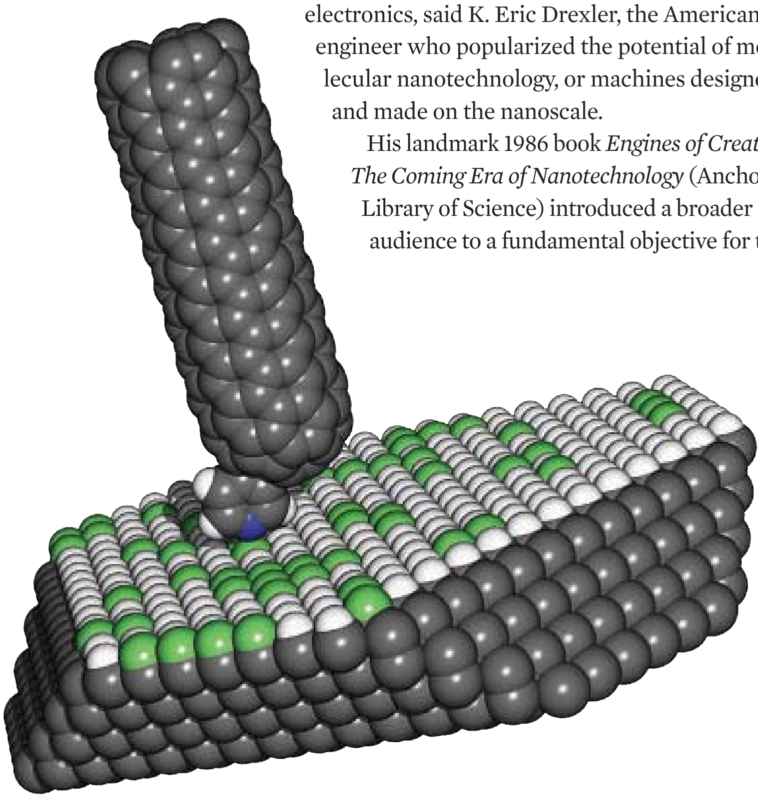
With a theoretical factor of one million advantage in throughput of both energy and materials, nanomechanical technology promises to revolutionize everything from automobiles to medical devices, just as the ability to fit billions of transistors on an integrated circuit transformed electronics, said K. Eric Drexler, the American engineer who popularized the potential of molecular nanotechnology, or machines designed and made on the nanoscale.

His landmark 1986 book *Engines of Creation: The Coming Era of Nanotechnology* (Anchor Library of Science) introduced a broader audience to a fundamental objective for the technology: using machines that work at the molecular scale to structure matter from the bottom up.

Drexler's 1991 doctoral thesis in molecular nanotechnology from the Massachusetts Institute of Technology was expanded and published as the book, *Nanosystems: Molecular Machinery Manufacturing and Computation* (Wiley, 1992). More recently, he authored *Radical Abundance: How a Revolution in Nanotechnology Will Change Civilization* (PublicAffairs Books, 2013).

The nanomechanical revolution Drexler predicts would open up new jobs to mechanical engineers. For right now, however, the key to progress is at the intersection between mechanical engineering and the molecular sciences, where atomically precise fabrication has reached the scale of designing and building structures with millions of precisely arranged atoms.

Drexler spoke to *Mechanical Engineering* from his home in England, where he works with the Programme on the Impacts of Future Technology at Oxford University.



We have a **nanotechnology revolution** in progress today.

NOTHING SMALL ABOUT NANO-TECH-NOLOGY

Complex functions can be accomplished through machines built at the molecular scale. At left, a design for a computer memory system uses a nanotube probe. Above, this motion controller was developed by Drexler.

INTERVIEW By JEAN THILMANY

J.T: Can you tell us a bit about what you mean by "nanomachinery"?

K.E.D: What I mean by this term is a particular kind of nanomachine-based technology on the horizon today, one that has enormous potential. The best way to understand the potential is by comparing this machine technology to the leading nanoscale technology in the world today.

Today we have a nanotechnology revolution in process, nanoelectronics, the ubiquitous chip technology that has already transformed many industries. It's not commonly called "nanoelectronics" or "nanotechnology," but that's what it is. We still use the prefix "micro," though the technology has gone beyond this.

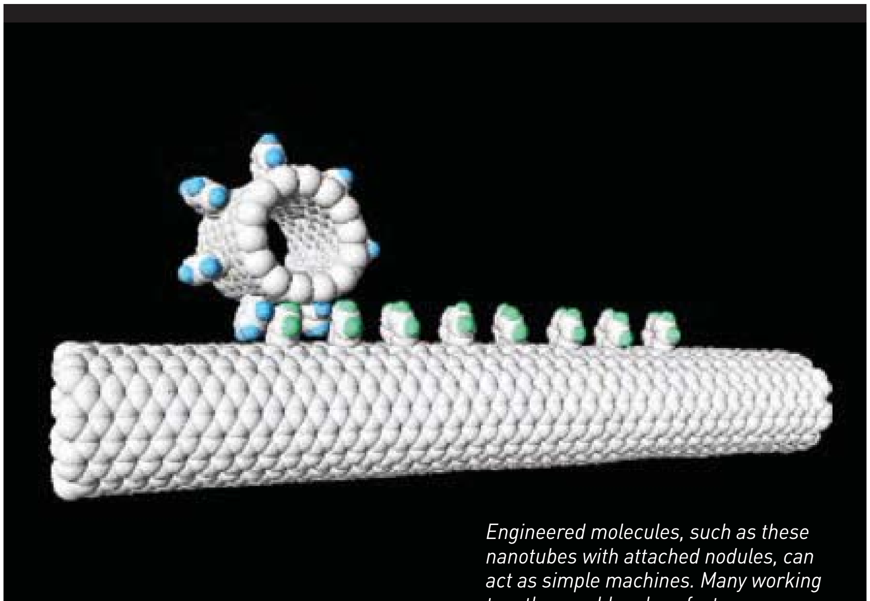
Nanoelectronics today is based on intricate systems with features as small as 20 nanometers. Like future nanoscale machines, these nanoscale electronic systems operate at high speeds and perform useful functions. "Nanoscale" refers to the component level, since chips with billions of devices are built on a centimeter scale, and future nanomachine-based systems with trillions of devices can be much larger.

The impact of electronic nanotechnology has been enormous. Today's digital electronics—cell phones, computers, and so on—are based on nanoelectronic technologies.

These electronic systems are based on arrays of nanoscale components that work together at high frequencies and process little discrete things. In the case of electronics it's bits of information.

Nanomechanical production technology will likewise be based on arrays of nanoscale components that work together at high frequencies and handle small, discrete things. But in the nanomachine world the things aren't bits packaged in bytes, they're atoms packaged in molecules.

This kind of technology is already surprisingly well understood, even though making the actual physical devices is still beyond reach of today's fabrication technologies. What we do have is the modeling tools needed to do detailed computational simulations and explore the design space, and these tools can be used by mechanical engineers to design nanomachines.



Engineered molecules, such as these nanotubes with attached nodules, can act as simple machines. Many working together could make a factory.

J.T: What will nanomachines look like?

K.E.D: In a literal sense, nothing, because the smallest components will be invisible, just a few nanometers in diameter, and only barely resolved by an electron microscope. Useful systems of machines, of course, will often be large.

In terms of their structures, when atomically precise fabrication capabilities become more advanced, it will be possible to build a class of nanoscale machines that is quite extraordinary, with every atom in a position chosen by designers, and densely bonded to form strong, stiff materials. This class of nanoscale machines will have components with shapes and functions very similar to devices designed by mechanical engineers today.

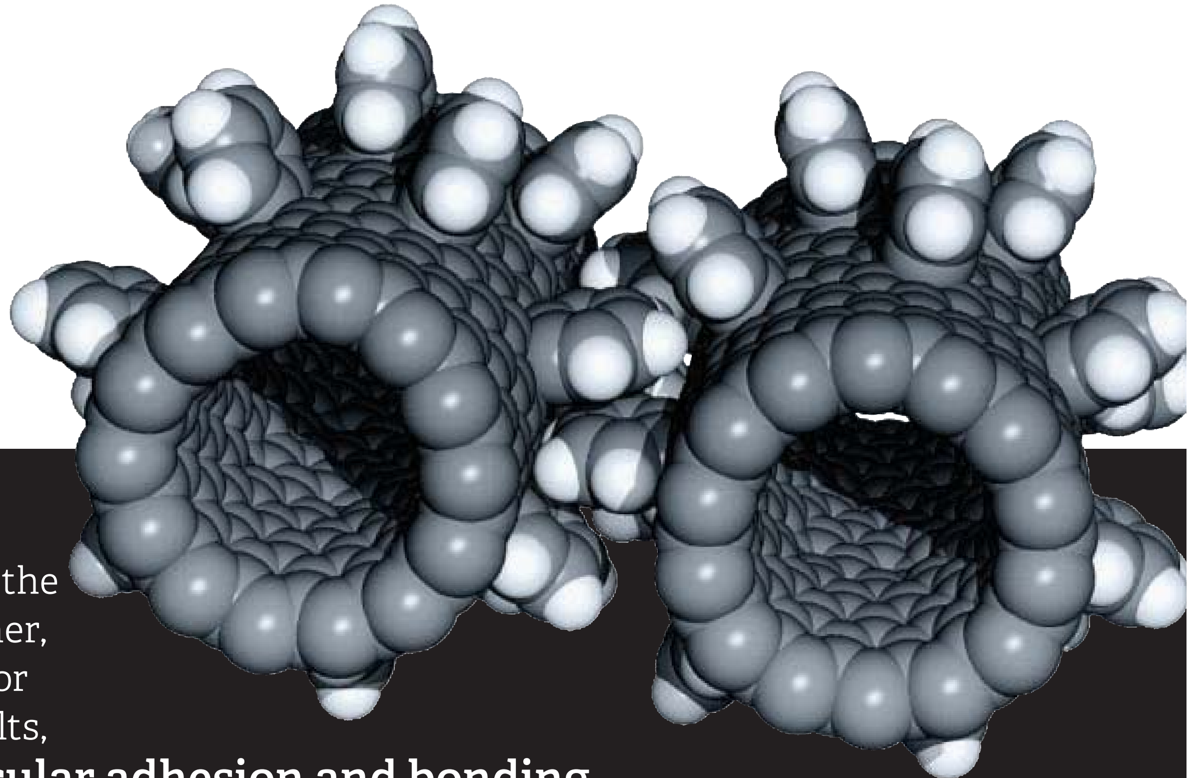
The prospect for this kind of technology includes ultrastrong materials and high-performance mechanical systems of all kinds. The machines will be built on a range of scales, but they'll demonstrate their most extraordinary properties at the nanoscale.

Because of basic mechanical scaling laws, nanoscale machines can operate at high frequencies, and nanoscale production systems will be able to process many times their own mass in a short time. For both energy and materials, there's a factor of one million advantage in throughput per unit mass between nanomachines and similar machinery at the macro level. The consequence is that you don't need a whole lot of machinery to get a large result. A thin-film configuration would be typical.

At this scale, you can get enormously higher power densities in motors and gear boxes—for example, a power density on the order of 100 GW per kilogram is natural, just because of scaling laws. Of course, you couldn't use a kilogram of machines like that all in one in place, because cooling will only be possible with much smaller amounts of hardware or lower power densities.

J.T: Where does the development of nanomachines stand today?

K.E.D: Both the physics and engineering of these technologies are well understood today, but the pathway to their development will depend on



What holds the parts together, isn't rivets, or welds, or bolts, **but molecular adhesion and bonding.**

organization and investment, and on all sorts of detailed technological developments. And as all engineers know, these factors are less than predictable.

It's interesting to note that in nanoelectronics, the Moore's law trend, the exponential decline in size and the increase of components on a circuit, have been smooth. But what's delayed nanomachines is that there isn't the same kind of smooth path. The technology has to be built up—not scaled down—starting at the molecular level.

The reason comes down to surfaces: In electronics, charge flows through the interior of a device, and rough surfaces are OK. In machinery, motion depends on having smooth surfaces for bearings, and at the nanoscale, this means having all the atoms in the right place. Lithography just can't do that.

Atomically precise fabrication in the molecular sciences has come a long way, up to millions of atoms, but it has a long way to go before building nanomachinery at this level. The problem isn't scale, but materials.

J.T: It's interesting because in this issue Yan Wang of Georgia Tech has written an article about a CAD system his team is working on that would allow engineers to create materials specific to their design.

K.E.D: His work and the kind of work I'm outlining here ultimately fit together. And when you consider nano- and macroscale together, you end up needing multiscale and multiphysics modeling.

This model of a molecular gear set, created at the NASA Ames Research Center, uses carbon nanotubes with teeth added via a known benzyne reaction. Building such nanomachines has been a challenge.

J.T: What needs to happen to advance the state of nanomechanical systems?

K.E.D: What's most needed today is focused research organized around system-level objectives. We need to develop a field of molecular mechanical systems engineering. It's a matter of research, organization, and funding, based in the molecular sciences, but going in new engineering directions.

Some of the roots are in molecular biology, but this field is organized as a science, a branch of biology. But small groups organized around studying and imitating biology don't build the kinds of components needed for a mechanical engineering technology that builds toward more and more advanced nanomechanical systems.

J.T: How would nanoscale production machinery work?

K.E.D: To a remarkable extent, it will work like macroscale production machinery, the kind used to assemble components to make larger components. As components get larger, later in the process, assembly becomes entirely conventional.

The picture is of nanoscale machinery making nanoscale parts and of those parts being put together to make microscale parts by microscale machinery, and parts on the centimeter-scale assembling centimeter-scale components, and so on.

At the bottom, at the start, the key is to apply nanoscale mechanical systems to move things—molecules—and put them together. This is entirely parallel to what we see in factories, but what holds the parts together isn't rivets, or adhesives, or welds, or bolts, or snap fittings, but molecular adhesion and bonding. Different in many details, but the same function. Also, the smallest parts at the start of assembly, instead of being cut from bar stock or injection molded or stamped out of sheet metal, will be reactive molecules of the kind used in chemical synthesis.

Considering these earliest steps in the process, the best parallel today is continuous-motion assembly machines, the machines used to assemble things like the mechanisms of plastic spray bottles. These assembly machines process a continuous stream of parts and some of them produce as many as 50 assembled products per second. The assembly isn't done with little arms. Instead, the parts are carried and transferred by spinning disks with gripping fixtures around the circumference. What's most like "programming" is in the shape of the cam surfaces that guide some of the motions.

This principles of these continuous-motion assembly machines could be applied on a nanoscale, then the nanoscale products would be handed off to larger machines. These would naturally be organized much like a factory, with parts passed from machine to machine and conveyors moving them along. The final products used by people would be on the familiar human scale, like today's products, even though the parts they are made from would be much smaller, and the properties of the small parts can result in high performance on the macroscale.

This kind of manufacturing process is somewhat like additive manufacturing or 3-D printing which is also about building small bits of materials together under programmable control to make any of an unlimited range of larger objects.

J.T: So the end product would be something you could see and touch. What is an example?

K.E.D: Well, some examples of potential products are photovoltaic arrays, cars, computers, spacecraft, and small medical devices that can work at the level of cells—a list would go on and on. Bottom-up atomically precise manufacturing is a general-purpose manufacturing technology.

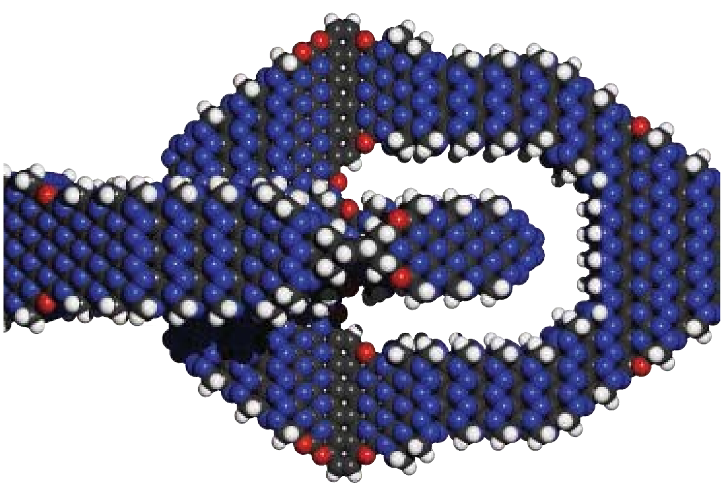
Think of the very general applications of computers. They have totally transformed areas as different as photography, music, scientific equipment, and mail. At the heart of a cell phone are sets of small, fast devices that transform patterns of information at the smallest bits. Using nanoscale devices to build up from molecules is similar in many ways, and will also have very general applications and products.

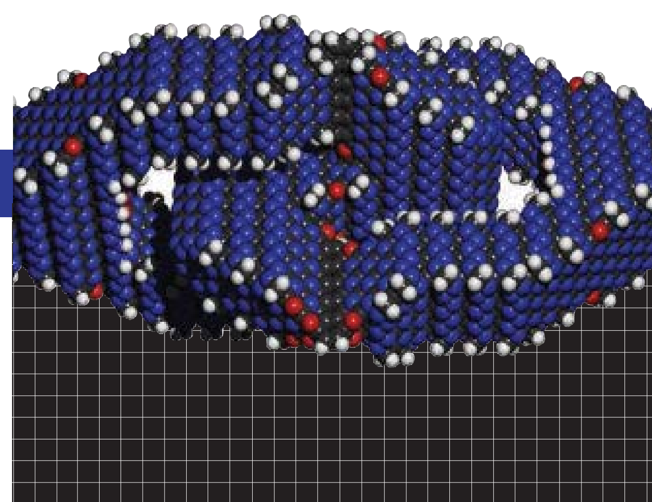
J.T: How should mechanical engineers think about nanomachinery?

K.E.D: Scaling laws tell us that machine-parts that move at equal speeds with similar shapes and patterns of motion will have the same dynamics (and stresses and strains), except for a scale factor in space and time. This means that much of mechanical engineering translates directly to the nanoscale.

At the very bottom, the atoms do matter. They can't be scaled. The meshing teeth of the smallest machines will be on the atomic scale, just rows of atoms. Bearings are a special case, because ordinary lubricants won't work. Instead, properly structured surfaces can slide over one

A universal joint (below) and bearing (opposite) designed with atomic precision. (Images copyright: Institute for Molecular Manufacturing, imm.org)





another, in direct contact, with the "bumpiness" of individual atomic interactions adding up in a way that results in smooth motion. This phenomenon is called "superlubricity" and has been demonstrated in a lab.

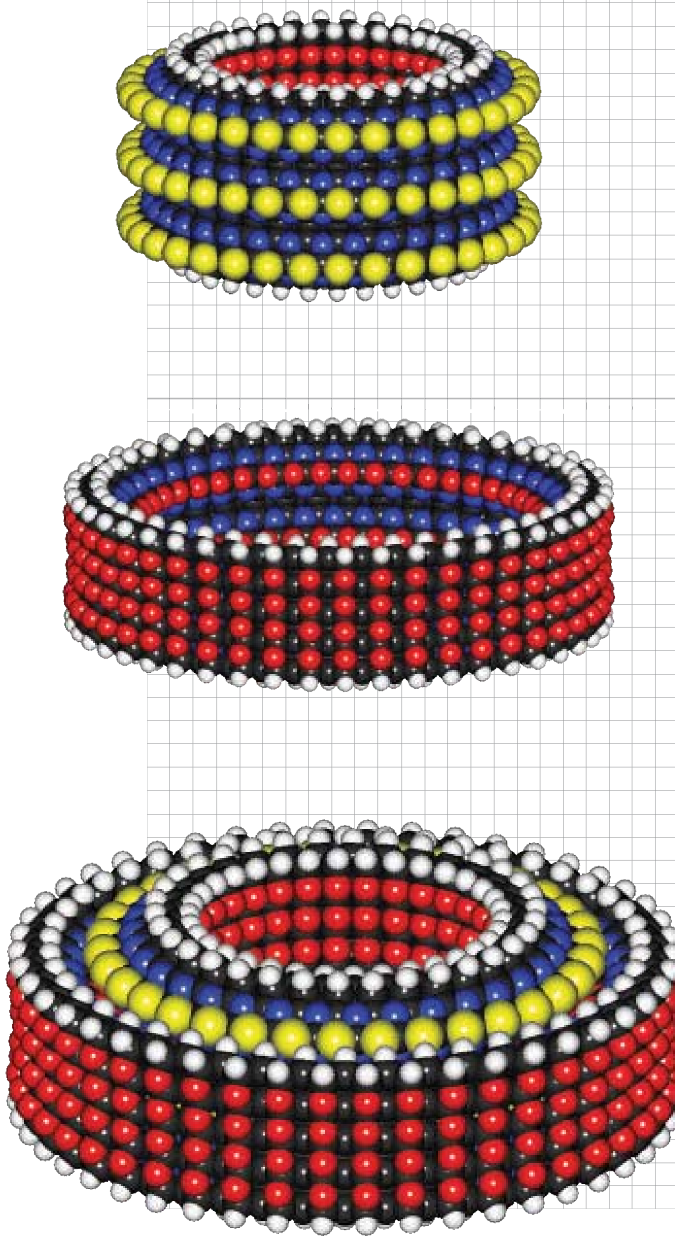
Thermal fluctuations are a special concern at the nanoscale, but they're statistically predicable and are part of standard dynamic models. In mechanical engineering terms, thermal motion amounts to an especially well-understood source of vibrations—but ones that are impossible to damp!

Today, however, the modeling software used to describe and test atomically precise machines machine designs comes straight out of the molecular sciences, and it doesn't directly support abstractions at the component level. The description is very fine-grained.

Traditional CAD would then apply at scaling levels not too far above the nanoscale. At much less than a micron non-atomistic solid models become realistic. Atomistic models can establish elastic properties, friction properties, and so on, and these can then be used to parameterize conventional models. Likewise, atomistic machine designs can be characterized as lumped components, in terms of properties like gear ratios, torque, elastic compliance, friction, and so on.

Mechanical engineers today can work with the existing atomistic models, and can make an enormous contribution to understanding the potential of advanced nanomachinery. In these models, they can build parts and machines, and after testing in simulation, they can calculate performance parameters, then try to come up with better designs. This could make a great area for online competition.

There's a lot to learn in this area of technology, even before we can actually build the machines. I hope that today's mechanical engineers will learn about nanomachinery and help explore this new domain. It's important, exciting, and fun. **ME**



At the very bottom, the atoms do matter. They can't be scaled.
The meshing teeth of the smallest machines will be
on the atomic scale, just rows of atoms.

Properly structured surfaces **can slide over one another,** with the **individual atomic interactions** resulting in smooth motion.

CONSUMER ELECTRONICS MAKERS ARE PUTTING ACOUSTICAL ANALYSIS INTO THE HANDS OF DESIGN ENGINEERS TO GET NOISE OUT OF PRODUCTS EARLIER.

BY JEAN THILMANY

the quiet

YOU DON'T WANT the cellphone speaker to buzz when you call for directions to a friend's new apartment.

YOU DON'T WANT the phone's housing to muffle the sound.

YOU DON'T WANT the laptop to rattle when the cooling fan switches on.

IN THE PAST, those concerns were analyzed and treated after a product was designed, passing down the line from design and mechanical engineers to acoustics analysts. Today, manufacturers are increasingly bringing acoustical analysis into play earlier in the design cycle. Indeed, they are putting that power into the hands of the design engineers.

We are told this by makers of acoustic analysis software. It seems that this kind of analysis is so new to their industry that consumer electronics manufacturers treat it almost as a trade secret. None that we approached would agree to be interviewed for this article.

Acoustics was previously "in the nice to have" category for those manufacturers, said Ruben Bons, manager for business development in the electronics sector at CD-adapco. The company, based in Melville, N.Y., makes Star-CCM+, which can be used for acoustical analysis.

"It was something the electronics people thought about, but as design priorities go it wasn't first or even a second item," Bons said. "But I've been noticing in certain industries that priority is moving up quickly."

Acoustical simulation is being pushed from experts to designers, following the trend for the last 15 or so years that saw other types of engineering applications like finite element analysis and computational fluid dynamics become integrated with computer-aided design packages used by mechanical engineers.

Bringing acoustical analysis to front-end design helps reduce a product's time to market and, at the same time, cuts extraneous noise from consumer electronics, said David Burd, manager of engineering at MSC Software in Newport Beach, Calif. MSC makes Actran Acoustics.

According to Burd, in the design process of the recent past, industrial and mechanical engineers received sets of requirements for what a product must be able to do. They designed a device to meet those specifications and then sent the design over to what was often an ad hoc acoustics team to fix acoustical issues. Many of the acoustics analysts had come to their jobs by way of earlier engineering jobs coupled with on-the-job training.

"Televisions, cell phones, the compressors on refrigerators—these are all things that have acoustics issues," Burd said. "But in those industries, acoustics has been an afterthought."

But with the advent of software packages that allow for design and for acoustical analysis in tandem, design engineers are increasingly running these analyses early in the development cycle and are making design changes to decrease noise and vibration issues they find.

Because automotive and aerospace makers commonly run acoustical analyses, “their competitors know they’re doing these analyses. It’s no big deal,” according to Bons of CD-adapco. “In electronics they’re still looking at acoustics as a competitive advantage.”

Some of the recent emphasis on earlier acoustical analysis is prompted by regulatory concerns. The European Telecommunications Standard Institute and the Network Equipment Building System guidelines in the United States both are beginning to include some noise specifications, Bons said, although they apply only to the telecommunications industry.

For the makers of consumer electronics, the wider move to bring acoustical analysis to the front is an effort to design more efficient devices and to woo potential buyers, Bons said.

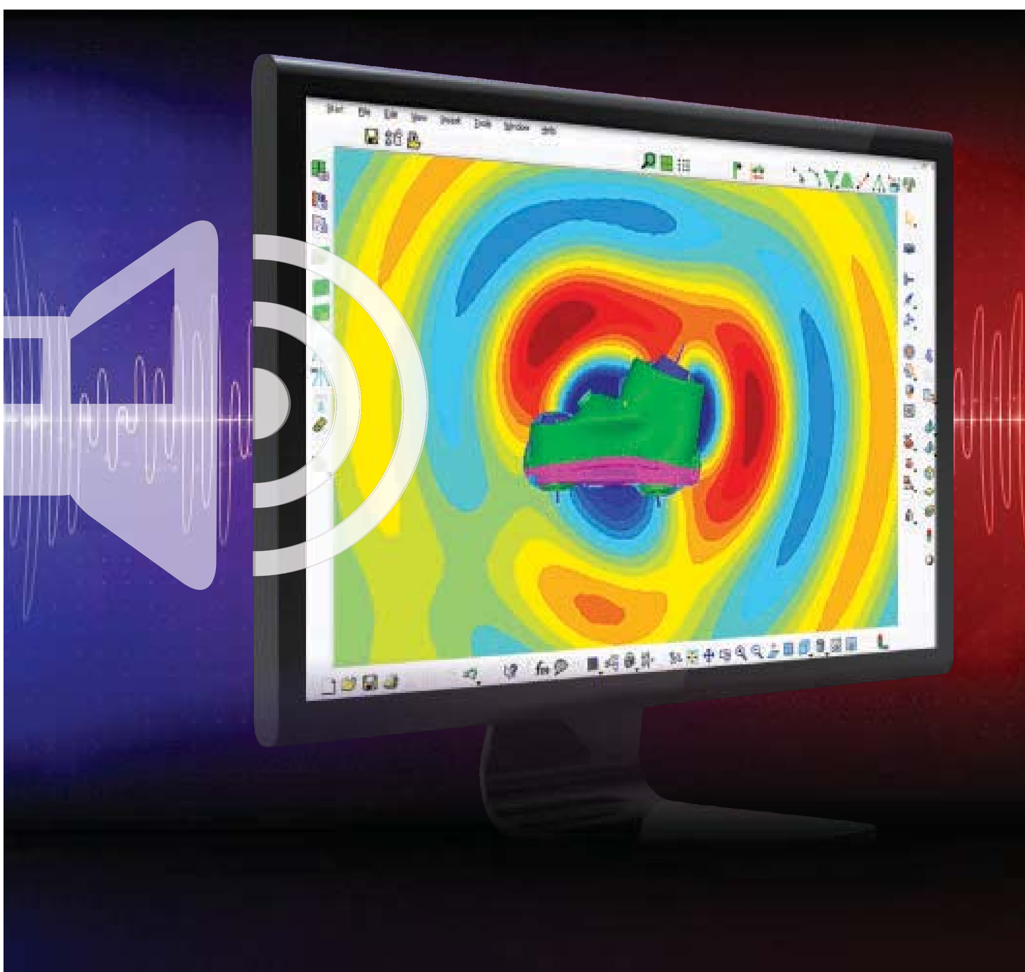
Noise or vibration could alert the manufacturer of underlying issues or inefficiencies within a product’s operating system. “More noise means less efficient,” he said.

And a great deal of the emphasis on how a product sounds as it operates comes about because consumers will associate noise and vibration with poor product performance. They’re more likely to seek out quiet products in a hypercompetitive industry, Bons said.

“With electronics, it’s the impression of quality,” he said. “If you can hear the laptop, you’re on the undesirable side of quality.

“It’s not a new concern, but I’ve been noticing the visibility and priority of concerns about acoustics are growing,” he added.

Because acoustical analysis followed the design stage, it sometimes resulted in sending the product back for adjustments—and design cycle time suffered. Or the sound quality itself suffered if the product was ushered out the



Noise or vibration could alert the manufacturer of underlying issues or **inefficiencies within a product's operating system.** A great deal of the emphasis on how a product sounds as it operates comes about because consumers will associate noise and vibration with **poor product performance**. They’re more likely to seek out quiet products in a hypercompetitive industry.

door on time.

Consumer electronics makers know they need to look at acoustical issues at the place where the electronics and the mechanics and the physical body of the device come together, which is often the purview of design engineers, said Sudhir Sharma, director of high-tech industry strategy at ANSYS in Canonsburg, Pa.

"They have to look at the intersection of all these physics," Sharma said.

NO MORE NOISE

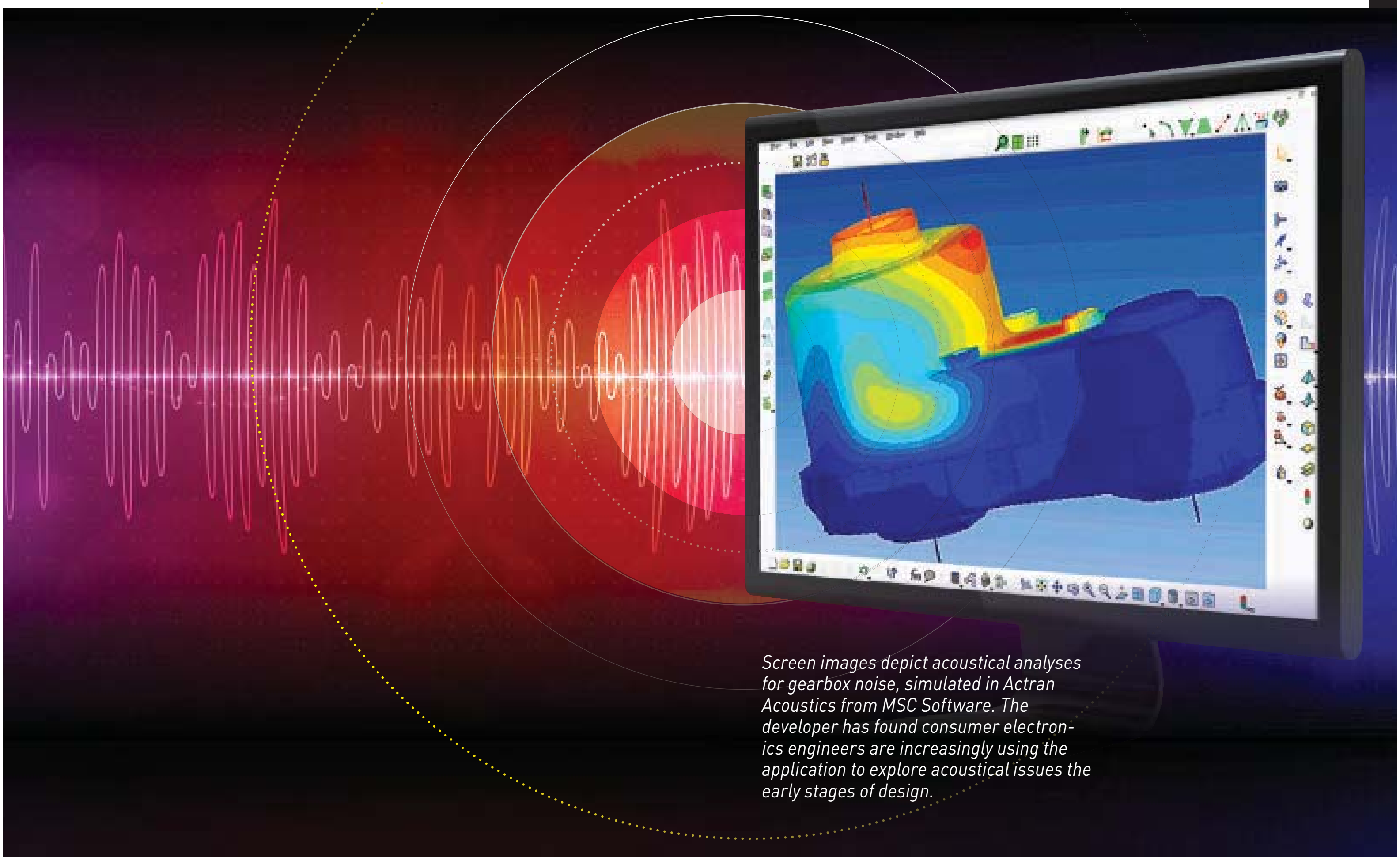
Mechanical engineers, working with industrial engineers, can use the software to predict a device's pattern of sound radiation, sound quality, loudness, and how the components inside will contribute to overall sound through vibration, Burd said. In the same way that they can simulate assemblies, subassemblies, or components with CAD in tandem with engineering software, engineers can perform either component-level or system level noise and vibration analyses while they design, he added.

Take the example of a cell phone.

According to Burd at MSC, "An engineer would have the geometry for a cell phone in CAD and then they'll take the speaker they want, put the simulation of that speaker inside the CAD simulation, fit it together in CAD, and put it into the acoustics software and work on sound performance. All within a virtual prototype."

Often the speakers used in consumer electronics are purchased from suppliers who provide speaker parameters, such as loudness and tone, for the design engineer. The speaker can then be simulated inside a cell phone housing that exists only in the form of a CAD file, he added.

If the predicted sound quality doesn't meet specifications, the design engineer can change the CAD model to decrease vibrations or unwanted noise, or can choose another speaker, Burd said.



Screen images depict acoustical analyses for gearbox noise, simulated in Actran Acoustics from MSC Software. The developer has found consumer electronics engineers are increasingly using the application to explore acoustical issues the early stages of design.

What's changed is the accessibility that allows expert tools to be used by a mechanical engineer or designer because those tools become easy enough to use and understand.

Design engineers have the geometry of a cell phone in their CAD system. They can take sound parameters for the speaker, simulate the speaker in the software, and compute an acoustical analysis.

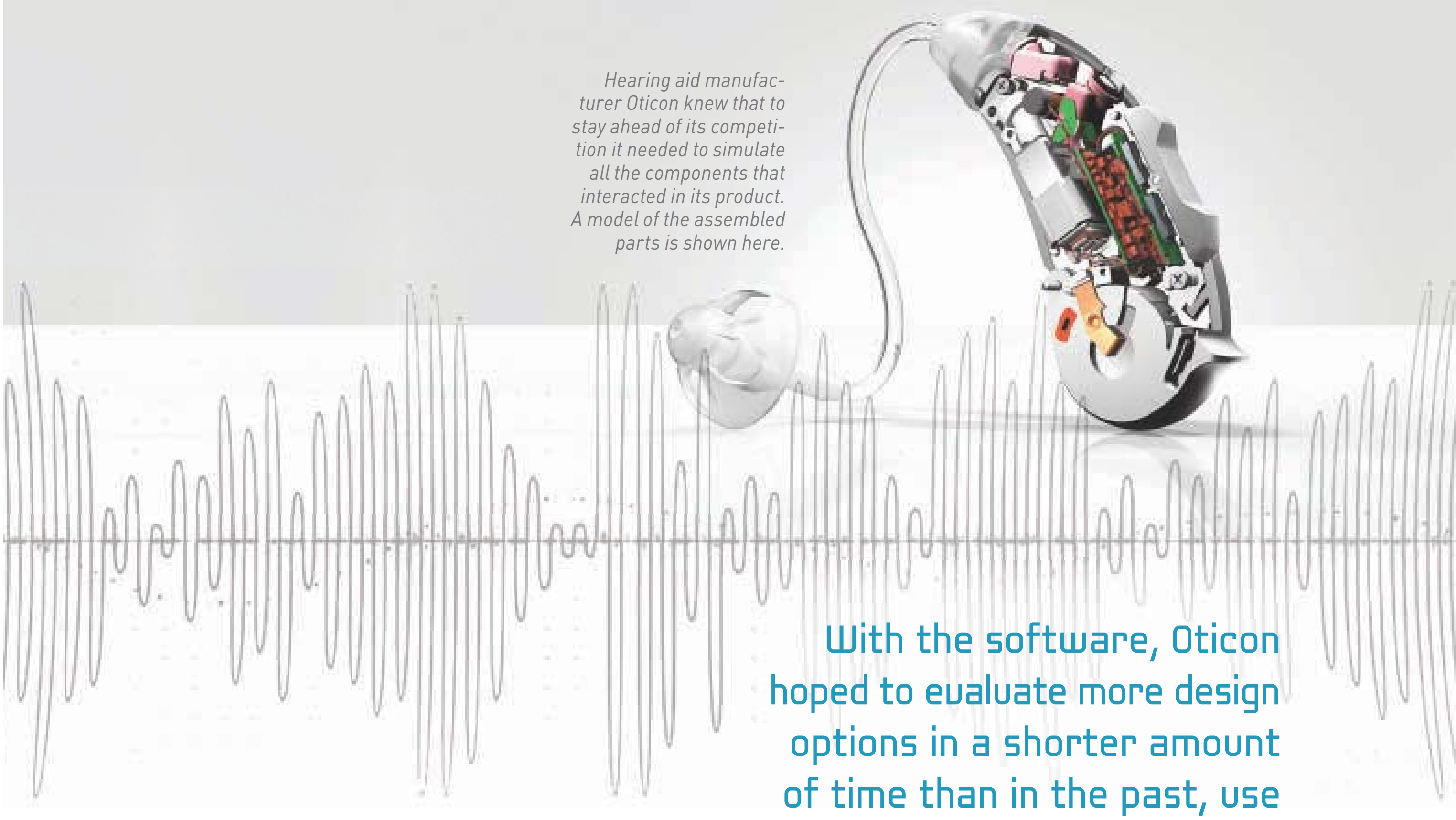
All this means that software makers are now coupling or integrating acoustical analysis software with the CAD software used by mechanical engineers or are customizing their software for a manufacturer to perform acoustical analysis earlier in the design cycle.

"What's changed is the accessibility that allows expert tools to be used by a mechanical engineer or designer because they've become easy enough to use and understand," Sharma said.

MSC Software recently worked with, Oticon, a Somerset, N.J., maker of hearing aids, which recently gave designers responsibility for initial acoustical simulation, Sharma said. ANSYS customized its Application Customization Toolkit, or ACT, software for Oticon users.

"I've known them for the past six years, and there were only experts doing acoustics," Sharma said. "Two years ago, they started on a project to make it easier for designers to do acoustics simulation. We helped them make the tools easier for everyone."

The hearing-aid maker knew that to stay ahead of its competition, it needed to simulate



Hearing aid manufacturer Oticon knew that to stay ahead of its competition it needed to simulate all the components that interacted in its product. A model of the assembled parts is shown here.

all the components that interacted rather than only the key parts of the hearing aid, said Martin Larsen, Oticon's simulation specialist.

With the software, Oticon hoped to evaluate more design options in a shorter amount of time than in the past, use simulation to create a more reliable product, and reduce cost and time to market by minimizing troubleshooting later in the design process, he added.

Oticon used the ACT software to simplify the creation of models for microphones and receivers. The hearing-aid maker also created workflows that walked the designers through the process of simulating device performance, Larsen said.

Now, Oticon designers do 75 percent of design validation formerly done by simulation experts. This allows the experts to focus on the sensitivity of the device and to better understand potential failures, Larsen added.

Earlier simulation also allows designers to order speakers earlier in the design process, Burd said. Usually, a manufacturer orders the speakers for devices such as cell phones or stereos from suppliers, and often, Burd said, the speakers are first tested in the prototyped device itself.

With the software, Oticon hoped to evaluate more design options in a shorter amount of time than in the past, use simulation to create a more reliable product, and reduce cost and time to market by minimizing troubleshooting later in the design process.

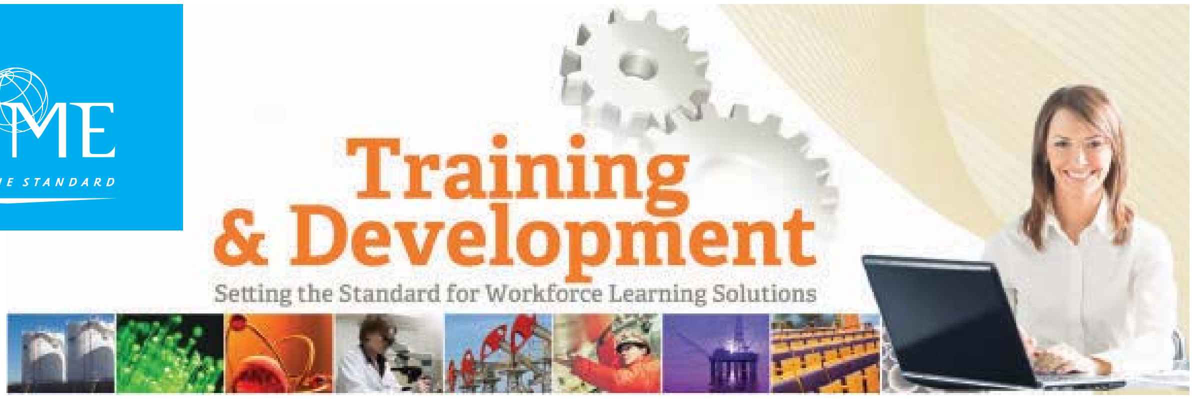
But with speaker sound quality and other pertinent information in hand, designers can actually design from the get-go with that information in mind, resulting in fewer design changes down the line, he added.

Though early acoustical simulation is still perhaps one of the consumer electronics' industries best-kept secrets, that's likely to change as word gets out about the many advantages of front-line simulation, Burd said.

According to Burd, "Electronics is a very strong and growing industry, and most people within it could benefit from acoustic simulation." ME

JEAN THILMANY is an associate editor of *Mechanical Engineering* magazine.

ASME
SETTING THE STANDARD



TRAINING COURSES FOR ENGINEERS AND TECHNICAL PROFESSIONALS

2014 AUTUMN

SEPTEMBER 2014 – LAS VEGAS, NEVADA USA

PD387	Understanding Chiller Performance, Operation and Economics	22 Sep
PD100	Introduction to Elevators and Escalators	22-23 Sep
PD475	The New Engineering Manager: Moving from Technical Professional to Manager	22-23 Sep
PD561	Geometric Dimensioning and Tolerancing Advanced Applications with Stacks and Analysis **TOP SELLER**	22-23 Sep
PD190	BPV Code, Section IX: Welding, Brazing and Fusing Qualifications *ASME CODE COURSE*	22-24 Sep
PD268	Fracture Mechanics Approach to Life Predictions	22-24 Sep
PD349	Design and Applications of Centrifugal Pumps	22-24 Sep
PD467	Project Management for Engineers and Technical Professionals	22-24 Sep
PD615	BPV Code, Section III, Division 1: Class 1, 2 & 3 Piping Design *ASME CODE COURSE*	22-24 Sep
PD685	The New Engineering Manager: Moving from Technical Professional to Manager and Strategic Thinking Combo Course **SAVE UP TO $465!**	22-24 Sep
PD711	ASME NQA-1 and DOE Quality Assurance Rule 10 CFR 830 **NEW!**	22-24 Sep
PD720	Layout of Process Piping Systems **NEW!**	22-24 Sep
PD010	ASME A17.1 Safety Code for Elevators and Escalators *ASME CODE COURSE*	22-25 Sep
PD184	BPV Code Section III, Division 1: Rules for Construction of Nuclear Facility Components *ASME CODE COURSE*	22-25 Sep
PD359	Practical Welding Technology	22-25 Sep
PD448	BPV Code, Section VIII, Division 2: Pressure Vessels *ASME CODE COURSE* **TOP SELLER**	22-25 Sep
PD603	Geometric Dimensioning and Tolerancing Combo Course **SAVE UP TO $380!**	22-25 Sep
PD620	Core Engineering Management	22-25 Sep
PD657	HVAC Systems and Chiller Performance Combo Course **SAVE UP TO $475!**	22-25 Sep
PD013	B31.1 Power Piping Code *ASME CODE COURSE*	22-26 Sep
PD602	Elevator and Escalator Combo Course **SAVE UP TO $635!**	22-26 Sep

CONTINUED, SEPTEMBER. 2014 – LAS VEGAS, NEVADA USA

PD629	Project Management Combo Course **SAVE UP TO $635!**	22-26 Sep
PD686	Layout of Process Piping Systems and Managing 3D CAD/CAE Systems	22-26 Sep
PD027	Heating, Ventilating and Air-Conditioning Systems: Sizing and Design	23-25 Sep
PD676	Strategic Thinking	24 Sep
PD570	Geometric Dimensioning & Tolerancing Fundamentals 1 *ASME CODE COURSE*	24-25 Sep
PD690	Economics of Pipe Sizing and Pump Selection **NEW!**	24-25 Sep
PD102	How to Perform Elevator Inspections Using ASME A17.2	24-26 Sep
PD496	Preparing for the Project Management Professional Certification Exam	25-26 Sep
PD583	Pressure Relief Devices: Design, Sizing, Construction, Inspection and Maintenance *ASME CODE COURSE*	25-26 Sep
PD606	NQA-1 Requirements for Computer Software Used in Nuclear Facilities *ASME CODE COURSE*	25-26 Sep
PD673	Design and Selection of Heat Exchangers	25-26 Sep
PD721	Plant Layout and Utilization of 3D CAD/CAM Systems	25-26 Sep

Visit go.asme.org/lasvegas5

SEPEMBER - OCTOBER 2014 – BARCELONA, SPAIN

PD146	Flow-Induced Vibration with Applications to Failure Analysis	29 Sep-1 Oct
PD389	Nondestructive Examination – Applying ASME Code Requirements (BPV Code, Section V) *ASME CODE COURSE*	29 Sep-1 Oct
PD442	BPV Code, Section VIII, Division 1: Design and Fabrication of Pressure Vessels *ASME CODE COURSE* **TOP SELLER**	29 Sep-1 Oct
PD635	ASME NQA-1 Quality Assurance Requirements for Nuclear Facility Applications *ASME CODE COURSE*	29 Sep-1 Oct
PD645	BPV Code: Section IX Welding, Brazing and Fusing Qualifications *ASME CODE COURSE*	29 Sep-1 Oct
PD616	API 579 /ASME FFS-1 Fitness-for-Service Evaluation	29 Sep-2 Oct
PD643	ASME B31.3 Process Piping Code *ASME CODE COURSE*	29 Sep-2 Oct

REGISTER NOW: United States and Canada 1.800.843.2763, Europe +32.2.743.1543

CONTINUED, SEPTEMBER – OCTOBER 2014 – BARCELONA, SPAIN

PD644	Advanced Design and Construction of Nuclear Facility Components Per BPV Code, Section III *ASME Code Course*	29 Sep-2 Oct
PD672	BPV Code, Section XI, Division 1: Inservice Inspection 10-Year Program Updates for Nuclear Power Plant Components *ASME Code Course*	29 Sep-2 Oct
PD675	ASME NQA-1 Lead Auditor Training	29 Sep-2 Oct
PD716	BPV Code, Section 1: Power Boilers **NEW!** *ASME Code Course*	29 Sep-2 Oct
PD443	BPV Code, Section VIII, Division 1 Combo Course *ASME Code Course* **SAVE UP TO €800! TOP SELLER**	29 Sep-3 Oct
PD684	BPV Code Section III, Division 1: Rules for Construction of Nuclear Facility Components *ASME Code Course*	29 Sep-3 Oct
PD441	Inspections, Repairs and Alterations of Pressure Equipment *ASME Code Course*	2-3 Oct

Visit go.asme.org/barcelona1

OCTOBER 2014 – ATLANTA, GEORGIA USA

PD107	Elevator Maintenance Evaluation	6-7 Oct
PD391	ASME B31.4 Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids *ASME Code Course*	6-7 Oct
PD539	Bolted Joints and Gasket Behavior	6-7 Oct
PD690	Economics of Pipe Sizing and Pump Selection	6-7 Oct
PD077	Failure Prevention, Repair and Life Extension of Piping, Vessels and Tanks *ASME Code Course*	6-8 Oct
PD370	B31.8 Gas Transmission and Distribution Piping Systems *ASME Code Course*	6-8 Oct
PD506	Research and Development Management	6-8 Oct
PD513	TRIZ: The Theory of Inventive Problem Solving	6-8 Oct
PD571	The Taguchi Design of Experiments for Robust Product and Process Designs	6-8 Oct
PD597	Risk-Informed Inservice Testing	6-8 Oct
PD618	Root Cause Analysis Fundamentals	6-8 Oct
PD683	Probabilistic Structural Analysis, Design and Reliability-Risk Assessment	6-8 Oct
PD394	Seismic Design and Retrofit of Equipment and Piping	6-9 Oct
PD632	Design in Codes, Standards and Regulations for Nuclear Power Plant Construction *ASME Code Course*	6-9 Oct
PD675	ASME NQA-1 Lead Auditor Training	6-9 Oct
PD432	Turbo Machinery Dynamics: Design and Operation	6-10 Oct
PD601	Bolting Combo Course **SAVE UP TO $1,260!**	6-10 Oct
PD386	Design of Bolted Flange Joints	8 Oct
PD449	Mechanical Tolerancing for Six Sigma	8-9 Oct
PD698	Predictive Maintenance Technologies **NEW!**	8-10 Oct
PD575	Comprehensive Negotiating Strategies®: Engineers and Technical Professionals	9-10 Oct
PD577	Bolted Joint Assembly Principles Per PCC-1-2013 *ASME Code Course*	9-10 Oct

CONTINUED, OCTOBER 2014 – ATLANTA, GEORGIA USA

PD591	Developing Conflict Resolution Best Practices	9-10 Oct
PD706	Inline Inspections for Pipelines	9-10 Oct

Visit go.asme.org/atlanta4

OCTOBER 2014 – HOUSTON, TEXAS USA

PD115	The Gas Turbine: Principles and Applications	20-21 Oct
PD313	Fundamentals of Fastening Systems	20-21 Oct
PD624	Two-Phase Flow and Heat Transfer	20-21 Oct
PD146	Flow Induced Vibration with Applications to Failure Analysis	20-22 Oct
PD231	Shock and Vibration Analysis	20-22 Oct
PD395	API 579-1/ASME FFS-1 Fitness-for-Service	20-22 Oct
PD410	Detail Engineering of Piping Systems	20-22 Oct
PD442	BPV Code, Section VIII, Division 1: Design and Fabrication of Pressure Vessels *ASME Code Course* **TOP SELLER**	20-22 Oct
PD523	Quality Assurance (QA) Considerations for New Nuclear Facility Construction *ASME Code Course*	20-22 Oct
PD619	Risk and Reliability Strategies for Optimizing Performance	20-22 Oct
PD633	Overview of Codes and Standards for Nuclear Power Plant Construction *ASME Code Course*	20-22 Oct
PD702	Process Safety and Risk Management for Mechanical Engineers **NEW!**	20-22 Oct
PD010	ASME A17.1 Safety Code for Elevators and Escalators *ASME Code Course*	20-23 Oct
PD014	B31.3 Process Piping Design *ASME Code Course*	20-23 Oct
PD672	BPV Code, Section XI, Division 1: Inservice Inspection 10-Year Program Updates for Nuclear Power Plant Components *ASME Code Course*	20-23 Oct
PD679	Fundamentals of Pumps and Valves and Their Selection for Optimum System Performance **NEW!**	20-23 Oct
PD443	BPV Code, Section VIII, Division 1 Combo Course **SAVE UP TO $645!** *ASME Code Course* **TOP SELLER**	20-24 Oct
PD581	B31.3 Process Piping Design, Materials, Fabrication, Examination and Testing Combo Course *ASME Code Course* **SAVE UP TO $575!**	20-24 Oct
PD665	BPV Code, Section I: Power Boilers *ASME Code Course*	20-24 Oct
PD699	Reliability Excellence Fundamentals **NEW!**	22-24 Oct
PD441	Inspections, Repairs and Alterations of Pressure Equipment *ASME Code Course*	23-24 Oct
PD567	Design, Analysis and Fabrication of Composite Structure, Energy and Machine Applications	23-24 Oct
PD634	Comparison of Global Quality Assurance and Management System Standards Used for Nuclear Applications *ASME Code Course*	23-24 Oct
PD457	B31.3 Process Piping Materials Fabrication, Examination and Testing *ASME Code Course*	24 Oct

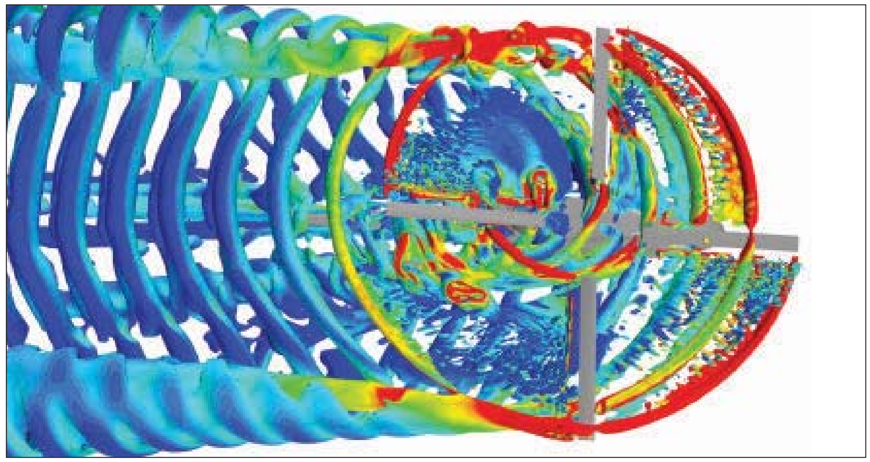
Visit go.asme.org/houston5

VISIT: go.asme.org/training

ENGINEERING SIMULATIONS

CD-ADAPCO, NEW YORK

The computer-aided engineering simulation software Star-CCM+ is now on to version 9.04, the second release of 2014. Users should see reductions in the time it takes to find a solution as well as improvements to workflow, parallel meshing, and optimization. The new physics models can perform engineering simulations that more closely represent the real world conditions. The concurrent per-part meshing feature allows users to distribute the wrapping and meshing of complex multi-part assemblies over many parallel processors. With the adjoint solver expression, users can mathematically combine individual cost functions into more representative expressions. The application's CAD robustness study feature identifies potential geometry failures and offers optimization studies, while dynamic fluid body interaction (DFBI) contact coupling allows for the modeling of contact and collisions between moving bodies and boundaries.



A rotor wake, colored by vorticity, around the blades of a Robin helicopter is simulated using computer-aided engineering simulation software Star-CCM+ from CD-adapco. Image: CD-Adapco

PLATFORM DEVELOPMENT

OPEN DESIGN ALLIANCE, PHOENIX

Teigha, a software development platform for engineering applications, has been upgraded to version 4.0. The developer is a nonprofit consortium of software developers involved in design. Members commit to open industry-standard formats for the exchange of CAD data. The Teigha platform gives developers tools to create a variety of applications. The upgraded version contains the alpha release of Teigha Cloud, the developer's framework for cloud-based rendering of .dwg (drawing) and .dgn (design) files. This cloud framework is intended to give users access to information and processing on mobile devices in order to minimize development time. It also enables users to deploy their applications without obligation to a hosting service. To that end, Teigha 4.0 contains enhanced support for mobile platforms, including Java support for Android.

3-D DATA VISUALIZATION

CREAFORM, LÉVIS, QUÉBEC

VXremote is a remote-access software application for visualization of scanned data on the developer's rugged 3-D scanning and measurement tablets. The application provides remote access to VXelements, the developer's 3-D software platform used for scanning and installed on the tablets. The remote-access application enables users to visualize real-time data and change parameters without use of a laptop. It's particularly useful when scanning large objects or when the scanning has to be performed in constrained or remote areas, according to the developer. It doesn't require users to have Internet access to log in to their accounts.

SHEET METAL MACHINING

LANTEK SYSTEMS, MASON, OHIO

Lantek 2D CAM for sheet metal and steel structures has been upgraded to include improvements to nesting algorithms with new options that include: defining ranges by thickness, destruction of holes, and improved drilling and overlap technology. Also, the geometry importer now automatically selects the technology required for a contour. The upgrade includes more accurate nesting capabilities than available in past versions. New options include: defining ranges by thickness, destruction of holes, and improved drilling and overlap technology. This upgrade also features the capacity to program for the latest generation of machines, such as fiber-optic laser cutting machines and machines combined with milling.

ENGINEER-TO-ORDER AUTOMATION

SIEMENS PLM, PLANO, TEXAS

The engineering software developer has paired with Tata Consultancy Services, an IT consulting and business service provider in Mumbai, to release ETO2Win, which automates a manufacturer's engineer-to-order process. The software captures, manages, and reuses engineering knowledge and uses it to automate business processes across a manufacturing company. The software package streamlines a product's inquiry-to-quote and order-to-release processes, enabling manufacturers to sell according to their engineering and manufacturing capabilities, according to the developers. ME

SUBMISSIONS

Submit hard copy or e-mail memag@asme.org, using subject line "Software Exchange." *ME* does not test or endorse software described here.

BI-POLAR LIFTING MAGNETS

ERIEZ, ERIE, PA.

Lifting magnets enable users to lift and move steel without direct attachment by slings, hooks, or cables. The magnets, available in a wide range of optional pole-plate configurations, are designed to provide contact and holding strength for pipe, rounds, bundles, angles, and other shapes. They can be used in both single and multiple magnet applications. They are available in square and rectangular designs in six sizes.

CORROSION-RESISTANT ALLIGATOR CLIPS

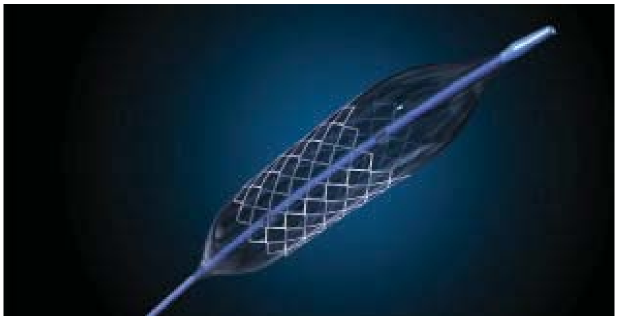
MUELLER ELECTRIC CO., AKRON, OHIO.

Corrosion-resistant alligator clips feature solid copper construction for soldering, along with 302 grade stainless steel springs and rivets. Alligator test clips are available in five styles, including 5-amp elongated jaw copper (BU-34M); 10-amp copper (BU-60M); 50-amp mini battery version (BU-46M); 50-amp center spring general purpose (BU-27M); and 100-amp heavy duty marine.

TORQUE SENSOR

SENSORDATA TECHNOLOGIES INC., SHELBY TOWNSHIP, MICH.

The BT4000 Series offers Bluetooth wireless rotary torque sensing in high-vibration environments. The series offers transmission of measured torque data, and can measure torque up to 8,000 Nm at speeds up to 7,000 rpm, with analog voltage, digital, or frequency signal outputs. Design of the BT4000 Series features encapsulated on-board electronics that provide strain gauge bridge excitation, bridge output amplification, and offers amplified signal conversion into a 16-bit digital word.



COMPOUNDS FOR CATHETERS

FOSTER CORP., PUTNAM, CONN.

LoPro Plus radiopaque compounds are reinforced with nanoparticles for pushability of thin wall catheters. The compounds allow for extrusion of single layer tubes with radiopacity and strength properties equivalent to conventional two layer tubes, in which each layer provides the distinct properties. LoPro Plus reduces material and inventory costs when compared to standard two layer constructions. Radiopaque compounds typically include barium or bismuth filler to provide fluoroscopic visibility of catheters within blood vessels, but the fillers are not designed to improve strength.

REVOLVING BALL KNOBS

J.W. WINCO INC., NEW BERLIN, WIS.

These RoHS-compliant revolving ball knobs can be utilized instead of other revolving handles, i.e. with handwheels. The tapped shoulder allows the ball knob to be mounted from the underside via a screw or bolt. The knob can then be mounted to sheet metal in a variety of thicknesses, flat bar, or castings, to create a quick cranking or turning mechanism. The hand piece is black phenolic plastic (Duroplast PF), and the shoulder is made of zinc-plated, blue passivated steel, blind tapped.

WORKPIECE CLAMP

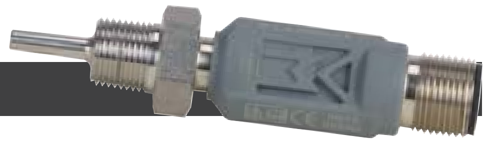
LEXAIR, LEXINGTON, KY.

The OML VariClamp modular clamping system uses a floating mechanism of fixed and movable jaws and a variety of gripper forms to provide custom clamping of irregular-shaped workpieces, including round, curved, elliptical, rectangular, stepped, and slanted parts. VariClamp vises can be configured with any combination of fixed or swiveling jaws, and various styles and heights of grippers—including smooth, serrated, soft, high, and with or without stops.

PROCESS TUBING BUNDLES

CHROMALOX, PITTSBURGH.

Jacketed process tubing bundles are used to protect viscous materials from freezing, to avoid gas condensation, and to improve employee safety. The tubing bundles are available with copper, stainless, high alloy, or fluoropolymer process tubing as well as a variety of insulation and jacket materials. Traced bundles incorporate steam tubing or electric heat trace with choice of self-regulating or constant wattage heating elements.



TEMPERATURE TRANSMITTERS

OMEGA ENGINEERING INC., STAMFORD, CONN.

The M12TXC series of compact and programmable M12 RTD temperature transmitters features a 4 to 20 mA output and has a unique probe that can be used for areas with space limitations where traditional head connections are too large to fit. The M12 thread design offers a secure industrial fit and is good for food and beverage, chemical, petrochemical, pharmaceutical, pumps, and plumbing applications.

FAILSAFE CONTROLLER

SIEMENS CORP., PRINCETON, N.J.

The SIMATIC S7-1518F is a failsafe controller that is available with a bit performance of 1 nanosecond. It is designed to increase flexibility, safety, efficiency, and productivity at the plant floor level and is suitable for high-end standard and safety-related machine and plant automation applications. The S7-1518F has four communication interfaces: a Profinet interface with a 2-port switch for communication with the field level, two Profinet interfaces, and one Profibus interface.

CONTROLLER WITH MOBILE APP

NANOSPARK, ALTOONA, WIS.

The new Nanospark Controller connects Apple mobile devices to any type of sensor or actuator. It allows users to gather instrument data and create custom control systems to manage and improve equipment operations. Nanospark, comprising a machine interface controller and an iOS app, connects an iPad, iPhone, or iPod touch with a wide variety of sensors and switches. The machine interface controller component has eight digital and six analog inputs as well as eight digital and two analog outputs. Outputs can be set and inputs can be read by communication with the iOS framework.

SUBMISSIONS

Submit electronic files of new products and images by e-mail to memag@asme.org. Use subject line "New Products." *ME* does not test or endorse the products described here.

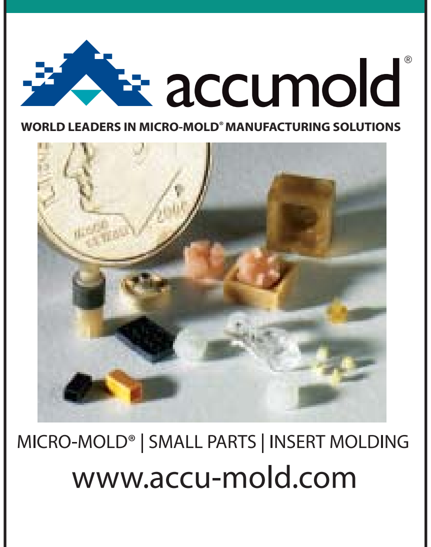
RESOURCEFILE

- Instrumentation & Control
- Power Transmission & Motion Control
- Fluid Handling
- Materials & Assembly
- Engineering Tools
- Other Products & Services

A bimonthly listing of the industry's latest technical literature and product information available FREE to *Mechanical Engineering* readers.

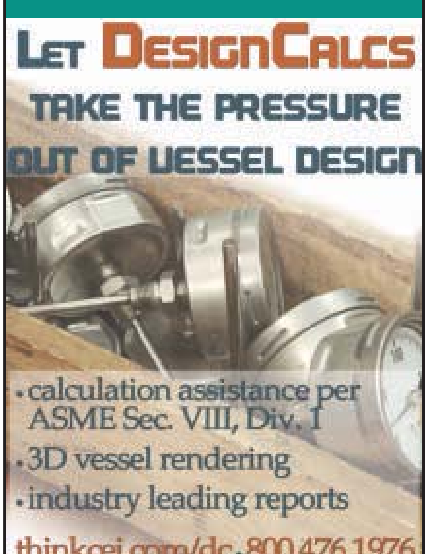
Receive an item by visiting **http://mecheng.hotims.com** and click on the company name.

A&A MANUFACTURING

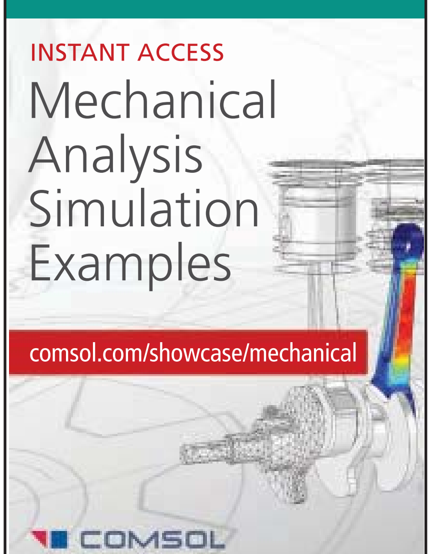


ACCUMOLD

CLIPPARD



COMPUTER ENGINEERING



COMSOL

FOREST CITY GEAR

FOR ALL
RECRUITMENT
ADVERTISING
INQUIRIES

CONTACT:
MICHELLE
LEWITINN
(212) 591-8379
LewitinnM@asme.org

THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

Design and Agile Manufacture of
High Performance/Lightweight Structures for Transportation
Department of Mechanical and Aerospace Engineering

The College of Engineering at The Ohio State University (engineering.osu.edu) seeks to fill three tenure-track faculty positions with individuals with outstanding expertise and demonstrated records of accomplishment in areas related to the design and manufacture of high performance and lightweight structures for transportation applications. The cluster hire is intended to be synergistic with a renewed regional emphasis on manufacturing, exemplified by the recent decision by the federal government to establish the American Lightweight Materials Manufacturing Innovation Institute (ALMMII), a public-private partnership led by EWI, University of Michigan, and The Ohio State University. The faculty members appointed through this cluster hire initiative will find strong infrastructure support (facilities and technical staff) to enable their success and effectiveness. They are expected to work together and, in collaboration with existing and developing research strengths in the OSU science and engineering community and our commercial partners, to develop extraordinary new programs of research that have a tangible impact on the manufacturing community.

As part of this cluster hire, the Department of Mechanical and Aerospace Engineering (MAE) seeks candidates who would be appropriate for a majority appointment in MAE and a minority appointment in another engineering department. Research leadership is expected of the hire, with preference for senior-level appointment at the full and associate professor levels. However, junior level appointments at the assistant professor level will also be considered under exceptional circumstances.

Expertise in one or more of the following areas is desired, with an emphasis on lightweight and multi-material structures and assemblies:
•High performance structures (dynamics of vehicle body structures, mechanics issues related to safety/crashworthiness, nonlinear material response, large-scale structural simulation, modeling and experimental validation of structural response, and mechanics of joined and multi-material structures)
•Agile manufacturing systems (advanced robotics and agile manufacturing, design and control issues related to automation, integrated systems for manufacturing processes, and manufacturing system development and integration)

We offer a vibrant research environment at one of the largest, best equipped and connected academic research platforms in North America. The Strategic Plan of the College of Engineering at Ohio State holds ambitious teaching and learning objectives that enhance the overall research and discovery goals and align with major national initiatives such as the National Network of Manufacturing Innovation (http://manufacturing.gov/nnmi.html). The successful cluster hire candidates will possess agility across the material structure-properties-processing-performance paradigm and be able to couple this to modern concepts in modeling, material processing, and analysis, to develop compelling teaching and research programs. These new programs are expected to have strong links to industry needs and provide essential training to the next generation of practicing engineers and leaders in manufacturing.

We seek candidates with demonstrated track records of leadership or compelling promise of such potential, and collaboration in an academic and/or R&D environment. Industrial experience and/or a record of successful collaboration with industry would be an asset. Candidates must have earned doctoral degrees in engineering or closely related fields. Successful candidates will be expected to attract significant federal funding and industrial partnerships in order to develop and sustain active sponsored research programs, teach core undergraduate and/or graduate courses, and develop new graduate courses related to their research expertise. The anticipated start dates are flexible, with a preference for starting dates no later than August 2015. Screening of applicants will begin immediately, and will continue until the positions are filled. Interested candidates should upload complete curriculum vitae, separate 2-3 page statements of research and teaching goals, and the names and postal/email addresses of five references electronically at http://www.mecheng.osu.edu/faculty_positions

The Ohio State University is an equal opportunity employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation or identity, national origin, disability status, or protected veteran status. Columbus is a thriving metropolitan community, and the University is responsive to the needs of dual career couples.

POSITIONSOPEN

ASSISTANT/ASSOCIATE/FULLTIME PROFESSOR (TENURE-TRACK/TENURED) DEPARTMENT OF MECHANICAL AND INDUSTRIAL ENGINEERING COLLEGE OF ENGINEERING Duties include undergraduate and graduate level teaching, initiating and sustaining independent, externally funded research, and supervising graduate students to successful degree completion. Candidates for Assistant Professor rank are expected to demonstrate potential to develop a viable and nationally visible research and educational program, while candidates for Associate or Full Professor ranks are expected to possess a well-established prominent record of excellence at the appropriate level for the rank. Required Qualifications: Ph.D. in Engineering with specialization in engineering mechanics and composite materials with experimental and modeling experience. Preferred Qualifications: A proven record in the mechanics, manufacturing and/or synthesis of composite materials, including smart, self-healing composite materials and the associated manufacturing processes; experience with applications relating to lightweight piping, pressure vessel and automotive and aero structures; balanced experience in experimentation and modeling. Salary and rank are commensurate with qualifications and experience. An offer of employment is contingent on a satisfactory pre-employment background check. Application review will begin October 30, 2014 and continue until a candidate is selected. Apply online and view a more detailed ad at: www.lsusystemcareers.lsu.edu. Position #008843. Quick link at ad URL: https://lsusystemcareers.

POSITIONSOPEN

lsu.edu/applicants/Central?quickFind=56970. LSU IS AN EQUAL OPPORTUNITY/EQUAL ACCESS EMPLOYER

THE DEPARTMENT OF MECHANICAL ENGINEERING AT THE NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY (New Mexico Tech) invites applications for a tenure-track Assistant Professor of Mechanical Engineering position, beginning August 2014. Responsibilities include teaching undergraduate and graduate mechanical engineering courses and developing research programs. In addition, they include advising students and participating in service activities in the profession and for the university. Areas of specialization in the department include: solid mechanics, mechatronics and robotics, explosives engineering, and fluid and thermal sciences. Requirements: Ph.D. in Mechanical Engineering or closely related field; college-level teaching experience and demonstrated scholarly research. Preference will be given to candidates with a background in solid mechanics, with further background in mechanical design, fracture mechanics, structures and vibration very desired. Well-qualified applicants with backgrounds in the other specialties mentioned above will also be considered. Candidates would be expected to develop original research efforts and to collaborate with current faculty in the department. To apply, submit a letter of application that includes teaching and research philosophy, curriculum vita and three letters of recommendation to Human Resources, 801 Leroy Place, Brown Hall Box 052, Socorro, NM 87801. Application

THE ARGONNE NAMED FELLOWSHIP PROGRAM

Argonne National Laboratory is accepting applications for the 2015 Named Fellowship. Argonne awards these special fellowships internationally on an annual basis to outstanding doctoral-level scientists and engineers who are at early points in promising careers. The fellowships are named after scientific and technical luminaries who have been associated with Argonne and its predecessors, and the University of Chicago, since the 1940's.

Candidates for these fellowships must display superb ability in scientific or engineering research, and must show definite promise of becoming outstanding leaders in the research they pursue. Fellowships are awarded annually and may be renewed up to three years. The 2014 fellowship carries a highly competitive salary with an additional allocation research support and travel. The deadline for submission of application materials is October 7, 2014.

Applications must be submitted online through: http://www.anl.gov/careers/apply-job . Correspondence and supporting letters of recommendation should be submitted to Named-Postdoc@anl.gov.

For more information visit the Argonne Postdoc Blog at https://blogs.anl.gov/postdoc/ or by contacting the Postdoctoral Program Coordinator, Kristene Henne at khenne@anl.gov.

Argonne is an equal opportunity employer and we value diversity in our workforce. Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC

POSITIONS OPEN

review will begin immediately and will continue until the position is filled. New Mexico Tech is a nationally-recognized Science, Technology, Engineering, and Mathematics university offering degrees through the PhD with a strong program in Mechanical Engineering. For more information about New Mexico Tech, visit our web page at http://www.nmt.edu/. (Candidates qualified beyond the Assistant Professor level will be considered at the Associate Professor level).

NANJING TECH UNIVERSITY FACULTY POSITIONS in College of Mechanical and Power Engineering This announcement invites applications for tenure-track faculty positions in: Mechanical Engineering, New Energy Science and Engineering, Welding Technology and Engineering, Mechanical Design Manufacturing and Automation, Vehicle Engineering, Process Equipment and Control Engineering. Required Qualifications: Ph.D. in Mechanical Engineering or a closely related field is required. Initial appointments are at the assistant professor level. Exceptionally qualified candidates at the associate or full professor level may also be considered. Rank and salary are commensurate with experience and accomplishments. Candidates should send application to chunlei-shao@njtech.edu.cn. A CV, list of publications, statements of research and teaching plans are required. Applications received before December 31, 2015 will be guaranteed full consideration. Additional information is available at http://www.njtech.edu.cn.

THE UNIVERSITY OF BRITISH COLUMBIA DEPARTMENT OF MECHANICAL ENGINEERING The Department of Mechanical Engineering at the University of British Columbia seeks an outstanding individual for a tenure-track position at the Assistant Professor level in the broad area of Applied Mechanics. Areas of particular interest include, but are not limited to, solid mechanics, biomechanics, advanced materials, and smart structures. The starting date will be July 2015, or as soon as possible thereafter. The ideal candidate will complement our existing strengths and develop an internationally recognized, externally funded research program. Applicants must have either demonstrated or possess a clear potential and interest in achieving excellence in teaching, and provide service to the University and community. Industrial experience is an asset. She/he will hold a Ph.D. degree or equivalent in Mechanical Engineering or a closely related field and will be expected to register as a Professional Engineer in British Columbia. Further information on the department is available at www.mech.ubc.ca, and information on the employment environment in the Faculty of Applied Science is available at www.apsc.ubc.ca/careers. The University of British Columbia hires on the basis of merit and is committed to employment equity. All qualified persons are encouraged to apply. We especially welcome applications from members of visible minority groups, women, Aboriginal persons, persons with disabilities, persons of minority sexual orientations and gender identities, and others with the skills and knowledge to engage productively with diverse communities. Canadians and permanent residents of Canada will be given priority. Applicants should submit a curriculum vitae, a statement (1-2 pages) of technical and teaching interests and accomplishments, and names and addresses (fax/e-mail included) of four referees. Applications should be submitted online at http://www.hr.ubc.ca/careers-postings/faculty.php. The closing date for applications is September 30, 2014. Please do not forward applications by e-mail.

CONSULTING

ADVERTISER INDEX

To purchase or receive information from our advertisers, go to **http://me.hotims.com,** visit the advertiser's website, or call a number listed below.

RECRUITMENT

CONSULTING

ONE ASME CONCEPT UNVEILED

MEMBERS OF ASME LEADERSHIP DISCUSSED a new organizational plan for the society during the Member Assembly held at the ASME Annual Meeting in Portland, Ore.

Under the new structure, called One ASME, the society's Knowledge & Community and Institutes sectors will be replaced by a new Technical Events and Content sector. The sections, technical divisions, institutes, and affinity groups currently under the K&C and Institutes sectors will remain intact, but will engage with ASME through a new Group Pathways and Support system.

The plan aims to encourage participation in ASME, leverage the expert knowledge of its members, and ensure that resources support projects with the most value to advance the society's mission. The plan was endorsed and approved by the Board of Governors at a meeting in April.

The discussion of the new approach was led by ASME senior vice presidents Karen Ohland and Bobby Grimes; Michael Ireland, managing director of the new Technical Events and Content sector; outgoing ASME president Madiha El Mehelmy Kotb; and ASME executive director Thomas G. Loughlin.

The program included a short video highlighting areas that One ASME will affect, everything from conferences, journals, and ASME.org to initiatives in areas such as advanced manufacturing and energy.

According to Kotb, "One ASME is a new approach to working collaboratively across the society, with an increased focus on the needs of the global engineering market."

Ohland said, "One ASME is about uniting the organization and getting out of our silos. It will allow us to leverage the impact of what we do across the board."

ROGERS ELECTED TO ACADEMY OF ARTS AND SCIENCES

ASME member John A. Rogers, Swanlund Professor of Materials Science and Engineering at the University of Illinois at Urbana-Champaign, has been elected to the American Academy of Arts and Sciences.

Rogers is also the director of the Frederick Seitz Materials Research Laboratory where he has pioneered flexible, stretchable electronics.

Rogers won the ASME Robert Henry Thurston Award in 2013.

The American Academy of Arts and Sciences is one of the oldest honorary societies in the United States. ■

SIMS CONFIRMED PRESIDENT;

J. ROBERT SIMS, AN ASME FELLOW AND member of the Industry Advisory Board, began his term as the Society's 133rd president during the President's Dinner at the ASME Annual Meeting in Portland, Ore.

At the same event, the ASME Nominating Committee announced the selection of **Julio Guerrero** as president-nominee for 2015-2016. The committee also announced the nominees for six other ASME leadership positions, including the next three members of the Board of Governors.

Passing the torch: ASME president J. Robert Sims and his predecessor, Madiha El Mehelmy Kotb.

Sims is a senior engineering fellow with Becht Engineering Co. Inc. and has been extremely active as a volunteer during his 35 years as an ASME member. He has served in a variety of leadership positions, including as a member of the Board of Governors and a senior vice president for Standards and Certification. Sims was the recipient of the Melvin R. Green Codes and Standards Medal in 2006, the J. Hall Taylor Medal in 2004, and the ASME Dedicated Service Medal in 1995.

Sims used his inaugural address to make the case for embracing an interdisciplinary approach over the coming years to ensure the Society's continued growth.

Using the analogy of athletics, Sim said, "Cross-training advances an athlete's workout regimen by varying the exercises to use muscles in different ways. It energizes the whole body and keeps the mind engaged. You build flexibility, power, and speed through an interdisciplinary approach. ASME members can benefit from an intellectual interdisciplin-

ASME OFFERS RECOMMENDATIONS TO CHINA:

REFOCUSING CHINA'S MANUFACTURING CAPACITY FROM inexpensive merchandise to products of value—from "big" to "strong" manufacturing—was the theme of the four-day Sino-American Technology and Engineering Conference held in Beijing in May.

The theme of transitioning China's manufacturing industry from big to strong was the connecting thread that ran through the one-day SATEC Forum on New Industrial Revolution and Intelligent Manufacturing.

Organized by ASME, the Chinese Academy of Engineering, the Chinese Mechanical Engineering Society, and the State Administration of Foreign Affairs Experts, the forum featured representatives from China and the United States discussing robotics, automation, additive manufacturing, and other emerging technologies, and sharing their thoughts on the new business models, product innovations, and improved standing in the world manufacturing market that widespread adoption of intelligent manufacturing could bring to China.

Speakers at the forum included ASME Fellow Thomas Kurfess, professor of engineering at Georgia Institute of Technology and former assistant director of advanced manufacturing at the White House Office of Science and Technology Policy; ASME Fellow Steven Schmid, professor of engineering at the University of Notre Dame; and Ralph Resnick, founding director of the National Additive Manufacturing Institute.

ASME staff and volunteers, including ASME president Madiha El Mehelmy Kotb and executive director Thomas G. Loughlin, participated in the SATEC meeting, where leaders from various engineering organizations and government agencies met to offer the Chinese government advice for developing its industrial policy.

Qiang Zhang, executive director

GUERRERO NAMED PRESIDENT-NOMINEE

ary approach, while pursuing common goals."

Sims said that, during his term, he will focus on implementing a new ASME structure intended to encourage members to participate in Society activities and to strengthen ASME's role in the global engineering profession.

(Sims talks to **Jean Thilmany** in this month's One on One, page 20.)

The new president-nominee, Julio Guerrero, is a principal, R&D and business development, at Draper Laboratory in Cambridge, Mass., and founder of Cambridge Research and Technology LLC. Prior to joining Draper in 2011, Guerrero served as a principal research scientist for seven years at Schlumberger Research.

Guerrero served as a member of ASME's Board of Governors from 2011 to 2013, and as vice-chair of the society's Industry Advisory Board from 2008 to 2010.

Presidents future, present, and past: From left, Guerrero, Sims, and Kotb.

The Nominating Committee also announced the names of three Board of Governors members and three vice presidents who will begin their three-year terms at next year's Annual Meeting, following membership approval by proxy ballot this autumn. Bryan Erler, Sriram Somasundaram, and Caecilia Gotama are the three Board of Governors nominees. The three vice president nominees are William Predebon, Education; Louis Bialy, Safety Codes and Standards; and Richard Stevenson, Conformity Assessment. ME

"SHIFT YOUR MANUFACTURING FROM BIG TO STRONG"

of ASME Asia Pacific LLC; and Michael Michaud, managing director, ASME global alliances, also represented ASME at the meeting.

During the first part of the four-day meeting, the ASME Advanced Manufacturing Team, consisting of 10 ASME volunteers from the society's Manufacturing Division, conducted inspections of four manufacturing sites in the Hunan Province.

The team—including experts from Ford Motor Co., General Motors, and Cummins—then composed a list of recommendations, which Kotb presented to China's Vice Premier Ma Kai and several other senior officials from various ministries during the conference's wrap-up meeting held at the Great Hall of the People in Beijing.

The team noted that each of the four companies inspected exhibited "notable strengths," but that "significant challenges exist for each company to transform itself from big to strong in terms of manufacturing."

The team recommended that manufacturing issues should be assessed from the product life cycle management perspective to ensure global optimization and lowest cost of ownership. Also, the team promoted developing smart services because in today's market, product design must go beyond satisfying explicitly expressed customer requirements and meet hidden customer requirements.

On the subject of safety, the team stressed the importance of promoting the use of proper protection equipment, such as ear plugs and protective eyewear.

The team also offered three long-term recommendations to help advance manufacturing in China. First, industry must identify gaps in critical components and subsystem manufacturing, and attempt to close those gaps. Chinese companies should also prioritize protecting intellectual property and developing a smart patent strategy. And the team said China should improve its research on critical manufacturing technologies in order to produce more world-class products.

THE TEAM RECOMMENDED THAT MANUFACTURING ISSUES SHOULD BE ASSESSED FROM THE PRODUCT LIFE CYCLE MANAGEMENT PERSPECTIVE TO ENSURE GLOBAL OPTIMIZATION AND LOWEST COST OF OWNERSHIP.

Other groups participating the 2014 SATEC meeting included the Chinese Institute of Engineers–USA; the Canadian Society of Civil Engineers; China's Ministry of Science and Technology, and Ministry of Water Resources; the Beijing Municipal Government; the Provincial Governments of Anhui, Fujian, and Hunan Province; and the Commercial Aircraft Corporation of China Ltd. ME

George Kellerman, Jake Johnson, and Jeff Moriarty in their engineering-themed brewery.

ART, SCIENCE, AND BEER

The line from engineering to brewing is more direct than some may think.

TIN WHISKERS NO LONGER LIVES IN JEFF'S BASEMENT. IT HAS MORPHED into a real, live brewery with a space of its own.

Wait, what? Those with an electrical background may know that a tin whisker is a small tendril that grows between adjacent integrated circuit pins and can short circuit electronic devices, like a printed circuit board.

"They're the bane of electrical engineers' existence," said George Kellerman, who is, in fact, an electrical engineer.

Tin Whiskers is also the name of a brewery in St. Paul that Kellerman owns with two partners, Jeff Moriarty and Jake Johnson. The names of its beers come from the world of electrical engineering. That's because the three owners are all EEs. They met at the University of Minnesota and then found themselves working in Minneapolis at Etherios Inc. During after-work happy hours they discovered a shared love of home brewing.

Because they are engineers, the interplay between the art and science of brewing beer was a topic of conversation they could never quite shake, Moriarty said. Wanting to test their theories, Johnson and Moriarty began brewing seven years ago on Moriarty's mom's stove. That operation moved to Moriarty's basement and Kellerman soon joined in. Early prototypes were successful.

The whole thing might have stayed a basement operation but for a tour of the local Surly Brewing Co. during which Moriarty had an epiphany: "We could do this on our own," he said.

A primer in all-grain brewing (versus extract brewing, as done on the stovetop), a 150-page business plan, private-equity fund raising, and the search for a location followed. The trio still works day jobs, though now at separate companies. Johnson is a field application engineer, and the other two guys rib him about it.

When it came time to name the brewery and its beers, the three sat down with a glossary of electrical engineering terms.

"That's how engineers name things," Kellerman said.

They tried to find names with cross-over appeal. So, they brew Short Circuit Stout, Flip Switch IPA, Wheatstone Bridge (an American style wheat beer), Schottky Pumpkin Ale (an homage to Walter Schottky, who helped develop the theory of electron and ion emission phenomena), and Ampere Biere.

One still-wintery day in the middle of March, the three and several of their friends found themselves assembling the huge silver kettles and drums used in brewing. Tin Whiskers resides in a many-windowed former industrial space on a tucked-away downtown corner. A wooden bar within the open-layout brewery serves as the taproom.

Connecting the mash tun, the boil kettle, and the fermenter was an extreme project, as the pieces arrived with only a picture of how the final layout should look. Little about the weekend of setting up the brewing equipment was fun, Johnson said, even for engineers.

The mash tun, the first vessel in the lineup into which go water and ingredients like barley and malt, is used in the mashing process that converts starches in crushed grains into sugars for fermentation. The mashing process produces wort, which goes into the boil kettle along with hops and is boiled to create hopped wort. After it cools, yeast is added to hopped wort and fermented into beer.

The fermenter is connected to the kegs and the kegs to the tap.

This setup, of course, is a much bigger job than stovetop brewing.

"It was like an advanced LEGOs project," Johnson said. "Even bigger than that. I think putting together furniture from Ikea would have been easier. At least it would have come with an Allen wrench."

"Oh, it did come with several wrenches," Moriarty assured him.

But with the equipment in place and a huge mural of the brewery's robot logo painted on one wall of the taproom, now came the fun part. The three got to relax with pints of their own, as they chatted with their first customers. A brewer's dream come true. ME

JEAN THILMANY