Putting the Brakes on Paint Waste

Written by Jeff Worley and Keith Elkins

Albert Einstein looms large atop a black bookcase in the office of Kozo Saito. In the poster-sized photo, Einstein's white hair is wild and tangled. His eyes are crinkled in merriment.

"Yes, he's a hero of mine," says Saito, whose easy smile makes you think of a boy who's just discovered a new Christmas bike under the tree, "but not so much for his mathematical theories. It's Einstein's *philosophy* that interests me more, his belief that science should serve human ends."

Saito, a professor of mechanical engineering at the University of Kentucky, readily admits he is a "philosophy-based engineer," a result, he says, of his Japanese heritage.

"I'm a big believer in the principles of *Genchi-Genba*, a manufacturing philosophy in Japan rooted in age-old craftsmanship. '*Genchi*' means, roughly, 'exact location'; '*Genba*' refers to function. The philosophy underlies the importance of interacting with things and problems directly, and in a specific context. It's a way to contextualize problem-solving in a very concrete way."

And for Saito, who began his work at UK in the late 1980s by tackling the problem of fire detection and spread (he even helped build and "nurture," he says, a robot capable of being guided remotely to fight fire), seemingly no branch of engineer-

Kozo Saito, seen here with a small plastic model of the revolutionary scrubber he designed, went to Japan in 1997 with only a computer sketch of the device to see if the Trinity Industrial Corporation would be interested in producing it. Trinity, which works closely with Toyota, was sold on the idea and built 12 prototypes.

ing is uninteresting. He specializes, at the moment, in combustion, fire research, painting technology, thermal sensing and control, and scale modeling and lean production.

In the past few years, this Renaissance Man of Engineering has narrowed his research focus, somewhat, to the problem of paint waste in automobile assembly plants and its environmental repercussions. And Saito says there's an interesting story that led him into this work.

パートナーシップ

Saito rolls the years back to New Year's Day, 1987. He was at a meeting in Lexington of the Japan Club of Central Kentucky, and he met a man who changed his life.

"You are Dr. Saito," the man said. "I am Fujio Cho."

Saito didn't recognize the name and exchanged pleasantries. He learned later that evening that his new acquaintance was president of Toyota's Georgetown, Kentucky, plant. Feeling that he had slighted Cho, Saito sought him out to apologize for not recognizing him.

Cho assured him he was not offended, and asked Saito about his current work at UK. Then Cho, clearly intrigued by Saito and his research background, floated out an idea: He said they should work together to build toward some kind of grand project, something that would allow the two, in a significant way, to say thank you to Kentucky, which had welcomed the Japanese natives so warmly and had given them so much.

"Think about it," Cho said, placing no demands or restrictions on the possibilities. "We'll start small."

This conversation led to an important partnership and, 10 years later, a solution to one of the automobile industry's most costly problems—the waste of electrical energy and paint during the coating process.

But we're jumping ahead of the story. First, there was the smaller project Cho alluded to, a trial balloon of sorts. This project focused on a problem Toyota was having with transmission fluid levels in cars exported from Japan. Engine fluids are typically removed from cars before they leave Japan for the United States in order to lighten the shipping load; but inconsistency in the amount of transmission fluid drained resulted in varying amounts of fluid left in the cars. When the transmissions were given a standard amount of fluid in the United States, some cars would be overfilled, others underfilled.

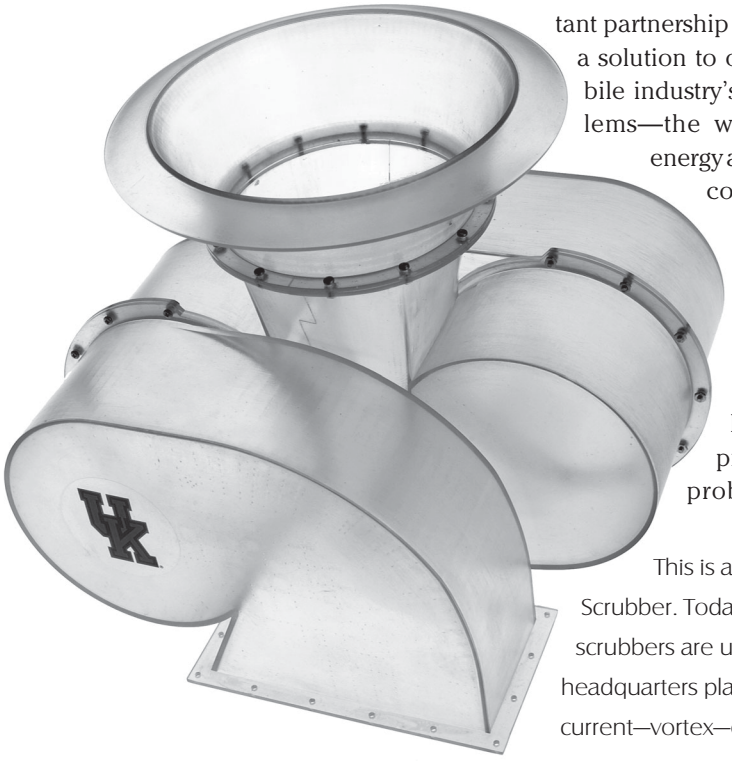
The goal was for each car to have the same volume, and to reach that goal Saito tapped into the engineering principles of volume and pressure.

With two engineering colleagues, he designed a pipe with a sensor attached to the end that could accurately detect, through the principle of "back pressure," the amount of liquid pressure released in the refilling process. In this way, just as a gas pump automatically shuts off when your tank is full, the sensor could register "full" no matter how much transmission fluid was initially present.

Was this a tough nut to crack?

"No," Saito chuckles, "it was really pretty easy. It was a small project. Mr. Cho just wanted to get a sense of how our group at UK would handle a problem like this."

A few months later, though, Cho, obviously pleased with Saito's first assignment, called him for some help on a much larger problem.



This is a plastic, one-eighth scale model of Saito's Vortecone Scrubber. Today, several dozen of these four-foot-tall, stainless steel scrubbers are used in seven Toyota facilities worldwide, including the headquarters plant. The device gets its name by combining the circular current—vortex—of water and paint with the scrubber's conelike shape.

Kozo Saito (second from right), director of UK's Painting Technology Consortium, inspects an automotive rotary-sprayer testing system used to validate the results of his group's computer models. From left to right: Abraham Salazar, assistant director of the consortium; Tianxiang Li, engineer associate senior; Kazunori Kuwana, engineer associate; and Fengiuan Wang, a Ph.D. student in mechanical engineering. The goal of the consortium, established in 1999, is to help industries understand mechanisms of the painting process so that it can be done more efficiently, more cleanly and more cheaply.

"Close to 50 percent of the energy consumption in the entire automobile assembly process is taken up by the paint process," Saito says. "Wasted paint due to overspray costs nearly $1 billion a year, industry-wide, and of course environmental issues are an additional concern."

Saito, who had no experience with paint operations, toured Toyota's plant in Georgetown, with Naoji Tanaka, a vice president of the company, and saw firsthand the waste of paint as cars inched through the process. "You could see the paint particles in the air like a cloud of gnats, and you could see thick rivulets of paint run into the drains," Saito says. "It was clearly a huge problem."

Over the next two years, in addition to his regular work at UK, Saito visited over a dozen auto manufacturers around the country and in Japan to learn all he could about paint operations and the feeble overspray capture systems. On weekends, with production lines stopped in Georgetown, he changed from his street clothes into safety boots, thick gloves, and a "paint-booth suit," a body wrap of nylon overalls. Only the oval of Saito's face was exposed.

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UK and Industry: Partnering for Success

UK dean of the College of Engineering Tom Lester (left) talks with Toyota's Rich Alloo, who keeps an office in the UK Center for Manufacturing. At UK, Alloo monitors a variety of research activities to determine possible implications for improving productivity and quality at Toyota's plants in the United States and abroad. "This type of 'in-residence' relationship on a university campus is unique as far as I know," says Lester.

Eric Grulke, College of Engineering Associate Dean for Research and Graduate Studies, says, "Our research-for-development teams will infuse new technology into Kentucky's existing manufacturing industries, keeping them vital and competitive in today's global marketplace."

Faculty in UK's College of Engineering are working with the following companies:

- Akebono Brake Systems Engineering Center—Tingwen Wu
- Ashland Inc.—Eric Grulke
- The Asphalt Institute—Kamyar Mahboub
- Bussan Nanotech Research Institute—Kozo Saito & Eric Grulke
- CerWat Corporation—Rick Honaker
- Cypress Semiconductor—J. Robert Heath and Bruce Walcott
- Falkirk Mining Company—Rick Honaker
- Flashscan 3D—Larry Hassebrook
- Florida Institute of Phosphate Research—Dongping Tao
- General Electric Aircraft Engines—James McDonough
- General Motors Research—Fuqian Yang
- Honda—Kozo Saito
- Lexmark International—George Huang
- M2 Technologies Inc.—Daniel Lau
- NanoSonic Inc.—Robert Adams
- NextGen Aeronautics—Jamey Jacob
- Optical Dynamics Company—Eric Grulke
- Procter & Gamble Company—D. B. Bhattacharyya

"These painting platforms are wet and messy," says Saito, "and with the flashlight I carried to inspect the undersections, I looked a little like a coal miner," he laughs. Based on engineering precepts he had already considered, and the guiding principle of *Genchi-Genba*, Saito examined the scrubbers housed in the undersection that were used to suck up, much like a vacuum cleaner, the wasted paint. "For one thing, these scrubbers weren't very efficient in getting up the 'dust,' the tiny paint particles left over. And we discovered that the scrubbers operated at around 95 percent efficiency, which sounds good but isn't: typically, a plant wastes 150 gallons of paint a day." These devices also were using a huge amount of energy—up to 200 kilowatts per vehicle.

"I knew what was basically wrong," Saito says. "Now all I had to do was figure out how to design a better scrubber."

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In thinking about how to solve this problem, Saito caught a break: he met UK Ph.D. student Abraham Salazar. Salazar was looking for a new direction in his research, and Saito knew that with Salazar's expertise in computational fluid dynamics, he might be the ideal research partner.

"I knew we needed a new scrubber model to test, but before we could even think about building something, we had to work through mathematical equations and computer simulations, and I didn't have that background," Saito says. So he and Salazar went to work, with Cho's blessing and around $150,000 from Toyota.

A few months later, based on his equations and simulations, Salazar

came up with a computer-drawn design for a new and much more efficient scrubber. Saito and Salazar showed Yukio Tamara, a newly arrived vice president at Toyota in Erlanger, Kentucky, what they'd sketched and explained how it would work. Tamura was impressed. He contacted the former vice president, Tanaka, and suggested he invite Saito to come to Japan (where Tanaka had gone to become senior managing director of the Trinity Industrial Corporation) to give a presentation on the potential of a revolutionary scrubber.

Armed only with this design rolled up in his briefcase, Saito went to Japan in late 1997 to present his invention-to-be to Trinity. Tanaka and half a dozen engineers heard Saito's presentation and were sold on the idea; and Tanaka agreed to produce a prototype. "We had the support of Yasuo Tanigawa, Toyota headquarters' general manager, and his endorsement was essential, since Trinity works closely with Toyota," Saito explains.

"This was a major executive decision," Saito adds, recalling that he was "a little stunned" at the impact this computer-drawn model had on the group there. Trinity not only built a prototype—they built 12 of them, all different sizes to see if size made a difference in the scrubber's efficiency.

"Mr. Tanaka put a dedicated team on this. It took six months of more than full-time work and, I heard later, around $2 million once all the testing had been done." And that's how the Vortecone Scrubber, a joint invention by UK and Toyota, was born, says Saito, adding that he has great respect for Tanaka, who took a "sizeable gamble" on a device that hadn't, literally, even gotten off the drawing board.

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Today, several dozen of Saito's Vortecone Scrubbers, which look a bit like a four-foot-tall meat grinder, are used in seven Toyota facilities worldwide, including the headquarters plant. (The device gets its name by combining the circular current—vortex—of water and paint with the scrubber's conelike shape.)

This invention, which Saito patented through the UK intellectual property development office, has significantly improved overspray capture while using much less energy than conventional scrubbers. Paint capturing efficiency is 98.2 percent, up from the 95 percent that was typical of traditional scrubbers, and the 3.2 percent difference is a significant one, according to Saito. The energy savings are impressive by anyone's standards: the Vortecone uses nearly half the energy that's sapped by old-style scrubbers. And the Vortecone needs to be "maintained" far less often—it has to be disassembled, examined and cleaned only every 24 months, compared to every three to six months for traditional scrubbers.

発明

Saito's projects are continuing, and his working relationships have expanded into the international arena. He is now working with nine companies and 10 academic groups worldwide. During a weeklong trip to Japan last February, Saito visited three major companies—Admatechs Co. Limited, Toyota and Nissan—to discuss ongoing projects focused on advances in painting technology and future collaborations.

And Saito's trip was merely a prelude to bigger things to come for UK.

Last December, Kentucky Governor Ernie Fletcher announced Kentucky's participation in the 2005 World Expo in Aichi, Japan, the first world exposition in the 21st century. Fifteen million visitors are expected to attend the expo, which runs from March 25 to September 25. The United States is one of 125 participating countries. Kentucky was featured at the U.S. Pavilion the week of May 16 to 22, hosting Japanese business executives, international tour operators and others.

"The upcoming world expo is extremely important to the Japanese people, who value education and culture exchange highly," says Saito, a Japanese citizen. "Such an event is one of the most important activities in Japanese culture."

The University of Kentucky used the pavilion during Kentucky Week primarily as an opportunity to further Saito's partnerships in Japan. UK President Lee Todd and Executive Vice President for Research Wendy Baldwin hosted a luncheon meeting for companies Saito is currently working with such as the Nippon Steel Corporation, the Asahi Sunac Corporation, Kansai Paint, Sekimoto SE Engineering, and Mitsui Bussan. Eric Grulke, College of Engineering associate dean for research and graduate studies, led the group from the college, which includes Saito; Keng Hoo Chuah, a postdoc in Saito's research group; Kazunori Kuwana, a research staff member; and Salazar.

And for Saito, there's a pleasing personal connection involved in this event, since he'll again be crossing paths with Fujio Cho, now president of Toyota Motor Corporation. "In a way, my old friend and I have come full circle since meeting in Kentucky in 1987," Saito says. ■