Flying Without Fear: Sonic IR Identifies Cracks In Airplanes

Wayne State University

Researchers at Wayne State University found a way to discover cracks in layered structures, which promises good things for the airline and other industries — and for the people who depend on them.

Electrical and computer engineering professor Xiaoyan Han doesn't spend a lot of time worrying about little cracks in air- planes as she flies across the country at 30,000 feet. But the thought of what would happen if an engine fell off or the fuselage peeled open in mid-flight has crossed her mind. That's why Han's research gives her some comfort.

Han and fellow Wayne State University faculty members Skip Favro and Robert Thomas have developed an ultrasound technology called Sonic IR that can detect cracks as small as one-thousandth of an inch. The professors began working on the effort about five years ago and received their first patent in 2002.

Now, the U.S. Federal Aviation Administration and aircraft manufacturers are studying the ultrasound technology. "I hope this will be applied to airplanes soon," Han says. "It could make them safer."

She says the technology is especially good at discovering cracks in layered structures. “If they are below the surface, it’s hard to find them,” Han says. “But with Sonic IR, we can locate delaminations and disbonds quite easily.”

Making the Skies Even Safer

Favro, a research scientist in the Detroit-based university’s Institute for Manufacturing Research, says he thinks flying in airplanes is safe. “But clearly, there is a great interest in the aviation industry because the results of a failure can be catastrophic,” says Favro, whose institute is working with the FAA.

“I think the airline industry does a pretty good job,” he says. “But some things do sneak up. Little cracks do tend to get bigger.” Favro explains that the FAA’s aging aircraft program began after the fuselage of Aloha Airlines flight 243 came apart in 1988. The accident, which occurred 24,000 feet over Maui, killed one flight attendant and injured eight passengers.

David Galella, project engineer at the FAA technical center in Atlantic City, N.J., calls the Sonic IR technique “very promising because of its ability to potentially detect crack tips, which can be the source of the friction.” In airplanes, he says, cracks often grow away from their starting points at the heads of fasteners or rivets.

“We’ve developed a couple of different prototypes and are trying to understand the best applications for the technology,” he says. “We certainly hope to see the technology implemented within this decade.”

Galella says Sonic IR could supplant some of the technologies already in use. “Our jobs here are to find improvements,” he says. “Whether or not a technology is picked up depends on a number of things including cost benefits. But we certainly think this technique has a lot of potential for aircraft.”

Technology Has Applications in Various Industries

Meanwhile, Sonic IR — for which Wayne State has six patents — is being adapted for uses with pipelines, power plants, transmission towers and in the automotive industry. “Who wouldn’t be interested in this technology?” Favro asks. “Cracks are everywhere and they can cause a multitude of problems.”

Siemens Power Generation Inc. is using Sonic IR to test the power turbine parts it makes for utilities and their electricity generation plants. “Wayne State’s work is a major step forward from the historic processes of finding natural or propagated cracks. It is unsurpassed, a powerful new technology,” says Paul Zombo, head of nondestructiveevaluation technologies for the Orlando, Florida-based company.

Zombo, whose company has named its version of Sonic IR SIEMAT, for Siemens Acoustic Technology, says the old techniques did not define cracks as well. The company uses SIEMAT to test new parts and service-exposed parts that have been in use at power plants. “This gives you a more accurate analysis of the true defects in a part,” he says. “It gives us a better ‘truth,’ so you can estimate the real remaining life of the part.”

Zombo says the technology can work on a variety of metals, ceramics and composites. It is also easier to use than previous devices. “Before it was squiggly lines on an Oscilloscope,” he says.

“This is an imaging method, so you can actually see the defect. You can also superimpose your data onto a finite element analysis model and apply stresses and loads to see if the crack is dangerous or benign. It’s great,” Zombo says.

> *The technology has many applications outside the utility industry, too. “Obviously, aeroframes and aeroturbines would be two of them,” Zombo says. “I can see why airlines and the FAA are interested.”*

Zombo declined to speculate how much money the Wayne State technology has saved his company. “That’s hard to say,” he says. “But just from a comparison standpoint, we have a much higher probability of finding defects and we can do it in about 50 percent of the time it used to take.”

Another company that has licensed the technique is Indigo Systems Inc., which has introduced it under the trade name Thermosonix.

The Wayne State technology also can replace time-consuming and environmentally toxic dyepenetrant methods of looking for cracks. “They soak what they are testing in a bath of a horrible dye,” Zombo says. “But first they have to clean the part, etch it with acid, soak it in a fluorescent dye, clean it again and then look at under a UV light. Frankly, it is a pain in the rear end,” he says.

Sort of Like Rubbing Your Hands Together

Favro says the Wayne State technology blends the diagnostic powers of ultra-high frequency sound waves and thermal imaging, using infrared radiation to detect heat. The technology is based on friction, he says. When sound waves are sent through a material — whether it’s fiberglass, laminate or steel — it moves. But if there is a crack, the two sides don’t move in unison. Instead, one side will rub against the other.

“A byproduct is heat, just like when you rub two sticks together in that Boy Scout trick,” says Favro, a former Scout himself. “It’s not a lot different than rubbing your hands together on a cold day to keep warm.” To locate the crack, researchers use an ultrasonic welder. To capture the image, they use infrared video camera. The heat that the crack produces is depicted in pixels of an image on a computer monitor.

Another benefit that intrigues developers is the technique’s ability to detect what are called fatigue cracks, which X-ray examination sometimes misses. When under stress, many critical components used in aviation are highly vulnerable to fatigue cracks, which is one reason that the Wayne State technology shows such promise for aircraft design and manufacturing.

Favro says the best thing about this technology — and what makes it superior to existing techniques — is that it can detect cracks from any angle. “Using flash lamps, we could see the disbonds and delaminations that were parallel to the surface, but we couldn’t see the cracks that were perpendicular to the surface,” he says. “Now we can. This is much better."

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