Lab focuses on new technology to prevent icing on planes, helicopters

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A little rain or fog may seem like an insignificant threat to a helicopter or airplane. But minor clouds and precipitation can be the cause of canceled flights -- or fatalities.

It's dangerously easy for water droplets to turn to ice and coat an airplane's wings, unless something could prevent the ice from adhering, lessening or eliminating the problem.

That's what Ed Smith has dedicated his time and research to for the past decade.

"The basic problem is when you fly through an icing cloud, which is about freezing temperature and has water in the cloud, and water of a certain size, [the particles] hit and start forming," Smith, professor of aerospace engineering and director of the Penn State Rotorcraft Center of Excellence, explains. "They call it accreting on the surface of the blades—or the airplane itself—and it ruins the aerodynamic characteristics of the blades."

Smith, along with Jose Palacios, a research associate in aerospace engineering, run an adverse environment rotor test stand lab in Hammond Building. The idea was conceived 10 years ago and built in phases, Smith said.

The lab has two purposes, he says: to take measurements and quantify how ice builds up, in what shape and how fast it accretes; and to test how tightly ice grips to the surface of the blade, something they call "adhesion strength."

With the help of donated equipment from Boeing, Smith and his associates remodeled the lab. It was previously the high temperature testing lab before it was handed over to the Department of Aerospace Engineering.

After installing a motor, drive system and freezer in the lab, researchers spent the last three years completing the complicated process of creating an ice cloud. Smith and his researchers sought the help of NASA's icing center in Cleveland, which provided them with a series of nozzles required to create the cloud.

Besides NASA and Boeing, the lab has numerous sponsors that help fund its research: the Army, Navy and Goodrich, as well as several small companies in State College, including FBS, Inc.

The past year has seen substantial progress not only in verifying that the lab is getting proper icing conditions and proper icing shapes with its equipment, but also with the ice protection system itself—a new system involving ultrasound technology, instead of the existing electrothermal system.

"The current way ice protection is done is with heat. They imbed little heater elements just under the skin of the blade," Smith explains. But these systems are heavy and unreliable, and they use enormous amounts of power. This allows only the largest helicopters to even attempt to use them, meaning most helicopters simply can't fly in any type of icing condition in the winter.

Airplanes, however, have hot engines to help prevent icing. Many planes have a sophisticated system that uses the engines' hot air to blow over the inlets, melting ice, Smith said -- but the systems are no guarantee.

"You always hear every winter, 'icing results in the crash of an airplane,'" Smith says. "If the ice forms on part of the blade and not the others, you can really have bad vibration problems, so it's a lot of fatalities over the last several decades. Usually either the ice protection system didn't come on or it didn't work right."

For helicopters, no such hot air or de-icing system exists for its rotor blades. Ice can form, weighing down the rotor and causing blades to shed off. This leads to violent shaking, much like if one would attach a weighted object to a blade on a ceiling fan, Smith says.

Fortunately, he says the new ultrasound system has been very promising over the last eight years, since he and researchers started working on it.

Smith describes the new process as a mechanical stress—the ice forms on the blade and the blade shakes back and forth at high speeds, peeling the ice off.

"It's the same thing you're really doing when you use an ice scraper, hit the ice at an angle and shear it off, that's what it's doing."

Now, Smith says his team is working to develop the technology to make it work in a practical way. In addition to helicopters, it could be relevant to airplanes, engine inlets, wing turbines—anything that is outside and subject to the elements.

Another aspect of the system is a new, efficient way to evaluate the condition of the blades, further improving a helicopter's safety. The technology uses a piece of metal located in the front of each rotor blade intended to balance their center of gravity, Smith says.

The idea is to remove that and replace it with a ceramic material, which has the same density of lead. "We take this mass out and replace it with something that can move at high frequencies ... in this case, we take advantage of the fact that all blades and wings have this mass in the leading edge that don't do anything useful except moving the center of gravity forward," Smith explains. "So now we can make better use out of a heavy material in the nose—we think that is very attractive."

When blades and wings are manufactured, they are inspected using ultrasonic CAT scans to make sure there are no cracks and the bonds are in good shape. But usually, Smith says, they're never inspected again after they leave the factory.

The ceramic masses, however, serve as ultrasonic transducers and can double as vehicles for periodic inspection for damage, in addition to de-icing aids.

So far, Smith says he doesn't have any patents for the technology he's helped develop. Though he has filed several invention disclosures over the last few years, he says the university gets many invention disclosures and can only choose a certain number to pursue a patent. But that doesn't bother him.

"So far, we haven't had our disclosures picked up; a lot of things are in public domain," he says. "I'm personally not motivated by patents—that drives some people nuts. That's not what's driving us; we want to educate the community."

Smith says his lab's new ultrasound system could be useful, but implementing it would be tricky due to the decades-long history with the current, electrothermal system.

"It's kind of like a hybrid car—it takes a long time. You're so used to a gasoline engine, if you want to switch over, there are a lot of questions people have to ask before you can just replace everything," he explains. "We're trying to answer as many of those questions as we can."

Provided by Pennsylvania State University

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