RESEARCH NEWS

Green aviation

Using Vibration to Deice Aircraft Wings

In the Clean Aviation project, Fraunhofer researchers teamed up with partners to develop a system that causes icy spots on aircraft wings to vibrate, removing the ice. This dramatically reduces the amount of energy needed for deicing in comparison to conventional methods. The technology is also suitable for low-emission propulsion of the future.

Formation of ice on an aircraft's wings is dangerous to the entire plane. Ice reduces lift, increases drag and can impair the mobility of flight control surfaces such as elevators, ailerons and rudders. In the worst case, the plane can stall in the air and crash. The issue can arise at any time of year, especially when a plane passes through clouds or layers of cold, moist air after takeoff or on approach. To address this problem, aircraft are equipped with thermal systems that draw hot air from the engines and channel it across the surface of the wings. However, this process requires a great deal of energy, and it also impacts engine efficiency.

The Fraunhofer Institute for Structural Durability and System Reliability LBF has now teamed up with partners to develop an energy-conserving deicing method. The basic idea is that the iced part of the aircraft wing is made to vibrate, so the ice cracks and flakes off.

First, sensors detect ice formation on specific sections of the wing. Then, the natural resonance frequency, i.e. the frequency range where the material starts to vibrate, is determined, followed by the activation of piezoelectric actuators. The actuators trigger low-frequency material vibrations targeted at the spots where the ice has formed. "The vibrations are in the range of just a few kilohertz. They are invisible to the naked eye but very effective. The ice clinging to the wing breaks up and falls off," explains Denis Becker, a researcher at Fraunhofer LBF.

Resonant frequency of wings

To calculate the vibration frequency, the Fraunhofer researchers first needed to study the highly complex interaction of a range of different factors that are responsible for the natural resonant frequency when ice forms. "The determining factors include the material the wings are made from, the speed, the altitude of flight, the temperature, humidity and how thick the layer of ice is. Algorithms use that information to calculate the natural resonant frequency," Becker explains.

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Because exterior conditions are constantly changing in flight, the resonance frequency changes as well. Whether the coat of ice thickens or melts is also a factor. For this reason, the sensors continuously supply new measurement information so that the electronics can activate the actuators at the adjusted frequency at any time.

For the research project, the experts at Fraunhofer went through various steps, including placing a wing inside an icing wind tunnel and optimizing the way the piezoelectric actuators work.

The idea of using vibration to remove ice has been talked about in aviation circles for a long time now. Now, for the first time, researchers have succeeded in creating a highly dynamic and accurate system that puts this idea into real-world practice. "Our experiments in the icing wind tunnel showed that electromechanical deicing works. As the next step, we will be conducting further tests in the wind tunnel to get the system ready for in-flight testing," Becker says.

Low-emission aircraft powertrains of the future

The experts at Fraunhofer LBF realized this research project as part of the European Union's Clean Aviation research and innovation program. Partners include aircraft manufacturer Airbus and aerospace company Parker-Meggitt.

The field of aviation is facing tremendous challenges these days. Energy consumption and carbon emissions will have to decrease dramatically in the next few years. Across the industry, manufacturers are working on ecofriendlier powertrains such as electric and hybrid drives. "But the propulsion systems of the future will no longer produce any hot exhaust gas or waste heat, which thermomechanical deicing systems require to do their job. Our method holds out the prospect of cutting energy consumption by up to 80 percent, making it an important contribution to sustainable aviation," Becker explains.

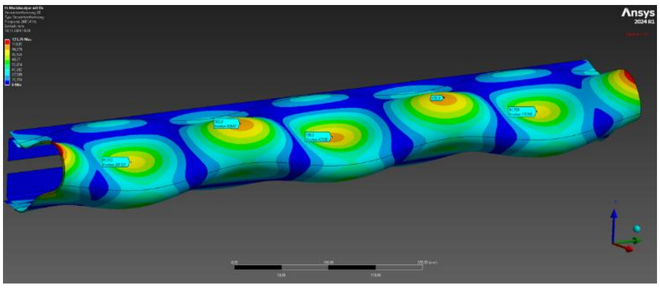

Fig. 1 Simulation of a wing vibration showing a typical eigenmode like that occurring in vibration.

Fig. 2 Test in an icing wind tunnel: Realistic ice deposits form on the integrated leading edge of the wing.

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