Protection against wing icing

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When ice builds-up on the wings of aircrafts, it drives up costs and impedes safety – and in the worst case scenario, could even cause an aircraft to crash. At the ILA Berlin Air Show from September 11 - 16, researchers will demonstrate new ways to keep ice off of the aircraft's wings.

Regardless of how fluffy and plush white clouds against a blue sky may appear from ground level, the conditions inside them are forbidding indeed: If aircrafts fly through these clouds, the low temperatures, combined with wind speed, can cause the rapid formation of ice sheets on the wings. This icing could have two serious consequences: First, the ice sheet may cause an up to 40 percent rise in the aircraft's aerodynamic drag; second, the aircraft becomes heavier and can lose up to 30 percent of its lift. Both conditions lead to a marked spike in fuel consumption, impede safety and – in the worst case scenario – the ice may even cause the aircraft to crash.

Aircraft manufacturers therefore must prevent icing. Various technologies can help with this. For example, by conducting the heat from the jet engines to the hollow spaces inside the wing leading edges, the wings can be de-iced during flight. Other manufacturers are integrating "rubber boots": basically, rubber mats that can be pumped up when needed and "blast" the ice from the wing surface. A major disadvantage of these technologies is the exorbitant energy requirement. Moreover, they cannot be combined with fiber composite materials – or only with great difficulty – but carbon fiber materials are increasingly being used in aircraft construction.

Wing heating using nanomaterials

Researchers at the Fraunhofer Institute for Structural Durability and System Reliability LBF in Darmstadt have now engineered a heat-based option for the wings that skirts around this material disadvantage. "We are integrating nanomaterials into the wing materials that generate an electrically conductive layer and heat the wings," says Martin Lehmann, deputy head of department at LBF. The scientists would prefer not to disclose more details than this, at the moment. The advantages of the system: Since the electro-conductive layer is integrated into the material, it is protected by the overlying fabric. In addition, no metals are integrated: This improves lightening protection and avoids the weak points that the metal would form. "Since we are combining like with like, the material does not fatigue quickly," explains Lehmann. The effect of the heat is immense: at ground level, it heats the wings up to 120° Celsius.

The wing heating already passed the first test. In the wind tunnel, at temperatures of -18° Celsius and the relevant wind speeds, the researchers sprayed a wing with water. They initially let an ice crust form before they turned on the integrated heater – the scientists wanted to examine the de-icing process this way first. In a second test run, they switched on the heater right when they sprayed the wings, so that the wings could not even form an ice sheet at all. This approach is referred to as anti-icing. Both test runs were conducted successfully and validated the simulations that the researchers conducted beforehand. In addition, the experts studied two different models in which the hot zones were each set up slightly differently, as well as an unheated wing – the control subject. "We were able to maximize heat output this way – because the heater needs to keep the wings reliably free of ice, and yet consume as little energy as possible," Lehmann explains.

The wing heater undoubtedly works under laboratory conditions; now the researchers want to try out their product design for industrial use. At the ILA Berlin Air Show from September 11 - 16, 2012, researchers will show one of the segments that they tested in the wind tunnel (Hall 3, Booth 3221). The segment will be heated, which the visitors will be able to feel on the surface of their hands, and be able to see through a heat imaging camera.

System solutions for de-icing

Researchers at the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM in Bremen are taking another approach. Through an EU-funded project that is scheduled to begin in the autumn of 2012, they will engineer new technical solutions (besides de-icing through heat) for the mechanical removal of ice from the wings. "We will use innovative materials here, such as 'shape-memory materials'," explains Dr. Stephan Sell, scientist who specializes in paint technology at IFAM. What's so unusual – and special – about this approach: If the temperature changes, or if one applies an electrical current, then the material changes its volume. This way, scientists can blast the ice off of the wing surface. "We expect energy savings from this to reach up to 80 percent compared to conventional heating methods," Sell explains.

At the same time, the scientists wanted to combine the active de-icing of the wings with new kinds of sensors. If the wings ice up, the sensors detect this condition through an optical system, and notify the crew. Previous techniques were based merely on indirect measurements. This integrated sensor system makes it possible to identify the icing in real time, and to monitor the success of the de-icing process in real time, too. The result is greater energy efficiency for the entire system, and a manifold increase to airline traffic safety.

Protection through anti-ice coatings

Where there is no water, there can be no ice. Therefore, researchers at IFAM engineered coatings with anti-ice capabilities under the "CleanSky" program. Among other things, the hydrophobic, water-repellant coating should protect against runback ice, which forms from the melted ice coming from the wing leading edges. At the wing leading edges, once the heaters melt the ice back into water, it flows down to the lower part of the wing as melt water, where it freezes again and turns back into ice. "Our hydrophobic coatings are intended to ensure that water at the rear part of the wing flows off the wing instead of cleaving to it. We can achieve that by blending certain additives into the paint, such as fluorinated compounds," explains Stephan Sell. "The main challenge is figuring out how to produce water-repellant coatings so that they remain stable for several years – resisting the effects of UV radiation and high erosion stresses."

The areas of application for these new technologies are not limited to aviation. Icing is also a problem for ships, rail-based vehicles, cars, rolling doors, refrigeration aggregates and wind power farms. For example, iced rotor blades at the wind turbines cause the facility to produce substantially less power – in the worst case, the icing leads to irreparable damage. If parts of this ice drop off, they could even cause injury to people below.

The IFAM researchers have a custom-built ice chamber at their disposal for testing anti-ice technologies. This lets them adjust conditions to a variety of realistic icing scenarios. For example, they can drop the ambient air temperature by up to -20° Celsius, blow wind through the test chamber at speeds of up to 70 meters a second, and simulate rain through a nozzle. This means the researchers can identify ice formation on surfaces, quantify the efficacy of de-icing processes and measure the adhesive strength of the ice. They can also use, for instance, individually produced models of wing profiles, with new anti-ice coatings, for testing purposes. One of these will be exhibited at the ILA Berlin Air Show

(Hall 3, Booth 3221).

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