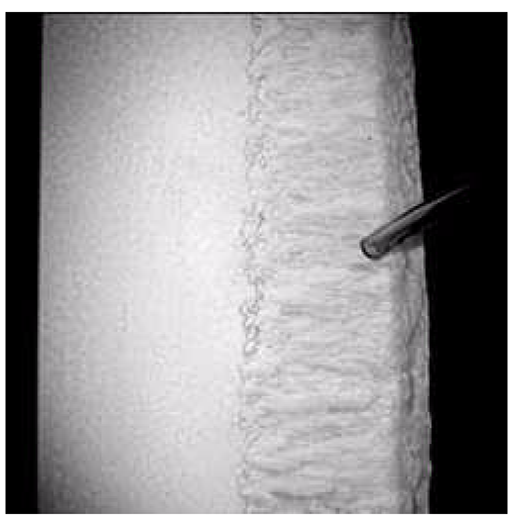
Pressure-Sensitive Paint Applied to Ice Accretions

Aircraft icing occurs when a plane flies through a cloud of supercooled water droplets. When the droplets impinge on aircraft components, ice starts to form and accumulate. This accumulation of ice severely increases the drag and lift of the aircraft, and can ultimately lead to catastrophic failures and even loss of life. Knowledge of the air pressures on the surfaces of ice and models in wind tunnels allows researchers to better predict the effects that different icing conditions will have on the performance of real aircraft. The use of pressure-sensitive paint (PSP) has provided valuable information on similar problems in conventional wind tunnel testing.

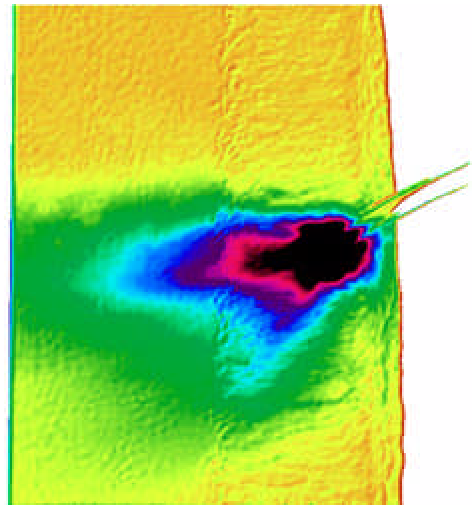
In NASA Lewis Research Center's Icing Research Tunnel, Lewis researchers recently demonstrated the world's first application of PSP on actual ice formed on a wind tunnel model. This proof-of-concept test showed that a new paint formulation developed under a grant by the University of Washington adheres to both the ice shapes and cold aluminum models, provides a uniform coating that preserves the detailed ice shape structure, and responds to simulated pressure changes.

Three different samples of ice were acquired on a length of aerodynamic tubing attached to the ceiling of the IRT. The samples consisted of glaze ice (-0.7 °C, 30.7 °F), mixed ice (-8.1 °C, 17.4 °F) and rime ice (-15.4 °C, 4.2 °F). Prior to painting, the samples were removed from the wind tunnel and stored in the facility cold room at a temperature of -6.7 °C (20 °F). The PSP was cooled to the cold-room temperature prior to application. Then PSP was applied to the samples using a automotive type spray gun, with cooled nitrogen providing the atomization pressure. After the curing time, which was less than 5 min with this paint, finish details were noted.



Painted rime ice and the detailed ice structures that remain after the application of the pressure-sensitive paint coating.

A low-pressure nitrogen jet was used to determine the pressure responsiveness of the paint. The nitrogen locally displaces air and simulates a region of low pressure. PSP works on the oxygen quenching principle: in a vacuum, no quenching occurs and the intensity of the paint is at its maximum. At higher air pressures, oxygen quenches the luminescence and the normalized intensity ratio behaves in a linear fashion. The success of this test lends optimism to the final application of PSP to icing research wind tunnel testing.



False-color reduced data image of a nitrogen jet impinging on the ice surface.

Lewis contact: Timothy J. Bencic, (216) 433-5690, Timothy.J.Bencic@grc.nasa.gov
Authors: Timothy J. Bencic
Headquarters program office: OAT
Programs/Projects: Aeronautics Base R&T