Sequential model chips away at mysteries of aircraft

February 6 2018

Credit: CC0 Public Domain

Ice accumulation on aircraft wings is a common contributing factor to airplane accidents. Most existing models focus on either ice that freezes as a thin film on the airfoil, or immediately after it impacts the wing.

Researchers have announced a new model, accounting for a combination of these forms, that they hope will melt our misunderstanding of ice accretion.

A team at the University of Nottingham used a simulation that matches experimental and in situ observations to characterize ice on a spectrum between rime ice that forms from water vapor and glaze ice that forms from supercooled water droplets. Their work builds on existing models by introducing a new parameter that accounts for changes in adhesion characteristics. Their paper, published in *Physics of Fluids*, provides a model for four stages of ice formation on aircraft wings. Notably, the authors expand the commercially available ICECREMO (ice accretion modelling) code to include a new definition of mixed ice.

"Up until now, there has been a lack of work conducted on researching mixed ice," said Zaid Ayaz Janjua, an author on the paper. "Our work will help inform research into thermally active nanocoatings for aircrafts to combat ice formation."

Most models consider two forms: glaze ice and rime ice. Glaze ice is smooth and is clear like glass, while rime ice is bumpy and opaque.

"You can think of rime ice as the kind of ice you could easily scrape off from the walls of your freezer, whereas glaze ice is more like ice cube ice," Janjua said.

The group introduced a freezing fraction to describe the proportion of supercooled droplets that freeze on impact. The ice mixture has the adhesion characteristics of glaze ice when this fraction is zero. They verified the fraction with previous experimental data on how the height of accumulated ice affects rime ice accretion over time.

Then, they modeled the stages of airfoil ice accretion. As rime ice covers the wing, less ice freezes on impact because rime ice is a poorer thermal conductor than aircraft materials. As a result, glaze ice forms an ice mixture on the wing. As this mixed ice gets thicker and the rate of conduction decreases, a water film begins to appear until the ice has taken on a predominantly glaze profile.

"For a particular set of atmospheric conditions, you can have vastly different ice heights, which would greatly influence the amount of energy needed to remove the ice or even the tools you might select to achieve that," Janjua said.

Janjua said he hopes future work will look beyond ice height and investigate how ice accumulates two-dimensionally across an airfoil. Further work is required to relate the freezing fraction to other ice parameters, such as the packing fraction. Ice accretion affects a wide range of other engineering applications, including power cables, radio masts and wind turbines, which Janjua is looking to study next.

More information: Zaid A. Janjua et al, Mixed ice accretion on aircraft wings, *Physics of Fluids* (2018). DOI: 10.1063/1.5007301

Provided by American Institute of Physics