High-fidelity simulation of conjugate heat transfer in aircraft in-flight icing

Rho Shin Myong
Professor, Department of Aerospace and Software Engineering and
Director, Research Center for Aircraft Core Technology
Gyeongsang National University
Jinju, South Korea

In Earth's atmosphere, supercooled water droplets can be observed in the airflow around aircraft (or wind turbine) moving inside clouds. Exposure to these water droplets may cause substantial ice accretion on the surfaces of wings, engine inlet, rotor and wind turbine blades, and air data systems, resulting in significant reduction of aerodynamic and propulsive performance. For example, ice accretion on the surface of an engine air intake can deteriorate the safety of aircraft due to the engine performance degradation. Thus, careful attention must be paid to how to protect the aircraft and rotorcraft from ice accumulation.

In order to tackle this problem, much effort has been put into the study of in-flight icing physics and its computational models. This talk presents recent advances in the high-fidelity computational simulation of aircraft in-flight icing—in particular, conjugate heat transfer associated with ice protection systems and effect of supercooled large droplet (SLD).

As the first example, ice accretion on the surface of an electro-thermal anti-icing system around a rotorcraft engine air intake was investigated on the basis of computational and experimental methods. Then application of the electro-thermal anti-icing system to Korean Utility Helicopter and lessons learned from the recent icing certification campaign (through Korea Aerospace Industries Ltd.) are briefly described.

Next, the unified computational solvers for clean air, large droplet impingement, ice accretion, conjugate heat transfer, and the aerodynamic analysis of ice effects were developed within a single unstructured upwind finite volume framework. The solvers were then applied to investigate ice accretion and the resulting aerodynamic effects on multi-element airfoils for near-freezing SLD icing conditions. Some non-intuitive results were found when compared with non-SLD case.