Applications of CFD in Aircraft In-Flight Icing Simulation and Certification: Current Status and Challenges

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ABSTRACT

Recently, new developments have been reported on the numerical simulation of ice accretion and aerodynamic performance penalties on the basis of state-of-the-art computational fluid dynamics codes. In this study, in order to realistically compute three-dimensional ice accretion on an aircraft, an Eulerian-based computational model for biphasic airflow was utilized. The effects of ice accretion on the aerodynamic characteristics of an aircraft such as the maximum lift coefficient and the stall are investigated. Finally, challenges in computational modeling for aircraft icing simulation and certification are discussed.

I. INTRODUCTION

Aircraft in-flight icing remains an important operation and certification issue. In particular, small transport aircraft such as general aviation are more sensitive to the adverse effects of icing than large commercial transport. Ice on wings and tail surfaces can be particularly hazardous incidents and have led to the loss of aircraft. Recent trends in the aviation industry, such as the increasingly widespread usage of lower altitude regional aircraft, have also increased the potential for icing incidents and accidents. In addition, concern about the dramatic effects of super-cooled large droplets has forced the icing community to reconsider certification minimum requirements and to re-evaluate the icing environment and the simulation tools used to comply with those requirements.

II. NUMERICAL SIMULATION

To simulate the flow fields around an aircraft, the compressible Navier-Stokes equation based on the finite volume method was used. The Spalart-Allmaras model was employed as the turbulence model. The codes, a commercial program FENSAP-ICE[12-15] and an in-house 2-D code, were used.

III. RESULTS

An airfoil NACA 0012 was chosen as a test model. It is shown that the shape of ice accretion is similar with experimental and simulated results.

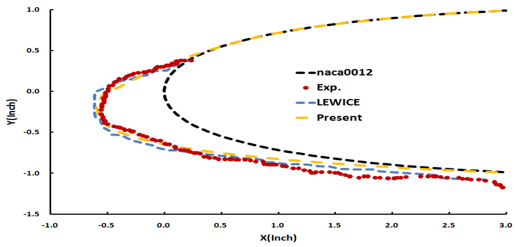

Fig. 1 Comparison of shapes of ice accretion (AoA: 3.5°, time: 7 min., LWC: 0.55g/m^3, MVD: 20μm)

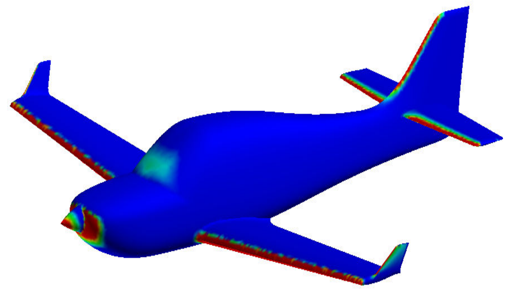

Fig. 2 Ice accretion and LWC contours (Mach: 0.24, temperature: -0.6°, time: 22.5 min., LWC: 0.7g/m^3, MVD: 15μm)

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