A Multidisciplinary Computational Model for Durability Assessment of Ice-phobic Coating in Aerospace

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Abstract

Ice accretion on aircraft is a serious hazard that have been reported to lead to enhanced flying maneuver difficulties and in worst case to the crash of airplane. Therefore, the protection of aircraft from the adverse effects of ice accretion has been a crucial design problem since the very early years of flight. The current methods used to prevent or eliminate the formation of ice require either the installation of specific equipment inside the airplane or the periodic application of toxic chemicals on the ground. These methods are generally energy intensive, costly and can cause environmental impacts. Furthermore, these methods cannot be applied or triggered to the whole aircraft during the usage phase owing to economic reasons leading to the potential ice accretion on unprotected fuselage.

Applying a passive, cost effective and durable ice-phobic coating is of great interest to overcome those drawbacks. Development of the ice-phobic coatings for aircraft has to consider the two essential properties: ice-phobicity and durability under the in-flight conditions. In this study a multidisciplinary computational model is presented in order to study the sand erosion of the in-house developed ice-phobic coatings. The platform includes: (a) a virtual nano-indentation and tribology experiment platforms to identify constitutive parameters of Johnson-Cook plasticity model and damage model; (b) a FEM model for impact and erosion simulations to study the erosion rate of the coating material under different impact conditions at particle length-scale; (c) a multiphase CFD model to study the trajectories of in-flight sand particles; (d) a statistics model integrating the data generated by the above three models to predict the erosion behavior of actual aircraft surface under in-flight conditions. The validation of the model is accomplished by comparing with the coating durability data under the lab condition. The model is employed to optimize the coating material composition in order to achieve the coating with the best durability and ice-phobicity, and to predict the coating lifetime under the actual in-flight condition.

Keywords: Computational Model, Erosion, Ice-phobic