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TEMPERATURE DISTRIBUTION ALONG A COMPOSITE AND METALLIC SHELL IN CRYOGENIC ENVIRONMENT

Abstract

Shell type structures are realized with both metallic and composite materials for launch vehicle. Structures designed with composite materials have reduced mass, for the same design capacity. The structure is interfaced to liquid oxygen (LOX) tank and load transfer is done through thermal barriers and the interface experiences cryogenic temperature. There are two major thermal considerations for the interface: i) reduce moisture condensation and frost formation and ii) reduce heat in-leak to the tank. To meet this objective, metallic structures used in cryogenic stages are provided with insulation. Insulation requirement for the interfaces for structures assembled to a cryogenic tank needs to be optimised. In the present study, two structures for cryogenic upper stage are studied, one made of aluminum alloy honeycomb sandwiched between carbon–epoxy layers and another with aluminium structure. A series of experiments are carried out with varying insulation length on a specimen. A setup configured to simulate the cryogenic temperature at the tank to structure interface, using liquid Nitrogen (LN2). Three dimensional model simulations of the setup was carried out using ANSYS® workbench using mechanical APDL solver. The results obtained from a previous similar study for a metallic structure was used to validate the analysis. The results are compared with another experimental study carried out without any thermal barrier at the interface. The temperature profiles for different insulation lengths, from the experiments compared with the simulation, show a good match. The presence of thermal barrier aids in reducing the area affected due to condensation. The results form a design input for configuration of cryogenic stage structures, in future designs.

Keywords: Composites, simulation, insulation, cryogenic, temperature profile, thermal barrier