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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems Technologies (5)

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DESIGN OF INTER TANK STRUCTURE FOR CRYO STAGE WITH A COMMON BULK HEAD

Abstract

Abstract Cryogenic stages of launch vehicles are widely used because of its versatile advantages such as non-toxic in nature, environment friendly, high specific impulse. Cryo stages contain liquid oxygen(LOX) at 80K and hydrogen (LH2)at 20K in two separate tanks generally connected through tubular truss elements. Load transfer from LH2 tank to LOX tank is very much localized resulting in a non optimum design. In the present study common bulk head insulated with polyimide filled sandwich panel with a skirt is introduced in the design replacing the tubular trusses to increase the payload mass.

The critical issue in the design of cryo stage is associated with the thermal problem. Any variation in the temperature of LH2 at 20K more by 5K may affect the performance of the cryo stage. LOX tank cylindrical length above fuel level has to be designed for slosh and thermal loads.

Polyimide precursor is used inside the non metallic honeycomb core to form as insulation filled curved aluminum skinned sandwich panel that is bonded on the outer surface of the LH2 common bulk head using cryo compatible adhesive. To validate the finite element model a scaled polyimide foam filled sandwich panel with metallic back up structure filled with liquid nitrogen on the top and bottom of the panel maintained at zero degree is conducted for 1000 seconds and thermal profile across the panel is measured for comparison with analysis.

An optimum length of the skirt where the temperature reaches the steady state temperature of 80K is arrived at by a transient analysis for a period of 1000 seconds. It is observed from the thermal analysis that through the thickness of the shell there is no thermal gradient across the shell thickness and hence no severe bending is observed at the common bulk head to skirt joint. Considering temperature dependent material property for modulus and coefficient of thermal expansion and associated strength values carries out an integrated thermo structural analysis. Further buckling analysis of the skirt is carried out to ensure a positive margin. A Payload gain of 350 kg is estimated based on the present study for the new design option with common bulk head in the place of the conventional tubular truss arrangements.