MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advanced Materials and Structures for High Temperature Applications (4)

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DESIGN AND THERMO-STRUCTURAL ANALYSIS OF THE INTERFACE BETWEEN SUBSCALE VERSION OF CARBON-CARBON (C-C) NOZZLE DIVERGENT TO METALLIC FLANGE HARDWARE FOR A GROUND SIMULATION TEST

Abstract

Carbon and carbon fiber reinforced materials are promising materials for use in space applications, due to their excellent thermal and mechanical properties. Carbon-carbon (C-C) is the material which is having lower density and lower coefficient of thermal expansion compared to metal at high temperature. Their dimensional stability, low outgassing and no change in mechanical properties at high temperatures also make C-C ideal candidates for various space structural applications especially throat and divergent Nozzle in the solid Motor. Supersonic film cooling concept in rocket engine with carbon-carbon nozzle divergent provides performance improvement in terms of payload gain. To demonstrate the performance of supersonic film cooling concept with 2-D carbon-carbon nozzle divergent, a sea level static test was conducted with less Aluminium fuel content in the sub scale solid Motor to simulate liquid engine combustion products. The motor was configured with a 17 area ratio nozzle (metallic up to AR10 and C-C from AR12 to AR17). A supersonic injection module was used to inject gaseous hydrogen at 2 bar pressure at AR10. Design of the C-C divergent to metal flanged joint was carried out based on the preload capability of the joint at high temperature for the 10 sec burn time. Thermo structural analysis of this set up was carried out using the temperature distribution from the thermal analysis. Three type of load steps viz., i) Preload ii) varying temperature at 10 sec and iii) varying internal pressure was used in this analysis. This paper covers the details of the thermo structural analysis and results viz., preload loss, bolt stress, O-ring opening, stresses in the C-C and metal flange and gap opening at Hydrogen injection point etc. and also covered the details of the post test inspection.