IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IPB)

Author: Mr. Paul Murugan J
Vikram Sarabhai Space Centre, ISRO, Thiruvananthapuram, India

Mr. Soumit Kumar Biswal
Vikram Sarabhai Space Centre (VSSC), India
Mr. Thomas Kurian
Indian Space Research Organization (ISRO), India
Mr. santhosh babu S
Vikram Sarabhai Space Centre, ISRO, Thiruvananthapuram, India
Mr. T Sivamurugan
Vikram Sarabhai Space Centre, Thiruvananthapuram-695 022, INDIA, India

THERMO STRUCTURAL ASSESSMENT OF UN-SUBMERGED FLEX NOZZLE SYSTEM (USFN) WITH 4-D CARBON- CARBON NOZZLE LINER

Abstract

Thrust vector control (TVC) system is being used in rockets to correct aerodynamic and performance perturbations and ensure that the launch vehicle maintains the intended trajectory. TVC is achieved through SITVC, Flex Nozzle control (FNC) and jet deflectors. Larger solid Motors use either SITVC or FNC system for TVC. Flex seal is a flexible or moving element in the FNC system which consists of alternate layers of elastomeric material and reinforcement shims. Conventional flex nozzles have a submerged configuration wherein the flex seal is housed inside the combustion chamber. The flex seal is shielded from the hostile thermal environment by providing adequate thermal protection and positioning it in a near stagnant flow region. Unsubmerged Flex Nozzle system (USFN) is a new type of flex nozzle mechanism which avoids the submergence in solid rocket nozzles. The advantages of USFN includes increased Isp, thermal protection optimisation due to non-accumulation of slag, reduction in actuation force on account of flex seal stiffness optimization for low pressure region and higher volume of propellant loading in solid Motor. It can be adopted in any operating solid motor without any major change in the nozzle system. In the USFN system, the flex seal is located in the downstream of the nozzle throat and a split-line is provided at the nozzle divergent for facilitating the mounting of the flex seal and thermal boot assembly. The vectoring of the USFN would yield a higher side force for the same vectoring angle due to the pressure distribution on the nozzle wall. The major challenge in developing USFN is obtaining requisite performance of nozzle liners in the vicinity of the supersonic split-line where severe thermo-mechanical environment would be created. This calls for the use of 4D carbon-carbon (C-C) material for the nozzle liners near the split-line. It was proposed to demonstrate this technology with RH560-M Motor and daisy-II flex seal to reduce the lead time for the subscale test and thus development cost. Design check and structural analysis of the hardware elements/flex seal proposed in this system was carried out for the pressure test condition. Also design check and thermo structural analysis of the system assembly especially the structural assessment of the 4D C-C throat and split line cavity liner for the static test condition was carried out. This papers covers the interface details, finite element analysis details, hot static test results and its comparison with pre-test prediction.