SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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DESIGN AND DEVELOPMENT OF FLEX NOZZLE FOR LARGE SOLID BOOSTER

Abstract

S200 motor is designed to function as a strap on boosters for the LVM3 launch vehicle capable of injecting 4T class satellites in GTO. The motor is configured as a 3.2 m diameter, 22m long loaded with 207T of HTPB based propellant. Thrust vector control (TVC) is facilitated with Flex Nozzle Control System (FNC). The FNC system consists of Flex Nozzle, a submerged/contoured nozzle with throat diameter of 886mm and area ratio of 12.1 and a vectoring capability of 7.8. Two electro hydraulic actuators of minimum 30T capacity at 90 apart are used to actuate the nozzle to 5.5 in actuator plane, powered by a hydraulic power pack in blow down mode. Mirror image sensors are provided to correct the tilt error due to flexseal axial compression under motor pressure.

S200 flex nozzle is designed with modular concept having five subassemblies. The development of S200 nozzle was challenging as it included flexseal of larger size, ablative liners with ply orientation varying from zero to 135 degrees to maintain the design criteria of flow to ply angle. Moreover, facilities like new 3m hydroclave had to be commissioned for the curing larger compact and defect free ablative liners. Flexseal system having low modulus rubber with 1.7mdiameter had been developed with the vectoring capability of 7.8 and employed for the hot test after completing the developmental and acceptance tests. In the first phase of development and qualification the flight version motor was subjected to two static tests (24th January 2010 and 4th September 2011) towards demonstrating the flight worthiness for the maiden LVM3-X mission. Subsequently with improved grain design and with additional design/process improvements for the flex nozzle a third static test was carried out successfully in June 2015. With respect to preliminary design, flex nozzle did not undergo any major design changes during the development/qualification phase except minor design/process improvements for better margins. For the first static test only limited commands in specific plane were affected to evaluate control system characteristics, as the primary objective was to demonstrate the propulsive element performance. For second and third static tests up to 7.1(resultant) vectoring of nozzle was carried out at the beginning of the tail off. Post-test investigations showed consistent behavior of ablative liners and the flex seal components.This

paper gives details on the design features of the flex nozzle, performance of the ablative liners in static tests and improvements introduced.