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DEVELOPMENT OF 58N BI-PROPELLANT THRUSTER FOR CHANDRAYAAN-2 VIKRAM MISSION

Abstract

ISRO has embarked on Chandrayaan-II Lunar Lander Mission to explore the lunar surface. Lunar lander encompass various scientific payloads required for the exploration. A conventional MON-3/MMH bi-propellant propulsion system is used to provide the necessary braking thrust required for soft landing of the lander on lunar surface. Eight numbers of 58N reaction control thrusters were employed to correct the attitude errors manifested during the soft landing of the lander.

58N thruster was freshly designed and developed exclusively for this mission. Preliminary design of the thruster was carried out using fundamental principles and equations taken from literature and text books. Subsequently, the design parameters were validated by using in-house developed software. Thermal and thermo-structural analysis was carried out for ensuring the thermal and structural margin of the design. Computational Fluid Dynamics analysis of the thrust chamber was carried out for estimating the Cf. Pressure drop across the injector and cone angle of the flow pattern was measured through cold flow studies on these thrusters. Subsequently, hot tests were done at sea-level condition to evaluate the performance. Based on the above test results, injector flow path dimensions of the thruster were fine tuned and the design was frozen.

Based on the frozen design, three qualification thrusters were realized and subjected to qualification level vibration for ensuring the structural integrity. Capability of the thrusters for the intended mission was demonstrated through pulse mode hot test varying from 2.5 to 97.5% duty cycle. Off nominal tests like variation in Mixture Ratio, Injection pressure, chamber pressure and hot restart test at maximum injector flange temperature were also carried out as part of qualification. Post-test visual inspection of the tested thrusters ensured the intactness of the hardware after hot test.

Subsequently, 8 thrusters were realized and successfully used for System Demonstration Model (SDM) & Lander Actuator Performance Tests (LAPT). Since SDM & LAPT tests were done in sea-level condition, the thrust chamber was trimmed to an area ratio of 3.5 to avoid the flow separation. Subsequently, eight numbers of flight thrusters were realized and delivered for Chandrayaan-2 mission. These thrusters performed as expected in the mission and all the flight measured parameters were well within the specification. This paper presents the details of 58N thruster development, theoretical analysis carried out as part of design verification, details of vibration and hot tests carried out as part of qualification.