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PERFORMANCE EVALUATION OF 4D CARBON-CARBON THROAT INSERT THROUGH HOT TEST OF SOLID MOTOR

Abstract

Third stage of Polar Satellite Launch Vehicle (PSLV) has a high performance upper stage Solid motor which uses submerged flex nozzle to meet the actuation requirements.Graphite is currently used as nozzle throat material. Though graphite is a good erosion resistant material, it has its own inherent limitations such as low thermal shock resistance, brittleness and low fracture toughness, which are compromising factors in terms of reliability.Besides the above, procuring graphite from reliable source and establishing the acceptability of the batch through extensive NDT checks are cumbersome and time consuming affair affecting the nozzle production rate.

As the motor performance is highly sensitive to the nozzle throat erosion, it is essential to have an erosion resistant material with good thermo structural properties as the throat material.In view of this, to enhance the HPS3 motor performance and to improve the reliability by overcoming the limitations of graphite, 4D C-C material was identified as an ideal candidate for nozzle throat owing to its extremely low ablation rate, remarkable thermal stability, low coefficient of thermal expansion and good thermal shock resistance.

4D Carbon-Carbon is processed in house wherein the carbon fibers are reinforced in the carbon matrix. The carbon fibers are braided in the required orientations (3D or 4D) called preform. The preforms were densified using molten pitch impregnation and carbonization process and the densified block was further graphitized to get the required properties.

Towards the qualification of new throat material, two subscale motors static test were conducted and the measured average throat erosion rate is 0.03mm/s.The observed throat erosion in subscale motor static test is normalized to flight motor operating condition which is used for performance prediction of HPS3 motor prior to static test.

The static test of motor adopting indigenously developed 4D C-C nozzle throat was successfully conducted and the observed performance is very close to the nominal prediction. Subsequent to the static test, the nozzle was disassembled and the throat erosion was measured.The observed 4D C-C throat erosion is 33

The performance of 4D C-C nozzle throat in HPS3 static test indicated promising results and this new throat material will be inducted in flight.