MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures 1 - Development and Verification (Space Vehicles and Components) (1)

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DESIGN CONSIDERATIONS FOR SOLID ROCKET BOOSTER FLEX NOZZLE HARDWARE

Abstract

One of the most effective methods of achieving control on the direction of thrust in a Solid Rocket Booster involves the use of a swivelable nozzle system often referred to as Flex Nozzle System (FNS) in rocketry. Most world class Solid Rocket Boosters in use today employ the FNS. Apart from the flexible element called the Flex Bearing, the flex nozzle hardware includes the structural backups for the converging, throat and diverging sections. An intermediate adapter termed as Bucket Flange connects the nozzle to the motor. The primary design considerations for the nozzle hardware of strap-on Solid Rocket Boosters (S200) for gsLVM3 were arrived at based on ISRO's years of experience in solid motor design and analysis. The ablative composite liners in a Solid Rocket Motor, with variable thickness and ply angles, inevitably result in a complex geometry for the backup hardware. Moreover, the load sharing between composite liners and structural backup is difficult to determine theoretically for motor operating conditions. Hence, unlike other solid motor hardware components, the design and testing of nozzle hardware needs to be tailored based on extensive analysis. The design of structural backup includes both stiffness and strength considerations. Stiffness needs to be adequate to minimize the stress in liners and interface bond while strength needs to be enough to withstand scaled-up loads during acceptance tests. This necessitates an integrated finite element analysis of the hardware and liner for various loading cases accounting for liner ablation with time during operation. While deducing the acceptance test criteria, care needs to be taken to simulate the estimated load in each component adequately while ensuring that the hardware is not over tested. For this purpose accurate estimation of loads from Finite Element Analysis assumes great significance. A detailed discussion is presented in this paper summarizing the methodology for design, development and validation through testing and numerical simulation.