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DESIGN ASPECTS OF HEAD END MOUNTED SAFE ARM (HMSA) FOR IGNITERS OF SOLID ROCKET MOTORS

Abstract

The Head End Mounted Safe Arm (HMSA) is proposed to be used to ensure safety against inadvertent initiation of the igniter of the Solid Rocket Motor. Although claimed to be functionally simple and efficient, this system has multiple components and joints that are subjected to high pressure loads. Thus it offers many challenges in the domain of structural and mechanical design. In this work we describe the critical design challenges, the problem formulation, the solution strategies and the final solution through analytical methods and/or FE analysis in the mechanical design of the Safe Arm and associated components. The general design criteria followed is also mentioned. First was the design of the barrier shaft. The relevant loads on the shaft were estimated for the system torque. The Statically indeterminate problem was first solved using Euler beam theory with necessary stiffness relations and subsequently the results were crosschecked and finer details obtained through FE analysis. Secondly, the barrier disc was designed to withstand the firing of the initiator in safe position and also had to satisfy strict space constraints. The disc was idealized as a plate to theoretically estimate the stresses for preliminary design, iterative FE analyses were performed to fine tune the design. The design check of the quadruple shaft seals was done with a combination of theoretical estimates (including thermal effects) and FE analysis. A separate cavity was designed to contain the motor gases in case of the failure of these seals. The design pressure for this cavity was a realistic pressure value estimated through compressible flow calculation rather than the maximum system pressure. Thirdly, concave shaped domes were introduced and designed for very high motor/igniter pressures in order to reduce the hardware mass, fasteners stresses and improve the seal compression levels. Fourthly, joints were introduced .A Modular Flanged Interface for HMSA which is to be common for all motors was designed. Certain design strategies employed for the design of flanged joint with unequal bolt spacing are also mentioned. Finally integrated 2D FE analysis with the methodology of Equivalent Stiffness Approach for Flanged Joint (ESAF) was performed for the HMSA-Igniter-Motor Assembly for simulating simultaneous/individual loading sequence of the Safe Arm, Igniter and Motor firing. Ideas and strategies to improve the overall design further are also discussed.