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Space Structures I - Development and Verification (Space Vehicles and Components) (1)

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ENGINEERING CHALLENGES IN CONFIGURING A MODULAR CRYOGENIC UPPER STAGE

Abstract

Cryogenic propulsion systems are essential in a launch vehicle upper stage to impart about half the total GTO velocity. Cryogenic stage requires a large number of control components and flow regulation modules, which are mounted on the propellant tanks. Mounting on tank domes has two major disadvantages. Tank skin thickness is to be locally increased, which necessitates exhaustive chemical milling and machining operations. Stage integration can be initiated only after the readiness of propellant tanks with insulation and structures after acceptance tests. A new configuration with closed inter-tank structure is engineered that can enable stage integration in three standalone modules, that can reduce the overall stage realisation time. In the proposed configuration, the tubular truss type intertank structure is replaced with a closed stiffened structure that is designed to take care of thermal contraction of cryogenic tanks during chilling and filling. The structure also has provision for mounting all control components. Since the mounting requirement is removed from the tanks, tank thickness is also optimised. Fluid sub-systems can be realized once this structure is available. The engineering of the closed inter tank structure has many challenges that include design of mass optimized structure to accommodate thermal contraction of tank interfaces while retaining its capacity to transmit vehicle loads. Mounting provisions for fluid control components, umbilical and fluid lines are to be implemented with minimum changes on flight proven sub-systems. The integration / acceptance test philosophy has to be reworked considering the new modular integration. Other challenges include finalizing the relative location of mounting for the control components with reference to tank nozzles for optimal lines routing. Joining the fluid servicing lines between three modules through proper interfacing with each other is also a challenge. This paper outlines the configuration of closed inter tank structure for a cryogenic upper stage, the challenges faced during engineering as well as development and how the structure was optimized, to meet the challenges in thermal contraction, fluid line interfacing as well as mounting of fluid control components.