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EXPERIMENTAL INVESTIGATION OF 150N LIQUID OXYGEN-LIQUID METHANE ATTITUDE CONTROL ENGINE

Abstract

Next generation propulsion systems are currently being developed to enable future exploration missions. Cryogenic bi-propellants are attractive for their high performance. Liquid oxygen /liquid methane (LO2/LCH4) in particular, is gaining appeal for combination of high specific impulse (Isp) potential, moderate thermal storage requirement, simple handling and In-Situ Resource Utilization compatibility. Although recent work in LO2/LCH4 technology advancement has shown progress, this propellant combination is still considered novel and requires a series of risk reduction activities prior to proceeding with detailed design, development, and fabrication of an integrated LO2/LCH4 propulsion system. Shanghai Institute of Space Propulsion (SISP) has been focusing on the novel technology since 2010, and has made substantial progress in the development of the components and subsystems that are deemed lacking in technical maturity but are considered to be essential to successful application of LO2/LCH4 propulsion system. To demonstrate performance and prove feasibility of this propellant combination, a comprehensive test program of a 150N attitude control engine is underway at the SISP's cryogenic combustion stand at sea-level. This stand has the capability to test up to a thrust level of 3000N with precise measurement of propellant conditions, propellant flow rates and engine thrust. The split-triplet unlike impinging injector and spark torch igniter are utilized to develop the 150N engine. The integrated injector and igniter in one monolithic component, which is fabricated using a platelet diffusion bonding process, is applied to eliminate the need for a separate set of propellant valves for the igniter. The platelet process enables intricate and precise flow passages to be incorporated into the injector to promote uniform fluid distribution at the injection face. The radiative and liquid fuel film cooling (FFC) is employed for the thrust chamber, which is fabricated from a niobium alloy with an oxidation resistant coating. The nominal mixture ratio (MR) is 2.5, the designed chamber pressure is 1.0 MPa, and the percent of fuel flow used for FFC is 25. The ignition margin test, pulsed-mode operation test and steady-state test are conducted investigating the engine performance of ignition reliability, impulse bit and specific impulse. The resulting data validates that the 150N LO2/LCH4 engine utilizing innovative design solutions performs as expected, with fine Isp, repeatable pulse performance and short minimum impulse bit (MIB). In addition, the engine can successfully ignite reliably over a broad range of propellant conditions from gaseous to two-phase to sub-cooled liquid.