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PROJECT ICE RABBIT: INTEGRATED LIQUID OXYGEN/LIQUID METHANE PROPULSION SYSTEM FOR FUTURE PLANET EXPLORATION VEHICLE

Abstract

Spacecraft trade studies planning the future flights to Mars and other planets frequently recommend the liquid oxygen/liquid methane (LO2/LCH4) propellant combination as the right combination of high specific impulse (Isp) potential, moderate thermal storage requirement, simple handling and In-Situ Resource Utilization (ISRU) compatibility. 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. In 2018, the project Ice Rabbit is approved to develop a prototype integrated pressure-fed liquid oxygen/liquid methane propulsion system for verifying the key technologies involved in the future spacecraft in-space cryogenic propulsion system. The Ice Rabbit utilizes one 5000N-vac main engine, two 150N-vac and two 25N-vac reaction control engines (RCEs) mounted in two pods, two 400L spherical aluminum propellant tanks containing up to 375kg of LO2 and 125kg of LCH4, and a helium system for propellant tanks pressurization. The 5000N-vac main engine employs a split-triplet unlike impinging (F-O-O-F) injector fabricated using a platelet diffusion bonding process and a liquid fuel film cooling (FFC) thrust chamber/nozzle assembly with oxidation resistant coating. The two 150N-vac and two 25N-vac RCEs constitute the reaction control system (RCS), and RCS feedline conditioning is accomplished via bleed flow through a thermodynamic vent system (TVS) on the RCS manifolds. All these five engines use a coil-on-plug (COP) ignition system, which eliminates the corona discharge issues associated with a high voltage lead between a conventional exciter coil and the spark plug. The propellant tanks are insulated with a polyurethane foam layer to reduce the heat leakage in sea-level operation, and to ensure that the cryogenic propellants do not heat up more than 10K within three hours. Multiple innovative verification tests will be performed on the Ice Rabbit, including integrated main engine/RCS operation, pressure-fed cryogenic RCS characterization over a wide range of conditions, COP ignition system demonstration at the vehicle level, and cryogenic propellant tank helium pressurization characterization. The acquired data of engine operation, water hammer and heat leak will be used in future vehicle design activities.