66th International Astronautical Congress 2015

SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems (4)

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MEASURING CRYOGENIC TWO-PHASE FLOW DURING COASTING FLIGHT OF S-310-43 SOUNDING ROCKET FOR UPGRADING H-IIA UPPER STAGES AND FUTURE REUSABLE ROCKETS

Abstract

Upper stage of Japanese primary launch vehicles, e.g., H-IIA is now being upgraded for improving payload capacity. Currently, regarding GTO (Geo Transfer Orbit) missions, the upper stage engine of H-IIA burn twice and insert satellites in 28.5 degree inclination GTO. The H-IIA upgrade aims to decrease inclination for satellites with third burn of upper stage at apogee after long-duration coast. In order to realize these missions, it is desired for the upper stage propulsion system improving LOX chill-down procedure. The method called "trickle chill-down system", is now under development. Trickle chill-down system supply small quantities flow of liquid-gaseous two phase oxigen to the LOX turbopump. The Japan Aerospace Exploration Agency (JAXA) launched the S-310-43 sounding rocket from the Uchinoura Space Center on Aug. 04, 2014 for the purpose of investigating such behavior as boiling and flow of cryogenic liquid rocket propellant in an environment simulating coasting flight on orbit by using the sounding rocket's sub-orbital ballistic flight. In the low-gravity state, the cryogenic fluid (liquid nitrogen) was

introduced into the test sections of similar shapes to the complex channels in the cryogenic propulsion systems. The boiling of liquid nitrogen inside the test-sections and the transition of flow regimes from gas/liquid two-phase flow to liquid mono-phase flow were visualized. The temperatures, pressures and void fractions of each channels were measured as well. Compared with the corresponding ground test, it was confirmed that the two-phase flow in the complex channel could wet the heat transfer surfaces more easily due to the absence of gravity, and that more uniform chill-down effect could been obtained. Development of the experimental equipment for S-310-43 sounding rocket is described in this paper.