SPACE PROPULSION SYMPOSIUM (C4)
New Missions Enabled by New Propulsion Technology and Systems (6)

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CONCEPTUAL STUDY ON FLIGHT DEMONSTRATION OF MIXTURE-RATIO-CONTROLLED THROTTLING OF HYBRID ROCKET

Abstract

Results of conceptual study on technology demonstration in flight of a newly proposed hybrid rocket (HR) being enabled mixture-ratio-controlled throttling (MRCT) are described in this paper. The proposed system, named Altering-intensity Swirling-Oxidizer-Flow-Type (A-SOFT) hybrid rocket[1], is essentially-non-explosive and equipped with an MRCT technology. By performing a multi-objective optimization of A-SOFT HR, it has been shown that MRCT is remarkably effective for expanding mission applicability of a sounding rocket[2]. The A-SOFT is realized by independently modulating axial and tangential oxidizer mass flow rates so that both thrust and mixture ratio (O/F) are simultaneously controlled.

In most cases, during throttling of a hybrid rocket, O/F varies in accordance with the $(1-n)$-th power of the oxidizer mass flow rate, where n is usually in the range of 0.5-0.8. So, the propulsion performance deteriorates remarkably in throttling down at lower-than-optimum O/F, or in throttling up at larger-than-optimum O/F, since the specific impulse is usually an upward-convex function of O/F[3]. From launch-system-wise viewpoints, one of the most serious problems caused by O/F shift is the resulting propellant residue[4]. So, MRCT is one of the most-important key technologies for the achievement of high-energy mission, such as a satellite launch, of hybrid rockets in space transportation.

Mission requirements for the technology demonstration of MRCT of a hybrid rocket in flight, are to demonstrate 1) capability of designing a compact thrust chamber employing a method of high fuel regression rate, 2) capability of lowering propellant residual and of wide-range thrust control with MRCT technology, and 3) capability of re-ignition in space. During the flight demonstration, for a feedback control of both two quantities being assured, real-time on-board measurements of the fuel web-thickness and of the combustion pressure have to be done.

References

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