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Author: Mr. Landon Kamps
Hokkaido University, Japan

Mr. Pau Molas-Roca
Luleå University of Technology, Sweden
Ms. Erika Uchiyama
Hokkaido University, Japan
Mr. Tomohiro TAKANASHI
Hokkaido University, Japan
Prof. Harunori Nagata
Hokkaido University, Japan

DEVELOPMENT OF N2O/HDPE HYBRID ROCKET FOR MICROSATELLITE PROPULSION

Abstract

One attractive use for state-of-the-art hybrid rockets is as satellite thrusters which will alleviate operators from relying solely on piggy-backing on larger satellite buses, thus reducing launch wait times, and increasing freedom of movement to desired orbital placements. At previous IAC conferences, Jens et al. have reported the concept for a hybrid rocket apogee kick motor using gaseous oxygen as the oxidizer for placing CubeSats into deep space. One major technical limitation to such a vehicle is the maximum size and cost of the pressure vessels necessary to store the oxidizer. In the case where payloads larger than CubeSats are desired, it may be advantageous to have a vehicle that uses an oxidizer that can be stored as a liquid to avoid the requirement for large and expensive high-pressure vessels. One such oxidizer is nitrous oxide (N2O).

Our laboratory is currently developing a hybrid rocket propulsion system that fits within a 50 cm cubic microsatellite to accelerate a 6U (10x20x30 cm) payload weighting up to 30 kg from GTO to Mars orbit (1200 m/s). The propellants selected for this hybrid rocket motor are N2O and high-density polyethylene (HDPE). One key aspect of this propellant selection is the ability to store and supply N2O as a liquid at room temperature by maintaining it at a pressure over 5 MPa. The authors developed empirical correlations for fuel regression rate and graphite nozzle erosion rate from the analysis of over 30 static firing tests using liquid N2O as the oxidizer. In this case an impinging-type injector was shown to reduce pressure oscillations with minimal pressure loss, and the aft-combustion chamber shape and size proved crucial to ensuring relatively high combustion efficiency (>95 %).

The objective of this research is to identify the effects of nozzle throat erosion, fuel shape, and payload mass on the change in velocity (ΔV) capability of the hybrid rocket-propelled microsatellite, based on detailed empirical correlations from previous research. Preliminary results show that with a tubular fuel grain, a bulky graphite nozzle, and a split-payload (i.e. 2 x 3U compartments) weighing 30 kg, a change in velocity of 1200 m/s (GTO to Mars Orbit) is attainable even when allowing for nozzle throat erosion. Static firings tests in a high-altitude chamber on a six-degree-of-freedom thrust stand will begin in April. Discussions related to ignition/re-ignition and satellite stability may be possible by the manuscript due date as a result of these tests.