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Author: Dr. Yen-Sen Chen
American Institute of Aeronautics and Astronautics (AIAA), United States, ychen_esi@yahoo.com

COST-EFFECTIVE HYBRID ROCKET LAUNCH VEHICLE OF TAIWAN

Abstract

Hybrid rocket propulsion has been incorporated in the development of micro launch vehicles for space launch and flight experiment applications in Taiwan. With the proposed hybrid rocket launch vehicle design, hybrid rocket engines can also deliver vacuum thrust performance close to that of kerosene liquid engines but with much reduced development and production costs.

High fidelity design approach and hot-fire experiments are employed to assess the overall performance of the enhanced-mixing hybrid rocket engines. Flight tests using hybrid rocket launch vehicles are conducted to validate the performance of the propulsion and flight control systems.

In the hybrid rocket propulsion literature, the engine performance is usually discussed with a fixed geometry at ignition or assumed geometry at certain point into the burn. Detailed discussions on the history of the solid grain burning surface variations are still lacking which can impact the internal flow pattern and the overall performance of the hybrid rocket engine.

To further assess the thrust performance of the present enhanced-mixing hybrid rocket design, a comprehensive computational approach is proposed to analyze the internal ballistics of the hybrid rocket engine throughout its entire burn time such that the issues of O/F ratio variations, fuel grain regression history and overall Isp performance can be revealed in a single analysis. The baseline design of the present enhanced-mixing hybrid rocket engine incorporates nitrous oxide and SBR (Styrene-Butadiene Rubber) high-density propellants system for combustion.

Based on the optimized designs using the present computational method, a hybrid rocket launch vehicle is designed and integrated for flight tests. The launch vehicle system is a three-stage design with thrust levels of 55,000 kgf, 8,000 kgf and 1,000 kgf for the first-, second- and third-stage, respectively. Thrust vectoring control systems and a reaction control system are employed and integrated with the GNC system of the launch vehicle such that stable flight trajectories can be performed to optimize the launch operations.

Numerical simulations of the hybrid rocket internal ballistics, ground hot-fire tests and flight tests of the present hybrid rocket launch vehicles will be presented in this paper. The overall rocket performance will be presented in terms of Isp and O/F ratio variations throughout the propulsion phases of the launch operations. These technical results provide a firm foundation for the development of a 3-stage space launch vehicle that is capable of delivering 350 kg class of satellites to 700 km altitude LEO/SSO orbits.