IAF SPACE PROPULSION SYMPOSIUM (C4)
Solid and Hybrid Propulsion (1) (3)

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

TISPACE HYBRID ROCKET LAUNCH VEHICLE DESIGN FOR SPACE MISSIONS

Abstract

Hybrid rocket propulsion is incorporated in the design of micro launch vehicles for suborbital science experiments and orbital satellite launches. With the proposed launch vehicle systems, hybrid rocket engines can also deliver system performance comparable to their liquid counterpart but with much reduced production costs.

High fidelity design approach is employed to assess the overall performance of the present hybrid rocket propulsion system. Flight tests of a suborbital launch vehicle, Hapith I, based on the present propulsion system design are conducted to validate the system performance. This presents a very efficient way of rocket system validations that pave the way for the production and flight tests of an orbital launch vehicle, Hapith V.

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 hybrid rocket engines, a comprehensive computational approach is employed to reveal the internal ballistics of the hybrid rocket engine throughout the entire burn such that the issues of O/F ratio variations, fuel grain regression history and overall Isp performance are obtained in a single analysis. The present hybrid rocket engines are operated based on the combination of liquid nitrous oxide and solid SBR (Styrene-Butadiene Rubber) propellants with their rocket system performance enhancing characteristics.

Based on the development efforts of the present program, hybrid rocket launch vehicles are designed and integrated for flight tests. The orbital launch vehicle, Hapith V, is a three-stage system with vacuum thrust of 65,000 kgf, 8,000 kgf and 1,000 kgf for the first, second and third stage of the rocket, respectively. Thrust vectoring control systems and a reaction control system are employed and integrated with the GNC system of the launch vehicle such that space launch flight trajectories can be performed and optimized for best payload delivery performance. The present launch vehicle is designed to deliver 350 kg satellite to 700 km altitude LEO and SSO orbits. The second and third stages of the launch vehicle are employed to produce the suborbital launch vehicle, Hapith I, for performing science experiments such as ionosphere studies supported by the National Space Organization of Taiwan.