

SPACE PROPULSION SYMPOSIUM (C4)  
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## DEVELOPMENT OF A MULTI-FUNCTION HYBRID SOUNDING ROCKET

**Abstract**

Hybrid rocket propulsion is deemed to be advantageous to its solid and liquid counterparts for the safety nature of the designs. With the proposed multi-function hybrid sounding rocket design in this research using an enhanced-mixing combustion method, 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 numerical modeling design approach and hot-fire experiments are employed to assess the overall performance of the enhanced-mixing hybrid rocket engines. Flight tests using hybrid sounding rockets have been conducted to validate the performance of the propulsion system.

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 associated with the variations in the internal flow dynamics can be revealed in a single analysis. The baseline design of the present enhanced-mixing hybrid rocket engine incorporates hydrogen peroxide and HTPB propellants system for combustion. A conventional single-port hybrid rocket engine is also analyzed for benchmark comparisons.

Based on the optimized design using the present computational method, a multi-function hybrid sound rocket is designed and integrated for flight tests. The present rocket system is a two-stage design with thrust level of 8,000 kgf and 1,000 kgf for the first- and second-stage, respectively. A thrust vectoring control system and a reaction control system are employed and integrated with the guidance, navigation and control system of the sounding rocket such that more precise flight trajectory can be performed to maximize the overall outcome of the flight experiment.

Numerical simulations of the hybrid rocket engine internal ballistics, ground hot-fire tests and flight test preparation processes of the present multi-function hybrid sounding rocket will be presented in this paper. The results show that good performance can be delivered in terms of Isp and O/F ratio variations throughout the propulsion phases of the launch operation.