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DESIGN OF SCALABLE HYBRID ROCKET MOTOR FOR SPACE PROPULSION APPLICATIONS

Abstract

Provided their safety of operation among other benefits, multiple hybrid rocket motors (HRM) are currently under development while some have already flown successfully (ex. SpaceShipTwo from *Virgin Galactic*). The applicability range of this kind of space propulsion, which combines non-explosive liquid oxidizer and solid fuel as propellants, is yet to be proven. One technical issue is the available volume for the propulsion system on launchers' upper stages and satellites, that are wider than higher, which constrains the accommodation of HRM in the vertical dimension. Thus, a major concern of relevant consideration is for what payload mass and change in velocity (ΔV) ratios these motors are feasibly scalable within the mentioned spacecrafts' range.

Consequently, this research focuses on a non-traditional horizontal arrangement of HRM components to examine how the propellant choice and mixture ratio affect the use of space and the performance of the motors for three relevant cases.

Case 1: apogee kick motor for small satellite payload and small ΔV ($700m/s$, Lunar Orbit).

Case 2: apogee kick motor for small satellite payload and medium ΔV ($1200m/s$, Mars Orbit).

Case 3: third stage motor for a large payload and large ΔV (between $2500 - 3000m/s$).

In order to conduct this study, the author is developing a software, based on inherited empirical data from the analysis of multiple firing tests, that enables the best estimated motor configuration for any use to be found. This method is currently being applied and fine-tuned on the simultaneous development of the aforementioned HRM preliminary designs for real space missions. Specifically, it is important to clarify whether a scalability method exists by understanding the limitations in performance arising from payload to mass ratio and propellants configuration, for a horizontal motor layout. Comparative relation between cases 1 and 2 will show the design's consequences of varying ΔV for a given payload mass. Case 3 is meant to reflect if the scalable model is still suitable for larger payloads and ΔV.

The opportunity of procuring reliable baseline designs of HRM for small to medium-sized space applications might set a milestone in the spacecraft design scene. It would provide the tools to obtain a customized motor preliminary configuration and design depending on the user's needs. The end goal of this research is to clarify whether HRM scalability is applicable to a wide span of spacecrafts, from launchers' upper stages to small satellites, making it of great use for the space industry.