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

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EXPERIMENTAL VERIFICATION OF ADVANCED HYBRIDS PERFORMANCE AND SCALING FACTORS

Abstract

Hybrid propulsion technology has attracted considerable amount of interest over the past decades for use in space applications in light of its numerous advantages. Some of them are (1) environmentally friendliness, thanks to the possibility of using green propellants; (2) safety, enabled by the physical separation of oxidizer and fuel; (3) simplicity, with only a single liquid feeding line and a fuel lined combustion chamber; (4) controllability, with the possibility of easily deep throttling the thrust, shut down and restart the motor multiple times. Furthermore, many recent studies have successfully proposed various solutions to the typical problems of this technology, such as low regression rate and low combustion efficiency, but often experimental verification remains stuck at lab-scale, leaving questions on its effective scalability to operational sizes. Within the framework of the PHAEDRA (Paraffinic Hybrid Advanced Engine Demonstrator for Rocket Application) program, funded by the Italian Space Agency, the objective of the work is to design, manufacture and test a Technological Demonstrator that can experimentally validate the concept of hybrid propulsion based on paraffinic fuel on a significant scale for an identified application. In particular, it will help to evaluate the feasibility of the design of a 50kN class hybrid rocket engine for access to space application that has been performed in the initial phase of the program

and identified as a target application for this technology. Vortex injection, HTP as oxidizer, and paraffin wax as fuel are distinctive features of this hybrid propulsion system, which guarantee high efficiency, stability, and compactness, thanks to a high volume loading combustion chamber. The aim of this paper is to describe the cascade logic process that, starting from the performance requirements of the launcher's third stage engine, has led to the definition, through the use of scale factors, of the requirements for a 10kN class demonstrator, and subsequently, for its lab-scale thrust class counterpart. Afterwards, from the experimental results obtained in each campaign, the scale factors used were verified, and the program's initial inquiry assessed. Particularly, the outcomes of the lab-scale motor campaign were used to determine the proper paraffin blend and to identify the optimum volume of the post combustion chamber for the DEMO 10kN class demonstrator. Finally, the findings from the DEMO experimental campaign will be used to assess the feasibility of developing an upper stage hybrid propulsion system with 50kN class thrust and to confirm its first preliminary design.