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DESIGN AND OPTIMIZATION OF A SCALABLE HYBRID ROCKET MOTOR

Abstract

In recent years, there has been a surge in interest from the space industry to develop hybrid rockets. Some studies show that there are clear advantages to this kind of rocket over both liquid and solid propellants, the most commonly quoted being the combination of the simplicity and ease of operation of a solid propellant rocket with the controllability of a liquid propellant rocket. However, a very commonly mentioned disadvantage is the low-regression rate when compared to regular solid propellant. This is translated into a lower thrust density and/or a high length-to-area ratio. The different combinations of grain shapes and fuel compounds presented aim to counteract this problem.

Swedish Lapland region is experiencing a crescent growing in activities related to the space access according SSC's planning (Swedish Space Corporation). Tracking this demand, Lulea University of Technology, The northernmost University of Technology in Scandinavia, is increasing the investment in research on rockets and propulsion systems, being the development and manufacturing of a Hybrid Rocket the first step.

In this paper a preliminary design of a hybrid motor using CAD/CAE software is developed and optimized. Different fuel grain shapes are studied in order to determine the effectiveness of the combustion process and find the optimal configuration while also considering the manufacturability of the proposed shapes. The desired thrust values for this study are 5, 10 and 15 kN using a bell-shaped nozzle. HTPB/N_2O and Al-doped HTPB/N_2O are examined as propellants. HTPB (Hydroxyl-terminated polybutadiene) is commonly used as a binder agent for solid propellant, but it has seen use as solid fuel by itself, most recently with Virgin Galactic's SpaceShipTwo using HTPB and N_2O as the propellant in its hybrid rocket motor. N_2O is a well-known liquid oxidizer used both in hybrid and liquid propellant systems. Both N_2O and HTPB are very safe to handle and store since they are not toxic nor reactive by themselves, which would facilitate testing of this system.

This study aims to find the best-suited thrust level for this kind of motor, keeping a reasonable efficiency and providing insight into the scalability of hybrid rocket motors. The obtaining of all the necessary parameters to manufacture this motor for experimental testing is also an objective. Given the intended thrust range, this design would be suitable for an Academic Rocket and, in a near future, a small sounding rocket.