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FUEL CHARACTERIZATION, PERFORMANCE ASSESSMENT AND THERMAL ANALYSIS OF A HYDROGEN PEROXIDE-BASED HYBRID THRUSTER FOR CUBESATS

Abstract

In the last decades, the interest in space missions carried out using small satellites has steadily increased. Consequently, the demand for miniaturised, high-performance systems has grown in step with the development of scientific and commercial missions based on small satellites. Hybrid thrusters can play an important role owing to their characteristics: relatively high thrust levels with respect to electrical propulsion devices, monopropellant engines and cold gas, re-ignition capabilities and thrust modulation, reduced weights and dimensions in comparison with those of liquid propellant rocket engines of equivalent thrust, non-toxicity and safety. Although this propulsion system has shown great potential, it remains a challenging technology and is not currently used in actual space missions.

In this context, the Space Propulsion Group at the University of Naples Federico II is extensively performing studies concerning a 10N class, small-scale hybrid rocket engine for CubeSats. Among the various possible combinations of propellants, the research team has selected High Test Peroxide as the oxidizer and polymeric grains as fuels. This work is conceived to pursue two main objectives: the characterisation of different materials, and the assessment of the thruster's thermal behaviour.

The first goal has been achieved through extensive experimental campaigns of a ground breadboard of the system under investigation, exploiting the instrumented test bench available at the Aerospace Propulsion Laboratory located in Grazzanise (CE). Different cylindrical grains have been tested, comparing the thruster's performances under varying fuel compositions (PVC, HDPE, and ABS) while keeping unchanged the engine configuration, the oxidiser characteristics, the feed pressure, and the grain port diameter. The engine's internal ballistic has been studied through the post-processing of fire test data, supported by numerical CFD simulations and ballistic reconstruction techniques. As a result, regression laws as a function of the fuel composition have been defined, showing a significant increase in the $\dot{r}$ dependency with G_{ox}, with respect to values available in the literature for bigger scale thrusters.

On the other hand, a new design of the hydrogen-peroxide rocket engine has been developed to address the crucial aspect of its thermal management in an extremely limited volumetric envelope. The new thruster configuration with a larger fuel grain diameter will allow to carry out longer fire tests. The analysis of the temperature distribution along the combustion chamber will enable to optimisation of the design of future thrusters and will be used to validate a numerical model implemented to characterise the

thermal behaviour of the engine.