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Title

Experimental investigation of paraffin-based fuel doped with MgB_2 and MWCNTs in a 1-kN hybrid rocket engine

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Abstract

Hybrid Rocket Engines (HREs) are a class of chemical propulsion systems where the propellants are in different states of the matter, usually, the oxidizer is a liquid and the fuel a solid, and that brings advantages such as low cost, thrust throttling, safety, and simplicity. Despite the various investigations carried out during the last decades, hybrid rocket technology improvement efforts still face several problems, like combustion instabilities, low regression rate of the solid fuel, and combustion efficiency [1]. On the other hand, the development of hybrid propellant propulsion systems based on hydrocarbon fuels is becoming a technological asset for small launchers and new-generation space transportation systems [2].

In HREs, the fact that the fuel is in the solid phase makes it very easy to add performance-enhancing materials and the use of compound micro powders is a promising approach to improving the physical and mechanical properties of the fuel grain. Methods of production of non-metallic micro-nanoparticles can significantly affect the morphology and physical properties of nanopowders [3]. Meanwhile, the addition of certain reactive metal powders such as aluminium, magnesium, and boron powders, can increase the specific impulse of hybrid and solid propellants [4].

The Aero-Thermo-Mechanics at the Université libre de Bruxelles (ATM-ULB) and the Chemical Propulsion Laboratory at the University of Brasília (CPL-UnB) have been studying the influence of metal and non-metal powders as an additive for hybrid rockets, and the team was one of the firsts to suggest the using of the Magnesium-Diboride (MgB_2) for HREs [5].

Previous small-scale tests, using a slab-burner, carried out by ATM-ULB indicate that the Magnesium-Diboride and the Multiwalled Carbon Nanotubes (MWCNTs) reveal a gain in terms of c^* efficiency for MWCNTs concentrations up to 1.5%; while the MgB_2 impacts positively the regression rate of the solid fuel grain. Two tests using the 1kN hybrid motor developed at the ATM-ULB show average values for the regression rate of 9.95 mm/s when doped with 5% of MgB_2, and 7.02 mm/s for pure paraffin [6], [7]. However, the samples doped with MgB_2 were completely consumed during the firing test, together with part of the polyvinyl chloride that was used as grain casing, and that impacted the accuracy of the average regression rate measurements. In this work modifications in the experimental apparatus allow us to repeat the tests with Magnesium-Diboride for different port diameters, and to do tests with MWCNTs at similar conditions.

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