Paper ID: 70494
oral

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

Author: Dr. Artur Bertoldi
University of Brasilia, Brazil, bertoldi@unb.br

Mr. Riccardo Gelain
Université Libre de Bruxelles, Belgium, riccardo.gelain@ulb.be
Prof. Patrick Hendrick
Université Libre de Bruxelles, Belgium, patrick.hendrick@ulb.ac.be

CHARACTERIZATION OF HYBRID ROCKET PARAFFIN-BASED FUELS

Abstract

In the recent past hybrid rocket propulsion systems have received a substantial and renewed interest as a suitable alternative to liquid and solid propulsion systems (Bouziane et al., 2017). Nowadays, the development of hybrid rocket engines (HREs) is still limited by the maturity of the technology, and at the state of the art, the main drawbacks of the HREs, such as low regression rate of the solid fuel, O/F shift, and poor efficiency have not yet been fully solved (Carmicino et al., 2014). Part of these problems have been overcome by the use of paraffin-based fuels, the introduction of new machining processes, the exploitation of electric pump feeding for the liquid propellant (Casalino et al., 2019), and the adoption of control valves for throttle-ability (Zhao et al., 2022). The use of paraffin as a fuel increased the regression rate of the solid grain from 3 to 4 times more than the classical fuels used in the past, such as HDPE (high-density polyethylene) and HTPB (hydroxyl-terminated polybutadiene). On the other hand, paraffin-based fuels have a poor structural strength, which makes it very difficult the employ the fuel in practical commercial applications. Preliminary investigations carried out at the Aero-Thermo-Mechanics Department (ATM) of Université Libre de Bruxelles (ULB) with paraffin doped with magnesium diboride (MgB2) showed that this additive has the potential to improve some characteristics of the pure paraffin grains as the average regression rate and the average specific mass of the grain, but with negligible impact of the structural resistance of the fuel grain (De Morais Bertoldi et al., 2018). This paper expands on the study of paraffin-based fuels by doping the paraffin-matrix with polymers and metal powder. The combination of pure paraffin with polymers and metal powders, and carbon-based nanotubes, shows that it is possible to improve the strength of the grain with minimum impact over the fuel regression rate. In the article, a comparison between the different fuel formulas is presented. The tests were carried out using the ULB-ATM MOUETTE Slab Burner, a small hybrid rocket engine with optical access that allows the visualization of the fuel specimen in the combustion chamber. The motor is also equipped with pressure transducers and thermocouples in the pre-and post-chamber, as well in the feed system. The use of MOUETTE Slab Burner allows investigating a reduced quantity of propellant, as a consequence increasing the number of specimens that can be tested.