RHEOLOGICAL AND BALLISTIC INVESTIGATIONS OF PARAFFIN-BASED FUELS FOR HYBRID ROCKET PROPULSION USING A 2D RADIAL MICRO-BURNER

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This paper describes combined rheological and ballistic experimental analyses performed on paraffin-based mixtures that might profitably be used as solid fuels in hybrid rocket engines. High regression rates of paraffin-based fuels are explained by the presence of a low viscosity unstable melt layer on the surface of the fuel grain which entrain liquid droplets in the port gas flow [1]. Because of this relation between viscosity and the entrainment effect [2], which strongly increases the regression rate, rheological and viscosimetric analyses were carried out to obtain viscosity measurements at different temperatures and shear rates. Joint experimental activities were performed at both Politecnico di Milano in Italy and DLR Institute of Space Propulsion in Germany. Both pure waxes and doped ones were initially selected based on Differential Scanner Calorimetry (DSC) measurements, in order to consider fuel mixtures with different thermal properties and obtain a well-structured database. Mixtures of different kinds of pure waxes, both macro and micro crystalline, doped with 10% of stearic acid and 2% of graphite were considered. The melting peaks of the considered waxes vary from 50 °C to 95 °C. Rheological investigations were made using a rotational parallel plate rheometer, while viscosimetric experiments were performed using a conical plate and couette rheometer. The ballistic behavior of these wax-based fuel formulations was evaluated in terms of regression rate. Experimental investigations were carried out at Space Propulsion Laboratory (SPLab) of Politecnico di Milano, using a 2D-radial micro-burner with centrally perforated cylindrical strands. The results so far collected point out a clear correlation between regression rates and the measured viscosity of the melted paraffin layer.

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