IAF SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

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HYBRID PROPULSION: INNOVATIVE FORMULATIONS BASED ON PARAFFIN / ETHANOL INTERACTION

Abstract

Over the years, hybrid propulsion has been researched as a low-cost option of propulsion system. Due to their characteristics, hybrid motors have many applications, from large launchers to small propellers of altitude control and orbit transfer. In hybrid engines, the oxidizer and the fuel come in two different physical states, differentiating their combustion in relation to the solid and liquid rockets, so as to use the strengths of each of these systems. However, the major problem encountered in hybrid engines is the low regression rate during burning. Several modifications and solutions have been proposed and studied over the years, but one of the most interesting is based on the use of paraffin as fuel base. Paraffin still does not reach an ideal regression rate and mechanical requirements (compared to solid propellants), therefore the use of additives in the formulation is common. In this context, the present work deals with the proposition of innovative formulations of solid fuel for hybrid rocket engines, based on paraffin and ethanol emulsions, in order to increase the heat released in the combustion and, at the same time, increase the regression rate. The first step was to evaluate the optimum content of ethanol in paraffin, i.e. development of the base fuel. Then, several formulations composed by paraffin emulsified with ethanol and carbon black and aluminum as additives were developed and analyzed, in order to improve the thermal and ballistic properties of the grain (compared to pure paraffin) and, therefore, enable its application for the use and improvement of hybrid rocket motors. The best base formulation obtained contained a maximum of 10% ethanol relative to paraffin in order to avoid phase separation. The optimum amount of additives were 1% carbon black and 10% aluminum, which generated a homogeneous solid fuel with a high heating value of 45.118 MJ/kg. Using Gox as oxidizer, the use of ethanol and additives generated an increase of approximately 20% in the observed regression rate, and also reduced the amount of unburnt fuel expelled from the combustion chamber when compared to the pure paraffin burning behavior.