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HYBRID-ROCKET MOTOR PERFORMANCE TRADE OFF WITH PARAFFIN BASED AND METAL-LOADED HTPB FUEL GRAINS

Abstract

Hybrid engine technology is an innovative, high performance and promising propulsion technique in a number of space missions by combining features deriving from both solid and liquid propulsion. Among the advantages offered over conventional solid and liquid rockets there are safety, low cost, throttleability, and simplicity. However, the standard fuels, mostly based on hydrocarbon polymers, suffer from a low regression rate which entails complex fuel grain shapes and low loading ratios, this being the main drawback to the development of hybrid propulsion for a launch vehicle booster. Hence, in order to make hybrid booster a more viable contender, the burn rate has to be increased several times. Among the effective means of increasing the regression rate, there is the addition of aluminum, or of other metals powders to the fuel grain. Indeed, in comparison with the pure fuel, one may expect that the regression rate increases with the mass fraction of metallic particles; the latter reduce both the effective heat of gasification of the bulk fuel and the blocking effect of mass blowing. In addition, also the flame temperature is increased contributing to the regression rate enhancement on a lower extent. Furthermore, paraffin-based fuel shows higher burn rate because its low molten viscosity promotes unstable waves on the solid surface that atomize the fuel, nearly tripling the combustion rate. Whereas the regression of more viscous fuels, such as Hydroxyl-Terminated-PolyButadiene and polyethylene, relies only upon heat of vaporization. This paper reports the results obtained in an experimental campaign on a lab-scaled engine to assess the improvement in the regression rate deriving both from adding several metals or metal hydrides to pure HTPB fuel and with paraffin based grains. The outcomes in terms of regression rate, combustion efficiency and motor stability are discussed. Single bore cylindrical grains have been burned by injecting oxygen with an axial conical subsonic nozzle. A summary of the results obtained with pure HTPB fuel is presented and compared with the ones achieved with metal loaded HTPB and paraffin based fuels, in order to perform a trade-off on potential advanced fuels.