Paper ID: 16585
oral
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SPACE PROPULSION SYMPOSIUM (C4)
Propulsion System (2) (2)

Author: Ms. Francesca Scaramuzzino
Second University of Naples, SUN, Italy, francesca.scaramuzzino@unina2.it

Dr. Carmine Carmicino
university of naples, "federico II", Italy, carmine.carmicino@unina.it
Dr. Giandomenico Festa
university of naples, "federico II", Italy, festagiandomenico@virgilio.it
Prof. Antonio Viviani
Second University of Naples, SUN, Italy, antonio.viviani@unina2.it
Prof. Annamaria Russo
university of naples, "federico II", Italy, annamaria.russo@unina.it

EXPERIMENTAL INVESTIGATION ON A LAB-SCALE HYBRID ROCKET BURNING N2O/PARAFFIN-BASED FUEL AND N2O/METAL-LOADED HTPB

Abstract

Hybrid rocket engines show some features typical of either conventional solid or liquid propellant rockets, on the one hand offering some interesting advantages such as reliability, on the other, hybrids using classical polymeric fuels suffer from slow fuel regression rate. The low regression rate is a consequence of the heat and mass transfer mechanisms involved from the flame to the fuel surface. Combustion occurs in the boundary layer developing on the fuel wall, where oxidizer and gasified fuel react. The diffusive flame develops relatively far from the fuel surface and it is fed, from the outer side, by the oxidizer stream and, from the inner side, by the products of fuel pyrolysis, which is sustained by the flame itself. Heat transfer to the fuel surface is reduced by the blocking effect induced by the gas blowing from the fuel surface. In the last years much effort has been expended to study fuel formulations to improve regression rate. Among the effective means of increasing the regression rate, the addition of metal powders to the conventional fuel grains has been often employed. Indeed, this technique, also investigated in the framework of the Operative Research Project on Hybrid Engine in Europe (ORPHEE) is expected to increase the regression rate with the mass fraction of metallic particles; the latter should reduce both the effective heat of gasification of the bulk fuel and the blocking effect of mass blowing. Furthermore the flame temperature should be increased contributing to the regression rate enhancement on a lower extent. A more recent technique is to use innovative propellants as paraffin-wax fuels. The main characteristic of the paraffin-based fuels is their non-diffusive-limited combustion mechanism relying on the onset of a low molten viscosity layer that promotes unstable waves on the solid surface leading to the outset of fuel droplets entering into the main gas stream that increases the fuel mass transfer rate. The work presented in this paper has been developed in this framework, with the main purpose of comparing the performance of novel paraffin-based fuel formulations and pure HTPB loaded with metal powders, both burnt with nitrous oxide (N2O). The results obtained in an experimental campaign on a lab-scaled engine burning N2O with two fuels (paraffinic materials and pure HTPB loaded with metal powders) are reported.