Paper ID: 69962
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student

IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IPB)

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FUEL REGRESSION CHARACTERISTICS OF AXIAL-INJECTION END-BURNING HYBRID ROCKETS USING NITROUS OXIDE

Abstract

The purpose of this research is to experimentally obtain the fuel regression rate in axial-injection end-burning hybrid rockets (AIEB) using Nitrous Oxide (N_2O) as the oxidizer. Previous studies using gaseous oxygen (GOX) as an oxidizer proposed a fuel regression formula of the form $V_f = \alpha V_o^m P_c^n$ and revealed that the pressure exponent n is close to unity. The high fuel regression and good throttling ability indicated by such findings have made AIEBs an attractive candidate for propulsion systems for small-scale satellites. N_2O is superior to GOX for the oxidizer of satellite thrusters because of its storability and safety; however, the fuel regression and combustion characteristics of AIEBs are not well understood.

The fuel regression characteristics of an N_2O/photocurable resin AIEB fuel were empirically investigated through multiple static firing tests. A 3D stereolithography printer manufactured single-port fuel grains with a port diameter of 0.8 mm. Gaseous N_2O flows through the port, and the fuel burns at the port exit. Chamber pressures ranged from atmospheric pressure to 2.0 MPa, and oxidizer flow rates in the port ranged from 0.1 to 15 m/s. Fuel regression rates from each test were obtained by visually inspecting video recordings of combustion tests captured with a digital video camera. Regression analysis was conducted to find the empirical constants of the fuel regression formula proposed in previous studies. The pressure exponent appeared to be 1.27, which is significantly higher than for AIEBs using GOX.

Closer inspection of firing test results showed significant differences in combustion characteristics compared with previous research using GOX; (1) blow-off occurred even when the oxidizer flow velocity was relatively low, and (2) combustion chamber pressure was relatively high compared with GOX tests. These results suggest that the blow-off limit depends on the oxidizer flow rate and chamber pressure, and must be considered in the fuel regression rate formulation. The blow-off limit condition was obtained and inserted, revising the fuel regression rate equation to $V_f = \beta[P_c - \frac{V_o - C_1}{C_2}]^n$. The pressure exponent in the new function became 0.95, implying that the characteristics of AIEB using nitrous oxide remain consistent.