Paper ID: 55053
student

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

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PARAMETRIC PERFORMANCE EVALUATION OF LIQUID INJECTION THRUST VECTOR CONTROL IN HYBRID ROCKETS

Abstract

A thrust vector control (TVC) system is a crucial component in rockets to guide the thrust toward the desired direction. When the liquid injection TVC (LITVC) mechanism is implemented in hybrid rockets, the overall system configuration can be simplified because the LITVC system requires only static components; control valves, feeding lines, and side injectors. Furthermore, this configuration may not require an additional injectant storage tank because the oxidizer stored in the main storage tank can be used as an injectant. Therefore, in this study, the hydrogen peroxide injection TVC was demonstrated in the 250-N-scale hybrid rocket which uses hydrogen peroxide as an oxidizer and polyethylene as a fuel. Influence of parameters such as the concentration of hydrogen peroxide (H2O2) and chamber pressure on the LITVC performance was evaluated. Hot-fire tests were performed under following conditions; 1) 90% and 95% H2O2 injectants under 20-bar chamber pressure, and 2) 95% H2O2 under 20- and 40-bar chamber pressure. Each injection was performed under injectant flow rates were about 10% of the primary gas flow rate and at the point on the nozzle divergent section of which distance from the throat is 30% of the diverging section. When the concentration of H2O2 increased, the side specific impulse, which is the ratio of the side thrust to injectant flow rate, was increased about 20 s. As the H2O2 has lower water content and releases higher heat from its exothermic decomposition than the lower concentration H2O2, 95% H2O2 was more likely to generate a stronger shock in the nozzle. The liquid injection performed under the 40-bar chamber pressure condition showed 143.5 s of side specific impulse and it was about 80 s higher than that in the case under 20-bar chamber pressure. The liquid injection in the nozzle supersonic region results in a shock formation and the induced pressure behind the shock generates a side force. The amount of pressure increment across the shock is dependent on the static pressure and Mach number ahead of the shock. These parameters were higher in the 40-bar chamber pressure condition than that in the 20-bar case by 37.5% (1.2 bar) and 16.7% (0.3), respectively, and it may result in a large discrepancy in side specific impulses between those two cases. In short, it can be concluded that a higher concentration of H2O2 and chamber pressure are desirable for the LITVC application in hybrid rockets.