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FEASIBILITY STUDY ON NON-CATALYTIC IGNITOR FOR HYDROGEN PEROXIDE/POLYETHYLENE HYBRID ROCKET

Abstract

A hybrid rocket using hydrogen peroxide (H2O2) as an oxidizer commonly utilizes a pelletized catalyst bed or a silver screen to initiate the combustion. The use of these non-consumable components, however, decreases the propellant mass fraction of the system. Moreover, an increased tank size is required to cope with the additional pressure drop that is involved in the use of a catalyst bed. To overcome these short comings, the concept of a consumable device, called a non-catalytic ignitor (NCI) is introduced in this research. The NCI is an ignitor which consists of a paraffin and sodium borohydride particles. Since the sodium borohydride directly combusts with H2O2 through oxidation-reduction, the NCI provides a reliable ignition regardless of the purity of H2O2. The ignition feasibility of the NCI was assessed by a drop test with 90 wt.% H2O2 droplet and the NCI showed a short ignition delay of approximately 6 ms which is comparable with the existing hypergolic bipropellant system. A 80 N scale hybrid rocket was used to assess the performance of the NCI as the ignition source. The thruster was originally designed with a catalyst bed, but the latter was replaced by the NCI and it placed next to a shower-head type injector. All the tests herein used 90 wt.% H2O2 and polyethylene as the main fuel grain. During the preliminary hot-fire test, a pressure oscillation with a 3.1% of root-mean-square was observed after the full consumption of the NCI, giving a combustion efficiency of about 87%. However, a pressure spike about 3 times higher than the designed chamber pressure at the start-up phase was also observed. During ignition, vigorous reactions between the oxidizer and sodium borohydride particles in the NCI caused feed system-coupled instabilities. To avoid the oscillations, the shower head injector was replaced with a spray type injector because of its higher differential pressure and the possibility of minimizing the oxidizer vaporization delay by atomizing the fluids. Reducing the surface area exposed to the injected oxidizer and an initial mass flow rate control method were proposed to eliminate the initial pressure spike. Furthermore, a one dimensional, transient heat transfer analysis was conducted to evaluate whether the NCI can generate enough heat to ignite the fuel grain. A ground hot-fire test was conducted with the improved thruster and the results show the concept of consumable ignitor is feasible.