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DEVELOPMENT AND VALIDATION OF HIGH-PERFORMANCE HYPERGOLIC HYBRID ROCKET FUEL IGNITOR WITH HYDROGEN PEROXIDE

Abstract

Hypergolic hybrid rocket has an ignition system in which the oxidizer is directly injected into the solid fuel. Solid fuel includes hypergolic fuel, contacted and spontaneously ignited with an oxidizer. Hence, this system gives a short response time and high ignition reliability. One of the important factors in designing hypergolic hybrid rocket is to reduce the ignition delay of the hypergolic ignitor. If the ignition delay of the hypergolic ignitor is long, the oxidizer can be injected excessively before ignition and occurs a hard-start. This may lead to rise in the pressure peak inside the rocket and loss the oxidizer, and consequently, slow down the response time of the hybrid rocket engine. Therefore, studies about lowering the ignition delay of the hypergolic ignitor should be processed for a safe and light rocket design. In this study, hypergolic hybrid rocket ignitor was developed, and ignition performance with an oxidizer, 95 wt% hydrogen peroxide (H2O2), was studied. Hypergolic ignitor was developed as an ignition source of rocket system, and placed at the front of the main fuel. Hypergolic ignitor contains hypergolic fuel, binder, and additives. Ammonia borane (NH3BH3) was used as hypergolic fuel, because it has a high hydrogen content of 19.6 wt% and highly reactive with H2O2 with ignition delay of 8.8 ms. Also, NH3BH3 exhibits a high specific impulse with H2O2. A binder, paraffin wax, was used since it has high regression rate, which can quickly dissipate ignitor and reduce the thickness of ignitor. The platinum-group nanoparticles and carbon black was used as an additive to improve the ignition performance and reduce the radiation into the ignitor. The ignition feasibility of the ignitor was assessed by a drop test with 95 wt% H2O2. The change in the compositions of hypergolic fuel, binder and additives was studied. Interestingly, optimized hypergolic ignitor exhibited lowest ignition delay about 0.87 ms. The storability of hypergolic ignitor was conducted to verify the stability of the manufactured ignitor in the atmospheric environment. The low-density polyethylene (LDPE) was used as post-combustion fuel grain to maintain thrust after the ignitor is exhausted. Atmospheric spray combustion tests of various spray types were conducted to ensure ignition reliability and to determine the injector distances that sprayed H2O2 meets the hypergolic ignitor properly. Based on this, 50 N class hypergolic hybrid rocket was designed, and combustion performance and feasibility were verified through the hot-fire test.