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DEMONSTRATION OF CENTRIFUGAL CASTED PARAFFIN WAX-BASED HYPERGOLIC SOLID FUEL FOR HYDROGEN PEROXIDE

Abstract

Hypergolic hybrid rockets have become an attractive option for space missions where speed and reliability are paramount, due to their simple ignition system and high specific impulse. As oxidizer candidates for hypergolic hybrid rockets, research has been focused on using NTO or nitric acid-based oxidizers, which have conventionally constituted hypergolic thrusters. However, the major shortcomings of toxic propellants are their potential health hazards to humans and the restricted environment during manufacturing, storage, and handling. Meanwhile, hydrogen peroxide has emerged as a potential alternative to conventional toxic hypergolic oxidizers due to its high energy density, environment-friendliness, and ability of hypergolic ignition. This study includes the development and testing of a paraffin wax-based hypergolic solid fuel for use with a hydrogen peroxide oxidizer. Since paraffin wax-based solid fuel is expected to have a high regression rate compared to other binders, it has been highly considered as a fuel binder candidate for hybrid rockets. However, due to the low viscosity of molten paraffin wax, it was difficult to uniformly disperse and mold the reactive fuel particles. Therefore, a centrifugal casting system with constant rotational speeds was devised, and the fuel grains were fabricated using this system. The fabricated hypergolic solid fuels were investigated for their reactivity with 95% hydrogen peroxide through a drop test. The paraffin wax-based hypergolic solid fuel was tested by reducing the content of reactive fuel from 25 to 10 wt%. The ignition delay time was reduced from 2.75 ms to 1.88 ms as it increased from 10 to 20 wt%. Compared to the case of HTPB and epoxy in the molding method, and polyethylene and paraffin wax in the pressing method containing the same content, it was more than 50% shorter. It indicates paraffin wax-based fuel can rapidly ignite with only a small amount of reactive fuel. The ignition delay time according to the axial direction of fabricated cylindrically solid fuel was measured, and it was almost constant. Finally, an atmospheric combustion test and hot-fire test were conducted to evaluate the hypergolicity and rocket performance. The hybrid rocket ignited without an additional ignitor and successfully re-ignited after the valve-off sequence. Overall, the results of this study demonstrate the potential of a centrifugally casted paraffin wax-based hypergolic solid fuel for use with a hydrogen peroxide oxidizer in rocket propulsion systems. This can lead to the development of more efficient and high performance space propulsion systems for future space missions.