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AN EXPERIMENTAL STUDY ON ROCKET PROPULSION BY REACTION OF MG-BASED PROPELLANT AND WATER

Abstract

Due to its high energy density and environmental benignity, the idea of utilizing the reaction of metal powder (Aluminum or Magnesium) and water for space and underwater propulsion has been studied by researchers recently. However, the direct use of metal powder combusting with water requires extra facility for powder feeding, and external ignition energy is also demanded for the reaction start-up. Therefore, efforts have been devoted by the authors to employ the metalized lean-oxidant solid propellant reacting with cold water, which could give a great feasibility to propulsion system, though the fuel energy density is slightly reduced. Previously, tests of scaled-down Mg-based rocket engines were carried out to testify the engine performance, and the effects of several design parameters on the engine performance were also observed during the testing. Numerical investigation was performed to study the influence of different water injection characteristics on the engine combustion efficiency. The objective of the present work is to examine the performance of a Mg-based rocket engine with different working conditions and configurations. In this study, two scaled-down engine configurations were operated under different water-to-fuel ratios in a direct-connect ground testing system. Data of pressure, temperature, water flow rate, and thrust were collected during the testing. The fuel used in the tests was a 50% Magnesium contained solid propellant, and cold water was injected into the combustion chamber as an oxidizer. Two engine configurations (I and II) were designed with the same chamber length, but with a larger length-to-diameter ratio for engine II. Self-sustained combustion was achieved in all tests. For both configurations, a large amount of slag accumulation mixed with white Magnesia was produced in the combustion chamber under the lower water-to-fuel ratio; while the ratio rose up to about 1.2, the amount of slag and Magnesia remained was significantly reduced. It was also found out that engine II exhibited stronger perturbation of thrust under different water-to-fuel ratios, and a 'dancing' flame was also observed in the engine plume, which might result from the interaction of heat release and acoustics in combustion chamber. Combustion efficiencies of all tests were computed and compared, and specific impulse was used to assess the overall engine performance. It's indicated that, while the water-to-fuel ratio is, to certain extent, higher than the stoichiometric one, the resulted combustion efficiencies and performances of both configurations were enhanced; for an increased length-to-diameter ratio, the combustion efficiencies and specific impulse were slightly reduced. The analysis of the thrust perturbation in engine II is under way, and the interaction of heat release and acoustics in it is being studied.