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EXPERIMENTAL STUDY OF A MG/N2O POWDERED METAL FUEL ROCKET ENGINE

Abstract

Powdered metal fuel rocket engines are a kind of new rocket propulsion systems that utilize high energy density metal powder as fuels. By controlling the supply of powder mass flow, thrust adjustment, multiple restart and flexible energy management can be realized with this kind of rocket engines, and the employment of the metal powder also offers the advantages of low-cost, high safety and reliability. Owing to these advantages, powdered metal fuel rocket engines have a great potential in propulsion systems for upper-stage rockets, and thrusters for attitude or trajectory control. Mg and Al powders are regarded as most promising fuel candidates for the rocket engines, in terms of energy density, safety and convenience in storage and utilization etc. N2O can be used as oxidants for the simplification of the supply system. The common oxidant, N2O possesses good energy performance and self-pressurizing characteristic which permits a simple propulsion system without external pressurization. Currently, the main challenges of this rocket engine technology lie in the realization of stable powder fuel supply, quick engine start-up, and high combustion efficiency. In this paper, an experimental powdered metal fuel rocket engine was preliminary designed, and the working process of the engine was investigated through the hot fire tests with Mg powder as fuel and N2O as oxidant. A ground test system, consisting of a high-precision test bench, a fuel feed unit, an oxidant feed unit, and a measurement and control unit, was designed and established. In the fuel feed unit, metal powder is fluidized by nitrogen and pushed by a piston driven by a stepping motor. In the oxidant feed unit, N2O is supplied utilizing its characteristic of self-pressurization, and the mass flow rate is stabilized by the use of a venturi. By using the ethanol-oxygen igniter (a small-sized liquid rocket engine), rapid start-ups of the experimental engine were achieved. The test results show that the combustion of Mg powder and N2O can be sustained by the heat released by N2O decomposition. Operation time of each test was no lower than 20s. The combustion efficiency of the engine was larger than 85%. The engine restarted 3 times in one test, with an interval of 1s before each re-ignition. The heat remained in the engine could regenerate combustion of Mg powder, and the igniter kept shut down during the restart.