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DEVELOPMENT STATUS OF HYDROXYLAMMONIUM-NITRATE-BASED PROPULSION SYSTEM WITH DISCHARGE PLASMA SYSTEM

Abstract

Green propellant propulsions have been continuously researched as a replacement for conventional hydrazine propulsions. In Japan, one hydroxylammonium-nitrate (HAN)-based green monopropellant, called SHP163, has been developed by the Institute of Space and Astronautical Science/ Japan Aerospace Exploration Agency (ISAS/JAXA). This monopropellant is a liquid mixture of HAN /ammonium nitrate /water /methanol in a ratio of 73.6/3.9/6.2/16.3 by weight percentages. When employing a green monopropellant in a conventional reaction control system (RCS) thruster with solid catalyst, there are technical problems in environments with higher operating temperatures (adiabatic flame temperatures) and atmospheric oxidation such that the solid catalyst sinters, reduces and then deactivates. To solve these problems, an ignition system for green propellants using the discharge plasma of noble gas, called a discharge plasma system, has been proposed in substitution for the conventional solid catalysts. Whereas a conventional propulsion system with a solid catalyst must be preheated for a few minutes, a new propulsion system with a discharge plasma system can be cold started (without preheating). This ignition system is expected to enhance combustion of the propellant through radical–molecule reactions from the discharge plasma. Additionally, this propulsion system has possibilities to operate with a dual mode using the same power, either in a high specific impulse mode (at high current >10 A and low voltage <100 V, such as the standard arcjet thruster) or a high thrust mode (at high voltage from 100 V to 1000 V and low current <1.0 A in the current operation mode). In this paper, At the high thrust mode of a 0.5 N-class laboratory model HAN-based propulsion with discharge plasma system, a steady thrust of 0.5 N is achieved for 15 s at an argon mass flow rate of 0.15 g/s, a HAN-based monopropellant mass flow rate of 0.31 g/s, and then the energy consumption for operation time of 15 s is approximately 2.2 Wh (power consumption of 527 W for 15 s). In vacuum condition (100 Pa), the ignition repeatability and long term steady state operations were demonstrated. For the 50 kg class small satellite, this propulsive capability is a maximum delta-V of 132 m/s. Here, the required propellant wet mass and accumulated operation times are 3.5 kg and 10000 s, respectively. This paper discusses the current development status of green propulsion system with discharge plasma system and propulsive capability for a small satellite.