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PARAMETRIC INVESTIGATION OF A WATER-VAPOR HALL THRUSTER FOR 100W OPERATION

Abstract

As the small spacecraft market is expanding yearly, the demand for 100 W-class propulsion systems is growing. To date, xenon Hall thrusters are among the most commonly used propulsion systems for small spacecraft as they provide high specific impulse and high thrust density. Higher specific impulse can contribute to greater ΔV and higher thrust density can contribute to less maneuver time. Furthermore, Hall thrusters using xenon have been widely studied worldwide proving reliable and steady operation. However, due to the increasing demand for xenon, the price and time to obtain have been rising, so alternative propellants become more attractive for future use in small spacecraft.

Water has emerged as a potential propellant alternative due to its abundance, affordability, and potential availability on the Moon or Mars. Moreover, water is non-toxic and easy to handle, and no high-pressure tank systems are needed because the propellant can be stored in the liquid phase at room temperature.

The EQUULEUS mission has already demonstrated the applicability of water in space by using a water resistojet for orbital transfer. Additionally, a water-vapor Hall thruster has also been tested in laboratory and stably operated.

However, current water-vapor Hall thrusters present distinct challenges for space use. The University of Tokyo laboratory thrusters perform significantly worse than those operated with xenon. Anode efficiency, which is one typical performance parameter, has been reduced from 45% to 5%. Moreover, the thruster cannot be operated with a discharge power of less than 200 W, while xenon allowed operation at power levels as low as 80 W. These issues limit the usability of the propulsion system in space.

To address these issues, several types of thruster geometries have been tested. A thruster shape that can achieve the anode efficiency of 10% at a discharge power of 100 W-class is the goal. Variations in channel length, diameter and width models have been made to improve performance. Scaled-down versions and cylindrical configurations have expected to reduce the discharge power.

This study focuses on typical operational characteristics like discharge power and anode efficiencies which were measured for several thruster configurations. For each model, low-power operation is first tested, and for those that operate stably, performance like anode efficiency is obtained by using plasma probes or a thrust stand. The obtained characteristics are compared to determine the proper dimensional parameters for a 100 W-class water-vapor Hall thruster.