Improved Hall Thrusters Fed by Solid Phase Propellant

Mg is more abundant than Xe and provides a much higher specific impulse.

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Hall thrusters normally use Xe propellant, which is expensive and scarce in the solar system. The weight of Xe is such that typical Hall thrusters are limited in specific impulse to approximately 3,000 s. The objective of this program was to improve and demonstrate Mg Hall thruster systems. Mg is abundant in the solar system and has an atomic mass approximately one-fifth that of Xe, which means much higher specific impulse is achieved than with Xe at typical thruster operating conditions (power, voltage).

Mg is solid at room temperature, which means that a typical gas feed system may not be used to feed the propellant to the thruster. Mg in the solid phase has been placed a-priori inside the thruster and been allowed to evaporate or sublimate. However, pre-feeding the thruster leads to control issues and limits the total propellant throughput of the device. A high-temperature external feed system (>600 °C) is viewed as impractical for space applications.

Improved Hall thruster systems were conceived and developed featuring a solid phase propellant feed system suitable for Mg, Zn, and other propellants that are normally solid at room temperature. The key components of the system are the Hall thruster, hollow cathode, and solid propellant feed system. The feed system includes a solid propellant supply, a heated sublimation or vaporization chamber, and an optional voltage isolator.

In the first embodiment of the invention, a wire or rod is fed into a heated sublimation chamber where it is converted to gas by radiative heat. In the second embodiment, a fluidized powder is fed into a sublimation chamber, where it is converted to gas by radiative heat and/or conduction. The gas may then pass through a voltage isolator to the thruster anode. The objective of either embodiment is to vaporize the solid in the sublimation chamber at the same rate at which it arrives. The sublimation chamber typically attains temperatures of 500 to 1,000 °C.

The specific impulse possible with this invention is 4,000 to 5,000 s with a discharge potential of 400 V. The resulting propellant savings with respect to a typical Xe thruster (1,500 to 3,000 s) can be easily estimated through the Tsiolkovsky rocket equation. Moreover, the current propellant, Mg, is available in-situ on Mars, the Moon, and elsewhere in the form of MgO. This enables future in-situ resource utilization (ISRU).

This work was done by James Szabo, Michael Robin, and Walter Foxworth of Busek Company, Inc. for Glenn Research Center. ***For more information, download the Technical Support Package (free white paper) at www.techbriefs.com/tsp under the Propulsion category****. NASA invites and encourages companies to inquire about partnering opportunities. Contact NASA Glenn Research Center's Technology Transfer Program at ttp@grc.nasa.gov or visit us on the Web at https://technology.grc.nasa.gov/. Please reference LEW-19251-1.*