Wesley Hileman & Matthew Hileman

Ion Propulsion: Electrostatic Thruster Design and Optimization for Space Applications

Electrostatic thrusters are promising alternatives to conventional chemical rockets in space applications. This engineering project focuses on maximizing key performance parameters by developing, implementing, and testing thrusters with various anode, cathode, and magnetic field configurations. The goal was to identify configurations providing high thrust output, high specific impulse, and low mass.

Our research and evaluation methodology consisted of six steps: (1) gather information, (2) develop thruster evaluation criteria, (3) design thrusters, (4) build thrusters, (5) conduct experiments, and (6) analyze and interpret data. All thrusters used air as a propellent. Measurements of thruster exhaust velocity (via the construction of a hot-wire anemometer), test-site temperature (thermometer), and atmospheric pressure (weather reports) allowed calculation of thrust and specific impulse. Measurements were normalized to a 0-100 range, then a multi-criteria decision analysis was performed to compare thrusters.

We found that thrusters one, four, and eight excelled in all criteria. Thruster one maximized the creation and axial movement of ions. Thruster four was efficient, but not as efficient as thruster one due to insufficient neutralization leading to partial thrust reversal. Thruster eight was efficient, but ion movement was hindered due to electromagnetic field interference resulting in increased exhaust dispersion.

We conclude that thrusters implementing pointed cathodes, tubular or gridded anodes, and no axial magnetic fields maximize efficiency. We recommend further research explore (A) the use of heavier propellent gasses (e.x. xenon, argon), (B) vacuum testing, (C) improved thrust measurement options such as strain and pendulum gauges, and (D) continued examination of divergent design options.