

The Summer Undergraduate Research Fellowship (SURF) Symposium
7 August 2014
Purdue University, West Lafayette, Indiana, USA

Microthruster Fabrication and Characterization: In Search of the Optimal Nozzle Geometry for Microscale Rocket Engines

Katherine L. Fowee, Andrew D. Strongrich, and Alina Alexeenko
Aeronautics and Astronautics, Purdue University

ABSTRACT

A major consideration in microsatellite design is the engineering of micropropulsion systems that can deliver the required thrust efficiently with tight restrictions on space, weight, and power. Cold gas thrusters are one solution to the demand for smaller propulsion systems to accommodate the advancements in technology that have allowed for a reduction in the size and thus the cost of satellites. While much research has been done in understanding the flow regimes within these microthrusters, there is a need to understand how different nozzle designs affect microthruster performance. This requires that experimental data be collected on varying nozzle shapes (orifices, channels, and an annulus). Due to equipment malfunctions, high vacuum conditions were not reached, and all tests were done at an ambient pressure of 4.1 Pascals with varying thruster plenum pressures and with Nitrogen as the propellant. Temperature was measured in both the thruster plenum and the vacuum chamber, while thrust was measured using a micronewton torsional balance. The nozzles were compared after calculating the specific impulse, thrust coefficient, discharge coefficient, and Knudsen number for each at the various plenum pressures. Of the nozzles tested, the rectangular plug array was expected to be the most efficient. This design was found, during stochastic numerical simulations, to have enhanced performance through increased pressure thrust, a desirable attribute in low Reynolds number flows. However, at the ambient pressures achieved, the rectangular plug array was less efficient than the channel nozzles. This research will be continued with tests at high vacuum pressures on a wider range of nozzles.

KEYWORDS

Microthrusters, Micronozzles, Micropropulsion, Cold Gas Thrusters