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A SIMPLE DESIGN FOR ABLATIVE LIQUID-FED PULSED PLASMA THRUSTERS FOR SMALL SATELLITES

Abstract

The miniaturization of technology has enabled the development of increasingly smaller satellites. This will inevitably reduce the individual cost of access to space. There has recently been increasing interest in small satellites weighing <100 kg, with many expected to be launched within the next several years.

A major limitation of small satellites, especially those in the lower range of 1 – 10 kg, is the lack of a suitable propulsion system for performing large ΔV maneuvers. Without this, they may add to the increasingly important orbital debris issue. A suitable propulsion system can also enable orbital transfers and provide de-orbiting capabilities. It can also potentially enable the use of lower orbital altitudes by compensating for atmospheric drag.

Pulsed plasma thrusters are a simple form of electric propulsion that have been flown many times since the onset of space exploration. A solid propellant is usually ablated by an electric arc, producing plasma that is propelled between two electrodes. A capacitor periodically stores and discharges the required energy. These thrusters are very attractive for use in small satellites due to their inherently simple design. However, despite the design simplicity, many operational aspects are complex and are still being investigated. Furthermore, issues such as propellant charring contribute to a reduction in the thruster lifetime.

The use of liquid or gaseous propellants is able to resolve some drawbacks, usually at the expense of increasing the complexity of the design. Gaseous propellants usually require high pressurization for propellant storage and high-speed valves for delivery. Alternatively, liquid propellants can potentially be stored and delivered using simpler concepts derived from microfluidics.

We present here results of investigations into a simple and novel design for liquid-fed pulsed plasma thrusters operating under principles similar to conventional ablative solid pulsed plasma thrusters. The design maintains most of the simplicity of solid pulsed plasma thrusters while utilizing a liquid propellant. The charring resistance of the liquid propellant and the exposed ablation area was examined over thousands of pulses both macroscopically and microscopically. Comparisons were also made with conventional solid propellant. Possible failure modes are discussed, along with design suggestions to enable long duration operation on small satellites. The results here will aid in the development of liquid-fed pulsed plasma thrusters with a simple design aimed towards reliable long term use in small satellites.