Thrust Stand Measurements of a Conical Inductive Pulsed Plasma Thruster

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I. INTRODUCTION

Inductive Pulsed Plasma Thrusters (iPPT) [1–3] are spacecraft propulsion devices in which electrical energy is capacitively stored and then discharged through an inductive coil. The thruster is electrodeless, with a time-varying current in the coil interacting with a plasma covering the face of the coil to induce a plasma current. Propellant is accelerated and expelled at a high exhaust velocity ($\mathcal{O}\left(10-100\text{ km/s}\right)$) by the Lorentz body force arising from the interaction of the magnetic field and the induced plasma current.

While this class of thruster mitigates the life-limiting issues associated with electrode erosion, inductive pulsed plasma thrusters can suffer from both high pulse energy requirements imposed by the voltage demands of inductive propellant ionization, and low propellant utilization efficiencies.

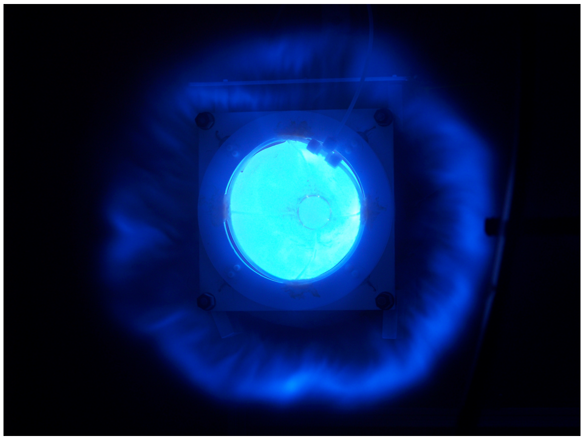

FIG. 1: Time-integrated, unfiltered photograph showing an axial view (along the thrust axis) of a conical iPPT operating on 60 mg/s argon with an initial capacitor bank charging voltage of 5 kV.

A conical coil geometry may offer higher propellant utilization efficiency over that of a flat inductive coil, however an increase in propellant utilization may be met with a decrease in axial electromagnetic acceleration, and in turn, a decrease in the total axially-directed kinetic energy imparted to the propellant.

II. EXPERIMENT

Three conical inductive coils (with half cone angles of 20°, 38°, and 60°) were constructed and operated on a thrust stand. Impulse bits were calculated from thrust data to determine how the initial charging voltage of the capacitor bank, the mass flow rate of injected propellant, and the cone angle affect the thrust of a propulsion device employing a conical inductive coil in the presence of preionized propellant. A maximum in impulse bit was found with respect to coil geometry, and the mass flow rate for which the impulse bit is maximized was found to decrease with decreasing initial capacitor bank charging voltage. Dependencies on these experimental parameters are discussed in the context of previous semi-empirical modeling of the effect of inductive coil geometry on thrust efficiency [4].

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