Inductive Pulsed Plasma Thruster Development and Testing at NASA-MSFC

Kurt A. Polzin *

NASA-Marshall Space Flight Center, Huntsville, AL 35812

I. Abstract

THE inductive pulsed plasma thruster (IPPT) is an electrodeless space propulsion device where a capacitor is charged to an initial voltage and then discharged producing a high current pulse through a coil. The field produced by this pulse ionizes propellant, inductively driving current in a plasma located near the face of the coil. Once the plasma is formed it can be accelerated and expelled at a high exhaust velocity by the electromagnetic Lorentz body force arising from the interaction of the induced plasma current and the magnetic field produced by the current in the coil.

In the present work, we present a summary of the IPPT research and development conducted at NASA's Marshall Space Flight Center (MSFC). As a higher-power, still relatively low readiness level system, there are many issues associated with the eventual deployment and use of the IPPT as a primary propulsion system on spacecraft that remain to be addressed. The present program aimed to fabricate and test hardware to explore how these issues could be addressed. The following specific areas were addressed within the program and will be discussed within this paper.

- Conical theta-pinch IPPT geometry thruster configuration
- Repetition-rate multi-kW thruster pulsing
- Long-lifetime pulsed gas valve
- Fast pulsed gas valve driver and controller
- High-voltage, repetitive capacitor charging power processing unit

During the course of testing, a number of specific tests were conducted, including several that, to our knowledge, have either never been previously conducted (such as multi-KW repetition-rate operation) or have not been performed since the early 1990s (direct IPPT thrust measurements).[2] Conical theta-pinch IPPT thrust stand measurements are presented in Fig. 1 while various time-integrated and time-resolved images the conical theta-pinch IPPT are given in Figs. 2 & 3. Note all images are at a cone angle of 20°.

References

[1] K.A. Polzin, "Comprehensive review of planar plused inductive plasma thruster research and technology," *J. Propuls. Power*, **27**(3), May-June 2011.

[2] C.L. Dailey and R.H. Lovberg, "The PIT MkV Pulsed Inductive Thruster," NASA CR 191155, July 1993.

*Propulsion Research Engineer, Propulsion Research and Technology Applications Branch, Propulsion Systems Department. Associate Fellow AIAA.

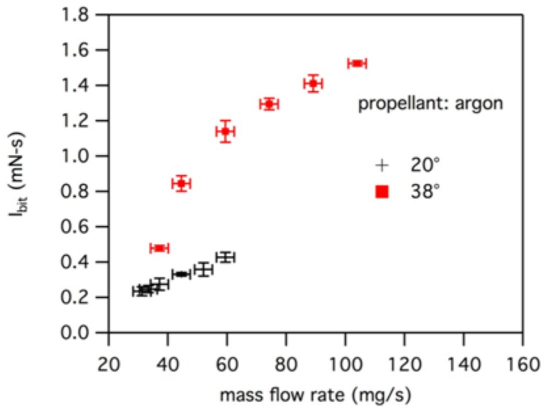

Figure 1. Measured conical theta-pinch thruster performance data on argon at different cone angles.

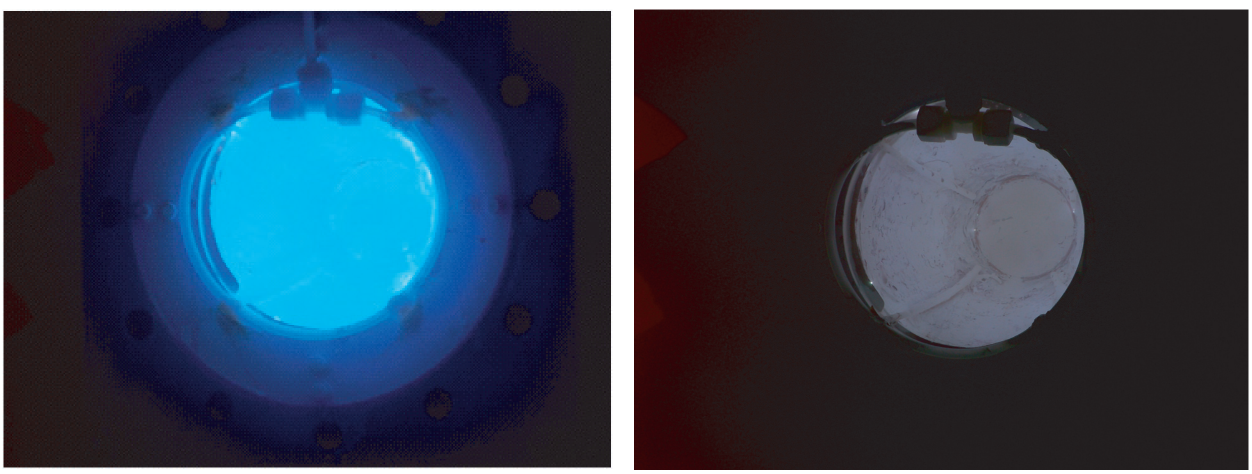

Figure 2. Time-integrated images (unfiltered) showing 20° conical theta-pinch thruster (left) at 500 J/pulse, 1000 sccm steady argon flow and (right) 500 J/pulse, 750 sccm steady CO_2 flow.

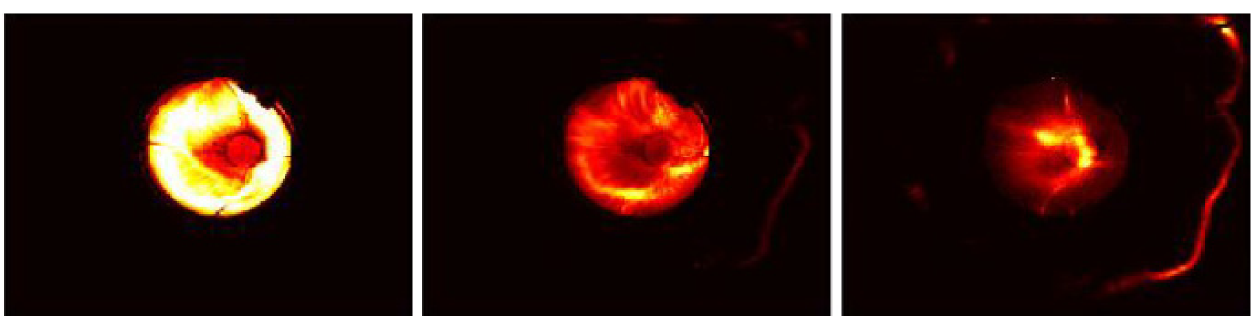

Figure 3. Time-resolved images (unfiltered) showing three false-color frames of 20° conical theta-pinch thruster operation during the first half-cycle, acquired at a frame rate of 1 MHz and an exposure time of 125 ns.