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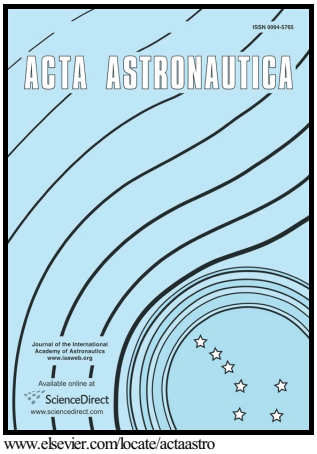

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Modeling of gas ionization and plasma flow in ablative pulsed plasma thrusters

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Abstract

A one-dimensional model to study the gas ionization and plasma flow in ablative pulsed plasma thrusters(APPTs) is established in this paper. The discharge process of the APPT used in the LES-6 satellite is simulated to validate the model. The simulation results for the impulse bit and propellant utilization give values of 29.05μNs and 9.56%, respectively, which are in good agreement with experimental results. To test the new ionization sub-model, the discharge process of a particular APPT, XPPT-1, is simulated, and a numerical result for the propellant utilization of 62.8% is obtained, which also agrees well with experiment. The gas ionization simulation results indicate that an APPT with a lower average propellant ablation rate and higher average electric field intensity between electrodes should have higher propellant utilization. The plasma density distribution between the electrodes of APPTs can also be obtained using the new model, and the numerical results show that the plasma generation and flow are discontinuous, which is in good agreement with past experimental results of high-speed photography. This model provides a new tool with which to study the physical mechanisms of APPTs and a reference for the design of high-performance APPTs.

Keywords: Ablative pulsed plasma thruster; Neutral gas ionization; Plasma flow; Simulation

1.Introduction

Ablative pulsed plasma thrusters(APPTs) have been studied and applied for over fifty years. They are reliable, relatively simple, inexpensive, and able to operate at less than 10W, making them useful for applications such as altitude control for satellites and propulsion for microsatellites and nanosatellites [1, 2]. In the last 5 years, the APPT has remained an important electric propulsion system, and is still being used in space missions [3, 4].

The schematic of a parallel-plate APPT is shown in Figure 1. The main capacitor is fully charged before spark-plug ignition. Once the ignition signal is sent, the spark plug starts to work and produces the initial plasma. This plasma triggers the breakdown between the electrodes of the APPT, causing the main discharge. After the main discharge begins, the solid propellant is ablated by an arc and provides neutral gas. If certain conditions are satisfied, this neutral gas is ionized to produce plasma. This plasma maintains the main discharge and is accelerated by electromagnetic and pressure forces to generate thrust.

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