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ESTIMATION OF THE MICRO PULSED PLASMA THRUSTER SPECIFIC IMPULSE

Abstract

Nowadays, small spacecraft, especially the CubeSat class, have become increasingly popular. Such nanosatellites are suitable for orbital-testing new technologies, which are planned to be used on expensive satellites, as well as for performing independently missions. To expand the functionality of nanosatellites there is necessity of propulsion system, which can be used to maintain spacecraft in low Earth orbit, orientation and disposal. The requirements for such propulsion system are stable operation at low-power mode under restrictions on weight and volume. Most of the thrusters used today in cosmonautics are not able to function stably under the restrictions imposed by nanosatellites, therefore, the task of developing the most suitable propulsion system is urgent.

Micro pulsed plasma thruster (μPPT) is one of the promising options for such propulsion system. The thruster operation principle is electromagnetic forces accelerating the plasma formed as a result of propellent evaporation. When evaluating the efficiency of an impulse thruster, it is important to determine the traction characteristics, such as specific impulse and impulse bit. Determining the specific impulse for μPPT is difficult, since it requires either precision devices or thruster operation for a long time.

In this paper, a method for determining the specific impulse is proposed. It is based on experimental data on the values of the impulse bit. Experiments were conducted to determine impulse bit. It was measured using a ballistic pendulum at discharge energies from 2.5 to 10 J. The discharge plasma temperature was estimated by solving the thermal conductivity equation considering Joule heating and Stefan-Boltzmann radiation in the approximation of plasma optical density. The heat generated as a result of plasma ohmic heating was calculated using experimentally obtained current oscillograms. The thermodynamic functions necessary for heat equation solution were obtained by solving the Saha-Eckert equation, in approximation of the large canonical Gibbs ensemble.

The evaporation of the propellant caused by plasma radiation was estimated by solving the Stefan problem with specific heat of evaporation amendment. Ablated per impulse mass was estimated based on the phase change interface rate obtained as a result of solving the Stefan problem. It made possible to estimate the specific impulse at different discharge energies considering experimental data on the impulse bit.