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ELECTRIC PROPULSION SYSTEM BASED ON THE AIR-BREATHING RADIO-FREQUENCY ION THRUSTER USING THE UPPER ATMOSPHERE GASES AS PROPELLANT

Abstract

For a spacecraft, there are tasks, for which it is advisable to choose orbits in the altitude range of 200-300 km. At such heights, a spacecraft is affected by the aerodynamic drag force caused by residual atmosphere. If not compensated, this force leads to a drastic reduction in the low orbiting spacecraft lifetime. Electric propulsion thrusters can be used to counteract the aerodynamic drag. In this case, the spacecraft lifetime is limited by the onboard propellant store for the thruster. To solve this problem, a thruster using residual atmosphere gases as propellant can be used for aerodynamic drag compensation. The paper presents the results of a study for the operation of air-breathing radio-frequency ion thruster on board a low-orbit spacecraft for a circular solar synchronous orbit with the altitude of about 200 km. Calculation of the thruster parameters is carried out using the physico-mathematical model for the processes in it. The mathematical model describes the behavior of four groups of particles: atomic and molecular oxygen and nitrogen, as well as the processes of ionization of such particles and of the atomic dissociation of molecules. The calculations take into account the influence of the particle density both on the mass flow through the thruster and on the aerodynamic drag force. The influence of the spacecraft geometry and of the location of solar panels on the available onboard power and on the aerodynamic drag is considered also. The thruster operation modes at various parameters of solar activity that affects the particle density in the atmosphere are discussed in the paper. The mathematical model makes it possible to define the density distribution for ions and neutral atoms of four types within the ionization chamber of the thruster. Having defined the distribution of local plasma parameters in the chamber, it is possible to calculate the thruster integral parameters, such as its thrust and power consumption. The results of the calculation show the possibility of a long-term life of a spacecraft with an air-breathing radio-frequency ion thruster. The paper presents the results of experimental studies for the prototypes of the propellant ionization and acceleration devices based on principles of a radio-frequency ion thruster using the atmospheric gases as propellant. Steady operation of the experimental model was achieved, and

the dependence of the radio-frequency generator power consumption on the propellant flow rate through the thruster was defined.