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CONDITIONS FOR THE LONG-TERM EXISTENCE OF SPACECRAFT WITH AIR-BREATHING ELECTRIC PROPULSION IN ULTRA-LOW ORBITS ABOUT PLANETS

Abstract

The problem of determining the conditions for the long-term existence of spacecraft with air-breathing electric propulsion (ABEP) using outboard atmospheric gases as a propellant in ultra-low orbits about planets is considered. The conditions for continuous compensation of aerodynamic drag by means of ABEP are obtained taking into account the limitations determined by the minimum allowable gas number density for stable ionization and the power of the energy sources. Systems both using (solar arrays) and not using solar illumination (fuel cells, etc.) are considered as primary power sources. The optimal spacecraft layout parameters are found by solving the problem of minimizing power consumption for given spacecraft useful volume, specific characteristics of energy sources, and total thruster efficiency. When using solar arrays (SA), the average specific power per unit area through orbital revolution is determined under the condition that the SA plane is optimally oriented by rotating around the free stream velocity vector.

The influence of the temperature and molecular composition of the planet's atmosphere on the aerodynamic drag coefficient and the characteristics of passive ABEP air intake of a honeycomb layout has been studied. Dependencies upon the atmospheric parameters for the altitude ranges of the Earth's and Martian orbits, on which the long-term existence of spacecraft with ABEP is realized, are obtained. The best altitudes of the spacecraft orbit, at which the required power is minimum one, have been determined, and the effect of variations in the properties of the atmosphere on the attainable orbits has been studied.

The generalized parameters of the problem are obtained, which determine the conditions for the existence of solutions. The requirements for the characteristics of the ABEP and the spacecraft power supply system were assessed.