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INTEGRATED OPTIMIZATION OF SPACECRAFT LAYOUT AND SCENARIOS FOR LONG-TERM MAINTENANCE OF ELLIPTICAL ORBITS WITH ULTRA-LOW PERICENTERS USING ONLY RENEWABLE RESOURCES

Abstract

Spacecraft (SC) in ultra-low orbits (120-250 km for the Earth) have significant advantages for communication and monitoring planetary surfaces. The use of outboard rarefied atmosphere gases as a propellant in air-breathing electric propulsion (ABEP) and solar arrays (SA) as a primary energy source makes it possible to ensure long-term maintenance of SC in orbits using renewable resources only. The application of elliptical orbits allows expanding the area of possible quasi-stationary flight of such SC due to the optimal redistribution of accumulation and consumption energy.

In this paper, we consider the problem of integrated optimization of ABEP, SC layout and scenarios for SC long-term maintenance in elliptical orbits with an ultra-low pericenters. Specific characteristics of primary (SA) and secondary (batteries) energy sources, the minimum admissible gas concentration in the ABEP for stable plasma ionization, the total thruster efficiency and the payload volume are considered as given parameters. The SC volume and energy consumption are regarded as objective functions. The optimal dependences of the SC shape, the SA area, the dimensions of inlet and outlet ABEP sections, the altitudes of the pericenter and apocenter of the quasi-stable orbit, as well as the location of the active orbital arcs on the parameters of the problem are obtained.

The influence of the atmosphere characteristics and the effective specific power of solar irradiation on the optimal solutions is studied for the optimal orientation of the SA. Scenarios with the optimal control of the SA wings deployment are considered, taking into account the energy costs for such operations. Dependences of the admissible ranges of pericenter altitudes on the parameters of the problem are determined. The solutions obtained make it possible to determine the requirements for the characteristics of ABEP and power supply system for long-term SC maintenance in orbits with an ultra-low pericenters.