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OPTIMAL CONTROL OF THE THRUST VECTOR OF A SPACECRAFT WITH AN AIR-BREATHING ELECTRIC PROPULSION

Abstract

The problem of the optimal control synthesis of the thrust vector of a spacecraft (SC) in orbits with ultra-low perigee (altitudes 120-250 km) is considered. Compensation for the aerodynamic drag arising at these altitudes is carried out by the thrust of an air-breathing electric propulsion (ABEP), using gases of the surrounding atmosphere as a propellant. The main factors to be taken into account to ensure the long-term SC maintenance at ultra-low altitudes are following: a significant dependence of ABEP characteristics on the angle of attack and gas concentration in the ionization chamber, and the required power of solar arrays, increase of which leads to an increase in aerodynamic drag and the need for a corresponding increase in thrust.

In conditions of limited energy, elliptical orbits may be preferable to ensure the long-term maintenance of the SC with ABEP due to the possibility of using in areas with a high density of the working gases the energy accumulated during the SC movement at high altitudes. In this case, the parameters of solar arrays (the area, specific power, duration of deployment/closing and corresponding energy costs), the batteries capacity, as well as changes in orbital parameters due to the gravitational field anomalies should be taken into account.

The synthesis of the optimal thrust vector control is obtained. The solution is based on the use of the Pontryagin maximum principle for a dynamic model of osculating orbital elements, taking into account the factors listed above.

The effectiveness estimations of the developed optimal control programs are obtained depending on parameters of orbits, the SC layout, ABEP, energy sources and the state of the ionosphere.