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OPTIMIZATION OF INTERPLANETARY TRAJECTORY OF THE SPACECRAFT WITH ELECTRIC PROPULSION TAKING INTO ACCOUNT THE POSSIBILITY OF ABNORMAL OPERATION OF THE PROPULSION

Abstract

A new formulation of the optimization problem of the interplanetary trajectory of the spacecraft with electric propulsion (EP) is developed. This formulation takes into account the necessary to parry the trajectory perturbations which connected with temporary inability to ensure normal use of the EP on the heliocentric segments of the flight trajectory (with a possible unplanned shutdown of the EP). Traditionally, the optimization of the trajectory of interplanetary flight is carried out using some mass criteria (e.g. the minimal mass of required fuel) without taking into account the possible temporary abnormal engine cutoff. We call this trajectory as the optimal nominal trajectory. Due to the existence of disturbances affecting the actual trajectory of the spacecraft, some additional amount of fuel (guaranteeing reserve of fuel) should always be provided. But even the big guarantee reserve of fuel cannot always provide the possibility of implementing the flight path. In these cases the nominal trajectory needs to be changed (corrected) so that the trajectory could be implemented under abnormal operation of the EP. We offer a method of deformation of the optimal nominal trajectory. Method consists of the introduction into the interplanetary flight additional coasting segments of trajectory and the choice of the characteristics of these segments. The method was being tested for the optimization of trajectory Earth - Earth for spacecraft with EP as the first phase of the entire trajectory of interplanetary flight for project "Intergelio-Probe". The possibility to use a gravity assist maneuver from Earth and four gravity assists from Venus on the trajectory of the spacecraft insertion into operational orbit is analyzed. The first gravity assist (from Earth) is provided by EP. It works along the heliocentric trajectory Earth - Earth. The optimal trajectory of the spacecraft flight on the criterion of maximum mass of spacecraft, delivered to the Earth for the gravity assist maneuver, was obtained. Analysis of the allowable duration of abnormal engine shutdown showed that there is a critical point on the trajectory of the flight. An unintended shutdown of the engine in critical point only for 0.3 days makes it impossible to ensure the gravity assist from Earth with the specified characteristics. Using the proposed approach has allowed due to increasing the duration of the last coasting segment and the introduction of one additional coasting segment to increase the allowable time of freelance shutdown of engine up to 4.5 days.