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JOINT OPTIMIZATION OF THE LOW-THRUST TRAJECTORY AND THE MAIN DESIGN PARAMETERS OF ELECTRIC PROPULSION SYSTEM

Abstract

It is considered the problem of joint optimization of the trajectory of the spacecraft with electric propulsion system (EPS) and main design parameters of EPS. This problem is one of the major at the feasibility study of space mission and in the substantiation of performance of newly developed electric propulsion for advanced spacecrafts. It is well known that for every space transportation operation there is an optimal value specific impulse of EPS corresponding to minimum total mass of EPS, the power supply system to ensure EPS operation, and the propellant. It is easy to show that there is also the optimal value of thrust (or EPS electric power), associated with the growth of the required characteristic velocity with decreasing of EPS thrust. It is obvious that optimal specific impulse and thrust can be found only by joint optimization of the trajectory and EPS design parameters. A simple spacecraft mass budget model and maximum principle are used for optimization. The fixed-time interplanetary mission optimization is considered. There are derived necessary optimality conditions for the specific impulse and thrust of EPS. As a result, joint optimization of trajectory and EPS parameters is reduced to the boundary value problem having two additional boundary conditions and two additional unknown parameters, namely EPS specific impulse and thrust. If necessary, one of the parameters (for example, the specific impulse) can be fixed, then the corresponding boundary condition should be excluded from consideration. It is proposed a method of solving of the problem, based on the sequence of power-limited trajectory optimization and a further continuation of the power-limited trajectory to the optimal trajectory with thrust switchings and optimal values of thrust and specific impulse. There are presented numerical examples of the joint optimization of interplanetary trajectory, EPS thrust and specific impulse values.