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ACCELERATED AEROBRAKING BASED ON OPTIMAL DRIVE CONTROL OF SOLAR ARRAYS FOR MARS EXPLORATION

Abstract

In the Mars exploration, the spacecraft enters an initial Mars highly elliptical orbit (HEO) after engine ignitions near the Mars, and then lowers the orbital altitude by orbital manoeuvres to a circular low Mars orbit (LMO). Using aerobraking technology to finish the transfer could save much energy. However, during the process of regular aerobraking, the spacecraft usually adopts a fix attitude control mode, and solar arrays have to keep sun pointing, so the total windward area of the satellite is unable to remain maximum, and that is one of reasons why regular aerobraking always costs so much time. Therefore, study on accelerated aerobraking technology in the Mars exploration in order to minimize time of the orbital transfer is needed.

Aiming at the long aerobraking time during Mars missions, an optimal drive control law of solar arrays during aerobraking is presented in this paper, according to specific attitude control mode of the satellite. The integrated optimization of transfer time and energy is also being taking into account.

The contents of the paper are listed as follows: (1)According to specific attitude control mode of the spacecraft, the relationship between the drive angle of solar panels and the total windward area of satellite is discussed.(2) For an orbital transfer between a HEO and a circular LMO, a regular aerobraking with solar panels pointing to the sun is simulated, and related time and fuel consuming is obtained. (3) Considering the rotation angle of solar panels during every aerobraking phase as a control variable and integrated optimization of time and energy consuming as a performance index, based on constraints of the maximum heat flow and thermal overload of the spaceflight, the optimal control problem is converted into a two point boundary value problem using optimal control theory, which is solved by optimization algorithm. According to specific attitude control mode, an optimal drive control law of solar panels with maximal windward area is presented. Compared with simulation results of the regular aerobraking, the accelerated aerobraking costs much less time.

The simulation results validate the accelerated aerobraking technology discussed in this paper, and it can be used for reference to engineering application.