SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – Part 2 (3B)

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OPTIMIZATION OF CONTROL AND DESIGN-BALLISTIC CHARACTERISTICS OF SPACECRAFT DURING THE MARS ATMOSPHERE REENTRY

Abstract

Unique rarefication of the Mars atmosphere defines specifications of spacecraft engineering designed for the landing on the Mars surface. As a result of the complex solution of that problem it is necessary to provide favorable terms to achieve the maximum efficiency for initial energy dissipation of the spacecraft using aerodynamic forces. The optimal control of spacecraft during the Mars atmosphere reentry is analyzed. Three spacecraft control modes are considered: with the help of roll angle, attack angle and joint variation of roll and attack angles. The efficiency of each mode is evaluated by the rate of minimal final velocity achieved under optimal control at the end of aerodynamic stopping segment. The choice of design and ballistic properties of SC is substantiated: aerodynamic quality K and front surface reduced load P_x. Optimal mechanical trajectories are determined under the different spacecraft control modes. Calculations has been made for three types of spacecraft: gliding spacecraft with the maximum aerodynamic efficiency K_{max} up to 0.6; all-body spacecraft with K_{max} up to 1.5; airplane type spacecraft with K_{max} up to 2.5. The values of P_x varied in the range from 200 up to $800 kg/m^2$. It is shown that the final velocity decreases on average by 20% in case of two-parameter control mode as compared with the one-parameter control mode for all spacecraft types under consideration. Increase of the balance quality does not lead to the deceleration at the end of the aerodynamic breaking stage in case of the optimal control in roll angle for any type of spacecraft. It is efficient to select certain balance angle of attack in terms of provision of other criteria. The use of gliding spacecraft becomes irrational in case of load increment on the frontal surface over $500 kg/m^2$ because of impossibility to slow down the speed of such spacecraft in the atmosphere to $3M$. The use of airplane type spacecraft expands the range of allowed values of loads on the frontal surface P_x.In order to slow down the speed of the spacecraft to subsonic values ($V < 200 m/s$) it is necessary to use airplane type spacecraft with sufficiently small $P_x$values. Thus the use of two-parameter spacecraft control in order to provide efficient speed bleedoff in the conditions of Mars rarefied atmosphere seems to be reasonable. At that it's expedient to use a gliding spacecraft with the maximum aerodynamic efficiency K_{max} up to 0.6 and P_x up to $500 kg/m^2$.