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Author: Prof. Vladimir S. Aslanov
Samara National Research University (Samara University), Russian Federation

Dr. Alexander Ledkov
Samara National Research University (Samara University), Russian Federation

INFLUENCE OF TETHER DEPLOYMENT ON THE ATMOSPHERIC STAGE OF TETHER-ASSISTED PAYLOAD RETURN MISSION FROM ELLIPTICAL ORBIT

Abstract

Space tethered systems is one of the most promising direction in modern space industry. Among the variety of space tethered missions, tether-assisted return mission of a payload is one of the closest to the wide practical implementation. This transport operation can be divided into three stages: controlled tether deployment, when the payload and mother satellite move as a single mechanical system, free orbital flight of the payload after tether cut to the border of the atmosphere, and the payload descent into the atmosphere. Each stage quite well studied, but there are few works devoted to control of tether deployment, taking into account atmospheric stage. The objective of this work is study of influence of tether deployment control on the payload's dynamical and thermal loads during its atmospheric motion.

It is supposed that the mother satellite is a mass point, which moves on an elliptical orbit. The mass of the satellite is many times greater than the mass of the payload. The tether is considered as variable length elastic massless rod. The payload has a spherical shape and moves along ballistic trajectory in the atmosphere. The mathematical models, which describe motion of the payload on the each stage of the above, were developed. The expressions for calculations the dynamic and thermal loads acting on the payload during its descent into the atmosphere were obtained. Estimation of the heat flows was produced for the stagnation point. The intensity of the heat input and the total amount of heat during the whole time of descent were considered.

It was shown that increase of the tether length leads togrowth of the maximum acceleration tolerance and maximum heat input but to decrease of the total amount of heat during descent and of the payload orbit perigee altitude. This factor should be taken into account in the design of the re-entry capsule and its thermal protection.The approximate analytical equationfor determining of the tether cutpoint on the mother satellite orbitthat provides transfer of the payload into the orbit with minimum perigee altitudewas obtained. For orbits with a small eccentricity (e¡0,25), this point is in the apocenter, but increase in eccentricity leads to a shift of thepoint to the pericenter. For the parabolic orbit (e=1) the true anomaly angle of the cut point is 1,23 rad. The results of this work can be used for creation of new tether-assisted deorbiting systems.