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DYNAMIC ANALYSIS OF SPACE TETHER SYSTEM WITH SLIDING BEAD-CAPSULE FOR PAYLOAD DELIVERY

Abstract

Delivery of payload from orbit is an important practical issue. Currently, capsules, which are transferred into the descent orbit by jet engines, are used to solve this problem. An alternative method is based on the applying space tethers. In this paper, space transportation system for the delivery of payloads to the Earth, which is consists of a radially oriented space tether system and a bead-capsule with payload, is considered. The space tether system includes a heavy satellite and a light lower module. Its center of mass moves in a circular orbit. The bead-capsule has cylindrical hole and slides-down along the tether under the influence of the gravitational force and the reaction force of the tether. The capsule separates from the tether near the lower module and passes into the descent orbit. The aim of this work is developing of a mathematical model of the described transportation system, analysis of the impact of the bead-capsule motion on the behavior of the space tether system, and choice of the system parameters to ensure safe descent.

The plane motion of the system was considered. Equations of motion were constructed with the help of the Lagrange formalism. In the framework of the mathematical model, the satellite was considered as a material point, and the bead-capsule and the lower module were rigid bodies. The tether was modeled by a massless three-segment rod, which takes into account its bending caused by the movement of the capsule. The influence of the initial velocity of the capsule, its mass, and a coefficient of friction between the capsule and the tether on the system's oscillations were investigated. It was shown that, the segment of the tether located below the capsule can swing-up and even turn into rotation as a result of the capsule uncontrolled sliding. Parameters of the system were chosen to prevent the occurrence of this undesirable situation. It was shown that high-frequency oscillations of the capsule around its center of mass can occur during its sliding. The effects of the moment of the capsule separation from the tether, its mass and initial velocity on the height of the perigee of the capsule orbit were analyzed. The results of the work can be used to design new space transport systems based on long tethers and moving capsules.