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Author: Mr. Ruinan Mu
Dalian University of Technology (DUT), China, mrn2013@mail.dlut.edu.cn

Dr. Shunan Wu
Dalian University of Technology (DUT), China, wushunan@dlut.edu.cn
Dr. Shujun Tan
School of Aeronautics and Astronautics, Dalian University of Technology, China, tansj.cn@gmail.com
Prof. Zhigang Wu
Dalian University of Technology (DUT), China, wuzhg@dlut.edu.cn
Prof. Zhaohui Qi
Dalian University of Technology (DUT), China, zhaohuiq@dlut.edu.cn

DYNAMICS OF SUPER LARGE SPACE STRUCTURES WITH MOVING COMPONENTS

Abstract

Increased size is one of the tendencies of recent space structures such as solar power satellite stations and space elevators, the scales of which vary from several kilometers to tens of kilometers in most of proposed configurations. The additional moving components, such as climbers on the space elevator for transportation and robot arms on the solar tower for on-orbit maintenance, are mostly indispensable to the super large space structures. Because of the high flexibility of such space structures, the coupling dynamics between the attitude motion and the flexible vibration are influenced by the movement of the moving parts.

The major objective of this study is to analyze the effects of the moving masses on the dynamics of the main structure and to design the optimal moving strategy of the moving masses to minimize the effect on the main structure. Based on the gravity gradient stabilized configuration (such as solar tower and space elevator), an Euler-Bernoulli beam with particles is used for simplification and the coupling dynamical model of the beam is derived by using Lagrange's equation. The attitude motion and flexible vibration of the main structure and sliding motion of the additional mass are governed by the coupling model. The distinction among the center of mass, the center of gravity, and the center of orbit are investigated when the additional masses move on the main structure. It is found that erroneous results will occur if this distinction is disregarded for such large space structure. Furthermore, the effects of the moving mass on the coupling dynamics are discussed by comparing the simulation results with different characteristic parameters including mass ratio between the moving mass and the main structure, shifting speed and scale of the moving mass. The optimization of the characteristic parameters is studied to reduce the effect of the moving mass on the motion of the main structure. Based on the minimum energy deviation criteria, the optimal design is achieved by using the genetic algorithm. It is verified that the amplitude of the attitude motion and the flexible vibration of the main structure is suppressed efficiently.

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