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Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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DEVELOPMENT OF ELASTIC FORCES MODEL FOR HIGH AREA-TO-MASS RATIO FLEXIBLE SPACECRAFT

Abstract

A high area-to-mass ratio flexible spacecraft have been applied into GEO communication mission and deep-space exploration fields in recent years. The main characteristics of this kind of spacecraft is that it forms a rigid-flexible multi-body system combining by rigid spacecraft body with low mass and large flexible appendages with high area, like large area flexible solar panel or truss antenna. While this flexible structures can complicate dynamic characteristic of the whole spacecraft systems. Besides, the high area-to-mass ratio flexible spacecraft mainly operates on high earth orbit, so the long-term accumulated thermal load induced by solar radiation will be also disturbed the whole spacecraft dynamics. Therefore, an accurate dynamic model of the high area-to-mass ratio flexible spacecraft is basis of analyzing its complex dynamic characteristics, as well as the following controller design. Moreover, an accurate description of elastic force of flexible appendages is a significant part of spacecraft dynamic equation, hence how to build reasonable and accurate elastic force becomes the most important problem in spacecraft dynamic modelling process. The research object in this paper is a high area-to-mass ratio spacecraft combined by rigid spacecraft and large flexible solar panels. The contribution of this paper is to develop reasonable and accurate elastic force models of large flexible solar panels of spacecraft. Different from traditional method that employs an element co-ordinate system and leads to a complex expression for the elastic forces, the paper first derives two elastic force models in the absolute nodal co-ordinate formulation (ANCF) based on continuum mechanics approach, which is account for non-linearity coupling characteristics between bending and axial deformations. The two new models are respectively for small deformation and large deformation situation. Then, the dynamic equation of flexible appendages is built through the absolute nodal co-ordinate formulation (ANCF), where the generalized external forces is thermal load force of solar radiation in the equation. Finally, numbers of simulations are set to illustrate the effectiveness of two elastic force models. In the simulations, the large flexible solar panels are divided into 12, 40, 60 elements respectively. Numerical results are presented in order to demonstrate that new elastic force models can be not only accurately described "strain-displacement" relationship of elastic force induced by thermal load effect in different deformation condition, but also achieved a significant elastic force simplification form that can greatly improve calculation efficiency.