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

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EVALUATION OF THE EFFECT OF THE COMPRESSION STIFFNESS AND THE BENDING STIFFNESS ON THE DEPLOYMENT OF A MEMBRANE-LIKE SPACECRAFT WITH THE MULTI-PARTICLE METHOD

Abstract

Research and development of membrane-like spacecrafts such as solar sail are widely conducted, including Interplanetary Kite-craft Accelerated by Radiation Of the Sun (IKAROS) launched by Japan Aerospace Exploration Agency (JAXA) in 2010. To launch such spacecrafts efficiently, it is required to have them folded until they reach outer space, where they will be deployed by centrifugal force. However, it is necessary to suppress the influence of the deployment on the attitude of the spacecraft, as well as to limit the stress applied to the thin membrane, and the rotational angular velocity required for complete deployment. Thus, the deployment method is one of the big challenges for the development of such spacecraft, and several numerical approaches have been taken in order to find one that suits the requirements of the mission. One of those calculation methods is the multi-particle method, which approximates the membrane with mass points, connected by springs and dampers. There are some studies which calculated the motion of membrane-like structures with this method, and showed its validity by comparing the calculation results with the experimental ones. In this study, we investigate the effect of the compression and the bending stiffness of the membrane on the deployment behavior with the multi-particle method. The compression and the bending stiffness are influenced not only by the physical properties of the membrane material, but also by the position and shape of the devices mounted on the membrane. That is the reason why knowing the effect of these parameters on the deployment can be important information for designing or developing such spacecrafts. In this study, we use IKAROS multi-particle model and its deployment method for the calculation. Calculation results were evaluated in terms of stress, effect on the attitude of the spacecraft, and whether it was deployed in a certain angular velocity or not. We also evaluated the validity of the calculation method of stress because it had not been confirmed in the past researches. The results showed that the compression and the bending stiffness greatly affect the deployment behavior, including the fact that high compression stiffness makes deployment impossible, and that a certain range of bending stiffness causes asymmetrical deployment.