Paper ID: 35153
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MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures II - Development and Verification (Deployable and Dimensionally Stable Structures) (2)

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A STUDY ON THE ASYMMETRIC SPINNING DEPLOYMENT OF MEMBRANE STRUCTURE WITH VARIATION THICKNESS

Abstract

This study is about asymmetric spinning deployment of a membrane structure with variations in its thickness. As an example of membrane structure with variations in its thickness, a solar power sail is focused on. A solar power sail has attached to the thin-film solar cells on its membrane. It generates electricity from these thin-film solar cells in addition to acceleration by solar radiation pressure. The solar power sail-craft to explore a Jupiter Trojan asteroid is currently developed at JAXA. It has 50-meter-square shaped sail membrane, which consist of four trapezoidal membranes called "Petals". Each of them consist of 10 micro meters thin base film and solar cells on it. The thin-film solar cells are attached in large area. Bending stiffness and compression stiffness at the points where thin-film solar cells are attached cannot be ignored. The deployment sequence of the solar power sail-craft consists of 2 stages. The 1st stage deployment is performed statically, and the 2nd stage deployment is performed dynamically by centrifugal force.

Asymmetric spinning deployment is a phenomenon that the deployment of one petal is greatly delayed in the 2nd stage deployment. This is called significant asymmetric deployment in this study. This significant asymmetric deployment could jeopardize the success of the future solar sail missions. If significant asymmetric deployment occurs, it could disrupt the balance of the spacecraft, and the membrane could wrap around the main body. Therefore, it is necessary to examine the significant asymmetric deployment in the 2nd stage.

In this study, the cause of significant asymmetric deployment is considered in terms of the difference in bending stiffness and compressive stiffness due to the variation in thickness between the thin-film solar cells and the base film. Spinning deployment experiments are conducted in a vacuum chamber using a test model of a square shaped solar sail. They shed light on the deployment behavior, influenced by differences in membrane thickness. Furthermore, simulation models are constructed to consider bending stiffness and compressive stiffness, and numerical simulations are compared with the deployment behavior observed in the experiments. The deployment behavior of the solar power sail-craft can be predicted.