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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 NEW DESIGN CONCEPT OF LIGHT-WEIGHT DEPLOYABLE MEMBRANE STRUCTURES FOR SPACE APPLICATIONS

Abstract

The object of this study is to establish a new design methodology for ultra-light-weight solar array paddles, which is defined as "an integrated structure". Several structural concepts for the future light-weight solar array paddles have been studied. They consist of a thin solar cell film, a shell structure (such as an Iso-grid shell) and/or a rigid frame structure. These concepts are designed aiming at power density of more than 100 W/kg, while current rigid-type solar array paddles are power density from 20 to 30 W/kg. Future solar array paddles applied for space explorations would require high power that greatly exceeds 100 W/kg. However, it is difficult to make such an ultra-light-weight solar array paddle by using the current design concepts, because additional structure and/or mechanisms are needed along with lightening functional materials. Moreover, we must integrate functional materials and structural material to design extremely light-weight structures. In other words, we must use functional materials as structural materials. A thin shell-type solar panel, which consists of thin solar cells laminated by polymer sheets, has been developed in Japan Aerospace Exploration Agency (JAXA). Using this solar panel, we would like to propose a hinge-less, ultra-light-weight deployable solar array paddle as a functional/structural integrated structure. It is well-known that we can easily give a great stiffness to a thin plate by adding a small curvature on the plate. By giving a curvature, the out-of-plane loading on a thin plate is transferred into the in-plane loading. The most efficient shape of the curvature is catenary form. The important issues to be considered are (1) how to deploy and give a curvature on a thin plate without any mechanism, and (2) how to keep the given curvature during various kinds of loading. We have designed and manufactured a thin plate sandwich panel. Inflatable tubes are used to give deployment force and curvature to the thin plates. To investigate the relationship between deformation modes on a whole plate structure and the shape of cross-section, static load testing was performed. And vibration testing was also performed to investigate the relationship between vibration mode and the curvature. Finally these test results are used to optimize our proposed design.