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

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HIGH-PRECISION POSITIONING OF REFLECTOR SEGMENT BY USING KINEMATIC COUPLINGS FOR BALLOON-BORNE RADIO TELESCOPE

Abstract

A mechanism for high precision positioning of reflector segments using kinematic couplings has been developed for balloon-borne radio telescope, and the effectiveness of the mechanism is demonstrated through experiments. A high precision reflector for radio telescope is under development, and it is intended to be used for the observation of radio waves of up to 300 GHz. Therefore, a surface accuracy of 50 μmRMS is required for the reflector. In order to realize such a high accuracy, segment reflectors and the mechanism for high-precision positioning by using kinematic couplings are utilized. The reflector consists of six segments, a back structure, and kinematic couplings. The segments are positioned and fixed precisely to the back structure by using the kinematic couplings. The positioning of the segment on the back structure is one of the largest sources of error in reflector systems, and an accuracy of 20 μmRMS is required. Therefore, kinematic couplings are important components of the reflector system for achieving a high surface accuracy. There sets of 2-DOR kinematic coupling, which is a combination of a ball and V-groove, are employed in the mechanism. Load applying mechanisms are used to apply and control pressing loads between the segment and back structure. The pressing loads are determined to satisfy the deployment completion condition derived in our previous study. The reflector segments and balls of the kinematic couplings are made of aluminum alloy to mitigate thermal deformation caused by difference in coefficient of thermal expansion. In order to demonstrate the effectiveness of the mechanism, the positioning repeatability of a segment to a back structure is investigated through experiments. In these experiments, the reflector segment is attached to and detached from the back structure, and the relative positions of the reflector with respect to the back structure are measured using a photogrammetry system during the process of attachment. The cycle of attachment, measurement, and detachment is repeated five times, and the positioning repeatability is evaluated. A positioning accuracy of approximately 20 μmRMS is achieved using the developed reflector system. The results demonstrate the effectiveness of the mechanism, which incorporates kinematic couplings for high-precision positioning of reflector of balloon-borne radio telescope.