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

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THERMAL DISTORTION COMPENSATION FOR IMPROVING ELECTRICAL PERFORMANCE OF SPACE REFLECTOR ANTENNA

Abstract

With the development of space science and technology, such as satellite communication, radio astronomy, space exploration, etc., space reflector antennas have received tremendous attention. The rapid developments in these fields have created demands for development of higher surface accuracy and better electrical performance. However, the harsh environment in space will affect the electrical performance of the antenna. For example, after the long-term work, the molecular escape of the organic material will deteriorate the performance in the high vacuum degree. Charged particle radiation from deep space also affects the performance of antenna. Especially, greater diurnal temperature difference in the space, about -200 +180 degrees Celsius, will decrease electrical performance due to thermal distortion of antenna reflector. This paper presents a method to compensate thermal distortion in order to improve the electrical performance by actively adjusting the shape of reflector panels supported on several actuators. Firstly, normal displacement constraints are imposed on each corner of a single panel, then the corresponding mode of panel deformation can be obtained. After determination of the relationship between adjustment and deformation, the local shape of reflector panel can be adjusted by actuators arranged between the panel and backup frame, and thermal distortion caused by temperature load can be counteracted accordingly, then the gain loss caused by the thermal deformation of antenna reflector is minimized. Based on the finite element model of 5m reflector antenna, the process of panel adjustment is simulated. The antenna reflector is locally deformed under the action of prestressing force. In order to reduce the influence of actuators' deformation, the elastic modulus of actuator ejector rod is increased to improve its stiffness. Then, according to the relationship between stress and strain in Hooke's law, actuator's travel is related to the local deformation of the panel. Finally, an optimization model is established, with prestressing forces of each actuator as design variable, and the minimum of gain loss as the optimization objective. A modified particle swarm optimization (PSO) algorithm is used to solve the optimization model. During the iteration, the weight value is changed to satisfy the precision of convergence. The experimental results show that the proposed method is more likely to converge to the global optimal solution. The reflector accuracy can be improved from 199m to 90m and the gain loss also reduced. Moreover, as a kind of active

surface compensation technique, this method can also be used in practice of land-based large reflector antennas.