Modeling of a Large Space Structure for Thermal Deformation Compensation Analysis

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ABSTRACT

Space structures encounter various severe environments in space. One of these environments is severe thermal conditions. When the Engineering Test Satellite -VIII (ETS-VIII) entered the Earth's shadow, the temperature of the large deployable reflector (LDR) mounted on the ETS-VIII decreased for about 200 ºC. During this eclipse time, the signal level of a radio wave from the LDR was observed to change. According to previous work [1], the midpoint of the LDR was confirmed to deform by approximately 5 mm as the temperature decreased, which led to a 65 km transition of the footprint of communication beam on the surface of the earth. This phenomenon was assumed to be caused by the thermal deformation of the LDR. It was not a critical issue for the ETS-VIII because the communication beam from the LDR tended to spread over a wide range. However, it may affect the performance of such satellites in the future where highly accurate pinpoint communication beams are expected to be required.

First, we sought a means to suppress the thermal deformation mechanically by focusing on the internal force generated by the spring used to deploy the antenna and by optimizing the coefficient of thermal expansion of the constituent members. We modeled a spring system of the deployable antenna by using beam elements to simulate thermal deformation phenomena and to realize the suppression of thermal deformation using the proposed means. According to the numerical results obtained from the finite element analyses, the thermal deformations at all apices that support the reflectors were suppressed at a high correction rate [2].

For the next step, we performed some thermal deformation analyses to investigate what factors can affect the correction rate of thermal deformations. Our thorough investigation had shown that the compensation rate relies highly upon the location of hinges in diagonal members and the stiffness of the members. This indicates that there may still be more effective structural design of a diagonal member to suppress the thermal deformation. Therefore, we revised the finite element model and introduced some hinges into the diagonal members, and sought out more effective structural design of a diagonal member to suppress the thermal deformation.

References

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