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# A Numerical Investigation to Suppress Distortions of Large Deployable Reflector in Space During Earth Eclipse

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Space structures are subjected to various environments in space. One of these environments is severe thermal condition where the difference of temperature during day-time and night-time is about 200 degrees Celsius (Fig.1). A signal level of a radio wave from the LDR (Large Deployable Reflector) mounted on the ETS-VIII (Engineering Test Satellite –VIII, Fig.2), which was launched in 2006, was observed to change during the Earth eclipse. This phenomenon was assumed to be caused by thermal distortion of the LDR. The distortion effect may become a considerable issue when maintaining the accuracy of communication beams reflected by a large space antenna in case of future artificial satellite.

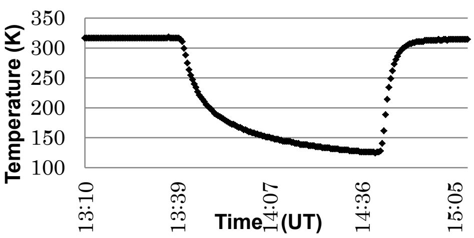



Fig.1 Temperature of the LDR during Earth eclipse

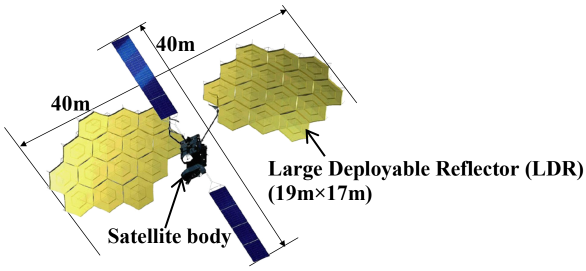



Fig.2 Overview of the ETS-VIII

From this point of view, a thermal distortion analysis using FEM was carried out on the LDR. The thermal distortion was suppressed, in the previous work [1], by finding optimal combination of CFRP tubes and titanium alloy joints constituting the antenna that had different thermal expansion characteristics. However, the means may not be used once the satellite has launched into space. Therefore, a different means to suppress the thermal distortion is proposed and demonstrated, in this study, by focusing into the internal force generated at the spring used to deploy the antenna.

For the first stage, a partial model of the LDR (one-module model) constituted of the structural tubes and the spring is constructed (Fig.3), and the behaviors of the model during several patterns of thermal transition are analyzed. From the numerical results, it is confirmed that the displacements in the antenna do not depend on the transition patterns of temperature. However, the increase speed of temperature does seem to affect the internal forces observed in the structural tubes (Fig.4).

For the next stage, we extended the numerical model to a full model of the LDR (14-module model), and applied the transition of temperature actually observed on the satellite. Distortion due to thermal change was observed in wide area on the antenna. The means to suppress the thermal distortion by controlling the internal forces is to be shown in the presentation.

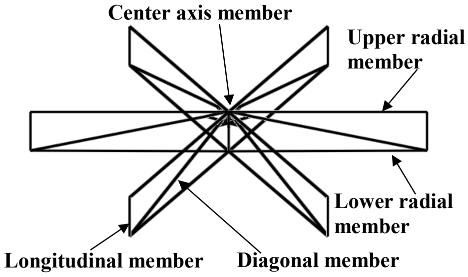
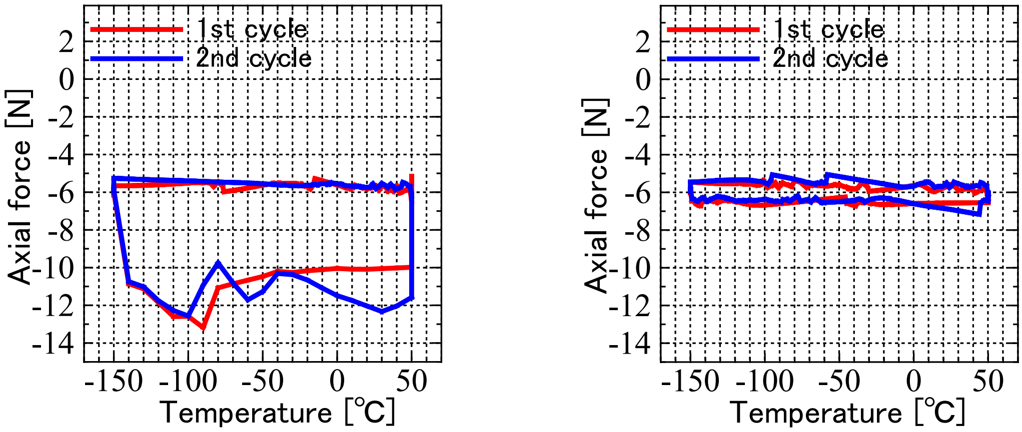



Fig.3 One-module model for analysis




(a) High increase speed of temperature (b) Low increase speed of temperature

Fig.4 Axial force occurred in diagonal member of one-module model during thermal transition

## REFERENCES

[1] M. Usui, K. Wakita, K. Kondo, L. T. T. Thanh, Y. Matsui and D. Isobe: Suppression of Thermal Deformation of the Large Deployable Reflector, *Transactions of the Japan Society of Mechanical Engineers, Series C*, Vol. 77, No. 777, pp.2107-2119, 2011, in Japanese.