By satellite systems across consideration

"Hodoyoshi satellite" search for the optimum design of a solar cell paddle structure

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1, Introduction

A wide variety of spacecraft have been developed from large to small in the current space industry. With the diversification of mission, power ensure becomes an urgent task, has been increasing spacecraft equipped with a deployment type solar panels. In addition, cost increases with the mission diversification, include the problem of increased development period.

Therefore, standardization and optimization design of the spacecraft has been promoted by the current number of researchers. The trouble in even testing phase is going well on the design and analysis are also many. Especially during spacecraft development has become the mainstream able to separate the charge, mechanical, thermal system, electrical system, it is much to activities parted mission system, with an equal, the system issues to solve in each. However, each system is involved in closely.

In this research, are intended to be searched across each system such optimal design the mechanical and thermal and electrical characteristics of the solar cell panel is focused on with a deployable solar panel "Hodoyoshi Satellite".

2, state-of-the-art research and development support program and "Hodoyoshi satellite"

Was adopted in the Cabinet Office cutting-edge research and development support program of the "from Japan" Hodoyoshi Reliability Engineering "construction of new space development and utilization paradigm by ultra-small satellite that introduced the" project Nakasuka Shinichi Professor (University of Tokyo) Many universities and companies has been carried out research and development in cooperation with the city center.

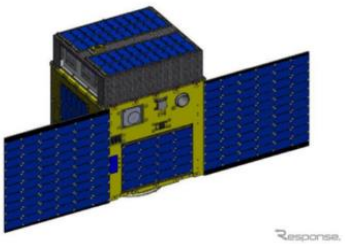

Fig.1　Hodoyoshi satellite-3 [1)]

It aims to further improve the technical capabilities of small satellite is the strength of Japan, small satellite of four aircraft between about 4 years (or less, Hodoyoshi satellite) is a project to develop. In Hodoyoshi development of satellite, designed from the excavation of the mission, to perform all of the development, to on-orbit operation after launch, it aims to take advantage of the results to the next development. To the subject of analysis in this study is the solar paddle of Unit 3 shows an external view of fig.1. Here, using a very simplified model the solar array, consider the optimal design.

3, Analytical method

Vibration Analysis for very simplified model the solar paddles alone. In this study, we thermal analysis, is compared with the temperature characteristics of the solar cell mounted the results, to search for optimal design. In view of the request from the launch vehicle side, solar paddles natural frequency must be designed to be 100 [Hz] or more axis direction.This request may be simply increasing the thickness of the solar arrays in order to meet but, on the other hand prevented the heat dissipation from the paddle back, the temperature rise of the solar cell, the generated power may be reduced.Therefore, when the cross considering the mechanical and thermal and electrical properties, it is believed that there is an optimum design for the trade-off of these properties.First, in this study, the natural frequency of expression of the bending of the beam at the vibration analysis, and using Equation heat balance in thermal analysis, and performs parametric analysis of when changing the plate thickness and material.

It shows a schematic diagram of the analyzed in Fig.2.

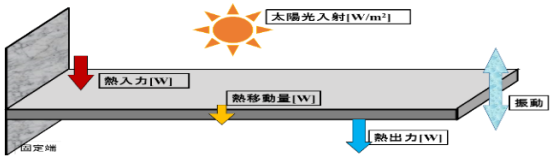

Fig2. Schematic view of a solar cell panel to analyze

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4, Analysis result

Result of two in the analysis of a simple aluminum plate and CFRP plate, in natural frequency exceeds 100 [Hz] or more, aluminum plate is 23.0 [mm] , a CFRP plate requires thickness of 19.7 [mm] obtained the result that there is. The results have been to the actual size and mutually exclusiveIn addition, the solar cell than the existing test results have found that lower temperatures may be high power generation, it is required to maintain a low temperature as long as the order can be a solar panel. In the thermal analysis, aluminum plate is also 25 [℃] by changing the thickness of the front and rear from without almost change, solar panels top temperature when you increase the thickness from 1 [mm] to 30 [mm] in the CFRP plate 24.1[℃] was raised from to 30.9 [℃].The change in the natural frequency of the CFRP plate in Fig.3, it show a solar panel upper and lower surfaces of the temperature in the CFRP plate in fig.4.

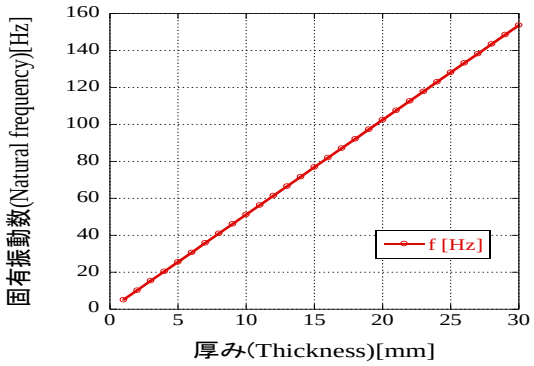

Fig. 3 Natural frequency of changes due to the thickness of the CFRP plate

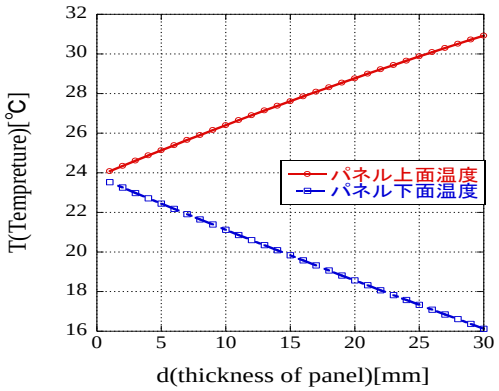

Fig.4 Temperature of the upper and lower surfaces by CFRP plate thickness

5, Consideration

When natural frequency in the first axis direction is think about satisfy plate thickness of 100 [Hz] above, in the case of the aluminum plate 23.0 [mm] at 25 [℃], CFRP plate 19.7 [mm] at 28.8 [℃] result that the obtained. Those of the aluminum plate temperature is lower. However, that CFRP plate 6.0 [kg] is not realistic for some more good satellite Unit 3 in an ultra-small satellite. Here I consider the methods of weight reduction.Changing the thickness d [mm] as a method for weight reduction without changing the size of the solar panel is considered. Thickness d [mm] only to reduce the order of the natural frequency is reduced, it can not meet the natural frequency of the requirements. Therefore, the lightweight hollow plate inside without changing the thickness for the natural frequency is increased to use the less dense aluminum honeycomb as the core material, without significantly increasing the weight, it is possible to establish as a structure .When viewed from the other hand the thermal point of view the aluminum honeycomb significantly reduced thermal conductivity by the core material, core thickness for aluminum honeycomb core CFRP sandwich panels for potential there to solar panel top surface temperature rises Optimal design of the skin thickness and the like my be considered necessary.

6. Future Tasks

This time has been finished only analysis of the steady state, it is necessary to verify the analysis results by the analysis and experiment in the non-steady state. The analyzes and experiments on a solar cell panel using a more specific aluminum honeycomb future, it is desirable to perform the comparison. Establishment of unified optimal design technique of future solar panels through these analysis and verification experiment is believed to be possible.

Reference

Ultra-small satellite center website ; http://park.itc.u-tokyo.ac.jp/nsat/main.html

2) Nishio Haruka, Ishihara Hiroshi , Keiichi Okuyama, "thermal characteristics of functional composite materials for small satellite", 56th Space Science and Technology Union Conference on collection (2012)