Paper ID: 8122
student

MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Smart Materials and Adaptive Structures (5)

Author: Ms. Azusa Muta
Tokyo Institute of Technology, Japan, muta@lss.mes.titech.ac.jp

Prof. Saburo Matunaga
Tokyo Institute of Technology, Japan, Matunaga.Saburo@mes.titech.ac.jp
Dr. N. Okuizumi
Japan Aerospace Exploration Agency (JAXA), Japan, okuizumi@isas.jaxa.jp

HIGH VACUUM EXPERIMENT OF SPINNING DEPLOYMENT USING SCALED-DOWN MODEL FOR SOLAR SAIL

Abstract

Solar sail is a type of spacecraft that deploys a large membrane in the space and gets accelerated by solar pressure from the Sun using the membrane. Even focusing to spinning deployment and maintain type of solar sail structure, the shape and the folding of membrane are various. Many spinning deployment experiments on the ground have done, and corresponding numerical simulations using nonlinear FEM and/or multiple particle models have been conducted. However, deployment dynamics of membrane is severely affected by friction of air and gravity. Also there are few experiment researches that consider membrane shape and folding procedure systematically.

In this paper, a small solar power sail demonstrator "IKAROS" by JAXA is considered. The shape of the membrane is square, with a diagonal distance of 20m. It is made of polyimide a mere 0.0075mm thick. The membrane is deployed, and kept flat, by its spinning motion. Four masses are attached to the four tips of the membrane in order to facilitate its deployment.

This paper deals with high vacuum experiment of spinning deployment using some scaled-down models for IKAROS. The thickness of the membrane is very thin and it is difficult to apply the similarity rule exactly to the scaled-down models regarding the thickness in particular. In this study, a dimensionless number is defined as ratio of bending stiffness force that constricts deployment to the centrifugal force that helps deployment. The deployment spin rate and the folding width of the membrane are selected as the parameters of the dimensionless number.

In this paper, the tendency of deployment behavior of membrane is observed when the dimensionless number of the scaled-down model gradually closes to one of the real spacecraft. Experimental result shows that the membrane can completely deploy only if its dimensionless number is smaller than the specific value. Also this paper shows the influence of air-pressure by changing the degree of vacuum during the deployment experiment.

A multiple particle system model is one of the numerical analytical approaches. The membrane is modeled by only multiple mass and spring. Because this model does not consider the influence of the membrane folding that may constrict deployment, the membrane can deploy in the numerical simulation even under the failed condition in the deployment experiments. By comparing with the model, the experimental results show that the multiple particle system model is feasible under high vacuum condition and small values of the dimensionless number.