66th International Astronautical Congress 2015

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

Author: Ms. Laura Bettiol
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, laura.bettiol.1@studenti.unipd.it

Mr. Francesco Branz
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, francesco.branz@studenti.unipd.it
Mr. Andrea Carron
Università degli Studi di Padova, Italy, andcarron@gmail.com
Mr. Matteo Duzzi
CISAS – "G. Colombo" Center of Studies and Activities for Space, University of Padova, Italy, matteo.duzzi@gmail.com
Prof. Alessandro Francesconi
University of Padova - DII/CISAS, Italy, alessandro.francesconi@unipd.it

NUMERICAL SIMULATIONS ON A SMART CONTROL SYSTEM FOR MEMBRANE STRUCTURES

Abstract

Membrane structures for space applications are attracting interest because of their low mass, low storage volume and reduced costs with respect to bulk structures. Example applications are solar sails, thin-film solar panels, antennae, drag augmentation devices and more. Nevertheless, the extreme flexibility of the membrane layer due to its thinness makes the structure not stiff enough to be effectively used in space. Therefore, a system that keeps the membrane in the desired deployed configuration is required. In addition to this, a system for reducing vibrations is necessary to reduce attitude disturbances on the spacecraft. Many different concepts of deployment and tensioning systems have been proposed so far, and a brief review of these technologies is presented. These technologies, like rigid and inflatable booms, have some disadvantages due to the complexity of the mechanisms and their deployment. Some research has already been done in the application of smart piezoelectric patches on membranes. In this paper, a different configuration of smart control system is proposed. Patches of smart material that act as both sensors and actuators connect different portions of the membrane. When the membrane undergoes a deformation, the patches change shape and a voltage is measured at the terminals of the sensors circuit. At the same time, the control system deforms the actuators patches to counteract this deformation. Numerical simulations with a multibody code are performed on a system based on the lumped mass method. Masses and joints represent the membrane, taking into account the elasticity and damping properties of the material. Similarly, the patches are represented by joints with the properties of the piezoelectric material. A control system on the joints simulates the behavior of the smart material. These simulations predict the behavior of the system, in terms of deformation and requested control authority. Afterwards, the results of an experimental test are reported, in order to make a comparison and validate the numerical simulations. The tests are performed in normal laboratory conditions, with the membrane suspended with long cables. In addition to this, the setup is equipped with an actuator that gives the initial input disturbance to the panel and visual sensors to validate the deformation results acquired by the piezoelectric patches.