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

Author: Dr. Atsuhiko Senba
Nagoya University, Japan

Prof. Tadashige Ikeda
Japan
Prof. Tetsuhiko Ueda
Japan

DYNAMIC SNAP-THROUGH USING PIEZOELECTRIC FIBERS FOR MORPHING BI-STABLE STRUCTURES

Abstract

Morphing structures, which change the shape and configuration of airfoils and surfaces, have received a lot of attention in the filed of adaptive structures. Shape-memory alloys (SMA) and piezo-electric materials for actuating these structures has been studied in order to provide large deformations of structural elements. On the other hand, bi-stable structures can be used as the structural elements for morphing aircrafts and space structures in order to introduce relatively large deformation of structures because bi-stable structures is based on the snap-through behavior with structural buckling.

The static deformation induced by the piezoelectric actuators is usually very small, which may not be directly used for morphing applications. Even though the macro fiber composite (MFC) has a number of piezoelectric fibers in a patch, the available force has still problems for actuating bi-stable composite plates for morphing structures. In particular, the effect of the stiffness of the MFC patch itself on the stiffness of the plates and the effect of the adhesive between the MFC and composite panels should be further studied to snap the bi-stable composite panels in the both ways of two stable states. Therefore, static deformation by the piezoelectric fibers is not enough to use snap-through behavior of both ways of bi-stable structures.

In order to overcome the drawbacks of the piezoelectric fibers, we propose a concept of dynamic morphing; the morphing using the frequency resonance of the bi-stable plates and shells. We focus on a possibility of the advantage of the large amplitude for the frequency resonance, and apply it to effectively snap the one stable state to the other state of the bi-stable structures even though the generated force of the fibers is small. The excitation with the piezoelectric fibers can induce the buckling to achieve large deformation of smart composite panels that has piezoelectric fibers in the laminations. The resonant frequency of each state of a specific bi-stable structure is usually different. Therefore, the excitation at each resonant frequency can be employed to induce snapping through between the two stable states. In preliminary experiments, the feasibility of piezoelectric fibers as an exciter is shown by vibration experiments using a cantilevered beam of the composite with piezoelectric fibers embedded. Moreover, the controllability of the snap-through behavior of the beam by the resonance is experimentally verified.