OPTIMAL SHAPES OF PZT ACTUATORS FOR PLATES SUBJECTED TO DISPLACEMENT OR EIGENFREQUENCY CONSTRAINTS

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In recent years, the application of piezoelectric actuators for active control of displacements, low frequency structural noise and vibration problems has drawn considerable attention. One of the primary reasons for this growing interest is the ability to tailor geometric and material properties of the actuators (e.g., shape, size, location, orientation and polarization profile etc.) in order to prescribe specific actuator/substructure mode coupling characteristics. Investigations on the effect of shaping and varying the polarization profile of the actuator (thus varying the moment distribution function over the surface of the actuator) have shown that selective mode coupling is possible. However, a comprehensive study into the effect of shaping the actuator and its polarization profile is still lacking, especially for the two dimensional case. To design actuators for specific applications, existing actuator models need to be viewed in terms of the equivalent forces and moments they exert on the structure and also analyzed in terms of their wave-number (spatial frequency) components to predict the modal excitation characteristics.

A main focus in static shape control using piezoelectric materials as the actuators is on finding the best control voltages so that the actuated shape is as close as possible to the desired one. Except for in some simple structures with simple boundary conditions, the shape control of structures is usually achieved using numerical methods (particularly the finite element method) and numerical optimization schemes.

The present formulation introduces boundaries of piezoelectric patches as new class of design variables. In addition, classical design variables in the form of ply orientation angles of orthotropic layers are also taken into account. The design objective is the minimization of normal maximal deflections or the maximization of the first natural frequencies. The standard Rayleigh-Ritz method is used, however, the accuracy of optimal design are verified with the aid of the FE package ABAQUS. Examples are presented to illustrate the performance of the proposed model.

In details, the aim of the present paper is two-fold:

– to analyze and discuss possible formulations of optimal design for structures with actuators,
– to model and solve optimization problems for smart laminated structures.
The discussed herein optimization problems are solved with the use of evolutionary algorithms in the similar manner as it is presented in Ref. [1]. It is assumed that piezoelectric patches are located symmetrically with respect to the host structure in the global normal direction denoted by the number 3 – see Fig.1. Let us note that such a definition of topological design variables is different than commonly used in the literature. On the upper/lower surface of the host structure piezoelectric sensors/actuators form an area closed by a curve \( \Gamma \). That curve approximates boundaries of individual rectangular sensors/actuators distributed over the area \( A \). In this way it is also possible to estimate the total number of individual sensors/actuators covering the area \( A \) – it is denoted by the symbol \( N_P \). In our opinion it is much better (from the optimization point of view) to use the curve \( \Gamma \) instead of the total number of individual rectangles since it is much more convenient to evaluate numerically different forms of curves and then insert them into the optimization algorithm. The boundary curve \( \Gamma \) can be easily build with the use of the classical B-spline functions and a finite number of key-points.

![Figure 1: Definition of topological design variables](image)

The formulation of the problem and the methods of the analysis are continuation of the works Muc and Kędziora [2,3]. In addition, due to the lack of the space we shall not dwell on the description of the used optimization methods; the details can be found in Refs [1-3].

REFERENCES

