Abstract

Piezoelectric actuators are being used increasingly in various novel applications. One of piezoelectric actuator design goals is to improve its performance for a certain mass of piezoelectric materials. Shape optimization is one important way to improve the performance of a piezo by changing its geometry. However, academic and industrial research of shape optimization is still developing, especially with several objectives considered simultaneously. This dissertation focuses on numerical modeling and multi-objective optimization of the shape of piezoceramics.

This work first explores the development of mathematical models and their related modeling procedure in detail. A mathematical model is introduced to describe the property of a piezo excited in resonance under weak electric fields. General eigenfunctions for piezoceramics with different shapes are derived. The description and numerical computation of a boundary value problem and the nonlinear dynamical behavior analysis are also presented. Both usual shapes (e.g. a rectangular shape) and (compared to the rectangular shape) unusual ones (e.g. a shape with curved sides) are considered, and the results show that some curved side piezoceramics perform better than those with a rectangular shape using both linear and nonlinear models for the dynamics.

In the next step a multi-objective shape optimization problem for the design of piezoelectric actuators is introduced. Two objectives, maximum amplitude (better performance) and minimum curvature (simple manufacturing), need to be optimized at the same time. The optimization is conducted with a subdivision algorithm based on the software package GAIO and the corresponding Pareto-optimal solutions are obtained both for linear and nonlinear models. The results show that there is indeed an advantage in using more complex shapes, as the Pareto set obtained using two design variables (in this case pa-

rameterizing a cubic B-spline) has substantially better objective function values than one with one design variable (in this case a quadratic curve).

Key words

Piezoceramics; Shape optimization, Eigenfunction; Boundary value problem; Bifurcation; Piezoelectric actuator; Multi-objective optimization; Subdivision algorithm