Topology optimization of piezoelectric smart structures under active control

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ABSTRACT

Smart structural systems with piezoelectric actuators and sensors are considered as an effective manner to reduce structural vibration for avoiding possible damage of a structure or degradation of system performance. Piezoelectric actuators are often used for providing active damping in the active vibration control system. It is clear that the active control effect can be promoted by optimizing the numbers and positions of piezoelectric actuators. Topology optimization of piezoelectric smart structures has also received increasing attention.

This study presents a topology optimization formulation for optimizing the piezoelectric actuator and sensor layout optimization to suppress the structural transient dynamic response under active vibration control. The structure is excited by a transient external load. For controlling the dynamic response, each sensor patch is connected to a charge amplifier, and the CGVF control algorithm is adopted to convert the sensor output to feedback control voltage in the corresponding actuator patch. Here, the control effect can be treated as an active damping of the dynamic system. The structure is discretized with finite element model, and the structural response is evaluated with a time-integration method. In the optimization model, an integral-type performance function in a given time interval is to be minimized. The pseudo-densities of piezoelectric elements (sensor and actuator) with penalization for indicating the presence or absent are taken as design variables. The sensitivity analysis scheme is derived with the adjoint-variable method and the optimization problem is solved with a gradient-based mathematical programming algorithm.

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