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Modeling, Analysis and Control of a Smart Composite Structure

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Abstract : In modern engineering, weight optimization has a priority during the design of structures. However, optimizing the weight can result in lower stiffness and less internal damping, causing the structure to become excessively prone to vibration. To overcome this problem, active or smart materials are implemented. The coupled electromechanical properties of smart materials, used in the form of piezoelectric ceramics in this work, make these materials well-suited for being implemented as distributed sensors and actuators to control the structural response. The smart structure proposed in this paper is composed of a cantilevered steel beam, an adhesive or bonding layer, and a piezoelectric actuator. The static deflection of the structure is derived as function of the piezoelectric voltage, and the outcome is compared to theoretical and experimental results from literature. The relation between the voltage and the piezoelectric moment at both ends of the actuator is also investigated and a reduced finite element model of the smart structure is created and verified. Finally, a linear controller is implemented and its ability to attenuate the vibration due to the first natural frequency is demonstrated.

Keywords : active linear control, lyapunov stability theorem, piezoelectricity, smart structure, static deflection
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