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UNIFIED PIEZOELECTRIC VIBRATION CONTROL OF ACOUSTICALLY AND ENVIRONMENTALLY EXCITED STRUCTURE

Abstract

Noise and vibration occurring in many engineering systems are closely related as a structural dynamics-environmental interaction problems. The coupling of the acoustic, environmental and the structure and their combined responses and control become extremely important. Structural vibration control using piezoelectric sensor and actuator is an attractive means. The problem can be formulated, analyzed and solved by synthesizing combined methodologies using acoustic and vibration analysis, piezoelectric dynamics and a generic control system synthesis. A unified Treatment of Acoustically and Environmentally Excited Beam is formulated and the solution scheme will consists of Use Euler-Bernoulli beam loading as baseline, and translation of aerodynamic loading and acoustic loading to be compatible with distributed loading, using appropriate fluid-structure loading transfer. In the Hamilton approach in setting the dynamic equation of motion, the energies of the beam and piezoelectric elements are functions of their deflections. The external nonconservative work, however, is a function of individual external loadings. Linear-Quadratic-Regulator will be utilized as a generic solver. The comprehensive methodological scheme will be exemplified by a generic system and assessed for its robustness. The generic problem for treating flexible beam with piezoelectric sensors and actuators attached to central-body space structure and its control is solved in great detail as a baseline. The approach can be utilized to solve more complex problems and in the selection and utilization of commercial software. For simplicity, Euler-Bernoulli theory is utilized to solve the free vibration of the beam by both analytical and numerical methods. The equation of motion of the beam is obtained by using Hamilton's principle, and the baseline problem is solved using finite element method. Treatment of the acoustic excitation consists of three set of generic approaches. The first generic approach consists of three parts, incorporating the formulation of the Helmholtz acoustic wave propagation and by using boundary element approach for the calculation of the acoustic pressure on the acoustic-structure boundaries, the structural dynamic problem formulation using finite element approach, and the unsteady aerodynamic loading problem on the structure using unsteady aerodynamics computational method. Analogous to the treatment of dynamic aeroelastic stability problem of structure, the effect of acoustic pressure disturbance to the aeroelastic structure is considered to consist of structural motion independent incident acoustic pressure and structural motion dependent acoustic pressure, referred to as the acoustic aerodynamic analogy. The comprehensive methodological scheme will be exemplified by a generic system and assessed for its robustness.