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VIBRATION ANALYSIS, CONTROL AND OPTIMIZATION OF A PIEZOELECTRIC ELEMENTS BONDED FLEXURAL - TORSIONAL COMPOSITE BEAM

Abstract

Vibration control of piezoelectric elements bonded flexural - torsional composite beam fixed to a rotating frame in space is one of the engineering problems to be solved in light-weight structures. In the present approach, which is a further development of earlier one, the beam is treated as composite Timoshenko beam with a generic control system designed for vibration control using piezoelectric sensor and actuator. Following a series of previous investigations on vibration analysis and vibration control of flexible structures, the main purposes of this study are twofold: a. to formulate the equation motion for a generic rotating composite rectangular cross-section beam under flexural and torsional loading, and b. to find full-state observer LQR controller weighting matrices using genetic search and optimization algorithm in the generically formulated vibration control problem. The Linear-Quadratic-Regulator control approach is designed to minimize an objective function or performance index in quadratic form, which depends on the selection of the weighting factors, Q and R. The quadratic function is considered to be appropriate, since it is taken as a relevant measure of the kinetic, potential and input energy. The best of Q and R are found by minimizing the settling time of the response of system output, which is the sensor voltage. The optimal control is intended to minimize an objective function or performance index of a synthesized system, is taken to be quadratic. The synthesized system consists of the actual plant and the controller. The focus of this investigation is chiefly on LQR controller. The general equation of motion of the beam bonded with piezoelectric sensor and actuator describes the transverse and angular (torsional) deflection of the beam. The equation of motion includes the control aspect of the smart beam through an externally applied moment and torsion. When the feedback voltage from the sensor is sent to the actuator, it creates an externally applied control moment and torsion which will be formulated accordingly following previous work. The equation of motion for the system is elaborated using energy principle and full-state observer Linear-Quadratic-Regulator. Using these previously carried out techniques that have shown its plausibility, accuracy and elegance, the problem of vibration analysis, control and optimization of a piezoelectric bonded composite beam under flexure and torsion is carried out step by step following each problem category.