Optimization of Active Constrained Layer Damping Beam Performance Considering Operational Temperature Variabilities

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This study aims to investigate the dynamic characteristics of an active constrained layer damping (ACLD) beam due to operational temperature variability, and to optimize the ACLD beam performance with consideration of the temperature variability. First, a finite element code is developed to simulate the active constrained layer damping beam using a 10 degree-of-freedom element. The active constrained layer damping beam consists of a base beam, a viscoelastic core material, and a piezoelectric constraining layer. In the developed element, transverse displacements and rotations of base and constraining beams, shear deformation of the core material, and the active control force are introduced. A constrained layer damping beam is introduced and modeled by the finite elements. Then, the effects of the operational condition variability on the control performance are simulated by the finite element model. To describe the frequency-dependent characteristics of viscoelastic core material, the fractional derivative model is plugged into the finite element formulation, which leads to an iterative solution scheme to obtain modal information of the structural system. To consider temperature variation, the shift factor concept of viscoelastic materials and the Arrhenius relation for the shift factor are also used in the formulation. To predict the variability of the control performance on the active constrained layer damping beam, the eigenvector dimension reduction (EDR) method is used with estimated temperature variability, material property uncertainties, and manufacturing uncertainties. In addition, the effects of the control gain on the performance of the active constrained layer damping beam are investigated. The simulation results by the finite element model for the active constrained layer damping beam show that the active control performance are heavily influenced by the variability of the operational condition, especially by the temperature variation of the viscoelastic core material. Modal dampings also show large variability due to the variability of the operational condition.

The ACLD beam performances will be optimized using a reliability-based optimization formulation with respect to the control gains. In the optimization formulation, manufacturing and material properties uncertainties will be included. The results of this study will demonstrate that the operation temperature variability has to be considered in designing the active control of constrained layer damping system.

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