Abstract

In this thesis, the Mesh Free (MF) models of smart composite structures have been developed for their active damping analysis using the Smart Constrained Layer Damping (SCLD) treatments**.** The SCLD treatments are composed of the constrained viscoelastic material (VEM) layer and the constraining actuator layer made of the vertically/obliquely reinforced 1-3 piezoelectric composites (PZCs). Since the 1-3 PZCs have higher transverse electromechanical coupling coefficients, the layerwise shear and normal deformation theories are used to conceive the kinematics of the deformation of the smart composite beam, plate, and shell considering their transverse extensibilities in the thickness direction. The constraining VEM layers are modelled employing the complex modulus approach in the frequency domain, while the fractional derivative models are used for the time domain analysis. In this regard, the two-dimensional and the three-dimensional form of the Bagley and Torvik's four parameter Fractional Order Derivative (FOD) model have been derived and implemented to obtain the transient response of the overall structures. The Grünwald's definition of the fractional order operator is used to numerically implement the FOD model such that the dissipative anelastic displacement components of the VEM layers can be expressed in terms of the generalized displacement components and the memory load terms (in terms of the Grünwald coefficients) without increasing the overall system degrees of freedom. This ensures higher computational efficiency of the FOD model, especially for the geometrically nonlinear analysis. The von-Kármán type strain displacements relations are considered to introduce the geometrical nonlinearity into the model, while the amplitude of loads are selected from the backbone curves such that substantial nonlinearity can be introduced in the initial phase of the response. Different types of SCLD treatments with triangular, elliptical, circular as well as rectangular shapes have been considered for the analyses and it is observed that triangular SCLD patches have better control authority in controlling both the linear and geometrically nonlinear vibrations of beams, while the elliptical SCLD patches are more effective for the plate and the shell type structures. The effect of variation in the orientation and aspect ratio of the elliptical SCLD treatments for the active damping of linear as well as geometrically nonlinear vibrations of the smart composite plates and shells is also investigated. The effect of variation in the piezoelectric fiber orientation angle in the constraining 1-3 PZCs layer on the control authority of the SCLD treatments is also analyzed. The analyses reveal that the centrally placed elliptical SCLD treatments with vertically reinforced 1-3 PZC constraining layer have the maximum control authority for active damping of laminated composite plates and shells.