Abstract

In this dissertation, two kinds of viscoelastic composite (VEC) layers are proposed by the names of 1-3 and 0-3 VEC layers. The 1-3 VEC layer is comprised of the inclusion of unidirectional graphite wafers or strips, while the other one (0-3 VEC) is composed of a rectangular array of thin rectangular graphite-wafers. The objective in these designs of the VEC layers is to augment the damping in the unconstrained layer damping (UCLD), passive constrained layer damping (PCLD) and active constrained layer damping (ACLD) treatments of structural vibration.

First, the1-3 VEC layer is employed as the damping layer in the UCLD and PCLD treatments of vibration of a substrate beam, and the corresponding damping mechanisms especially due to the graphite inclusions within the viscoelastic layer are investigated by developing a finite element (FE) model of the beam. The results reveal significantly enhanced magnitudes of the transverse shear and extensional strains within the viscoelastic phase for the presence of inclusions. So, the damping capacities of both the UCLD and PCLD treatments improve significantly. These observations motivate to extend the investigation for ACLD treatment of beams using the 1-3 VEC layer, and it is revealed that the active-passive damping in the ACLD treatment improves due to the use of 1-3 VEC layer instead of the conventional pure viscoelastic layer.

Next, the concept of 1-3 VEC layer is implemented to augment the constrained layer damping (CLD) of a circular cylindrical sandwich shell with the viscoelastic core. The graphite strips are axially inserted following the middle surface of the viscoelastic core, and a three-layered VEC core with the 1-3 connectivity of two phases is achieved. The sandwich shell is analysed by developing an FE model based on the layer-wise shear deformation theory, and it is observed that the passive damping in the overall shell arises mainly due to a transverse shear strain of the viscoelastic phase, but the damping increases significantly due to the inclusion of graphite strips. These strips are subsequently configured in an optimal manner for achieving improved damping in all modes of vibration of the shell within a frequency range of interest. The three-layered VEC is further utilized for the ACLD treatment of circular cylindrical shell where a new ACLD arrangement is proposed in layer-form using the vertically reinforced 1-3 piezoelectric composite layer with the printed patches of surface-electrodes. The main objective in this design of ACLD layer is to control all modes of vibration of the cylindrical shell effectively, and it is substantiated through the FE analysis of the shell. It is found that the three-layered VEC improves the active-passive damping of the treatment while the proposed arrangement of electrode-patches serves to achieve the improved damping in all modes of vibration.

The improved damping due to the 1-3 VEC layer is achieved by the enhancement of the transverse shear and the extensional strains of the viscoelastic phase at a transverse plane of the principal material coordinate system. In contrast, for achieving similar enhancement of all strains in the viscoelastic phase, a new 0-3 VEC layer is designed, and its performance as the passively constrained damping layer over a substrate plate is investigated by deriving an FE model of the overall plate. It is observed that all strains in the viscoelastic phase of 0-3 VEC layer increase due to the inclusions, and it results in improved passive damping in the plate over that in the use of the 1-3 VEC or pure viscoelastic layer. This improved damping depends on geometrical properties of the 0-3 VEC layer, and thus its (0-3 VEC) optimal geometric configuration for maximum damping is addressed. The study is further extended for investigating the performance of the 0-3 VEC layer as the damping layer in ACLD treatment of plates. This reveals the same damping mechanisms as observed in the previous PCLD case, and it leads to an improved active-passive damping capacity of the ACLD treatment through an optimal geometric configuration of the 0-3 VEC layer.