ABSTRACT

Vibration control is a useful technique particularly for the thin walled composite structures, as they possess low structural damping. Structural performance can be improved, if the vibration energy is dissipated through some mechanism, without adding much weight penalty. This can be accomplished by two vibration control techniques, namely active and passive. Passive control is simple, but not robust, and also adds additional weight to the structural system. On the other hand, active control is robust, adaptive and does not add much weight.

Active control system needs distributed actuators and sensors. With the development of active materials such as piezoelectric, which can be employed as actuators and sensors, the smart structure concepts are presently appreciated for structural control applications. The present work is an attempt in this fascinating area to address a few issues relevant to piezoelectric active materials modelling and their use in distributed active vibration control of laminated composite sandwich beams, plates and shells.

Control design is a key element in the development of structural vibration control schemes. Control algorithms are well developed and also are reported. In the present work, state and output feedback control techniques are employed as coupled and modal controllers. Linear quadratic regulator and eigen structure assignment algorithms are used to develop active control schemes. Velocity and displacements are considered as state variables and piezoelectric actuator voltage is the control input. Amplitude control, frequency control, and mode shape control are attempted in the present study.

A novel idea is proposed, combining classical d_{31} extension-bending actuation (EBA) and relatively new d_{15} shear-bending actuation (SBA) to develop hybrid actuated smart sandwich beam structures. Active stiffening effect is analysed with collocated and non-collocated EBA/SBA. Hybrid actuation facilitates to actuate EBA or SBA,

independently or simultaneously to have the benefit of both actuating mechanisms. However, to achieve a combined actuation effect (active stiffening) of EBA and SBA, they must be placed in a non-collocated fashion. Interestingly, SBA is found more effective in developing the piezoelectric resistive force (active damping) than EBA for the same control effort.

Eigen structure assignment algorithm is employed as a pole placement technique, where the shape constraints are imposed to achieve the desired mode shapes for a beam. It is observed that the vibration levels of controlled modes are significantly reduced by altering the first three eigenvalues without affecting much of the other modes. The controlled mode shapes are appeared to be quite different from uncontrolled ones and this is achieved through the application of shape constraints.

Aerospace structural systems have to respond and sustain different kinds of loading such as aerodynamic forces, environmental disturbances, during their service life. Thus, piezoelectric composite structures must be analysed to see their functionality under environmental disturbances, namely hygral and thermal. Therefore, modelling techniques are developed for piezohygrothermoelastic composite plates and shells. Stress stiffening effect of hygrothermal forces is included and the influence of hygral and thermal effects on active stiffening and active damping is further assessed. Temperature and moisture induced deflections are actively controlled by active stiffening effect. The frequency reduction due to temperature or moisture is also actively compensated by piezoelectric stiffening effect.

Geometric curvature has a critical role to play on the performance of actuator lamina, when it is surface bonded on the curved laminates. Actuator lamina is effective, if it is surface bonded on the top of curved laminates.

Influence of piezoelectric anisotropy on active stiffening and active damping effects is studied to qualitatively estimate the performance of directional actuators in