

Abstract

Composite materials are the primary requirements for modern aerospace, marine, automobile and construction applications due to its high strength and stiffness, lightweight, and tailorable properties. Composite material allows modulation of a large number of parameters, such as types of fiber and matrix, volume fraction of fiber and matrix, fiber orientations, etc. to achieve the design specific structures. In traditional straight fiber laminate, the fiber orientation is constant within a plane, which exhibits constant stiffness in a lamina. However, the advance manufacturing technique unlocked the possibility of getting variable stiffness within a plane of lamina by placing fiber in a curved path. The proper implementation of variable angle tow (VAT) lamina can significantly improve the static and dynamic response of the composite structures. The laminated composite structures serve several benefits over metallic structures, but the performance of composite structures may get deteriorated due to the presence of delamination. It is one of the most frequently occurring defects in laminated composites at which the adjacent plies may separate due to various reasons (improper resin between plies, fiber breakage, insufficient curing time, etc.). The detection and prediction of delamination location are quite challenging because it occurs within the layers of composite laminates. The effect of delamination on structural response varies with respect to delamination size and location. Thus, in the present analysis, the effect of delamination on the static, free vibration, and dynamic aeroelastic response of VAT laminated composite structures is carried out. The adverse influence of delamination on the static and dynamic response of the composite structures can be minimized with the use of curved fiber laminate. The investigation finds the most sensitive delamination locations for dynamic response with different boundary conditions. Further, the piezoelectric patches are integrated with the composite lamina to recover the flutter strength lost due to the delamination. Several locations are tested for the placement of piezoelectric patches with active feedback gains to enhance the flutter boundaries of the VAT plates.

A perfect design of the engineering systems to achieve the required objectives without failure during a preselected life is impossible. The term perfect design comes from the deterministic approach solution to engineering problems. An accurate or defect-free design is idealistic, impractical, and economically infeasible. There are several factors responsible for not getting the desired response of structures, such as deviation in materials properties, dimensional inaccuracy, unexpected environmental conditions, etc. These may cause variability in the composite properties and be the reason for the undesired response of the structures. Thus, for a proper engineering design, finding the sources of uncertainties that may influence the system's performance is very crucial. Moreover, defining the type and levels of distribution of the uncertain variables are indispensable. The stochastic-based design of an engineering system could be more safer and reliable. To compute the stochastic response of VAT laminated plates, two different stochastic models, such as polynomial neural network (PNN), and radial basis function (RBF) neural network are developed. The accuracy and efficiency of these stochastic models are established by comparing the results with Monte Carlo simulations. It is seen that the developed models predict stochastic response with a much less number of samples without compromising the accuracy.

Keywords: Variable angle tow laminated composite, Aeroelastic analysis, Delamination, Deterministic, Stochastic, Polynomial neural network, Radial basis neural network, Deterministic analysis