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Finite Element Analysis of Resonance Frequency Shift of Laminated Composite Beam

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Abstract : Laminated composite materials are widely employed in automotive, aerospace, and other industries. These materials provide distinct benefits due to their high specific strength, high specific modulus, and ability to be customized for a specific function. However, delamination of laminated composite materials is one of the main defects which can occur during manufacturing, regular operations, or maintenance. Delamination can bring about considerable internal damage, unobservable by visual check, that causes significant loss in strength and stability, leading to composite structure catastrophic failure. Structural health monitoring (SHM) is known to be the automated method for monitoring and evaluating the condition of a monitored object. There are several ways to conduct SHM in aerospace. One of the effective methods is to monitor the natural frequency shift of structure due to the presence of defect. This study investigated the mechanical resonance frequency shift of a multi-layer composite cantilever beam due to interlaminar delamination. ANSYS Workbench® was used to create a 4-plies laminated composite cantilever finite element model with [90/0]s fiber setting. Epoxy Carbon UD (230GPA) Prepreg was chosen, and the thickness was 2.5mm for each ply. The natural frequencies of the finite element model with various degree of delamination were simulated based on modal analysis and then validated by using literature. It was shown that the model without delamination had natural frequency of 40.412 Hz, which was 1.55% different from the calculated result (41.050 Hz). Thereafter, the various degree of delamination was mimicked by changing the frictional conditions at the middle ply-to-ply interface. The results suggested that delamination in the laminated composite cantilever induced a change in its stiffness which alters its mechanical resonance frequency.

Keywords : structural health monitoring, NDT, cantilever, laminate
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