Analytical and Numerical Analysis of Oval-Shaped Composite Beam

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Abstract

Composite materials are widely used in the aircraft industry because of its superior fatigue characteristics, greater fatigue tolerance and large stiffness-to-weight ratio as compared to the traditional metal alternatives. In helicopter rotor application, composite materials adds features like drastic reduction in number of parts and bulkiness, especially in rotor hub system which is typically a large source of profile drive. This paper aims at an analysis of oval-shaped composite beam. Carbon fiber composite box beam with 0 degree & 90 degree plies are used for simulation and analysis. The composite beam is fixed at one end and the load is applied at the free end of the beam. Figure 1 represents this model of the composite beam generated using COMSOL Multiphysics software.

The numerical analysis was carried out using COMSOL Multiphysics' Structural Mechanics module. The beam is modeled by assigning geometry command and boundary conditions to it, using the command Solid Mechanics. In this command, the fixed constraint is used to fix the beam at one end and load (point load) command is used to apply the load at the other free end. Also, material properties are defined to geometry by defining parameters like Young's Modulus, Poisson's ratio and density. Then, using the meshing command, the geometry is divided into a number of small structures, so coarse meshing is carried out on the given geometry. The given model is analyzed in a static condition. Therefore, the study type selected for the analysis is stationary and, not time dependent. The slice command from the result constraint is used to find out the stress and strain at particular points of the beam i.e. at the fixed end and in the middle. Figure 2 shows the boundary conditions given to the geometry.

Oval-shaped composite beam is analyzed for different parameters such as total deflection, strain-stress at different points on beam by varying the point load at its free end. Based on these results, as value of point load increases from the deflection at free end, the stress-strain at fixed end and the middle of the beam also increases. The deflection at free end and stress-strain results are carried out at a particular point of composite beam. Figure 3 and 4 indicate how deflection is calculated at the free end and the stress-strain at fixed end and at the middle of the beam.

Comparing the stress-strain values at fixed end and the middle of the beam, values at fixed end are greater than values for middle of the beam. Also, there is no more difference between analytical and numerical results. Finally, simulated results are compared with analytical results and a percentage error of less than 10% is observed.

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Figures used in the abstract

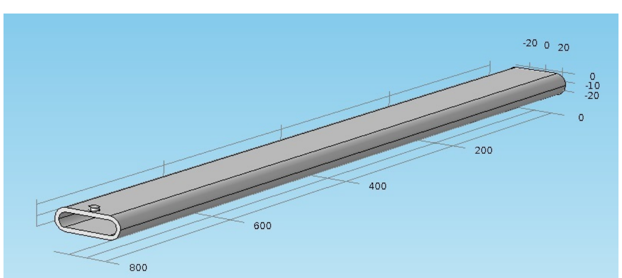

Figure 1: COMSOL Model for Analysis.

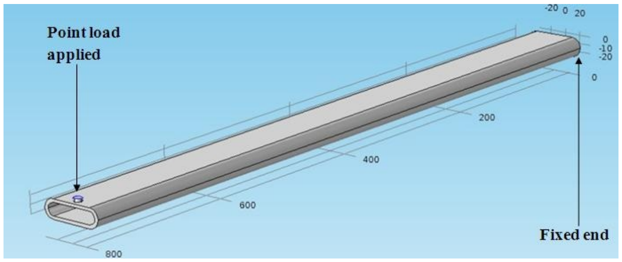

Figure 2: Boundry Conditions Applied to Geometry.

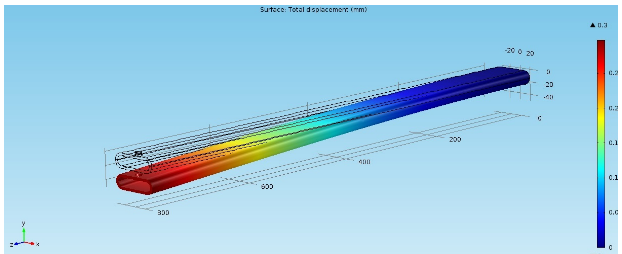

Figure 3: Sample Result of the Deflection at the Free End of the Beam.

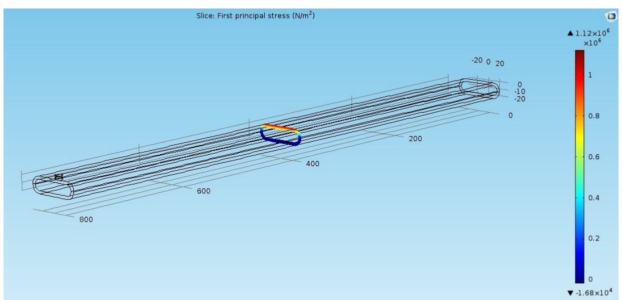

Figure 4: Sample Result of the Stress Induced at the Middle of the Composite Beam.