Helicoidal Laminates for Energy Absorption

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The mantis shrimp is capable of delivering high speed strikes to its preys, which can shatter shells of crustaceans and bivalves. During aggressive encounters with its own kind, the mantis shrimp uses its tail segment, known as the telson, as a shield to protect against the impact. Using scanning electron microscopy, the microstructure of the telson is found to be a laminated composite comprising unidirectional plies continuously rotating through the thickness. Inspired by this microstructure, the mechanical properties of a helicoidal layup sequence are compared against a cross-ply laminate by performing a quasi-static five-point plate bending test. Each test specimen is fabricated from 19 plies of unidirectional carbon fiber-epoxy prepreg. In the helicoidal layup sequence, the angle of rotation between adjacent plies is 10°. The bending test results show that the helicoidal specimens have lower peak stresses, but undergo larger deflections before failure, leading to higher energy dissipation. In addition, simulations are performed using ABAQUS to evaluate the stress fields in the specimens under the same load and boundary conditions. The results show that given the same amount of work done, peak normal and shear stresses are lower in the helicoidal model, thus suggesting better stress distribution in the laminate.

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