Paper ID: 100743
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures I Design, Development and Verification (Launch Vehicles and Space Vehicles, including their Mechanical/Thermal/ Fluidic Systems) (1)

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DESIGN, ANALYSIS AND COMPARISON OF BIOMIMETIC HIERARCHICAL HONEYCOMB SANDWICH COMPOSITES FOR AEROSPACE APPLICATIONS

Abstract

Hexagonal configurations are prevalent in nature, exemplified by honeycombs constructed by bees and the elaborate webs spun by spiders. This study investigates a novel biomimetic honeycomb structure inspired by these natural hexagonal motifs. Utilizing SOLIDWORKS, a conventional honeycomb core is designed, and three distinct honeycomb panel variant geometries are created. Each variant incorporates hierarchical hexagonal infill patterns interconnected by networked web-like frameworks analogous to spider silk, with minor variations among them. The composite structure comprises two carbon fibre-polyether ether ketone (CF-PEEK) face sheets with an Aluminium 7075 T6 (Al 7075 T6) honeycomb core interposed between them. To evaluate the mechanical performance of these bio-inspired designs, a static three-point bending test is performed on the composite specimens using ANSYS 2024 R1. This finite element analysis assesses the flexural behavior of the honeycomb panels, focusing on parameters such as stiffness and weighted stiffness. The simulation results are compared with those of the conventional honeycomb design, revealing significant variations in mechanical properties across the three configurations. The study illustrates how geometric modifications in the honeycomb structure distinctly impact stiffness and weight efficiency, thereby affecting the overall structural performance. These findings underscore the potential of biomimetic design principles in advancing high-performance materials, particularly for aerospace applications where weight optimization and structural integrity are critical. By emulating natural geometries, this research demonstrates the potential for developing innovative materials that significantly enhance mechanical properties, offering improvements for sophisticated aerospace engineering. The study contributes valuable insights into optimizing material designs to achieve an optimal balance between strength, weight, and durability.

Keywords: Biomimetic, Honeycomb, Hierarchical, Al 7075 T6, CF-PEEK, three-point bending, flexural, weighted stiffness, weight efficiency