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3D printing of composite sandwich structures using continuous carbon fiber and fiber tension

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Abstract

Many modern aircraft components are made from carbon fiber reinforced polymer sandwich structures with two outer skins possessing high tensile and compressive strengths separated by a lightweight core that provides shear stiffness. However, the conventional manufacturing method involves a complicated and costly bonding process. This study used a continuous carbon fiber 3D printer to manufacture sandwich structures with honeycomb, rhombus, rectangle, and circle core shapes as a single piece. The functional properties of the sandwich structures were quantified by shape evaluations and three-point bending tests. Three-point bending tests showed maximum load and flexural modulus increased as effective density increased for all core shapes, but the rhombus core shape was the strongest. Because the mechanical properties depended on the core shape, continuous carbon fiber 3D printers can be used to flexibly design core shapes that satisfy the desired strength and stiffness.

1. Introduction

In modern aircraft, carbon fiber reinforced polymer (CFRP) sandwich structures are used for flight control surfaces, including steering blades, elevators, and rudders[1-3]. Sandwich structures are integral constructions consisting of two skins possessing high tensile and compressive strengths, separated with a lightweight core that provides shear stiffness. However, the conventional manufacturing method, wherein the skin and core materials are manufactured separately and then bonded together, involves a complicated and costly bonding process [4-6]. Therefore, technology that facilitates forming the skins and complex-shaped core as one piece is desirable. It is also necessary to fully investigate the functional properties resulting from the core shape and demonstrate that these properties suit the application [7]. For this reason, technology that allows both flexible design and production of core shapes is required.