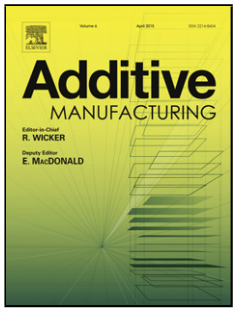

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Anisotropic Mechanical Properties of Oriented Carbon Fiber Filled Polymer Composites Produced with Fused Filament Fabrication

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Abstract

Fused Filament Fabrication (FFF) is a widely used Additive Manufacturing (AM) technique. Recently, mechanical properties of plastic FFF parts have been enhanced by adding short carbon fibers to the thermoplastic polymer filament to form a carbon fiber filled (CFF) polymer composite. Unfortunately, improvements to the material properties of commercially available CFF filament are not well understood. This paper presents a study of CFF FFF parts produced on desktop 3D printers using commercially available filament. Tensile test samples fabricated with CFF polymer composite and unfilled polymer were printed and then tested following ASTM D3039M. Test bars were printed with FFF bead orientations aligned with the direction of the applied load at 0 degree, and also at 45 degrees, ±45 degrees, and normal to the loading axis at 90 degrees. The filament considered here was purchased from filament suppliers and included both CFF and unfilled PLA, ABS, PETG and Amphora. Results for tensile strength and tensile modulus show that CFF coupons in general yield higher tensile modulus at all print orientations and higher tensile strength at 0 degree print orientation. The addition of carbon fiber was shown to decrease tensile strength for some materials when printed with beads not aligned with the loading direction. Additionally, CFF samples are evaluated for fiber length distribution (FLD) and fiber weight fraction, where it was found that the filament extrusion process contributes very little to fiber breakage. Finally, fracture surfaces evaluated under SEM show that voids between the beads are reduced with CFF coupons, and poor interfacial bonding between fibers and polymer become a prominent failure mechanism.

Keywords: Additive Manufacturing; Fused Filament Fabrication; carbon fiber filled polymer composites.