Experimental investigation and prediction model for mechanical properties of copper-reinforced polylactic acid composites (Cu-PLA) using FDM-based 3D printing technique

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ABSTRACT

Processing complex parts with high dimension accuracy and cost-effectiveness can be achievable using the fused deposition modeling (FDM) technique. It is one of the highly efficient methods in the additive manufacturing process. However, limitation in working temperature is the main drawback associated with the FDM technique, which has caused the applicability of low melting temperature materials in this technology, such as PLA. Lack of mechanical strength and critical parameters such as thermal/electrical conductivity in the final printed products through the FDM technique is another deficiency in this manufacturing process. The problems mentioned above have gained researchers' attention to explore new composite materials as filament for FDM technology. In this research work, copper-reinforced polylactic acid (PLA) specimens are printed with copper composition variation (25 and 80 wt.%) and various infill patterns including rectilinear, grid, concentric, octagram-spiral, and honeycomb to investigate its mechanical properties. The geometry of test specimens was fabricated according to ASTM standard using a low-cost FDM printer. The mechanical properties consist of tensile properties, flexural properties, and compression properties. The highest ultimate tensile strength (UTS) is obtained by applying 25 wt.% copper composition and concentric infill pattern recording 25.20 MPa. In contrast, the flexural strength revealed the maximum value of 38.53 MPa. The highest compressive strength is obtained by grid infill pattern with 25.94 MPa for 25 wt.% Cu compositions. Response surface methodology (RSM) has been executed to evaluate the influencing parameters, and mathematical models to predict the mechanical properties have been proposed to estimate the properties.

KEYWORDS

Cu-PLA composite; Tensile strength; 3D printing; FDM; Flexural strength; Compressive strength

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