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Preliminary investigation on the tensile properties of FDM printed PLA/copper composite

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A B S T R A C T

Recently, the rapid manufacturing of custom polymer-based composite components has been revolutionized by the Fused deposition modeling (FDM) process. Understanding the fundamental mechanical behaviours of these FDM-printed components is essential for engineering applications. FDM has been highly used inadditive manufacturing (AM) due to its ability to process complex parts with the lowest cost and accurate dimensions. The materials used are thermoplastic polymers, which are in the form of a filament. The aim of this study is to create testing specimens with varying infill percentages (25%, 50%, and 75%) and infill patterns (rectilinear, honeycomb, grid, concentric, and triangle) using the FDM technique on Polylactic acid (PLA) and PLA/Copper. The specimen is printed in accordance with the ASTM standard for tensile testing, which is ASTM D638. Following that, the mechanical properties of copper are assessed using tensile testing. The results demonstrate that the infill pattern for a triangle PLA/Copper specimen and concentric PLA specimen for 75% infill percentage produced the best performance in tensile strength; meanwhile, the grid copper pattern has the weakest properties among all the patterns. This research will be helpful to enhance the mechanical properties of the products in the electronics applications.

1. Introduction

Rapid Prototyping involves quickly manufacturing a product model before the final release. Rapid prototyping is no longer practical because this technology is being used to directly manufacture parts and products [1]. The ASTM International Technical Committee has approved the term Additive Manufacturing for this technology [2]. There are numerous uses for additive manufacturing in the defence, aircraft, medical, and automobile industries compared to the traditional manufacturing method, where the material is removed until the desired part is achieved [3]. AM is made up of a number of low-cost processes with reduced production time and greater adaptability. Many different AM processes, such as SLA, FDM, and LOM, exist. Fusion deposition modeling (FDM) is among the most widely used methods of additive manufacturing [4].

The FDM 3D printer is the most popular method because of its low cost, high reliability, and low waste. Automotive, aerospace, consumer, and biomedical applications are just a few of the industries that use FDM 3D printing. The poor mechanical properties of FDM 3D printed parts limit the range of possible uses for these parts [5]. A large majority of the polymers, such as polycarbonate (PC), Polyamide (PA), ABS, PLA, Polyurethane (PU), and HDPE, were made using FDM [6]. Due to incomplete diffusion during fabrication, the PLA polymer with lower impact strength fabricated using FDM was one of these polymers. The mechanical properties of the base material can be improved by using composite filaments reinforced with metal particles, such as iron, copper, bronze, and stainless-steel particles [7,8]. Until recently, most metal parts' raw materials were prepared as powders. Pure metals can only be used in very specific circumstances, such as in medical devices where high strength-to-weight ratios are required or in high-temperature and high-current electrical and thermal conductivity applications. The high electrical conductivity of copper makes it ineligible for laser sintering processes like SLS, which could easily sinter the excess copper powder [9,10]. Copper has long been used in electrical and heating appliances because of its excellent electrical, thermal, and corrosion resistance properties. Copper's ductility is largely responsible for the above-

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