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Thermo-mechanical properties of ABS/stainless steel composite using FDM

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ABSTRACT

Fused deposition modelling (FDM) process is the most common and traditional additive manufacturing methods for producing complicated three-dimensional (3D) samples from computer-aided design data at a cheaper cost than alternative methods. However, when compared to other common plastic production processes, such as injection moulding, FDM produced parts results in low mechanical properties. Hence, the objective of this study is to produce composite filament using stainless steel (SS) as filler material to enhance the mechanical properties of ABS. ABS is a petroleum based thermoplastic that commonly used in FDM. The production of metal/polymer composites utilising ABS as the matrix and varied SS powder compositions was studied in this work. ABS/SS composite filaments containing 5, 10 wt% SS powder were developed in this experiment to compare with pure ABS for the FDM process. The result shows that the higher the composition of SS powder the lower the ultimate tensile strength and yield strength where 10 wt% SS shows 38.42 MPa in ultimate tensile strength while for yield strength it shows 24.32 MPa. Meanwhile, 10 wt% SS filament has better elongation which is 18.28 % compare to pure ABS that is 9.89 % and 13.3 % for 5 wt% SS. Thus, the percentage of filler plays an important role in determining the properties of ABS.

1. Introduction

Additive Manufacturing (AM) is a manufacturing technique that involves layer-by-layer fabrication of materials to create structures from 3D model data [1]. This manufacturing method is now being employed in a variety of ways, the most popular are 3D printing (3DP) [2], which is FDM [3], stereolithography (SL), and selective laser sintering (SLS) [4]. In its early years, AM, also known as Rapid Prototyping, was primarily utilised to create theoretical and working prototypes (RP) [5] has and will always be the most popular method of AM in polymer, and it is well-known in industries such as automotive and aerospace [6]. These models were most commonly used as interface and testing devices, and the ability to quickly create a large number of physical models from solid models on a computer helped to speed up the production process. The SL was the first AM device to be commercialised, and it used a focused UV lamp beam to solidify a liquid photopolymer by drawing a two-dimensional (2D) surface in the form of a contour and an infill. There are several unique aspects of AM manufacturing [7] that leads to benefits such as requiring no tools to significantly cut manufacturing ramp-up time and cost, the ability to change the model quickly, and the ability to produce cost-effective products [8].

The FDM technology commonly uses thermoplastic polymer filament as the main material. FDM is the most widely used 3D printing method, although the materials that can be used for it are limited to a few polymers [9]. The filament is heated fed into the heated extruder from a spool. FDM uses hot extrusion and layer-by-layer deposition of materials to construct thermoplastic parts. The material that is deposited solidifies instantly, and adjacent tracks of material adhere to the extruded material to form the desired geometry [10].

One of the recent activities to extend materials for FDM process is manufacturing polymer/metal composites and adding powders to thermoplastics such as acrylonitrile butadiene styrene (ABS) [11]. It has the potential to increase electrical and thermal conductivity to improve the efficiency and performance of FDM 3D printer produced parts. Masood et al. [12] developed a composite nylon/iron filament and used in the FDM method to create plastic injection mould incorporating components. The inserts were put through their paces throughout the injection moulding process, and also the desired ABS parts were created.

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