World Conference on Sustainability, Energy and Environment

Paris, France 08 - 10 Apr 2022

The Effect of Process Settings and Materials Properties on Mechanical Properties of 3D Printed Structures

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Abstract.

Recent developments in the areas of 3D/4D printing have forced to rethink the ways of conventional manufacturing procedures by offering simple but effective alternatives for the product design and manufacturing. The fused deposition modelling (FDM) printing technology, which is one of the main additive manufacture technologies, is widely used in many fields with multiple materials. It shows a rapid development over the last decade, and hence FDM printing machines with remarkable advancements are commercially available today for a reasonable price. In this work, the effects of several set parameters on the properties of 3D printed parts and their printing quality were explored. It seems that the fill density significantly affects parts' mechanical properties where the maximum tensile stress and Young's modulus increased linearly with the fill density. Moreover, the shape of the parts can influence the fibre alignment and hence to their structural properties. The mechanical properties of the printed parts and the printing time were also affected significantly with different layer thicknesses. Parts with different fill patterns showed highly varying properties; e.g. samples with linear fill pattern showed the best tensile properties where samples with the "diamond" fill pattern proved to have large deformations during mechanical tests. Furthermore, the effects of different materials (i.e., PLA, ABS, carbon fibre reinforced PLA and ABS) on parts' properties were also observed and the results showed that the parts printed from both carbon reinforced PLA and ABS are better in tensile properties than pure PLA and ABS, while they are also more brittle in nature due to the fibrous structure.

Keywords: Additive Manufacturing, PLA, ABS, Carbon Fibre, Fused Deposition Modelling, Thermoplastic Materials, Mechanical Properties.