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Influence of Layer Thickness on the Tensile Properties of the Samples Manufactured by Fused Deposition Modelling

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Abstract

Nowadays, while fused deposition modelling (FDM) process is one of the most commonly-used additive manufacturing (AM) techniques due to its ability to manufacture very complex geometries, the major research issues have been focused on striking a balance between visual aesthetics and performance of the products manufactured by this method. In this study the effect of layer thickness on the tensile properties of poly lactic acid (PLA) samples were investigated. The results showed that the tensile strength and young modulus of the specimens decreased with the increase in layer thickness. Significant reduction of mechanical properties was obtained for the samples printed with 400µm layer thickness.

Keywords: Additive manufacturing, Fused deposition modeling, Layer thickness, Mechanical properties, Poly lactic acid.

Introduction

Additive manufacturing (AM) technology is an advanced manufacturing technology which is employed for fabricating different articles using a computer aided design (CAD) data file. An article is manufactured by the addition of a material in a layer by layer fashion to create a three-dimensional (3D) object, offering the benefit of producing any complex articles with shorter cycle time and lower cost compared to that of the traditional manufacturing processes. AM technology is widely used in engineering for customized products, functional, pre-surgical and conceptual models. The technology is now finding its applications in many fields of engineering and industry such as manufacturing aircraft, dental restorations, medical implants and automotive products. Among various AM technologies available today, Fused Deposition Modelling (FDM) is one of the most widely employed AM technologies because of its reliability, low cost and simplicity of the process. The mechanical properties of a 3D-printed sample can be influenced by the FDM processing parameters, such as layer thickness, raster angle, build orientations, fill pattern, air gap and model build temperature [1]. Layer thickness which is the thickness of the layer deposited by the nozzle is one of the most important parameters that affects on part quality. In this paper, the influence of layer thickness on the tensile properties of FDM manufactured samples was studied.

Experimental

To investigate the relationship between the layer thickness and the tensile properties of the specimens, the doumble-shaped samples were printed with four layer thickness of 50, 100, 200 and 400µm according to Iso 527A-5A. For printing all of the specimens, Sizan 3D-printing machine with nozzle diameter of 0.4 mm were used. The nozzle was maintained at 200 ºC for the extrusion of PLA filament (Filamaan, Man polymer co., Iran) and the build platform was set on 50 ºC. A universal testing machine (Santam Co., Iran) equipped with 100kf load cell was employed for the tensile experiments. Five samples of each layer thickness were printed and then tested by the machine.

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Results and discussion

Fig. 1 shows the tensile strength values of the specimens printed with different layer thicknesses. As it can be observed, the tensile strength of the samples decreased with the increase in the layer thickness. In addition, there is a slight difference between the tensile strength of the specimens printed with 100µm and 200µm layer thickness [2]. While the layer thickness is low, there is a short distance between the nozzle and the layer which has already been deposited. This is because the nozzle's heat keeps the deposited layer in fluid state, thus, a better fusion is occurred and more stronge bonding formed between the two adjacent. The value of Young modulus for all the samples is shown in Fig. 2. The highest modulus is also obtained for the samples printed with 50µm layer thickness and the value decreases with increasing of the layer thickness. Analysis of the SEM images revealed that the change in modulus may be related to the amount of air gap found in the images [3]. Fig. 3 shows that the amount of air gap has been increased for the specimens manufactured with 200µm layer hickness and beyond.

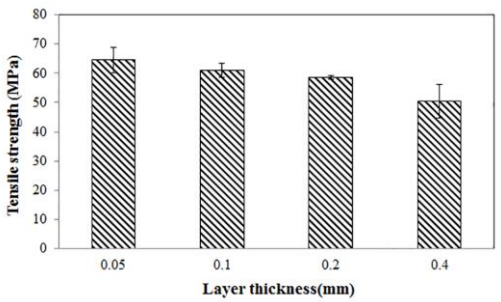

Fig 1. Tensile strength of specimens in different layer-thickness

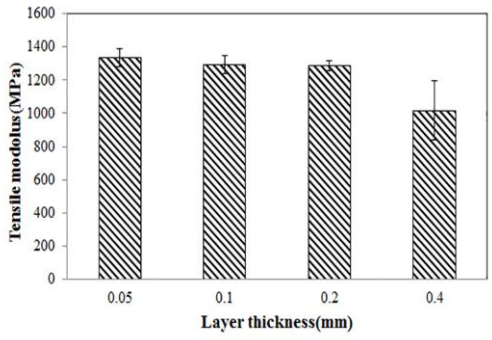

Fig 2. Tensile modulus of specimens in different layer-thickness

Conclusion

The aim of this study was to investigate the effect of layer thickness on the tensile properties of the samples printed by PLA. The tensile experiments confirmed the impact of layer thickness on tensile strength and modulus. The results showed that both of these properties decreased with increasing in the layer thickness.

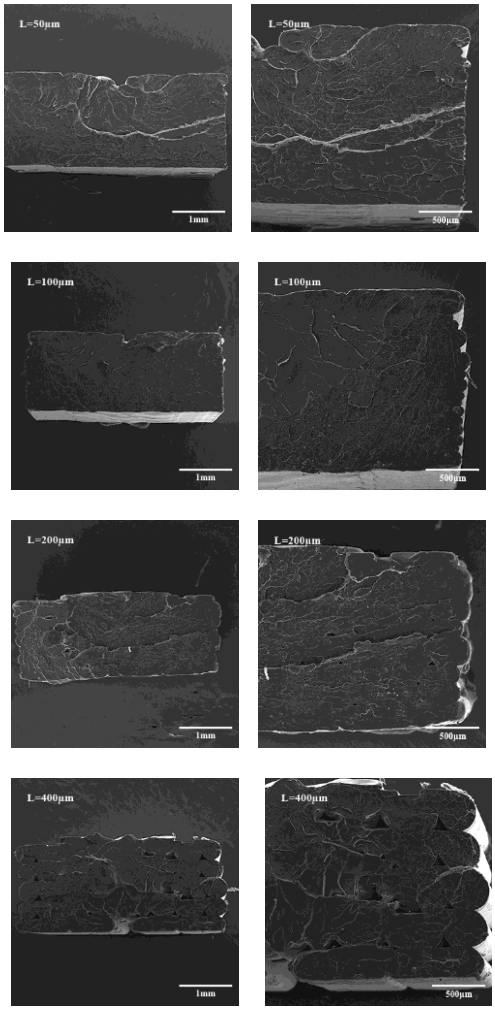

Fig 3. SEM images of specimens in different layer thickness

References

1. Mohamed O. a., Masood S. H., Bhowmik J. L., Adv. Manuf., 3, 1, 42–53, 2015.
2. Onwubolu .C.G, Rayegani. F, Int J Manuf. Eng., 1-13,2014.

3. Shojib H. M., Espalin D., Ramos J., Perez M. , Wicker R., J. Manuf. Sci. Eng., 136, 6, 061002, 2014.