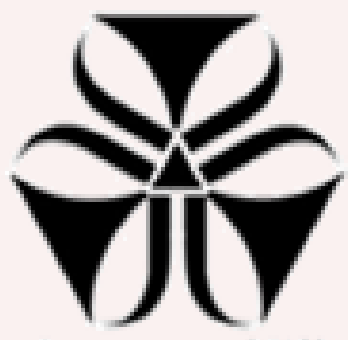




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Influence of additive manufacturing parameters on the tensile performance of 3D printed parts



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Ali Zohrevand¹, Javad Payandehpeyman^{1*}, Hadi Sobhani²

¹ Department of Mechanical Engineering, Hamedan University of Technology,

² Department of Chemical Engineering, Hamedan University of Technology
Hamedan, 65155, Iran

*(Corresponding Author: j.payandeh@hut.ac.ir)

Abstract

In this study, we investigate the effect of additive manufacturing parameters on Mechanical properties of 3D printed parts. The results can be used to optimize the printing parameters with the aim of increasing the performance and quality of the produced parts and improving the Mechanical properties of the produced parts.

Keywords : Additive Manufacturing; 3D Printing parameters ; Mechanical Properties

Introduction

In recent years, products with complex structures have become increasingly in demand, a challenge that has been largely addressed by additive manufacturing methods (AM), especially 3D printing [1, 2]. Among the various 3D printing methods, fused deposition modeling (FDM) is one of the most commonly used methods. Also, in the FDM 3D printing method, one of the most common materials used is polylactic acid (PLA) due to its cost-effectiveness, ease of use, and wide availability [3, 4]. The performance, quality, and final properties of parts produced by 3D printers are strongly influenced by the printer settings. In this study, we will understand the impact of each factor on the quality of printed parts so that we can optimize the mechanical properties.

Materials and method

All parts were produced using the Bambulab X1Carbon device. The nozzle diameter of this device is 0.4 mm and is made of hardened steel. The parts are in accordance with ASTM standards and designed with CAD software. Next, with the X1Carbon 3D printer interface software called Bambu Studio, various manufacturing parameters were applied on parts for manufacturing. According to Table I shown below, the experimental design of this study was carried out using the Taguchi L9 method. After manufacturing the parts according to the test design, tensile tests were performed using a Santam STM-20 machine, and the results were referred to the next stage for review and analysis.

Table 1 Samples

Set	Temperature	Speed	Orientation	Layer Height
Sample 1	T1 (200 °C)	V1 (50 mm/s)	0°	0.1 mm
Sample 2	T1 (200 °C)	V2 (75 mm/s)	90°	0.2 mm
Sample 3	T1 (200 °C)	V3 (100 mm/s)	±45°	0.3 mm
Sample 4	T2 (215 °C)	V2 (75 mm/s)	±45°	0.1 mm
Sample 5	T2 (215 °C)	V3 (100 mm/s)	0°	0.2 mm
Sample 6	T2 (215 °C)	V1 (50 mm/s)	90°	0.3 mm
Sample 7	T3 (230 °C)	V3 (100 mm/s)	90°	0.1 mm
Sample 8	T3 (230 °C)	V1 (50 mm/s)	±45°	0.2 mm
Sample 9	T3 (230 °C)	V2 (75 mm/s)	0°	0.3 mm



Fig. 1 Layer Orientation in the slicer

Results and Discussion

All specimens demonstrate the expected behavior of PLA. Increasing the extrusion temperature from 200°C to 215°C improves layer bonding and ultimate tensile strength, showing that specimens S4 and S5 outperform every specimen printed at 200°C. Specimen S7 printed at 230°C reveals the highest ultimate tensile strength. Moderate printing speeds (50-75 mm/s) demonstrate more stable stress-strain curves, and higher printing speeds (100 mm/s) lead to superior stress-strain curves only when the temperature is raised. Layer orientation has considerable effects on mechanical properties: specimens printed at 90° have higher aligned tensile strength, specimens at ±45° present balanced behavior, and specimens at 0° present lower tensile strength unless compensated for by increased temperatures. Lowering the layer height to 0.1 mm leads to increased mechanical properties due to higher contact between layers. temperature and layer height are associated as the leading parameters influencing tensile properties for each of the tested specimens.

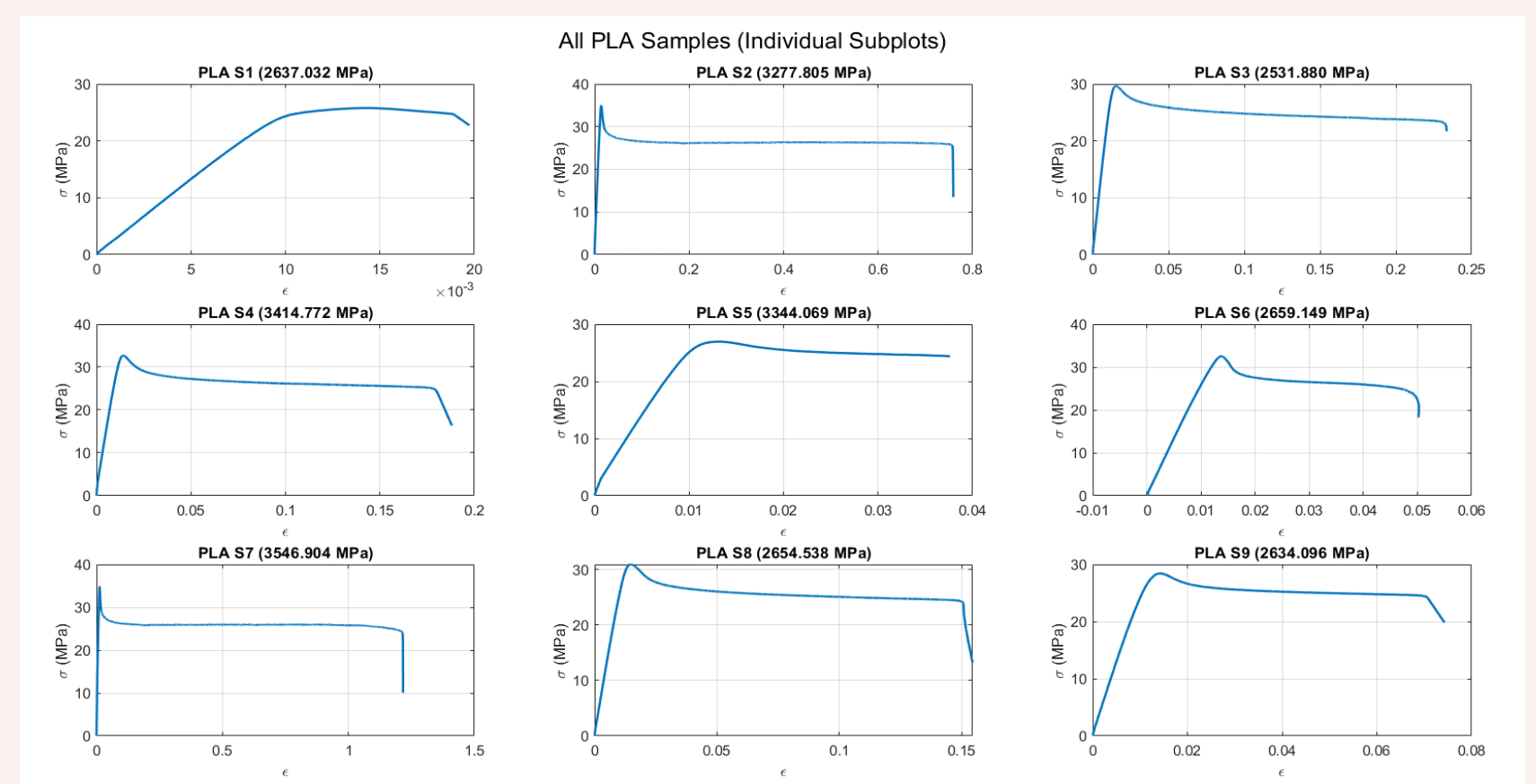


Fig. 2 Tensile stress-strain curves for PLA samples (S1-S9)

Conclusions

Results reveal that Samples S7 and S4 had the highest strength values, and it can be concluded that higher temperatures and lower layer height values are very effective in improving the layer bonding strength and mechanical properties. Even though printing speed and layer orientation affect strength, their relative values are of less consequence in this case. Overall, higher temperatures and lower layer height values are very effective in producing strong PLA prints at moderate printing speeds of 50-75 mm/s.

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Approval