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EXAMINATION OF TENSILE TEST SPECIMENS PRODUCED IN THREE DIMENSIONAL PRINTER

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ABSTRACT

In this study, the effect of different parameters on tensile test specimens produced by joint manufacturing with open source code and equipment using PLA type filament was investigated experimentally. Tensile specimens was designed and manufactured according to ASTM IV type tensile test standards. The test design was based on the L9 orthogonal array of the Taguchi Method and experiments was designed according to this plan. According to the results, Parameters of layer thickness and filling scan range parameters were found to provide significant improvement in the tensile strength increase.

Keywords: Fused Deposition Modeling. Experimental Design. Additive Manufacturing. Layered Manufacturing. Parametric Optimization. Tensile Testing.

1. INTRODUCTION

Recently, the name of the 3-dimensional printers coming up frequently; computerized 3D drawings, 3-dimensional solid objects that make the device [1]. In fact, this technology is not very new. The founder of 3D Systems was invented in 1984 by Chuck Hull (Charles W. Hull), who was born in 1939. When they first emerged, due to their high costs and dimensions, they were used only in industrial and industrial areas [1-3]. Together with the developing technology, these printers started to enter houses. For this reason, technology news among the name comes up frequently. The trend title of the recent years is an important field of study in many lanes of additive manufacturing technologies and applications[2-4]. Became like that. Three-dimensional design of a specific model with the addition of materials can be defined as being manufactured. Industry 4.0, defined as the new industrial revolution it is thought that 3D printers, which are an important component, will bring significant changes in production business models. This technology allows the use of low material, lightness of products and the design of multi-function components it serves. As additive manufacturing technologies progress, new materials can be manufactured. Traditional In order to make design for manufacturing, manufacturing complexities, eliminating difficulties and manufacturing cost by minimizing means to design better products [1-6].

The purpose of this work is to investigate the effects of layer thickness, filling range and filling rate parameters on tensile strength of tensile specimens produced by joint fabrication of open source code and equipment using a Polylactic Acid (PLA) type filament.

2. MATERIAL AND METHOD

In order to reach the correct results in experimental studies, the correct experimental design is required. In this study, Taguchi method was used as experimental design and analysis method. Dr. In this approach developed by Genichi Taguchi, a statistical performance measure known as the S / N ratio is used to analyze the results [7]. In this study, the Taguchi method was used to investigate the effects of three important parameters such as layer height, part placement position, filling ratio on the process (Figure 1). For this purpose, in Table 1 shows experimental parameters and their levels. The experimental setup is shown in Table 2.

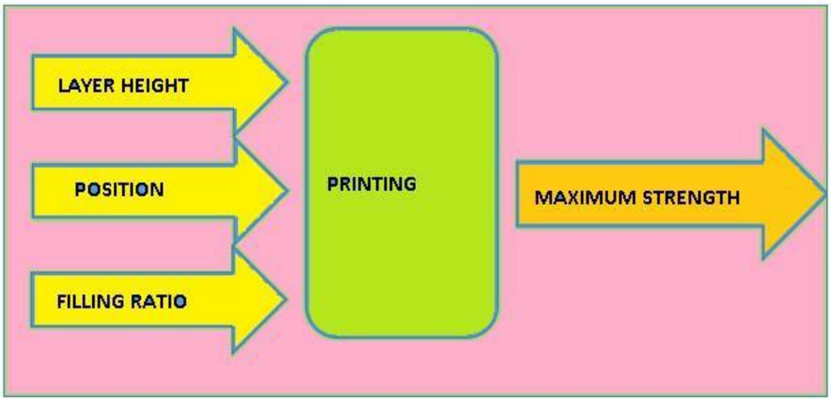

Figure 1. Process input and output parameters.

Table 1. Process parameters and levels.

Parameters	Unit	Level 1	Level 2	Level 3
Layer height	(mm)	0.15	0.25	0.35
Part placement	Orientation	Normal	vertical	horizontal
Filling rate	(%)	10	20	30

Table 2. Taguchi L9 Orthogonal experimental setup.

Exp. No	Layer Height (µm)	Placement Position	Filling Ratio (%)
1	150	Normal	10
2	150	Vertical	20
3	150	Horizontal	30
4	250	Normal	20
5	250	Vertical	30
6	250	Horizontal	10
7	350	Normal	30
8	350	Vertical	10
9	350	Horizontal	20

The height of the layer considered as the height of the layer shown in Figure 2. How to position the part in the heating tray of the three-dimensional printer is defined as shown in Figure 3.

Figure 2. Display of layer height.

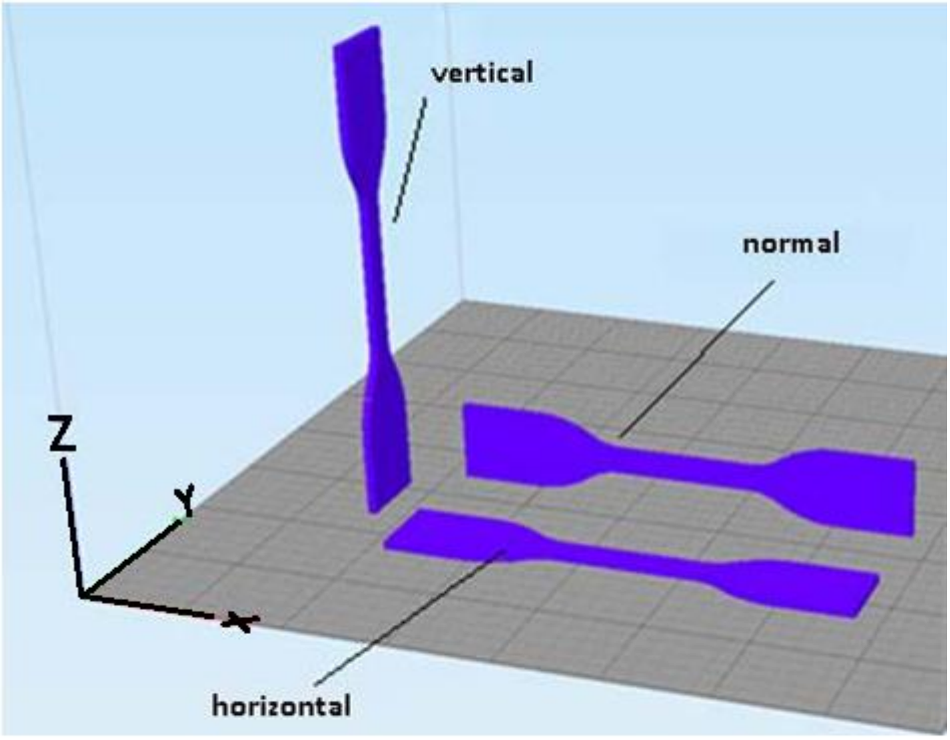

Figure 3. Printing positions of tensile test specimens.

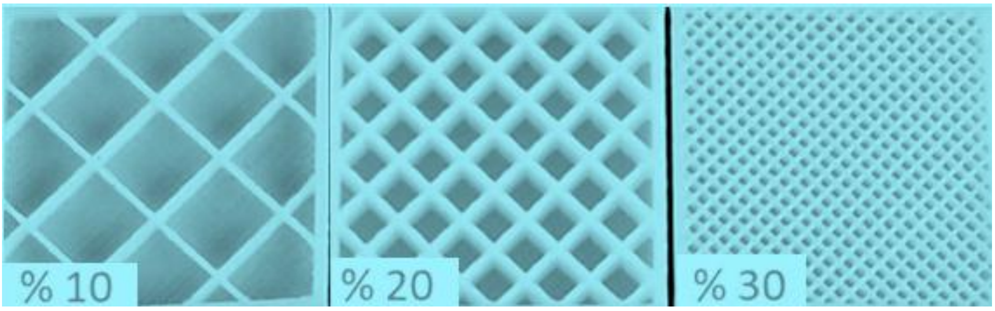

Figure 4. Display of internal filling ratio in parts.

The parts to be produced were modeled using SolidWorks modeling format of STL exantion. The STL file was transferred to the FDM Repiter-host software and the parts were manufactured using PLA filament in a 3D printer named Dream Maker with an open-source 0.4-micron nozzle diameter. The tensile test as shown in Figure 5 was performed using a tensile tester of 20 tons of rectangular sheet bar specimen according to ASTM [8-12].

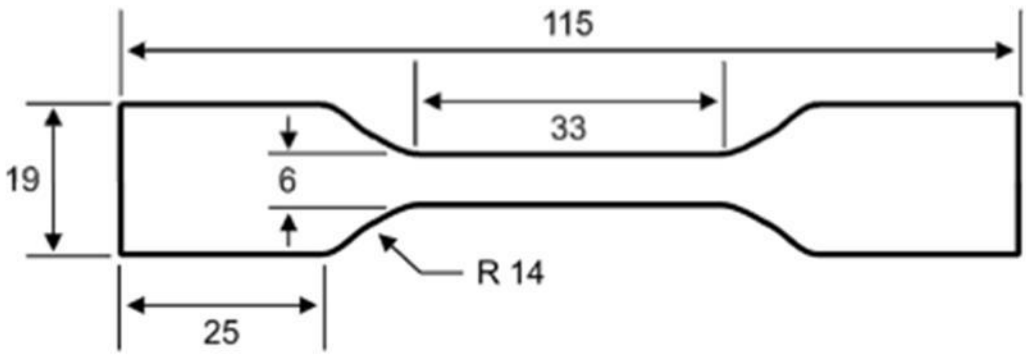

Figure 5. ASTM IV tensile test sample drawing.

3. FINDINGS AND DISCUSSIONS

Figure 6 shows an image of the samples at the end of the tensile test. The graph showing the maximum draw values of the samples prepared according to the Taguchi L9 test scheme is shown in Figure 7. The highest tensile strength values obtained according to tensile values are shown in Table 3. The maximum tensile stress value according to Figure 7 and Table 3 is obtained by printing in the horizontal and normal positions. The horizontal placement was better without looking at the layer height and fillings. It can be said that the spreading of the layers over a wider surface and the formation of a wider connection surface of the plastic melt layers have caused this situation. It was also found that the orientation between the Polylactic acid molecules during the sample placement phase and during the sample preparation phase and during the drawing process increased and interactions between the molecules increased in the course of this orientation. As a result, it can be said that intermolecular interactions increase and that increase in tensile strain occurs. All results were parallel to the literature [11,12].

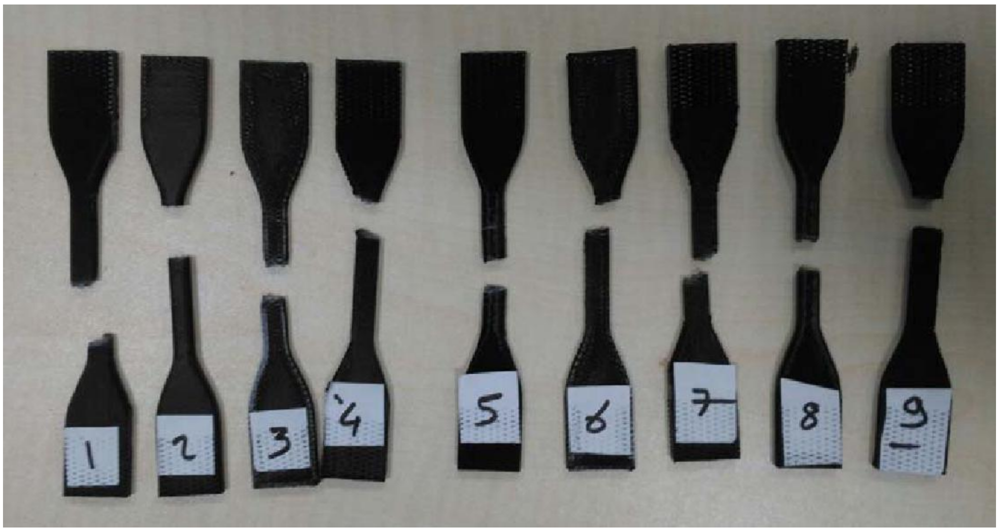

Figure 6. Appearance of test pieces after tensile test.

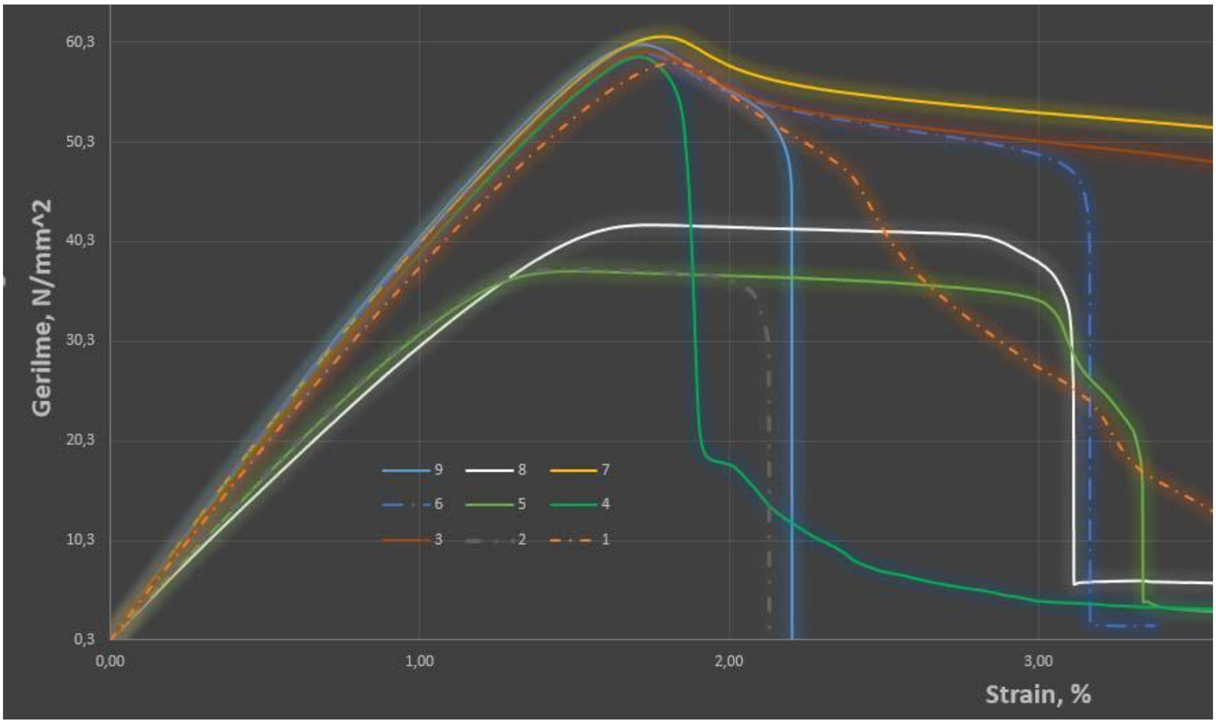

Figure 7. Tensile strain graph of tensile test specimens.

Table 3. Parameter values and corresponding maximum tensile stress values.

No	Layer Height (µm)	Placement	Filling (%)	Max. Tensile Stress (MPa)
1	150	Normal	10	58,25
2	150	Vertical	20	37,56
3	150	Horizontal	30	59,36
4	250	Normal	20	58,84
5	250	Vertical	30	37,35
6	250	Horizontal	10	59,12
7	350	Normal	30	60,87
8	350	Vertical	10	41,98
9	350	Horizontal	20	60,09

3.1 S/N Ratio and Verification Experiment

At the first, the function is converted to the signal - noise ratio. Then, The Taguchi technique uses a loss function to calculate the deviation between the experimental value and the desired value. Taguchi's philosophy includes three general ways of assessing the relationship between quality and variability. They are; nominal-the-best, larger-the-better, and smaller the better. In the present work, larger-the-better is selected for the maximum tensile stress. Figure 8 shows the main effects for maximum tensile strength. Based on the analysis of the S / N ratio, the most suitable process parameters to achieve greater tensile strength were obtained as 350-µm layer thickness, normal print position and 10% fill ratio.

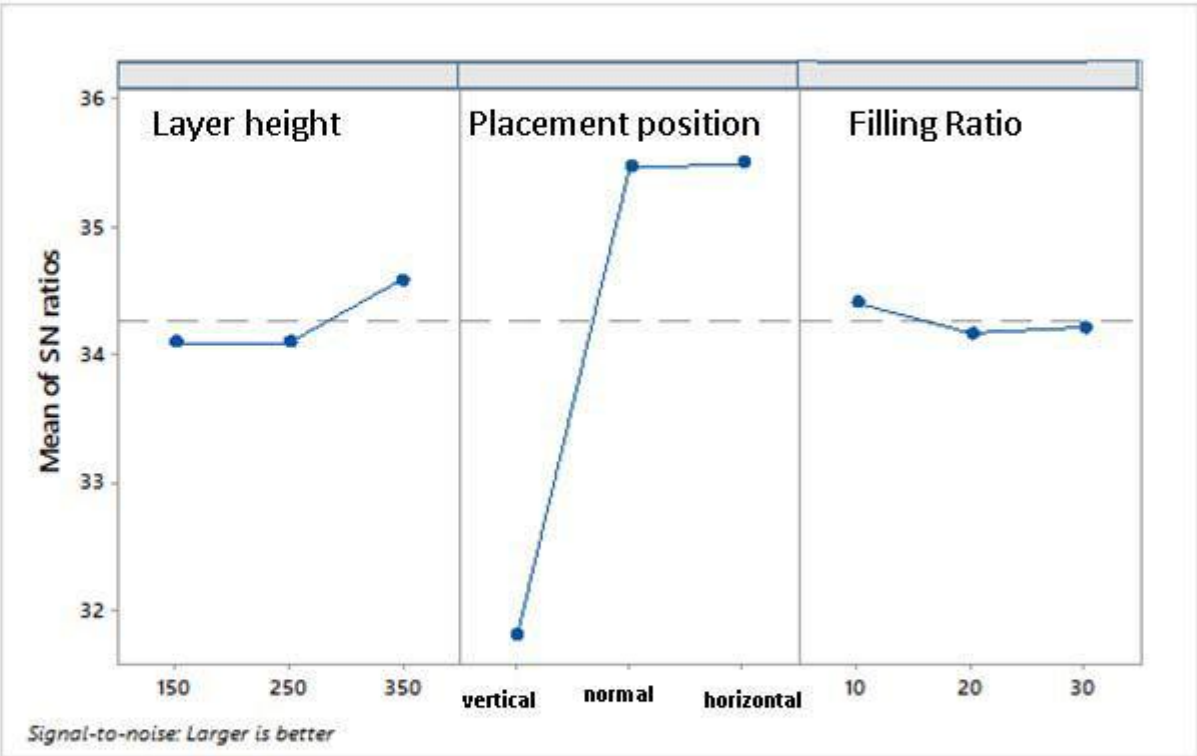

Figure 8. Main effects graph of parameters.

Verification experiments have been performed to confirm the performance of the optimal process parameters. The response properties obtained for each optimum situation are shown in Table 4. After setting the initial parameters of the process parameters and adjusting the parameters to the optimized values, the ultimate tensile strength determined was 61.55 MPa.

Table 4. Verification experiment result and comparison.

Parameters	**Level**	**Estimated Value (MPa)**	**Experimental (MPa)**	**Error (%)**
Layer Height	350 µm			
Placement Position	Normal	61.55	60.58	2
Filling Ratio	% 10			

4. CONCLUSION

In this article, the mechanical properties of the FDM samples generated by the FDM process are analyzed according to the structure. For this reason, the samples were produced with different parameters for g-code production and the mechanical tests performed were pull test. The results show that the mechanical strength properties depend on the specific internal structure of the structure resulting from the construction direction and the tool path production.

As a results of experiments; speciments are mainly effected by respectively placement position, layer height and filling ratio. According to experiments value directly effects by results. Clearly, the best results obtain from horizontal placement of speciments for all cases. This results verify experimental and estimated values. Estimated values obtain for %2 accuracy which is adequate for experiments.

The process parameters are optimized for fused deposition modeling Taguchi's L9 orthogonal array. After setting the initial parameters of the process parameters and adjusting the parameters to the optimized values, the ultimate tensile strength determined was 61.55 MPa. According to the verification experiments, the system can be modeled with a deviation of 2% and the system was found to be highly reliable.

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