International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

THE STRENGTH WITHIN LAYERS: ANALYZING PLA TENSILE STRENGTH IN 3D PRINTING

S.GUNASEKARAN [1], Prof. R. SURENDRAN [2], Dr.N.NANDAKUMAR [3], Dr.S.PERIYASAMY [4]

[1]PG Scholar, Engineering Design, Government College Of Technology, Coimbatore, India.

[2]Assistant Professor, Mechanical Engineering Department, Government College Of Technology, Coimbatore, India.

[3] Professor, Mechanical Engineering Department, Government College Of Technology, Coimbatore, India.

[4]Associate Professor, Mechanical Engineering Department, Government College Of Technology, Coimbatore, India.

ABSTRACT

One of the most popular Additive Manufacturing (AM) techniques is Fused Deposition Modelling (FDM), sometimes referred to as 3D printing. It is based on the extrusion of a thermoplastic filament. Lightweight items can be constructed utilising a variety of infill procedures and ratios thanks to layer wise technology. Furthermore, components with varied properties can be produced by adjusting other factors like temperature, printing speed, or layer thickness. Since Polylactic Acid (PLA) is a biobased and biodegradable plastic, it is one of the least expensive and most environmentally friendly materials for 3D printing. It is commonly used in 3D printing among amateurs and in communities like the Fab lab or the Makers movement.

In order to determine how key 3D printing factors affect the tensile strength of PLA products, Design of Experiment (DOE) is used in this work. In order to accomplish this, a 4x3 factorial plane with one replication was built and utilised to 3D print tensile PLA material samples. The findings of the tensile test demonstrate that for the resistance of PLA products, the layer thickness is more important than the infill. According to the values of these four factors, a regression model is also suggested to enable the user to forecast the final tensile strength of PLA products

Keywords

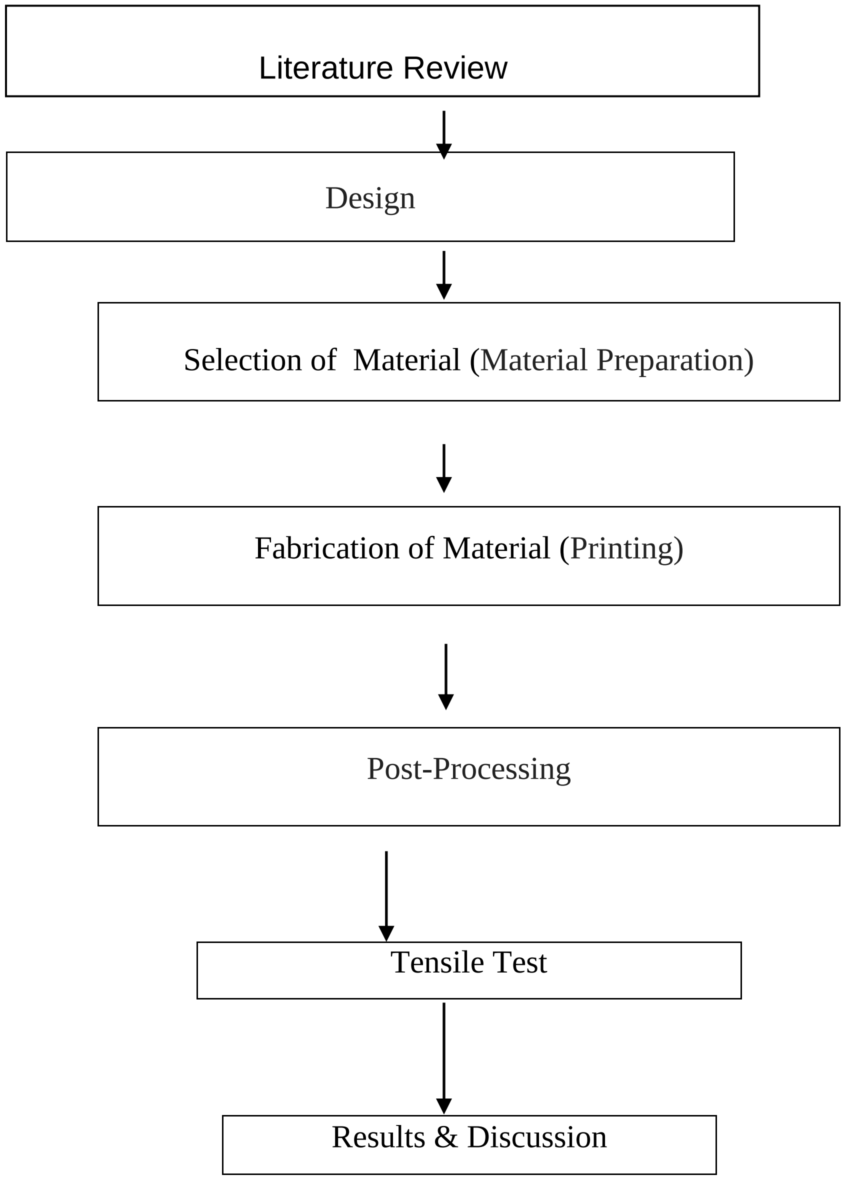
FDM technique, Tensile Strength,3d Printing,

INTRODUCTION:

The rapid advancement of additive manufacturing technologies, particularly 3D printing, has revolutionized various industries, offering unparalleled design flexibility and cost-effective production. Among the wide range of materials used in 3D printing, PolyLactic Acid (PLA) has gained substantial popularity due to its biodegradability, ease of use, and affordability. PLA is widely employed in various applications, including consumer products, medical devices, and prototyping.One critical aspect of 3D printing with PLA is the mechanical performance of the printed objects. The tensile strength of PLA plays a crucial role in determining its structural integrity and suitability for specific applications. Tensile strength refers to the maximum amount of tensile stress a material can withstand before it undergoes plastic deformation or breaks. Achieving optimal tensile strength in 3D printed PLA objects is essential for ensuring their durability and functionality.The tensile strength of PLA-based 3D printed objects can be influenced by several key parameters involved in the printing process. These parameters include layer height, infill density, print speed, extruder temperature, and cooling settings. Understanding how each of these factors impacts the tensile strength of PLA objects is vital for optimizing 3D printing processes and producing high-quality end products.In this research study, we aim to investigate and analyze the effect of various 3D printing parameters on the tensile strength of PLA-based objects. By systematically varying the printing parameters and conducting comprehensive mechanical tests, we seek to identify the optimal combination of settings that maximizes tensile strength while maintaining other desirable properties of PLA, such as dimensional accuracy and surface finish.The outcomes of this research will not only enhance our fundamental understanding of the relationship between 3D printing parameters and PLA tensile strength but also provide valuable insights to manufacturers, engineers, and designers seeking to improve the mechanical performance of their 3D printed PLA components.

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 07 | July - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

METHODOLOGY

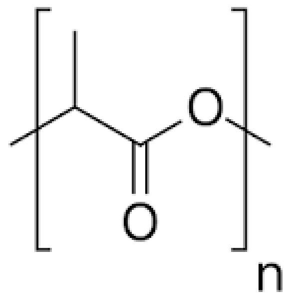


This section discusses the ISO standard for determining the tensile strength of FDM 3D printed materials. The 3D printing process is also discussed, along with the design requirements for the 3D printer and the testing tool used. Both 3D printing materials and printer technology have advanced significantly in recent years. The main components of the first printing supplies were powdered plastic, metal, or porcelain. However, new environmentally friendly printing materials like plastic, nylon, copper, lead, gold, silver, steel, and titanium have been developed as a result of cutting-edge research. They consist of both organic ingredients suitable for use in food, such as chocolate and sugar cups, and polymers. As a result, in some circumstances, distinct materials may be employed based on the intended 3D output.

MATERIALS AND METHOD

Physical properties of PLA

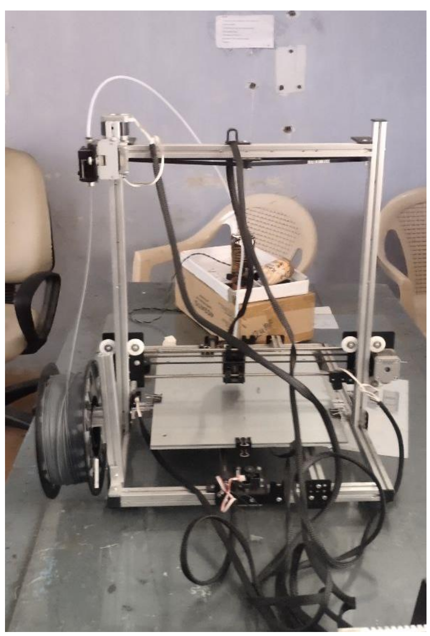
PLA polymers range from amorphous glassy polymer to semi-crystalline and highly crystalline polymer with a glass transition 60–65 °C,
Melting temperature 130-180 °C,
Young's modulus 2.7–16 GPa.



3D PRINTER MACHINE

The lab has created a brand-new open-source 3D printer with four stepper motors and three axes, as seen in Figure 1. The lead screw has been employed for all three axes movement to increase accuracy. The machine can be built up to a maximum size of 190 mm (length), 190 mm (width), and 150 mm (height).

Figure 1



PLA:

(PLA) Polylactic acid A biodegradable thermoplastic known as PLA is made from renewable resources such corn flour, sugarcane, and cassava. Being transparent, it is simple to dye into any color or light tone. Additionally, it has the ability to illuminate at night. It is less flexible and more brittle than ABS. But because it is more robust than ABS, it can occasionally be challenging to process machining for small details in the pieces that must be merged into each other, such as joints.

MATERIALS AND EXPERIMENT

Equipment and printing supplies for 3D printing PLA filament test specimens were examined in this paper. The printing layer's shell thickness varies (Figure 2) from 0.3 mm to 1.2 mm, and the printing speed ranges from 40 to 160 mm/s.So, for our tensile test, pick 4 layer thicknesses: 0.5 mm, 0.6 mm, 0.7 mm, and 0.8 mm.

Figure 2

Table-1. Variable parameters for the experiment.

NO	LAYER THICKNESS MM	SHELL THICKNESS	PRINTING SPEED MM/S
1	0.5	0.3	40
2	0.6	0.6	80
3	0.7	0.9	120
4	0.8	1.2	160

Constant parameters for the experiment are

i. Printing temperature: 200 °C

ii. Bed temperature: 50 °C

iii. Air gap: 0

iv. Raster angle: 45° angle

Advantages

This production process offers a number of advantages as compared with other traditional manufacturing methods, these include flexible design, rapid prototyping, print on demand, strong and lightweight parts, fast design and production, waste reduction, cost effective, ease of access and can be environmentally friendly

Specimen testing

The specimens tensile strengths and failure strains were examined after they had been created using an extensometer and a mechanical testing equipment with a constant displacement speed of 100 mm/min. To investigate the specimens' mechanical performance, more statistical analysis was done. Important details on the failure mode and values for ultimate tensile strength were revealed by the analysis. The experimental findings, including stress-strain graphs, are discussed in the section that follows. The report ends with a conclusion and suggestions for additional research.

RESULTS AND DISCUSSION

ANOVA evaluation It was determined that the variance was constant and normal using analysis of variance (ANOVA). The residual versus fits plot shows the random pattern, and the normal probability plot of residuals is used to determine the normal distribution.

The graph Figure 3 of load (N) versus extension (mm) indicates the maximum force applied to the specimen before the specimen breaks. All seventeen samples were created using a 3D machine. Good tensile strength is provided by layer thickness of 0.8, shell thickness of 0.3, and printing speed of 40 .

Table-2. Experimental results from tensile test.

NO	LAYER THICKNESS MM	SHELL THICKNESS	PRINTING SPEED MM/S	Tensile strength (Mpa)
1	0.5	0.3	40	30.42
2	0.6	0.6	80	35.34
3	0.7	0.9	120	37.55
4	0.8	1.2	160	40.23
5	0.6	0.3	40	36.35
6	0.7	0.6	80	38.68
7	0.8	0.9	120	42.23
8	0.5	1.2	160	31.26
9	0.7	0.3	40	35.23
10	0.8	0.6	80	39.32
11	0.5	0.9	120	32.36
12	0.6	1.2	160	37.86
14	0.8	0.3	40	43.54
15	0.5	0.6	80	34.65
16	0.6	0.9	120	38.65
17	0.7	1.2	160	39.49

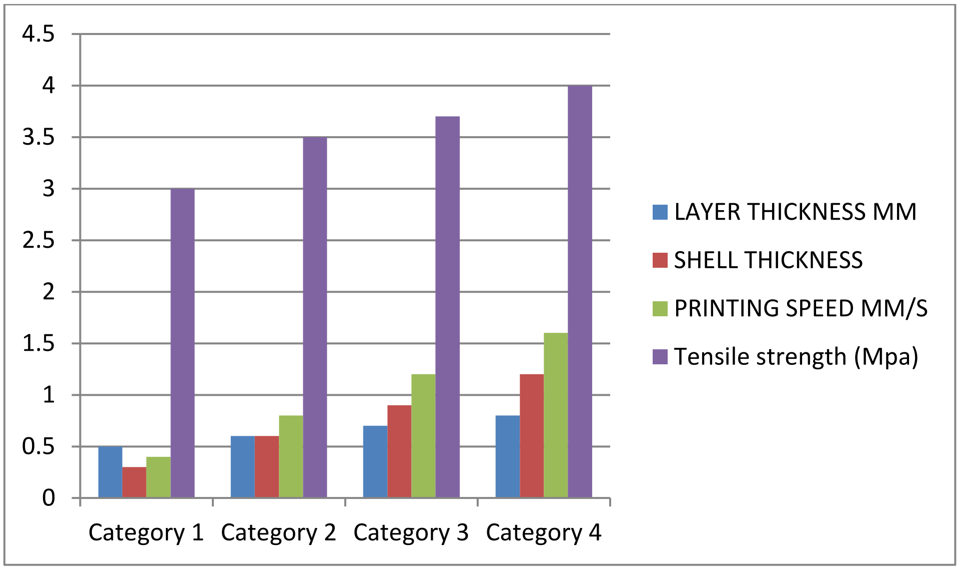


Figure 3 Graph

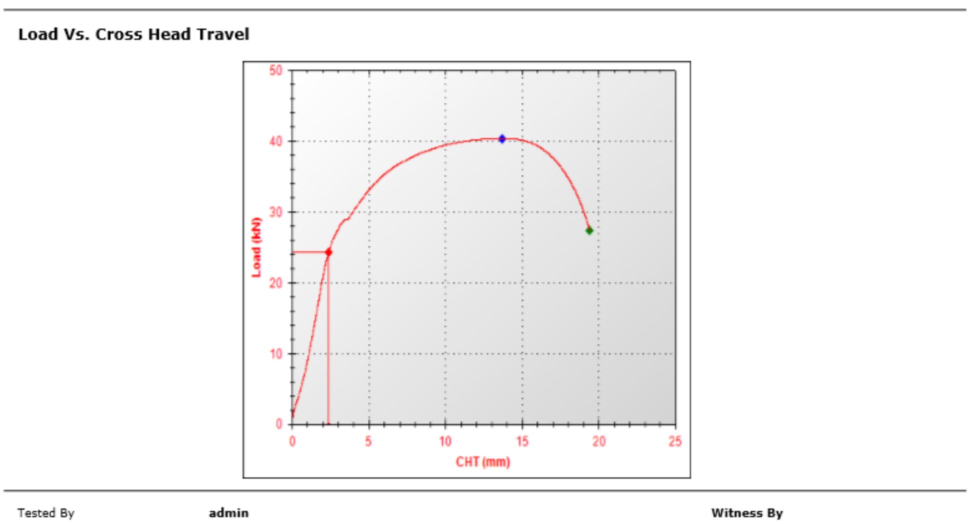


Figure 4

CONCLUSIONS

This study investigated the effects of several FDM process variables on the tensile properties of the specimens. Three process parameters were taken into account: material type, infill pattern, and infill density. The material type had the most influence on the specimens' tensile strength, whereas the infill density had the least. The infill density had the least impact on the specimens' tensile strength whereas the material type had the biggest impact. Future research on 3D printing can be based on the findings of this study. But the scope of this analysis is restricted to three process factors. It is suggested that the number of process factors be increased in later study to obtain a more precise outcome. The results tensile strength of this study can serve as a foundation for 3D printing research in the future. However, only four process elements are covered by this research.

REFERENCES

[1] O. Lužanin, D. Movrin, and M. Plan, "Effect of Layer Thickness, Deposition Angle, and Infill on Maximum Flexural Force in Fdm-Built Specimens," J. Technol. Plast., vol. 39, no. 1, pp. 49–58, 2014.

[2] I. Gibson, D.W. Rosen, B. Stucker, Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing, Springer, New York, 2014.

[3] Parandoush P, Lin D. A Review on Additive Manufacturing of Polymer-Fiber Composites. Composite 427 Structures. 2017;182

[4] Wang X, Jiang M, Zhou Z, Gou J, Hui D. 3D printing of polymer matrix composites: A review and 429 prospective. Composites Part B Engineering. 2016;110:442-58.

[5] K.J. Christiyan, U. Chandrasekhar, K. Venkateswarlu, A study on the influence of process parameters on the mechanical properties of 3D printed ABS composite, IOP Conference Series: Mater. Sci. Eng. 114 (2016) 1-8.

[6] J.M Chacón, M.A. Caminero, E. García-Plaza, P.J. Núñez, Additive manufacturing of PLA structures using fused deposition modelling: Effect of process parameters on mechanical properties and their optimal selection. Mater Des, 124 (2017) 143-157.

[7] C. Ziemian, M. Sharma, S. Ziemian, Anisotropic mechanical properties of ABS parts fabricated by fused deposition modelling. in: M. Gokcek (Ed.), Mechanical engineering, InTech, Rijeka, Croatia, 2012, pp. 159-180.

[8] Mohan N, Senthil P, Vinodh S, Jayanth N. A review on composite materials and process parameters 465 optimisation for the fused deposition modelling process. Virtual & Physical Prototyping. 2017;12(1):47-59.

[9] I. Durgun, R. Ertan, Experimental investigation of FDM process for improvement of mechanical properties and production cost, Rapid Prototyp. J. 20 (2014) 228-235.

[10] W. Wu, P. Geng, G. Li, D. Zhao, H. Zhang, J. Zhao, Influence of layer thickness and raster angle on the mechanical properties of 3D-printed PEEK and a comparative mechanical study between PEEK and ABS. Materials. 8 (2015) 5834-5846.

[11] Abadi HA, Thai HT, Paton-Cole V, Patel VI. Elastic properties of 3D printed fibre-reinforced structures. 488 Composite Structures. 2018;193:8-1