Pertanika Proceedings 1 (5): 115 - 118 (2025)

PERTANIKA JOURNALS

PERTANIKA PROCEEDINGS

Journal homepage: http://www.pertanika.upm.edu.my/

Optimization of Fabrication Parameters in 3D Printing

Sankar I*, Sudharsan S, Siva Shankar M S, Karthikeyan R and Libertin Raja R

Department of Mechanical Engineering, National Engineering College, K.R Nagar, Kovilpatti-628503, India

ABSTRACT

This experimental research aims to optimize the 3D printing fabrication parameters, such as infill density and pattern, to enhance the printing process efficiency and structural integrity. As expected, the optimal combination of the above parameters was identified through standard experimentations to reduce printing time and material requirements without compromising the structural integrity. Static mechanical tests such as tensile, compression, and flexural, were conducted to validate the influence of fabrication process parameters on the printed part properties. All tests were conducted at two different ambient temperature conditions to investigate the role of ambient temperature on structural integrity. In addition, ANOVA analysis was used to identify the optimum parameter combinations.

Keywords: Cost-effective, 3D printing, parameter optimization, PLA

INTRODUCTION

Additive manufacturing (AM), or 3D printing, fabricates solid objects layer by layer with predefined fabrication parameters. The ability to control fabrication parameters opens up possibilities for geometrical freedom. Raja et al. (2022) and Arivendan et al. (2025) optimized 3D printing settings for PLA filament to improve part strength and reduce fabrication time. The optimum settings followed were a 200°C extruder temperature, 50°C bed temperature, 0.18 mm layer height, and 60 mm/s printing speed. The research article was authored by Portoacă et al. (2023), Arivendan, Ramakrishnan, et al. (2024), and Arivendan, Keerthiveettil, et al. (2024) target optimizing additive manufacturing parameters for materials such as ABS and PLA. The study found that the optimal fabrication parameters to reduce friction and wear were 50% infill with 0.1 mm layer

ARTICLE INFO

Article history:
Received: 29 August 2025
Published: 31 October 2025

DOI: https://doi.org/10.47836/pp.1.5.021

E-mail addresses:
isankarmech@gmail.com (Sankar I)
2110047@nec.edu.in (Sudharsan S)
2110023@nec.edu.in (Siva Shankar M S)
2110018@nec.edu.in (Karthikeyan R)
2110024@nec.edu.in (Libertin Raja R)
* Corresponding author

e-ISSN: 3083-9475

© Universiti Putra Malaysia Press

thickness for ABS, and 50% infill with 0.15 mm layer thickness for PLA material. Wu (2018) and Bharathi et al. (2024) researched optimizing additive manufacturing processes with an emphasis on layer height and its impact on fabrication time, material volume, and accuracy of dimensions. It was noted that the lead print value of 0.14 mm was the most optimum as it reduced time without sacrificing quality.

Problem Statement

This study seeks to find the optimal values of infill density and patterns, and their effects alongside other environmental parameters constituting the part strength. The primary objective is to minimize material consumption and fabrication time without compromising the printing quality and strength of the part.

Objectives

- To achieve statuesque mechanical strength: Strength will be maximum attained by adjusting fill patterns, fill densities, and wall thickness to achieve maximum tensile and flexural, and compressive strength.
- To achieve a reduction of raw material: Raw material will benefit by capturing better part strength through enhanced control of process parameters.
- Improving overall efficiency: Overall efficiency of the printing could be attained through controlling layer heights, speeds of the nozzles, and injecting fills into already printed layers.
- Environmental impact analysis: Determining the material performance under different ambient temperature environments.

METHODOLOGY

Fabrication Process

The test specimens were fabricated using the ASTM standards (ASTM International, 2017; 2022), such as compression testing (Figure 1), D790 for flexural (Figure 2), and D638 for tensile (Figure 3) In addition, samples were fabricated with different infill densities, patterns, and layer heights.

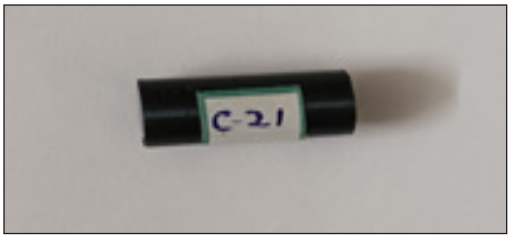

Figure 1. Compression workpiece

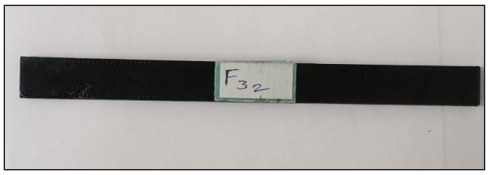

Figure 2. Flexural workpiece



Figure 3. Tensile workpiece

The test specimens were fabricated in three sets with different fabrication parameters: infill density, pattern, and layer height. The fabricated samples were tested to evaluate their static mechanical properties under various ambient temperature conditions.

Mechanical Testing

This study performed static mechanical tests to evaluate tensile, flexural, and compression strengths at various ambient temperatures. Testing the thermal sensitivity of PLA will be done in the next phase on hot and cold condition samples.

Data Analysis

In this work, ANOVA analysis was followed to assess the influences of 3D printing parameters on mechanical properties, material efficiency, and printing efficiency.

RESULTS AND DISCUSSION

The results of the analysis show that an infill density of 10% creates lightweight parts, but with lower tensile and compression strength. On the other hand, 50% infill density renders better strength but results in heavier, slower-to-print, and more material-waste parts, which is inefficient for practical purposes.

CONCLUSION

ANOVA results indicate that 30% infill density offered the ideal blend of strength, material efficiency, and printing speed. It yielded satisfactory levels of tensile, compression, and flexural strength, while print time and weight did not significantly increase. Thus, 30% infill density was determined as the strategic value in achieving material savings without compromising mechanical strength in 3D printing.

ACKNOWLEDGEMENT

The authors sincerely thank NewGen IEDC and the Department of Mechanical Engineering of the National Engineering College for providing the facilities to perform the fabrication and testing during the research work conducted.

REFERENCES

Arivendan, A., Chen, X., Zhang, Y. F., Sumesh, K. R., Gao, W., Siva, I., Kavimani, V., Syamani, F. A., & Thangiah, W. J. J. (2025). The effect of fibre length and content on Aloe vera and ramie fibre-reinforced epoxy hybrid composite properties. *Biomass Conversion and Biorefinery*, *15*(7), 10873-10884.

Arivendan, A., Keerthiveettil Ramakrishnan, S., Chen, X., Zhang, Y. F., Gao, W., Syamani, F. A., Thangiah, W. J. J., Siva, I., & Prabhu, S. B. (2024). Effect of moringa filler powder in *Eichhornia crassipes* fibre-reinforced polymer composites: Advancement in mechanical properties and environmental sustainability. *Polymer Bulletin*, *81*(17), 16121-16135. https://doi.org/10.1007/s00289-024-05469-6

Arivendan, A., Ramakrishnan, S. K., Chen, X., Zhang, Y. F., Gao, W., Syamani, F. A., Thangiah, W. J. J., & Siva, I. (2024). Extraction and characterization of novel *Prosopis Juliflora* bark and *Boehmeria nivea* fibre for use as reinforcement in the hybrid composites with the effect of curing temperature, fibre length and weight percentages. *International Journal of Biological Macromolecules*, *279*, Article 135093. https://doi.org/10.1016/j.ijbiomac.2024.135093

ASTM International. (2022). *Standard test method for tensile properties of plastics (ASTM D638–22)*. ASTM International. https://www.astm.org/d638

ASTM International. (2017). *Standard test methods for flexural properties of unreinforced and reinforced plastics and electrical insulating materials (ASTM D790–17)*. ASTM International. https://www.astm.org/d790

Bharathi, M., Karthikeyan, S., Sankar, I., & Siva, I. (2024). Acoustic properties of PVC core natural fiber sandwich structure. *AIP Conference Proceedings*, *3022*(1), Article 020002. https://doi.org/10.1063/5.0225444

Portoacă, A. I., Ripeanu, R. G., Diniță, A., & Tănase, M. (2023). Optimization of 3D printing parameters for enhanced surface quality and wear resistance. *Polymers*, *15*(16), Article 3419. https://doi.org/10.3390/polym15163419

Raja, S., Agrawal, A. P., P Patil, P., Thimothy, P., Capangpangan, R. Y., Singhal, P., & Wotango, M. T. (2022). Optimization of 3D printing process parameters of polylactic acid filament based on the mechanical test. *International Journal of Chemical Engineering*, *2022*(1), Article 5830869. https://doi.org/10.1155/2022/5830869

Wu, J. (2018). Study on optimization of 3D printing parameters. *IOP Conference Series: Materials Science and Engineering, 392,* Article 062050. https://doi.org/10.1088/1757-899X/392/6/062050