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Performance Analysis and Optimization of Bambu Lab A1 Based 3D Printing System Using Slicing Parameters

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Abstract

3D Printing *is an advanced manufacturing technology widely used for rapid prototyping and product development. This paper presents the performance analysis and optimization of a* ***Bambu Lab A1*** *based 3D printing system. The study focuses on key process parameters such as layer height, printing speed, nozzle temperature, and infill density, which significantly influence print quality and performance. The slicing process is carried out using* ***Bambu Studio****, where detailed evaluation of material usage, filament length, and total printing time is performed.*
Experimental analysis is conducted to study the effect of different parameter combinations on surface finish, dimensional accuracy, and layer adhesion. Graphical analysis of speed vs quality and temperature vs adhesion is also performed to understand the behavior of the system.
The results indicate that optimized parameter selection improves printing efficiency, reduces defects such as warping and stringing, and enhances overall print quality. This study provides practical guidelines for achieving high-quality output in 3D printing systems and highlights the importance of control systems and automation in modern manufacturing.

Key Words: 3D Printing, FDM, Bamboo Lab A1, Bamboo Studio, Slicing Parameters, Additive Manufacturing

1. INTRODUCTION

3D Printing is a modern additive manufacturing technology used to create three-dimensional objects by depositing material layer by layer. It has gained significant importance in industries such as automotive, aerospace, healthcare, and product design due to its ability to produce complex geometries with high precision and minimal material wastage.

Among various 3D printing techniques, **Fused Deposition Modeling (FDM)** is one of the most widely used methods because of its simplicity, low cost, and ease of operation. In this process, thermoplastic filaments are heated and extruded through a nozzle to form layers that combine to produce the final object.

However, the quality of printed parts depends heavily on process parameters such as layer height, printing speed, nozzle temperature, and infill density. Improper selection of these parameters may result in defects such as poor surface finish, weak layer adhesion, warping, and increased material wastage.

Therefore, optimization of these parameters is essential to achieve high-quality output and efficient performance. This study focuses on the performance analysis and optimization of a **Bambu Lab A1** 3D printing system using practical experimentation and slicing analysis.

In this work, slicing is performed using **Bambu Studio**, and the effects of various parameters on print quality, material usage, and printing time are evaluated. Graphical analysis is also carried out to understand the relationship between different parameters such as speed and quality, and temperature and adhesion.

The main objective of this study is to provide practical guidelines for selecting optimal parameters in **3D Printing** systems, thereby improving print quality and reducing defects in real-world applications.

2. LITERATURE SURVEY

Various studies have been conducted in the field of **3D Printing** to improve print quality and process efficiency. Researchers have mainly focused on the optimization of process parameters such as layer height, printing speed, nozzle temperature, and infill density.

Several studies indicate that layer height plays a significant role in determining surface finish. Lower layer height results in better surface quality but increases printing time. Similarly, printing speed affects both production time and quality, where higher speeds reduce printing time but may lead to poor layer adhesion and surface defects.

Temperature control is another critical factor in **Fused Deposition Modeling (FDM)**. Proper nozzle temperature ensures good melting of filament, resulting in strong bonding between layers. However, excessive temperature may cause defects such as stringing and deformation.

Modern slicing software like **Bambu Studio** has introduced advanced features such as automatic support generation, real- time preview, and parameter optimization. These tools help users to detect errors before actual printing and improve overall performance.

Although many studies focus on theoretical analysis, limited work has been done on practical experimentation using low- cost and user-friendly printers such as **Bambu Lab A1**. This study aims to bridge this gap by performing real-time slicing analysis and experimental evaluation.

3. METHODOLOGY

The methodology involves analysis of printing parameters using the **Bamboo Lab A1** 3D printer.

3.1 Machine Used

- Bamboo Lab A1 3D Printer

3.2 Software Used

- Bamboo Studio

3.3 Parameters Considered

- Layer Height
- Print Speed
- Nozzle Temperature
- Infill Density

3.4 Slicing Analysis

The model is sliced using **Bamboo Studio**, which provides detailed information about material usage and printing time.

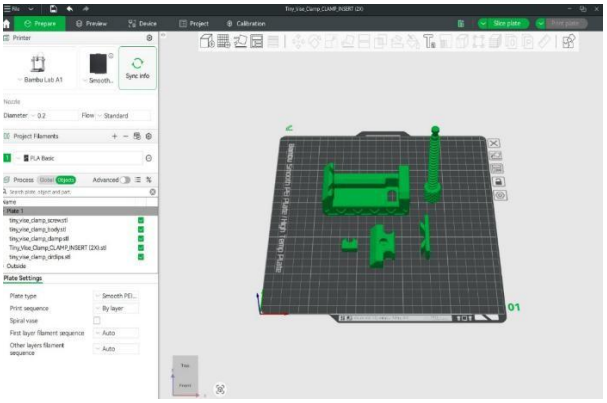

Fig 3.1: **Interface of Bamboo Studio**

The slicing result shows:

- Total material used: **48.20 g**
- Total printing time: **9 hours**
- Filament length: **15.90 m**

This analysis helps in optimizing printing performance before actual printing.

4. RESULTS AND DISCUSSION

The results are analysed based on different parameters.

4.1 Speed vs Quality

Speed	Quality
Low	High
Medium	Best
High	Low

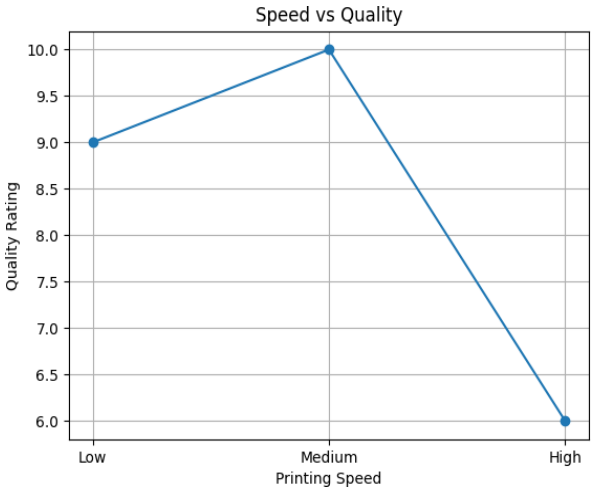

Fig 4.1: Speed vs Quality Relationship in 3D Printing

Explanation

The above graph shows the relationship between printing speed and print quality. It is observed that at low speed, the print quality is high, but the printing time is longer. At medium speed, an optimal balance between quality and time is achieved. However, at high speed, the quality decreases due to improper layer deposition.

4.2 Temperature vs Adhesion

Temperature	Adhesion
Low	Poor
Medium	Good

Explanation

The above graph shows the relationship between nozzle temperature and layer adhesion. It is observed that at low temperature, adhesion between layers is weak. As the temperature increases, adhesion improves due to better melting of filament. At higher temperature, strong bonding is achieved, but excessive temperature may lead to deformation.

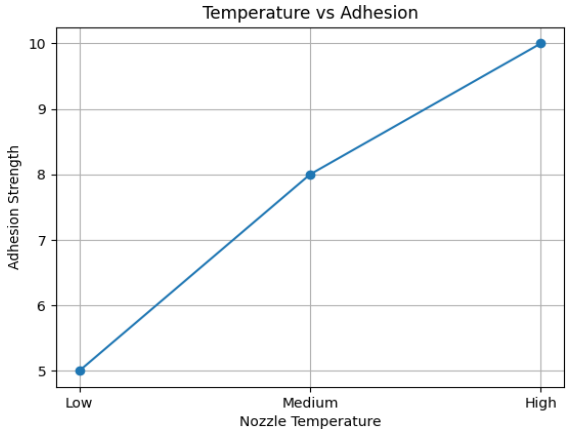

Fig 4.2:Temperature vs Adhesion in 3D Printing

4.3 Observations

- Moderate speed gives best results
- Proper temperature improves bonding
- Higher infill increases strength

The results clearly indicate that optimized parameters improve performance.

4. RESULTS & DISCUSSION

1) Table:

- Speed vs Quality
- Temperature vs Adhesion

2) Graph:

- Speed vs Quality graph
- Infill vs Strength

"The results clearly indicate that moderate printing speed and optimized temperature provide the best balance between quality and efficiency."

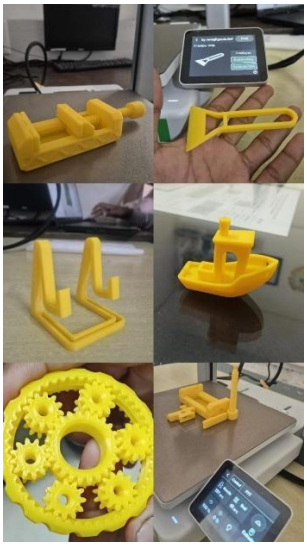

Fig 4.3: Final 3D Printed Model using Bambu Lab A1

The 3D model used in this study is designed considering practical application and printing feasibility in **3D Printing**. The model consists of multiple geometrical features such as flat surfaces, curved edges, and overhanging structures.

The design is created using CAD software and exported in STL format for slicing. The model is selected in such a way that it helps in evaluating various printing parameters like layer adhesion, surface finish, and dimensional accuracy.

The presence of overhangs in the model requires support structures, which are generated automatically using **Bambu Studio**.

5. CONCLUSION

The present study successfully demonstrates the performance analysis and optimization of a **Bambu Lab A1** based **3D Printing** system using slicing parameters.

The experimental results confirm that process parameters such as layer height, printing speed, nozzle temperature, and infill density have a significant impact on print quality, material usage, and printing time. Optimized parameter selection improves surface finish, dimensional accuracy, and layer adhesion while reducing defects such as warping and stringing.

Graphical analysis of speed vs quality and temperature vs adhesion provides a clear understanding of the relationship between different parameters. It is observed that moderate printing speed and optimal temperature provide the best balance between quality and efficiency.

This study highlights the importance of proper parameter selection and control systems in achieving high-quality output. The findings of this research can be useful for students, researchers, and industries working in additive manufacturing.

In future work, advanced techniques such as real-time monitoring, artificial intelligence-based optimization, and multi-material printing can be explored to further improve the efficiency and capabilities of 3D printing systems.

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