EFFECT OF LAYER WEIGHT ON THE FDM PRINTED PLA CUBIC AND CUBIC LATTICE STRUCTURE IN MANUFACTURING TIME AND WEIGHT

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ABSTRACT

In this study, we conducted a comprehensive analysis comparing software-predicted printing times with actual printing times, revealing a substantial disparity between the two. The line graph in Figure 2 (a) visually underscores the significant differences observed. Furthermore, our comparative investigation, focusing on cube and lattice structures with identical dimensions, unveiled intriguing patterns. Specifically, for lattice structures, an increase in layer height led to a linear escalation in the disparities, while cube structures exhibited a consistent linear behavior within a 6-10% range.

In summary, our study provides valuable insights into the discrepancies between software predictions and actual printing times, as well as the nuanced weight dynamics of lattice and cube structures. These findings contribute to the broader understanding of additive manufacturing processes and highlight the efficacy of lattice structures in achieving significant weight reductions without compromising mechanical performance.

1. INTRODUCTION

Fused Deposition Model (FDM) three-dimensional (3D) printing technique is considered as an emerging technology among the Additive Manufacturing (AM) technologies because of their higher accuracy in printing, lower cost in manufacturing, feasibility to print, ability to fabricate complex geometries, and being environmentally friendly [1-3]. With these positive effects, FDM 3D printing has been employing in aerospace, automobile, biomedical, drug delivery, health care (such as diagnostic, excellent treatment plan) [4-6]. The filaments or extrusion materials used in FDM are made of plastic. Generally, plastics are produced from chemical-based products such as petroleum and have serious effects to human health; most of the plastics are non-biodegradable [7]. Thus, the demand to design and fabricate the biodegradable, recyclable, and sustainable filament is crucial. Polylactic Acid (PLA) is suitable in the prospect of sustainability, which is mainly made from starch and collected from natural resources (sugar, potatoes, wheat, corn etc.) [8]. Moreover, PLA exhibits better mechanical properties, biocompatibility, and low immunogenicity and thus suitable for multiple applications including biomedical [9], bone scaffold [10], tissue engineering [11], additive manufacturing or 3D printing [12]. However, there are some drawbacks in PLA filament, such as poor elongation at break, small toughness, less water absorption capability, poor melt strength etc. [8]. Also, the uses of 3D printed PLA materials in main load-bearing structures are still restricted [13].

Lattice is a category of cellular structure, where the solid and void sections designed and fabricated to absorb the energy in accordance with different applications requirements

(large strains rate too) [14]. Lattice structures exhibits significant mechanical properties, and outstanding energy absorption capability; also, lighter in weight and lightweight structures can significantly reduce the fuel consumption in aerospace and automotive industries [15]. Thus, lattice structures are widely used in several industries ranging from aerospace to automobiles, medical and marine [4]. Furthermore, due to their multidisciplinary applications, this lattice cores have gained notable interest among researchers too. A comparative study based on the type of lattice structures (shell, truss, plate) and materials (PLA, ABS), demonstrated that different architectures of lattice cores and materials could exhibit different behavior. The outcomes suggested that truss-based lattice performed moderate mechanical characteristics [16].

Research motivation

- To compare between a cube structure and a lattice structure.
- Get an overview with the manufacturing time and weight reduction.
- Compare between software predicted time and original printing time.
- Effect of layer height on the manufacturing time and weight.

2. MATERIALS, MACHINE, METHOD AND SOFTWARE

The material has been used in this research is a commercial PLA filament with a diameter of 1.75 mm. The material purchased from creality (Shenzhen, P.R. China).
FDM 3D printer- Creality 5
Slicing software- creality slicer
ASTM-D695 (36.00 mm X 36.00 mm X 30.21 mm)
ABAQUS

3. CONSIDERED PARAMETERS

- Layer height, 0.1 mm, 0.15 mm, 0.20 mm, 0.25 mm
- Fixed parameters

Printing speed: 30 mm/s
Printing temperature: 210 degree Celsius
Bed temperature: 60 degree Celsius
Infill density: 100%

4. EXPERIMENTAL SET UP

Experimental set up for lattice structure fabrication.

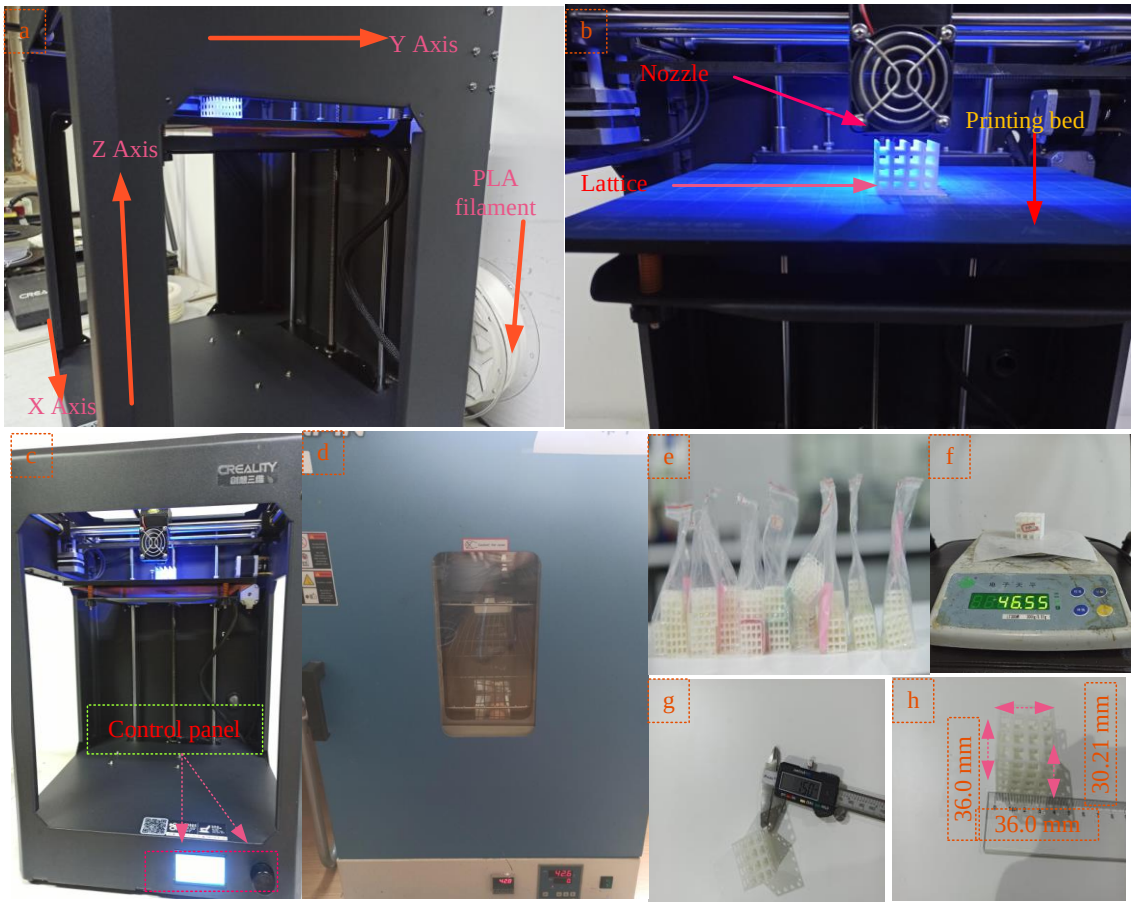


Fig. 1.
Experimental set up

5. RESULTS AND DISCUSSIONS

In this study, we compared the software predicted printing time to actual printing time. As illustrated in the line graph (fig. 2 (a)), there is a huge difference between software predicted time and actual printing time. In addition, the comparative study (between cube and lattice with same dimension) also revealed that, for lattice structure, with the increment of layer height the differences increased linearly. However, for the cube structure the line exhibited a linear behavior (in a range of 6-10%). Furthermore, this study also considered a constant and best strut diameter of the lattice structure (1.5 mm) [17] and make a comparison between the weight of the lattice structure with normal cube structure (with considering same parameters). Because, the main aim of the lattice structure is to reduce the weight, increase the efficiency and mechanical performances [15]. The obtained results found that, for both structure the manufacturing parameters does not have any crucial effect on the weight in figure 2 (b), for instance, 44.5±1.5 gram ,223.85±236.3 gram for lattice

and cube material respectively. Interestingly, this normal lattice cubic structure can be reduced the weight around 131.20% weight in compared to normal cube structure.

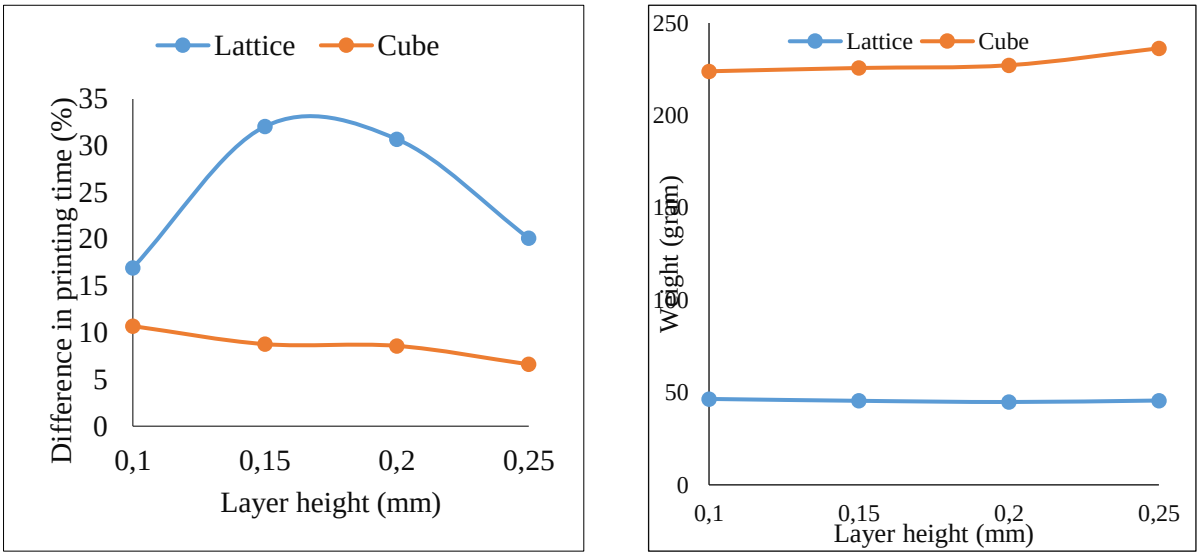


Fig. 2.
(a) Comparison in Actual printing time and software predicted time, (b) difference in the weight of lattice and cube stricture considering layer height

6. CONCLUSIONS

The obtained findings are as following.

- Layer height has a significant role in printing time.
- Software predicted time has huge difference with actual printing time. For cube structure 16-30% and lattice cube 6-10%.
- Lattice structure can be used as an alternative of normal cube structure.
- Using lattice structure can be reduced more than 131% weight.
- Layer height does not have any crucial role in weight reduction.

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