Surface roughness comparison between printed parts manufactured via open source and commercial 3D printing machine

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ABSTRACT – Additive manufacturing (AM) or 3D printing has been growing as a new trend in manufacturing in the era of Industrial Revolution 4.0. However, the cost of owning a commercial and high quality 3D printer is still considerably high and not affordable to everyone. Thus, a low cost 3D printing machine has been developed in house using open source system and later was analyzed for its performance based on surface roughness. Comparison was made between the in-house developed 3D printer to the commercial 3D printer. The experiment shown that the developed 3D printer has better surface roughness printing quality approximately 17.6% superior in comparison to commercial 3D printer.

1. INTRODUCTION

Additive manufacturing (AM), or also known as 3D printing, is a relatively new and emerging manufacturing technology that enables the physical creation of models and prototype parts in almost in any shape through computer aided design (CAD) data [1]. The technology contributes to the reduction of time and cost during product development. 3D printing is growing as a new and popular technologies in the field of design and low volume production [2]. AM can be defined as a layer by layer manufacturing technology which build up 3D components through layer by layer manufacturing [3]. 3D printing has the advantages of capable to manufacture complex part geometries. The process also produces less material wastage with shorter time compared to traditional manufacturing process [4].

Previously, 3D printing is a technology which was costly and only affordable by large-scale manufacturing industry [4]. However, the development of free and open source software (FOSS) have given an alternative way to expensive and proprietary system which greatly reduce research and development cost of 3D printer [5]. Most of the open source 3D printer are applying Fused Deposition Modelling (FDM) technology as it has the advantages of clean, simple-to-use, high processability, low cost and facile manipulation which is suitable for both household and industrial application [6]. Nevertheless, the quality of the printed part from open source 3D printing need to be examined scientifically. Thus, the objective of this research is to develop a low cost 3D machine based on open source technology and compare it to the commercial 3D printing machine.

2. METHODOLOGY

Open source 3D printer as shown in Figure 1 was constructed in house. The design features elements of simplicity, low cost, high stability and great space for modification. The 3D printer uses a simple cartesian system and box typed layout which is powered by low cost Arduino controller. The maximum printable size from the machine is 200mm x 200mm x 200mm. It integrates some normal open source components with hotend, Bowden extrusion, a heated bed, a rigid aluminium extrusion construction and others.

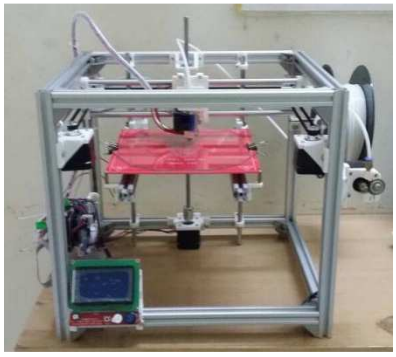


Figure 1: In house developed 3D printer

Ten samples were printed in cubes with the dimensions of 2mm x 2mm x 2mm by using both of the developed 3D printer and the commercial 3D printer model CreatorPro from FlashForge. The samples were printed using thermoplastic acrylonitrile butadiene styrene (ABS) material. The printing was made based on the standard parameter setting as tabulated in the Table 1.

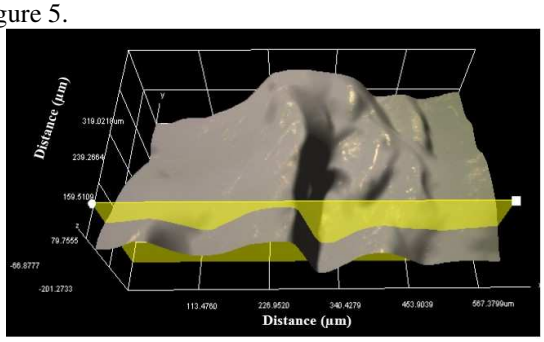
Table 1: Parameter setting for 3D printing

Speed, mm/s	30
Layer thickness, mm	0.2
Fill angle,°	45
Infill pattern	Linear
Infill density, %	20
Nozzle diameter	0.4mm

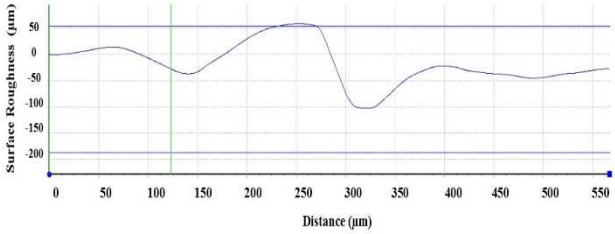
The surface roughness of the samples are measured by using MSI model GR3400 3D non-contact profilometer and average values are recorded.

3. RESULTS AND DISCUSSION

The results of surface roughness profile for the cubes printed by developed 3D printer and commercial 3D printer are shown in Figure 3 and Figure 4 respectively. The results are compared and presented in Figure 5.

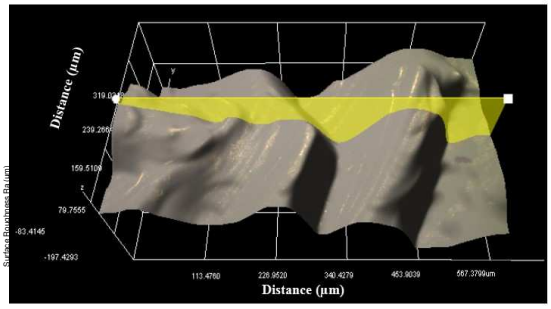


(a) 3D profile

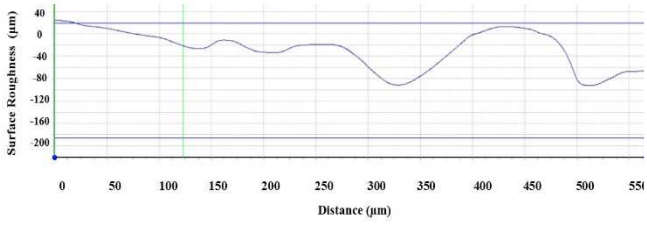


(b) Surface roughness

Figure 3: Surface profile of part fabricated using open source 3D printer



(a) 3D profile



(b) Surface roughness

Figure 4: Surface profile of part fabricated using commercial 3D printer

Based on the analysis made, the results show that the surface roughness of the cubes printed by developed 3D printer is 17.6% superior than the cubes printed by commercial 3D printer. These might be contributed by the factor such as more stable frame, lighter material extruder, and better calibration. The developed 3D printer is better than the commercial 3D printer in term of surface roughness and lower in term of the cost. The developed 3D printer is cost approximately RM1000 while the commercial 3D printer is cost more than RM6000.

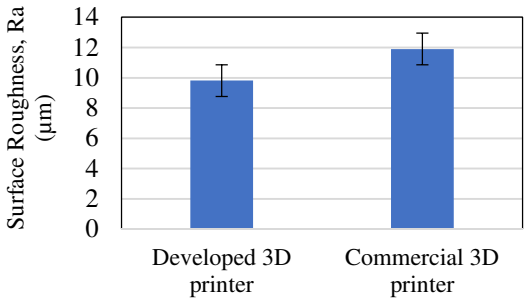


Figure 5: Surface roughness comparison between in-house developed 3D printer and commercial 3D printer

4. CONCLUSIONS

The surface roughness of open source 3D printer is better and is a good alternative for commercial 3D printer that end user might consider in fabricating 3D printed components.

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