

## IMPACT OF SLICING SOFTWARE ON GEOMETRIC CORRECTNESS FOR FDM ADDITIVE MANUFACTURING

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**Abstract.** The significance of additive manufacturing is progressively increasing in proportion to overall production processes. This study compares the various slicing software tools for 3D printers that are available using various setups under specific parameters. Describe the merits and downsides of FDM technology slicing software and compare its different versions in this section. The geometric and dimensional variances of the samples printed using Cura, PrusaSlicer, ideamaker, and octaprint were compared.

**Keywords:** *Slicing software, additive manufacturing, FDM, dimensional accuracy*

### 1. INTRODUCTION

It was in the early part of the twentieth century that the concept of additive manufacturing was originally proposed. It is relatively new when compared to other industrial methods, yet in that short period of time, it has grown quickly. As stated in the ISO/ASTM 52900:2015 standard, additive manufacturing is the technique of using 3D model data to make an actual object by layering and combining material, typically in thin layers. Conventional methods typically remove material during the production process; this notion of adding material is the contrary. The phrase "additive manufacturing" is frequently substituted with "3D printing," despite the fact that the two terms have different meanings and are defined differently by the aforementioned standard ISO / ASTM 52900: 2015[1]. All things considered, additive manufacturing is a more widespread use of 3D printing in the industrial sector. The market for these technologies has had a phenomenal rise due to the growing uses of additive manufacturing and the declining cost of making it[2][3]. These days, it is becoming more and more potential for use in a variety of contexts due to the development of new software and technology solutions for its improvement. Numerous industries make use of it. The automotive, aerospace, aviation, general engineering, biomedical, architectural, fluid technology, and, lastly, Rapid Prototyping the process of designing and printing models and prototypes in the product development process are its primary areas of application[4]. High geometric or dimensional precision and surface quality of printed items are the focus in these areas. Multiple conversions impact the quality of the printed item. Setting up printing correctly to meet requirements requires first understanding the influence of various factors and their interplay. While there are many other kinds of 3D printing technologies, fused deposition modeling (FDM) technology is one of the most popular and reasonably priced[5].

#### 1.1 Technologies for 3D Printing

A product is produced in additive manufacturing by adding layers rather than removing materials, as in traditional machining.

Additive manufacturing technology can be classified into seven broad types. Binder jetting, directed energy deposition, material jetting, material extrusion, powder bed fusion, sheet lamination, and vat photopolymerization are the categories. FDM is utilized in a variety of fields, including building, model making, commodity manufacturing, medical, electrical, and engineering fields, and others[6].

### 1.2 Fused Deposition Modeling (FDM)

Fused deposition modeling (FDM) was created in the 1980s for 3D printing. Solid-material 3D printing is FDM. The thermoplastic material is used in this manner as an external continuous filament. The filament is heated at the printer's extruder head and pushed through a large spool to melt it at the nozzle; then, it is extruded layer by layer to create the item. After that, the material layers are fused together in a pattern to create the thing. One horizontal plane or layer at a time is usually where the principal deposition occurs. The print head then slightly moves vertically to start a fresh layer[7]. Many different thermoplastic materials can be used with FDM. A 3D product with layers arranged horizontally is the end outcome. With the diffusion welding mechanism, bonds are formed with neighbouring fibres. Extrusion is a typically inexpensive and fast procedure for the material as shown in fig.1

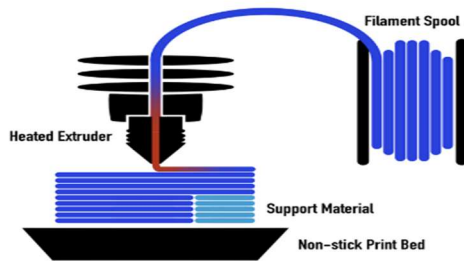


Figure 1. FDM

Fused Deposition Modeling (FDM) is a popular 3D printing method for plastic components. Feeding a thermoplastic filament into the 3D printer; the filament is heated to its melting temperature through a heated nozzle and then extruded onto the build platform, tracing the part dimensions specified in the STL file. After completing the first full layer, the print head advances one layer height and begins tracing the subsequent layer. Layer after layer, this keeps on until the part is finished[8].

Figure 2 illustrates the processes of FDM, from creating CAD models to cleaning parts.



Figure 2. Steps involved in FDM

## 2. SLICING SOFTWARE

Software is widely accessible, and new versions are constantly being released. The most widely used and convenient ones were selected for comparison[9].

### 2.1 Cura

It was created in 2014 by David Braam. He later joined Ultimaker, a company that makes 3D printers and Cura-compatible software. Although free, this program is open-source. Cura works with Ultimaker and other printers. Choose from 15 languages. Cura's simple UI offers suggested and personalized modes. The suggested solution is suitable for beginners because it requires no manual settings adjustment. Custom settings offer almost 400 choices. For Solid Works, Siemens NX, Autodesk Inventor, and others, it supports CAD plugins. Cura is still in development since Ultimaker often adds functionality. Ultimaker Cura Enterprise, for experts, was released lately. It provides enhanced security, technical support, and Ultimaker Marketplace licenced add-ons for \$300 annually.

Acceptable file formats	3MF, AMF, DAE, STL, PLY, OBJ, X3D, GLB, GLTF, BMP, GIF, JPEG, PNG
operating systems that work together	Windows, Mac and Linux
Adequate for	Beginners, intermediate and advanced.
cost	Free.

### 2.2 Prusa Slicer

The program was inspired by Alessandro Ranellucci's Slic3r. They split in 2016 and released Slic3r PE (Prusa Edition) on GitHub. As Prusa diverged from the original, it became Slic3r PE in May 2019. Since then, PrusaSlicer has been upgraded and enhanced. This fully open-source application is free. Other brands of printers can also use it. When you open the program, the PrusaSlicer configuration wizard lets you choose a printer and materials. The home screen will display and keep the finalized settings. A well-made, easy-to-use slicer is the Prusa Slicer. Keyboard navigation is available for most on-screen tools. Prusa Slicer's main interface categorizes similar variables to simplify profile building and management. Thus, fiber profiles can be changed without printer settings. Prusa Slicer's 3MF file format saves your objects, settings, modifiers, and parameters in one file. The profile used in earlier projects is easy to identify.

Acceptable file formats	3MF, STL, OBJ and AMF
operating systems that work together	Windows, Mac and Linux.
Adequate for	Beginners, intermediate and advanced.
cost	Free.

### 2.3 Slic3r

In 2011, the RepRap community created Slic3r. It was primarily created by Alessandro Ranellucci, while several individuals improved it over time. Since introduction, the official website has 48

Slic3r versions. The nonprofit project Slic3r is run by a group of contributors on Github, where they debate and experiment with new concepts. Most 3D printing software capabilities were planned, assessed, and implemented using Slic3r. Open source and free software is available. After the first launch, a window will open for you to calibrate and correctly configure the 3D printer. The graphics of the user interface are not as good as those of rival products. However, the fact that the menus have descriptions enhances the user interface. They answer fast and explain how the selected setting works. Using the software through the command line is a comprehensive approach. One of the most important aspects is the fast FDM G-code generation.

Acceptable file formats	STL, OBJ, AMF, 3MF.
operating systems that work together	Windows, Mac and Linux.
Adequate for	Intermediate and advanced.
cost	Free

#### 2.4 Tinkerine Suite

The Canadian firm Tinkerine makes educational 3D printers. Free Tinkerin Suite software is also available at Tinkerine. The interface and use of this software are easy. This allows kids to learn 3D printing. The software offers print parameters and instructions on how altering settings impacts printing. Features include 3D visualization, basic model modification, multi-model printing, support structure, and more. Generally, the main goal of this program is education [2].

Acceptable file formats	STL, OBJ
operating systems that work together	Windows and Mac.
Adequate for	Beginners and intermediates.
cost	Free.

#### 2.5 Octoprint

This software platform offers simple and effective remote monitoring of printing in progress. Monitor via a web browser or the Raspberry Pi app on a smartphone. STL files can be loaded into the 3D printer without an SD card because it's cloud-based. Progress, temperature, and expected printing time can be monitored remotely. Installing a webcam allows you to record videos or immediately check for printing problems. It integrates CuraEngine-based software with the key functionalities and the other software.

Acceptable file formats	STL.
operating systems that work together	Raspberry Pi, Windows, Mac and Linux.
Adequate for	Intermediate and advanced

cost	Free.
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**2.6 idea Maker**

The program was created by Raise3D. Raise3D develops FFF 3D printers and explores 3D printing. For 3D printers with two extruders, it had advanced settings. It works with Raise3D printers, idea Maker, and Raise Cloud. A web-based 3D printing platform with a mobile app, Raise Cloud lets users remotely manage, monitor, and track print operations. Simple texture development, automatic optimization parameters, a tool for optimizing specific areas, integrated basic operations for cutting, dividing, and combining models, and more are significant features.

Acceptable file formats	STL, OBJ, 3MF, OLTP.
operating systems that work together	Windows, Mac and Ubuntu.
Adequate for	Beginners and intermediates.
cost	free

**3. METHODOLOGY**

This section describes the 3D printing technique used in this project. This project aims to investigate experimentally how slicing software affects the geometric accuracy and print quality of PLA specimens manufactured using FDM 3D printing. Table 1 displays technical specifications for the Ender-3 open-source low-cost 3D printer utilized in this study for manufacturing specimens.

One of the most widely used FDM 3D printers, Ender-3 is utilized by both industries and private users to print parts in various polymers. Measured with a vernier caliper, the dimensions of the 3D printed specimen are found to be within ±0.1 mm accuracy, in compliance with the machine precision standard.

*Table 1.*Ender-3 Low-cost 3D Printer Specifications

Machine parameters	Value	Ender -3
Printing Speed	≤ 180 mm/s	
Printing Precision	± 0.1 mm	
Nozzle Diameter	0.4 mm	
Bed Temperature	≤ 100 °C	
Nozzle Temperature	≤ 270 °C	
Machine Weight	6.62 Kg	
Machine Size	440 x 440 x 465 mm	
Power Supply	Input AC 115V/230V Output DC 24V 270W	

**3.1 Deviations and tolerances in geometry**

To illustrate how one component of an object relates to another, geometric tolerances are employed. Finding the maximum allowable deviation of the actual manufactured product from the specified dimension is the goal of geometric tolerance. Production drawings specify individual tolerances, which are represented using a system of characters designed for this purpose. Geometric tolerances are prescribed depending on the functioning of the item, as the size and type of the geometric tolerance have a significant impact on the economic difficulty, manufacturing technique, technology, and machine selection. The standard ISO 1101:2017 defines and characterizes geometric tolerances. Tolerances of shape, orientation, position, and run-out are included in the geometrical product specifications (GPS) and geometrical tolerance.

In order to represent the true size or dimension, tolerances are defined. An increase in the cost of labour and manufacturing facilities is necessary to produce components with less dimensional variation or with greater accuracy. Actually, accuracy is engineered selectively depending on how the final product will be used. When producing components, then, various geometric dimensions need to be taken into account in addition to the actual size. Such differences ought to be covered by the tolerances that are stated. The total amount that a manufactured part's dimension might vary is known as geometric tolerance. A feature's shape is more significant than its size, as highlighted by geometric tolerance. Using common symbols, parts can be defined according to their functions through the use of geometric dimensioning and tolerance.

#### 4. COMPARISON OF THE CHOSEN SOFTWARE'S QUALITY

This section will examine the quality of 3D models generated using FDM printers using various software programs. CAD model with dimensions of length 5CM, width 3 CM and Height 2.5 CM as shown in figure 1. We selected Cura, PrusaSlicer, ideamaker, and octaprint as slicing software as shown in figure 2. Finally printed the model on Ender-3 printer as shown in figure 3, for dimensional accuracy comparison.

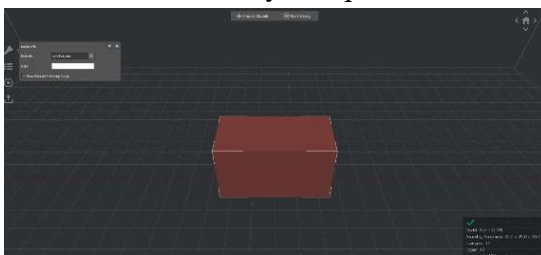


Figure 1. CAD Model of Speciman

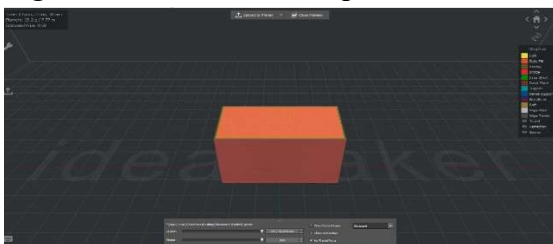


Figure 2. Slicing done by idea maker



Figure 3. FDM 3D Printed Speciman

We examine the accuracy of each piece of software as well as how the height of the layer affects the accuracy of the measured values from Table 2. We then ranked the software, placing it first for the best and fourth for the worst, in the table. The software's biggest deviations were recalculated based on the measured values, and the resulting values were assigned to the accuracy categories of the individual averages.

Table 2 Model in order to compare the print accuracy

Slicing Software	precision of dimension with layer of 0.15mm
Prusa	1
ideamaker	2
octaprint	2
Cura	3

## 5. CONCLUSION

It is clear that the Prusa Slicer software was the most successful after analysing the results of the comparison tests and ranking the other slicing software. When measured against other programs, it is the one that came out on top. Followed by ideamaker and octaprint. Finally, the Cura software was ranked last.

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