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## AN INVESTIGATION INTO THE SURFACE ROUGHNESS (RA) OF 3D-PRINTED COMPONENTS FABRICATED THROUGH BOTH DLP AND FDM TECHNIQUES.

**Gaurish Mahabaleshwar Samant**

Asst Professor, Mechanical Engineering Department, Don Bosco College of Engineering, Fatorda Margao Goa.

**Sudip Faldesai**

Project Officer, Goa State Innovation Council, Goa.

**Suraj R Marathe**

Associate Professor, Mechanical Engineering Department, Don Bosco College of Engineering, Fatorda Margao Goa.

### Abstract

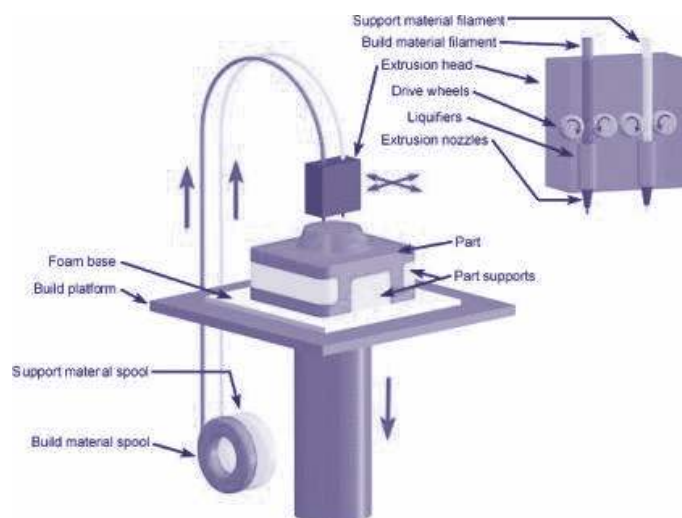
The developed world has quickly adopted the cutting-edge technology known as 3D printing, which has great promise for application in a wide range of human undertakings. This study examines the characteristics of creating three-dimensional products using FDM and DLP, two of the best three dimensional printing methods. These methods enable the production of samples using consumable material poly-lactic acid biopolymer (PLA) and enable the study of their geometry, and mechanical properties.

**Key words:** FDM machine, DLP machine, thermoplastic polymers, photopolymers, Bio Polymer, PLA.

### INTRODUCTION

The market for 3 dimensional Printing is currently expanding quickly and adding new models of innovative production machinery, the potential uses for which are virtually limitless when making goods made of various materials, including polymer ones. The list of accomplishments

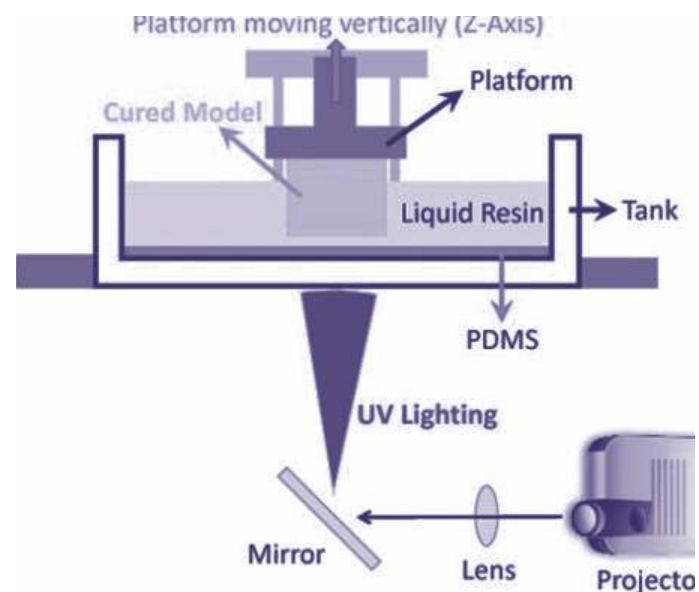
**Figure 1. Diagram illustrating the schematic of an FDM 3D printer [11]**



made possible by additive manufacturing is significantly longer than this one: printed apparel, printed medical implants, printed apartment buildings. Bodies and printed automobile bodies.

The most intriguing aspect of printing is that it can use different materials like polymers, sand, composite powders, metals, ceramics, engineering polymer, and others, even food items and biomedical materials [2-6]. One of the famous process of 3 dimensional printing by using plastic of different varieties because of its usefulness and availability. There are a many 3D plastic printing techniques that vary in terms of consumable materials used and its application principles, but due to its accessibility, (DLP) and (FDM) are the most widely used for industrial application and prototyping. The Aspects of the product forming process and the efficient quality of the finished products are determined in the paper using both technologies.

**Figure 3. DLP 3D printing [17]**



## MATERIALS AND METHODOLOGY

The quick development of current industrial development necessitates the selection of production processes that can be put into place with the fewest resources and with the highest return on investment. Additive technologies now meet these needs, which are the mostly intriguing and exciting areas of industrial production and are being used more and more in all facets. [7-9]. Generally, additive refers to a set of technologies that enable the gradual addition of three-dimensional objects based on CAD (Computer-Aided Design) models. This is in disparity to more conventional methods of part creation. The resulting digital layout, known as a CAD model, must be formed utilizing using a 3D printer. The computer-aided design method, a 3D CAD model can be constructed on one's own utilizing the

information gathered by a 3D scanner. The important thing to remember is that 3D printing drastically cuts the total time it takes to progress from an idea or drawing to a final product. It also uses a lesser amount of time, materials, and energy throughout manufacturing. As a result, three dimensional printing allows engineers to utilize a computer and printer to create fully functioning things directly from their design without the need for further technological procedures. This work chooses the settings for digital LED projection (DLP) and (FDM) 3D printing modes. This study has taken into consideration two types of resin: thermoplastic biopolymer Poly lactic acid (PLA) as an example of a solid-state filament with a 1.75 mm diameter for FDM process, and photopolymers UV resin based on polylactide and UV-hardeners for DLP three dimensional prints (Table 1).

**Table 1 Three dimensional printing parameters**

Sample №	Materials	Layer thickness, mm	Printing time, hrs.
Fused deposition modeling 3 D Printing (FDM)			
1	Poly lactic acid (PLA) thermoplastic biopolymer ( <b>polylactide</b> ) of 1.75mm diameter	0.2	18
Digital LED projection (DLP)			
3	Photopolymer resin ( <b>poly-lactic acid</b> )	0.2	18

The CrealityD1 printer is used as a FDM Printer. The parameters of samples printed in 3D using FDM process listed in table 2

**Table 2. Important Parameters of FDM 3D printing technique**

Output parameters	Values
Extruder temperature, °C	210
Worktable bed temperature °C	55
Layer height in millimeters	0.25
Base height in millimeters	0.35
Printing head speed, mm/sec.	90
Worktable Movement speed, mm/sec.	110
Filling pattern	In line

The Creality DLP printer is effectively capable of producing three-dimensional DLP prints. The DLP samples' printing parameters are mentioned in the Table 3.

**Table 3. Important Parameters of DLP 3D printed samples**

Output	Sample №1
Type of lens (mode)	1.1
Density of photo-initiator liquid, g/ml	0.05
Layers thickness, mm	2

Total number of layers in pieces.	15
Total duration for the polymerization in sec	60
Total time of the polymerization for the base in sec	90
Filling percentage.	1.1

Mititutyo Roughness Tester SJ-210 is handed down to record surface roughness, and Mititutyo Profile projector with 20x optical magnification range is employed to examine surface finish eight of the products made using both FDM and DLP technologies.

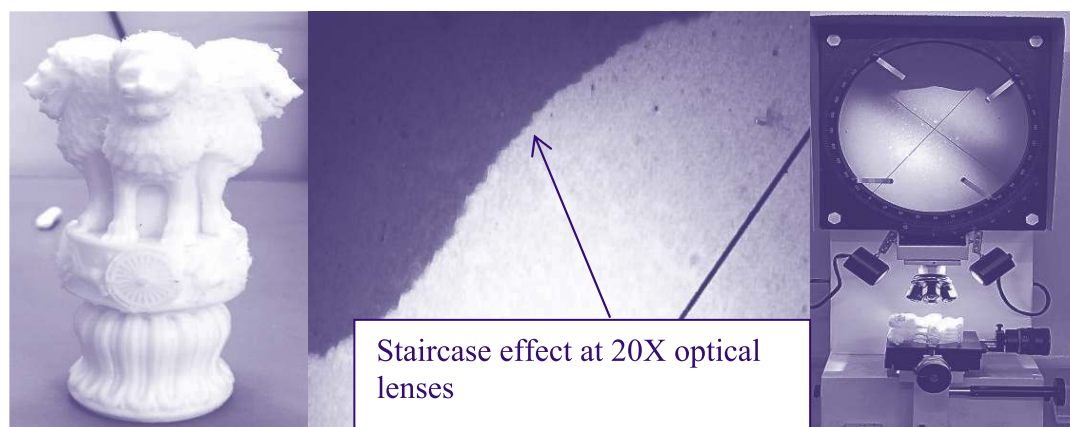
### RESULTS OF THE INVESTIGATION

Three dimensional printing with FDM model for fused deposition the most common three dimensional printing technologies in use today is FDM. From the most affordable to industrial three dimensional printing systems, millions of 3 dimensional printers rely on this technology. The filament, which is supplied in coil form and made from a range of thermoplastic materials, is accustomed to produce products using FDM 3D printing. Depending on the printer's specifications, the filament can have either of the two standard diameters of 1.75 or 3 millimeters [10]. The first step in producing a physical object by adopting three dimensional printing is to create a digital 3D model of it. Three dimensional printer software receives a three dimensional model in STL format. The model is positioned by the program either manually or automatically in the working chamber's virtual environment.

The program then calculates the necessary quantity of consumable materials. The extruder is a machine that has three parts: a heating source for melting filament, a mechanical driver for feeding filament, and a nozzle for direct extrusion, which entails feeding melted polymer material straight to the top layer of a created object (Figure 1). After saving the parameters, the CAD design/models are converted into a 3 dimensional printer control code. The extruder melts the filament, and in compliance with the printing algorithm and CAD 3D model, accurately feeds the melted polymer material in thin layers to the 3D printer's working surface. After that, the coil's filament is unwound in order to be inserted into the extruder, starting the 3D printing process. Following the application, cooling, and solidification of the polymer material, platform object is placed on is lowered by an amount equivalent to the thickness of the applied layer. Three-plane head and platform movement is

actuated by the pre-programmed algorithm that was made using specialized software (Figure 1).

**Figure 2. The image of samples 1 (FDM)**



**DLP:** The most efficient additive manufacturing processes is stereolithography (SLA) [12–14]. In essence, layer-by-layer curing and finished product formation occur on the sliced layers of liquid photo initiator polymer resin that correspond to the side walls of the model under the influence of laser radiation. Based on the similar principles as this 3D printing technique, DLP technology uses LED projectors rather than the pricey laser emitters used in SLA installations, which can occasionally lower the cost of 3D printers. Whereas a digital LED projector lamp in a DLP 3 dimensional printer instantly illuminates the whole layer, liquid photopolymer is polymerized gradually in

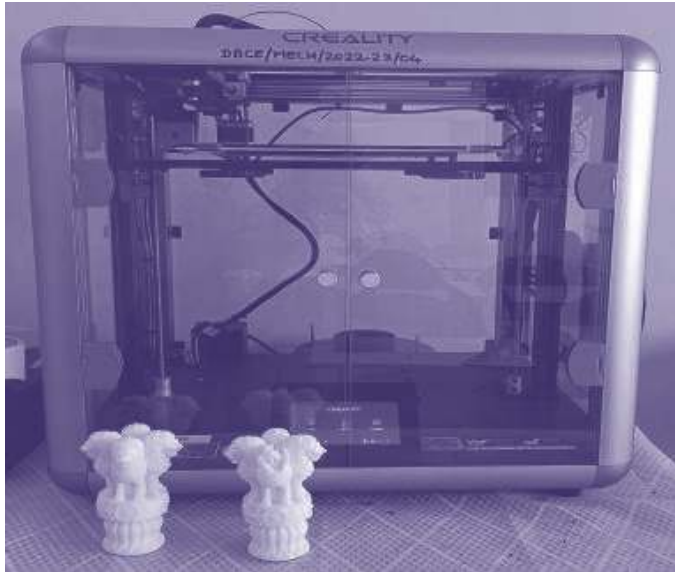
SLA installations (the laser beam swiftly traverses each point of the object)[15, 16]. This is anticipated to allow for faster item reproduction using DLP printing. Meanwhile, the quality and precision of the prints produced by DLP 3D printers are comparable to those of first-generation laser stereo-lithography (SLA) technology.

Like any other 3D technology, DLP technology begins the process of creating 3D objects by slicing down the digital three dimensional models into horizontal planes of different thickness and converting it into the G and M codes programming language for 3D printers. The print raw material is then added to the

printer inventory bath which has a transparent bottom and a working table that is submerged therein with an indentation from the base to the top layer of the finished product (Figure 3). The first layer image from the projector underneath the bath is projected on the base, and Ultra violet radiation causes the

polymer that the image from the projector reaches to photopolymerize. Workspace is then elevated to the distance of the subsequent layer, which is illuminated and adhered to the preceding one. Thus, a 3D printed object grows layer by layer.

**Figure 4. The FDM 3 dimensional printer**



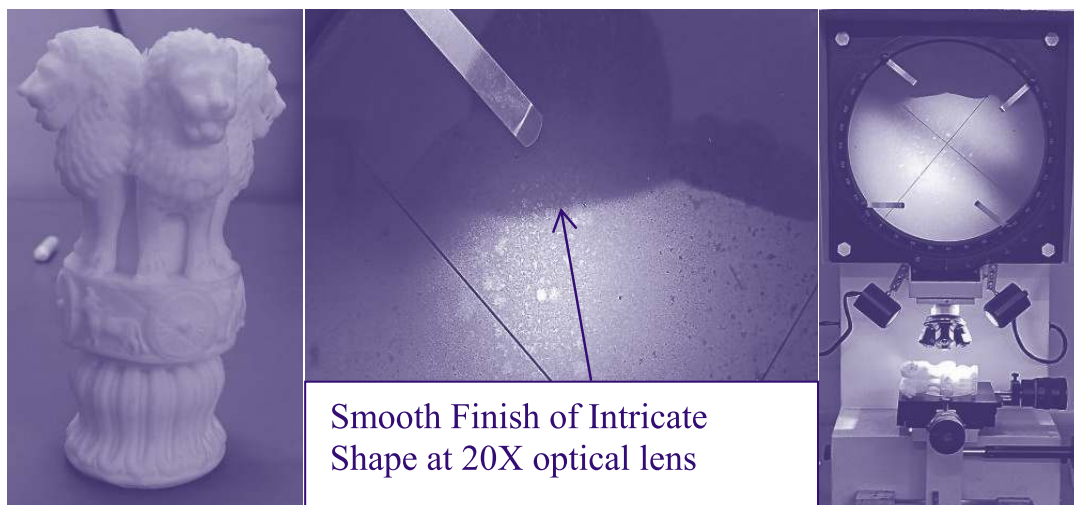
**Figure 5. The DLP 3 dimensional printer**



Similar to SLA 3 dimensional printing, DLP 3 dimensional printing machine have two options: one produces objects from the base to the tip (the working platform is descend), and the other produces objects from the tip of the object to the base of the object (the working platform is ascend). Both DLP and FDM manufacturing processes requires supports in addition to the fabrication of the item. These are required to secure the product sections to the bottom of the worktable and prevents deformation in case of overhanging structures. In addition, after 3D printing with DLP technology is finished, the products must

be washed in special solutions and exposed to ultraviolet light source. Both the first and the second are necessary for the parts to fully harden and for the complete separation of the products from photopolymer leftovers. Figure 6 depicts photographs of the configuration of samples No. 2 which was created using digital light processing (DLP) using the printing parameters from Table 3. The parameters are selected depending on the highest permissible values for the applicable technology and the thickness of the 3D printed object (Table 1), which have a direct impact on the quality of the samples.

**Figure 6. The configuration of samples 2 (DLP)**

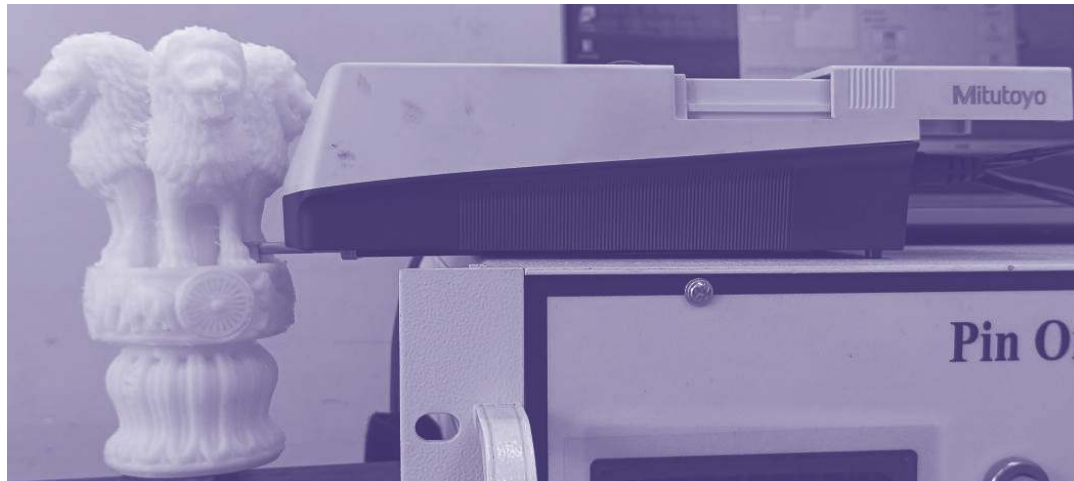


Smooth Finish of Intricate Shape at 20X optical lens

**Surface Roughness Measurement of models:** Ra and Rq were measured using the stylus as illustrated in figure 7, using a Mitutoyo surface roughness tester (SJ-210). To guarantee accurate measurements, three readings were collected

perpendicular to each specimen's printed layers. This method assists in taking into consideration any changes in the printed layers' surface roughness.

**Figure 7. Ra measurement**



The assessment length of 1.6 mm, inclination angle of tip 90°, Arc Radius of tip 2  $\mu\text{m}$ , tip speed of 0.25 mm/s and cut-off wavelengths of 0.9 mm were among the configurations of the surface roughness tester. Standardization of these parameters was done to ensure accuracy and uniformity in all

measurements. Ultimately, the average values of Ra and Rq were calculated for every product from the side walls, top flat surface, and bottom flat surfaces based on the data that were gathered. Table 4 displays the values that were obtained. Giving a summary of the product surface roughness topology.

**Table 3. surface parameters**

S.No	Type of Printer	Ra ( $\mu\text{m}$ )	Avg of Ra ( $\mu\text{m}$ )	Rq ( $\mu\text{m}$ )	Avg of Rq ( $\mu\text{m}$ )
1	FDM	1.125	1.2366	1.612	1.627
2		1.330		1.608	
3		1.255		1.663	
4	DLP	0.399	0.3023	0.528	0.391
5		0.206		0.257	
6		0.302		0.388	

## RESULTS & DISCUSSIONS

Figures 2 show that the product produced by FDM technique has lower resolution than those produced by DLP technique. The layer height of sample 2, which FDM technology created and is approximately 80  $\mu\text{m}$ , resembles that of DLP technology. However, imperfections (Figure 2) exist around complex surfaces, which supports (including soluble ones) removed. FDM samples' surfaces also can be polished mechanically and chemically to improve their quality. The samples 2 (Figure 6) made using DLP technology have minimally visible layer lines, sharp edges, and distinct part outlines. The sample with the greatest allowable quality does not change considerably from the developed products with the adequate level quality because

the possibility of estimating the layer height thickness and height, which relies on the kind of photo-polymer, changes within a restricted range of 40–60  $\mu\text{m}$ .

## CONCLUSIONS

One economical way to employ additive manufacturing to create engineering components is FDM. However, because there are so many process factors to take into account during printing, managing surface roughness becomes difficulties for production of functional parts. Thus, optimization and thorough examination were carried out in this research work in order to understand how the parameters of the FDM process affect the surface roughness measuring parameters (Ra and Rq). DLP is a great option among the 3D printing technologies currently

available for producing intricate geometric parts with close tolerances and a lot of demands on surface quality, roughness, and accuracy. The Fused Deposition Modeling method is preferred over single-product creation due to its effectiveness. Digital light processing printing speed is only influenced by the number of layers and the layer light time, regardless of whether printing one X part individually or printing multiple X parts. Table 1 compares the printing times for one part using FDM and DLP technologies. For simple models as well as swift and affordable simple part prototyping, FDM 3D printing is ideal. Based on experimental work surface roughness (Ra, and Rq) is higher for FDM than the DLP printed parts.

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