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Surface Performance Analysis of in House Developed Digital Light Processing based 3D Printer

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Abstract: Digital light processing (DLP) 3D printing is an additive manufacturing (AM) process that is utilized to produce parts by means of the photopolymerization process in which resin is cured by UV light. Vat photo-polymerization is a type of AM. it's a liquid bath of a polymeric resin which is cured layer by layer through precise control with the assistance of stepper motor UV light. Printing time, layer thickness, and lumens of the light play a crucial role within the printing. A series of specimens was designed, printed, and tested. Total printing time, layer thickness, and layer exposure time were examined. We utilized a 365 nm frequency of photopolymer vat. This paper studied printing parameters like surface roughness, printing speed and role of layer size, etc. It has found that if the printing speed 250 mm/min then the surface quality will be better otherwise surface roughness will increase if it will be greater than 250 mm/min.

1. Introduction

3D printing is a rapid manufacturing technique where a variety of materials can be printed using an additive process, where successive layers of materials are laid down in different shapes. A wide range of 3D printers is available commercially, such as stereo lithography (SLA), Digital light processing (DLP), fused deposition modeling (FDM) and laser type 3D printer, etc. Early Additive Manufacturing equipment and materials were created during the 1980s. In 1984, Chuck Hull of 3D Systems developed a procedure referred to as STL also referred to as stereolithography which utilizes lasers to fix photopolymer. There are various types of 3D printers. All types have their own sets of processes and applications. They all have their various principles and advantages. Additive manufacturing (AM) is the manufacturing process by which three-dimensional (3-D) parts are produced using an additive approach.

Vat photopolymerization is a form of AM [1] Vat polymerization 3D printing uses a liquid photopolymer resin which is solidified under the UV light source [5]. There are two main technologies in vat polymerization: Digital light processing (DLP) and Stereolithography (SLA). Basically, both use the resin but the major difference between them is the light source which cured the resin [3].

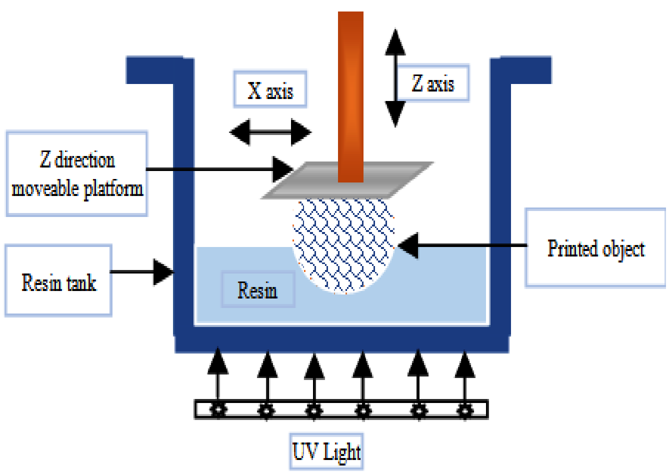

Fig. 1: UV Printing Process

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In DLP, the light source is a digital light projector screen that blinks the layer of part all directly. On the other hand, SLA takes more time than DLP because it uses a point-to-point method to cure.[2] Therefore, all points of layer cured simultaneously, and the printing speed is increased and at the same time printing time is decreased. Also, the accuracy of the part made by DLP is better than SLA. DLP 3D printer uses in dental, jewelry, art, and other sectors which require high detailing and finish.[1].

2. Working Principle

3D printing is any of the varied processes within which material is joined or solidified under computer control to make a 3D object.[2] SLA 3D printing uses UV light to solidify a liquid photopolymer. By changing the pattern of the light and incrementing the vertical position of the workpiece, the specified geometry is made up layer by layer.[6] During this process, once the 3D model is sent to the printer, a vat of liquid polymer is exposed to light from a LED light under safelight conditions. LCD displays the object of the 3D model onto the liquid polymer (Mask is generated for curing a specified layer). The exposed liquid polymer hardens, the build plate moves down, and therefore the liquid polymer is over again exposed to light.[8] This method is repeated until the 3D model is complete, and therefore the vat is drained of liquid, revealing the solidified model.

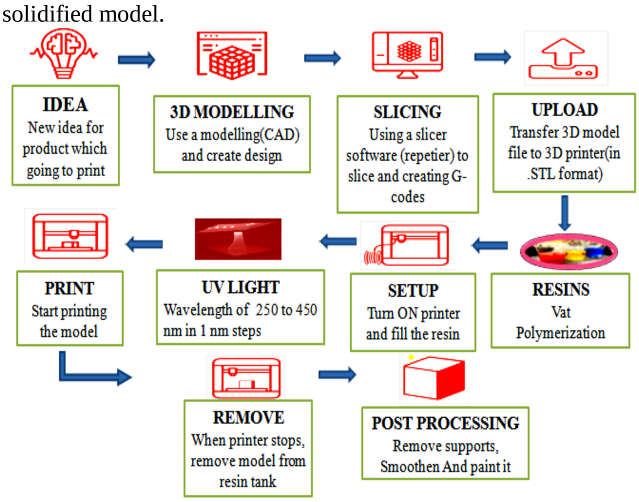


Fig 2: Process of UV curing based 3D Printer

2.1 Design of Sample

For the surface roughness testing, the samples were designed by using Creo 2.0 and comprised a 20 mm* 10mm * 5mm rectangular cuboids (Fig. 2) converted into a standard triangular language (STL) format. Then the .stl file imported into ChiTuBox software for G-codes conversion and then converted into a full high definition (FHD) format and then samples are printed at different parameters.

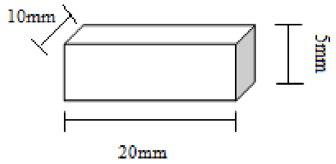


Fig 3: CAD file of sample

3. Material selection

Resin used for printing object is "AcryloCure CA-20" 3D printer resin of wavelength 395-405nm with high precision and quick curing & good fluidity for LCD 3D printing. This resin basically used for DLP and SLA based 3D printer.

There are few features of Acrylo Cure resin:

- Viscosity of 100cP
- The range of curing wavelength 395-420 nm.
- It is castable and non-castable resin.
- In castable resin have 0.15% of ash content after burnout.

Table 1: Parameters are recommended for AcryloCure CA-20 resin

Parameters	**Description**
Layer height	0.05 mm
Normal exposure time	12 sec
Off time	01 sec
Bottom exposure	30sec
Bottom layers	8

3.1 Preparation of sample

Figure 5 shows the printed sample of rectangular cuboid by the DLP process. The samples are prepared by varing the DLP process parameters such layer thickness, printing speed and printing time.

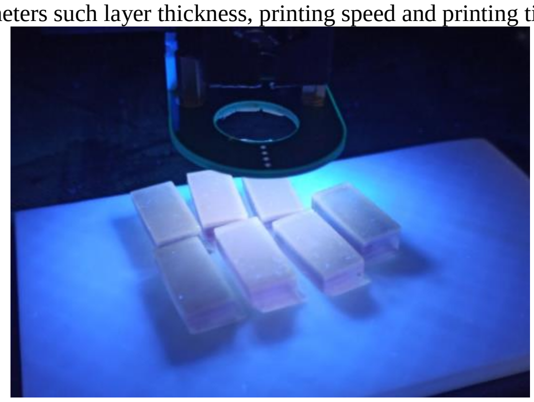
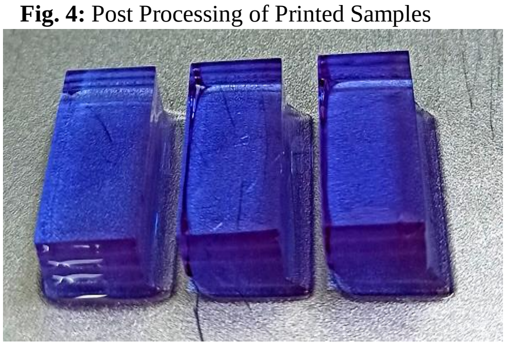
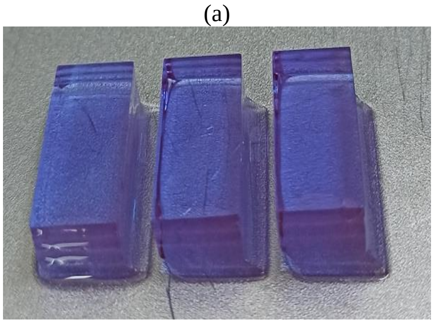


Fig. 4: Post Processing of Printed Samples



(a)



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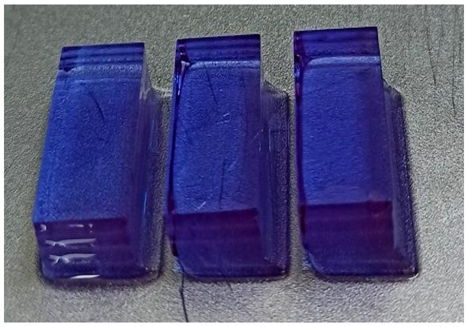

(c)

Fig 5. (a) Printed sample at speed 250 mm/min (b) Printed sample at speed 300 mm/min and (c) Printed speed at speed 350 mm/min

Table 2: Specification of the 3D printer taken from printing object

Parameters	**Description**
Layer Height	0.05mm
Bottom Layer count	8
Exposure Time	6s
Bottom Exposure Time	15s
Light-off Delay	0
Bottom Light-off Delay	0
Bottom light distance	5mm
Bottom lift speed	5mm
Lifting speed	300mm/min
Retract Speed	300mm/min

9 samples were printed at different speed and same layer thickness. An ultraviolet curing based 3D printer was used for experimentation for finding the level of parameter in view achieving better surface roughness. Figure 4 shows the samples of resin printed by ultraviolet curing process. The samples were prepared by varying the UV process parameters such as printing speed.

4. Experimental Work

For surface roughness, surface roughness tester was chosen to find the value from the previous year's papers [7]. To plot graph the printing speed vs printing time and actual surface vs predicated surface at various printing speed and constant layer thickness. Table 3 shows the various parameters of samples i.e. layer thickness, speed, printing time and actual roughness.

Fig. 6: Surface Roughness Experiment Setup

Table 3: Actual roughness

Sample no.	**Layer thickness**	**Speed (mm/min)**	**Printing time (min)**	**Actual roughness (µm)**
1.	1.20	250	33	2.88
2.	1.20	300	32	3.28
3.	1.20	350	31	3.54

4.1 Equation in term of predicated value

Following equation is used for predicated value of surface roughness:

R= -178.86190 + 3.72536*S + 0.90810*T + 21.07143*L + 6.91667E-003*S.*S - 0.019810*S.*T + 0.37619*S .*L - 0.100000*T*L

Where, S= Speed, T= Printing time, L= Layer thickness,

Table 4: Predicated roughness

Layer thickness	Speed (mm/min)	Printing time (min)	Predicated roughness (µm)
1.20	250	33	1.1855
1.20	300	32	1.5570
1.20	350	31	1.9651

Table 5. Comparison of Predicated and Actual data

Actual Roughness (µm)	Predicated Roughness (µm)	Residual (µm)
2.88	1.1855	1.6915
3.28	1.5570	1.723
3.54	1.9651	1.5749

5. Results and discussions

From the above table 3, the actual surface roughness for each sample is different even once the sample of material and geometry are same. Result have been obtained on the basis of input parameters which were shown in table3, 4 and 5.

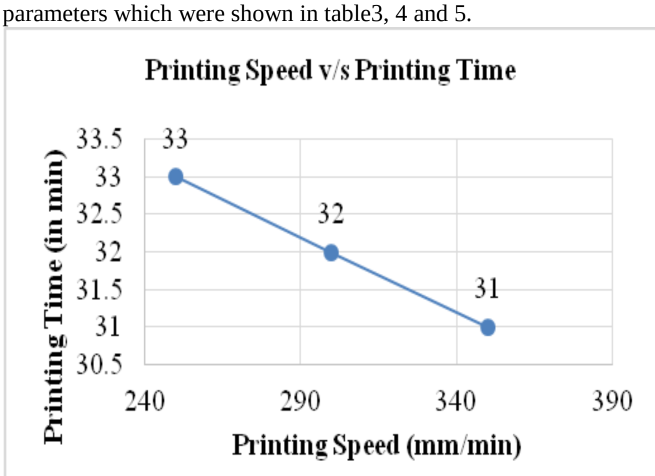

Fig. 7: Showing the variation of surface roughness with respect to printing time and speed

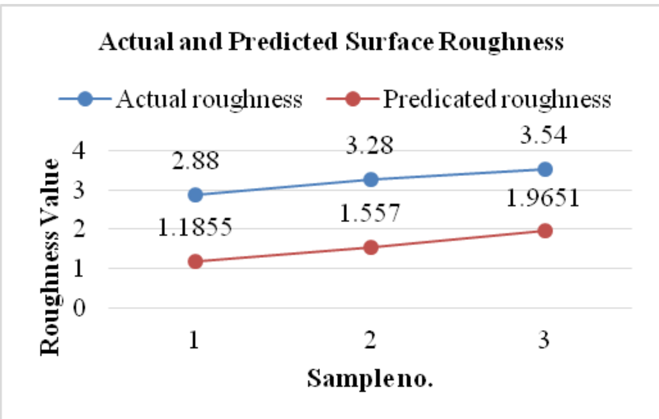

Fig. 8: Variation of surface roughness with actual and predict roughness

Figure 7, shows a linear relationship between printing speed and printing time. Increasing printing speed by every 50 mm/min will reduce the printing time by one minute.

6. Conclusions

Following conclusion made during the study, as-

i) The good strength and surface finish were obtained at 0.05 mm layer height, 15 sec bottom exposure time.
ii) Also, the great accuracy with minimum printing time.
iii) Printing time effects higher when layer size tends to increase.
iv) Increasing the Printing speed, roughness parameter tends to increase.

References

[1] PF Jacobs. Fundamentals of stereolithography, proceding of solid free form symposium.

[2] E Aznarte, C Ayranci. Digital Light Processing (DLP): Anisotropic Tensile Considerations, ISFFS 2017.

[3] G Taormina, C Sciancalepore. 3D Printing processes for photocurable polymeric materials: Technologies materials and future trends. Journal of Applied Biomaterials & Functional materials, 2017.

[4] H Banerjee, ZTH Tse. Soft robotic with compliance and adaptation for biomedical applications and forthcoming challenges, International journal of robotics and automation, 7, 2018.

[5] H Kadry, S Wadnap. Digital Light Processing (DLP) 3D Printed technology aand photoreactive polymers in fabrication pf modified-release tablet. European Journal of Pharmaceutical Science, 5, 2019.

[6] A Srivastava, J Bhaskar. Development and Performance Analysis of Fused Deposition Modeling Based 3D Printer. 7th International & 28th All India Manufacturing Technology, Design and Research Conference, AIMTDR 2018.

[7] PK Yadav, Abhishek, K Singh, J Bhaskar. Effect on Infill Percentage on Vibrational Characteristic of 3D Printed Structure. 4th International Conference on Advanced Production and Intustrial Engineering, 2019

[8] PK Yadav, K Singh, J Bhaskar. Design and Development of Ultra Violet Curing Based 3D Printer, Internal Journal of Advanced Production and Industrial Engineering, 5(3), 2020.

[9] J Bonada, A Muguruxa, X Ramis. Influence of exposure time on mechanical properties and photocuring conversion ratios for photosensitive materials use in AM. Manufacturing Engineering Society Internal Conference 2017.

[10] K Szykiedans, W Credo. Mechanical Properties of FDM and SLA cost prints, The 20th Internal conference: Machine Modeling and Simulations, 2015.

[11] NA Sukindar. Optimization of the Parameters for Surface Quality of the Open-source 3D Printing. et al., Journal of Mechanical Engineering, 3 (1), 33-43, 2017.

[12] V Chan, P Zorlutuna, JH Jeong, H Kong, R Bashir. Three-dimensionalphotopatterning of hydrogels using stereolithography for long-term cellen capsulation, Lab Chip 10 (16), 2010, 2062–2070.

[13] J Mueller, D Courty, M Spielhofer, R Spolenak, K Shea. Mechanical properties ofinterfaces in inkjet 3D printed single- and multi-material parts, 3D Print, Addit.Manuf. 4, 2017, 193–199,

[14] M Mohseni, DW Hutmacher, NJ Castro. Independent evaluation of medicalgrade bioresorbable filaments for fused deposition modelling/fused filament fabrication of tissue engineered constructs, Polymers (Basel) 10 (2018),

[15] L.R Lopes,A.F. Silva, O.S. Carneriro, Multimaterial 3D printing: The relevance of materials affinity on the boundary Interface Performance. ELSEVIER 30 June 2018

[16] G.D. Goh, V. Dikshit, A.P. Nagalingam, G.L. Goh, S. Agarwala, S.L. Sing, J. Wei, W.Y. Yeong, Characterization of mechanical properties and fracture mode of additivelymanufactured carbon fiber and glass fiber reinforced thermoplastics, Mater.Des. 137 (2018) 79–89.