Study of Dental Bridge Surface Roughness by Optimizing Parameters in SLA 3D Printing

Vijai P[a], Barath Raj S S[b] , Nidhish Nandan V[c]

Ramakrishnan R

Department of Mechanical Engineering, School of Mechanical Engineering (SMEC)

Vellore Institute of Technology, Vellore – 63201, Tamil Nadu, India.

E-mail: barathraj.ss2022@vitstudent.ac.in , nidhishnandan.v2022@vitstudent.ac.in

Vijai.p2022@vitstudent.ac.in

Abstract

This project's goal is to look at the precision of dental bridges made using the stereolithography (SLA) process. Rapid prototyping is a rapidly evolving technique that could replace plaster dental models in the future in a substantial way. AM creates objects by adding material, as the name suggests. In contrast, removing material through milling, machining, carving, shaping, or other methods is frequently required when creating an object the conventional way. In recent years, additive manufacturing has become increasingly popular in the medical industry. Currently, this procedure is used to create custom trays, models, including orthodontic models, provisional crowns and bridges, etc. for denture bases. Surface roughness is the key focuses of our study. The sculpture was printed using a variety of parameters, including UV power, layer thickness, normal exposure duration, and various orientation angles. The specimens are put through the following tests for the best optimal printing outcome: surface roughness . A comparison will be made in order to determine which form of structure produces the greatest results for the final product.

Keywords:

Additive Technology, Stereolithography, Dental Bridges, Resin, Surface roughness,

Introduction

The use of additive manufacturing (AM) in the production of dental materials has grown significantly in recent years. This is because the application of additive manufacturing (AM) for the production of different structures in almost all areas of dental medicine surgery, oral implantology, orthodontics, and prosthetic dentistry is expanding due to the continuous development of new and better printing technology and materials. Stereolithography (SLA), Fused deposition modelling (FDM), Selective electron beam melting (SEBM), Selective laser sintering (SLS), Selective laser melting (SLM), and ink-jet printing are the Additive Technologies most often employed in dental care (IJP). Our research is mostly focused on reducing surface roughness and comparing the printing sample's with different angle. [1] Prints oriented at 70 degrees exhibit less roughness than prints oriented at 30 degrees and 0 degrees, according to the results, albeit the outcome may vary based on the printer and resin/filament used. [2] By analysing the effects of a chemical vapour treatment on 3D printed parts, it was possible to obtain a roughness reduction of approximately 90% while also benefiting from a number of other factors such as solvent quality, treatment duration, and toxicity. [3] If you combine the internal fap with the marginal fit, a build orientation of 45° and 60° is advised. The marginal fit of a 3D printed prosthesis with a layer thickness of 100 microns was similar to that of a layer thickness of 50 microns. [4] A fibre laser source with a 100W output power may be used to lessen the surface roughness of 3D-printed onyx parts. Surface roughness may be reduced by up to 91.15% with further polishing using a 50W laser powder at a frequency of 50KHz. The sample shape will be affected by the use of higher frequency values. Better for the onyx part made with 3D printing are lower frequency values. [5] To assess the surface roughness and dimension accuracy of polymeric dental bridges produced by various 3D printers. [6] The sample was made with various layer thicknesses (0.0035mm and 0.050mm). [7] to determine the roughness of the surface by adjusting some parameters and the orientation [8] , To evaluate the effect of the build angle and the support configuration (Thick versus thin support) on the dimensional accuracy of 3D printed full-coverage dental restorations(SLA). [9] was to assess how the build orientation and build angle affected the dimensional precision of full-coverage dental restorations produced utilising digital light-processing technology (DLP-AM). [10] To research and examine the precision of various 3D printing technologies (SLA, DLP, LCD poly and monochromatic and Polyjet). The five separate 3D printers produced fifteen models. [11] To investigate the precision and reproducibility of dental models made from physical data using a variety of fast prototyping techniques, including digital light processing, jetted photopolymer, and 3-D printing.

Material and Methods

Material

The resins used in 3D printers that are predominantly produced from oils are known as plant-based resins. These oils are often derived from soy and maize, but they may also be obtained from sunflower, whey potatoes, beets, and even algae.

With the help of plants, we can produce 3D printer resin that is recyclable, biodegradable, and ready to be used for high-resolution print projects.

TECHNICAL SPECIFICATION:

Wide compability, Plant bases resin, Eco friendly, Low shrinkage

Industrial application:

Model, Dental, Jewely, Toy etc.

Dataset

SLA 3D printing is the major emphasis of our endeavour. Using liquid resin and a CAD file, the printing technology known as stereolithography (SLA) creates objects layer by layer.

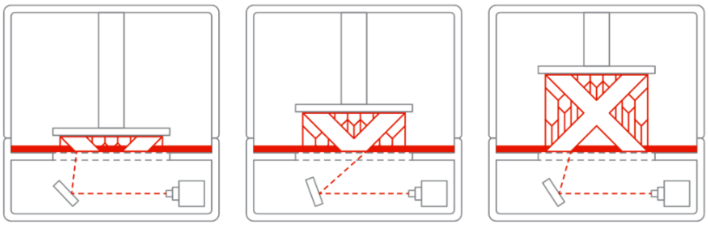

Fig.1

In a vat, layers of the liquid precursor are progressively subjected to UV radiation, which causes them to selectively solidify. The resin contains a photoinitiator (PI) molecule that responds to light and, when exposed to it, locally triggers the chemical polymerization reaction, which causes the resin to cure only where it has been exposed to light. In this way, the first layer is developed, and then a new resin coating is added, exposed to radiation, and then dried. As a result, the portion gradually adds more layers. This idea permeates every SLA procedure.

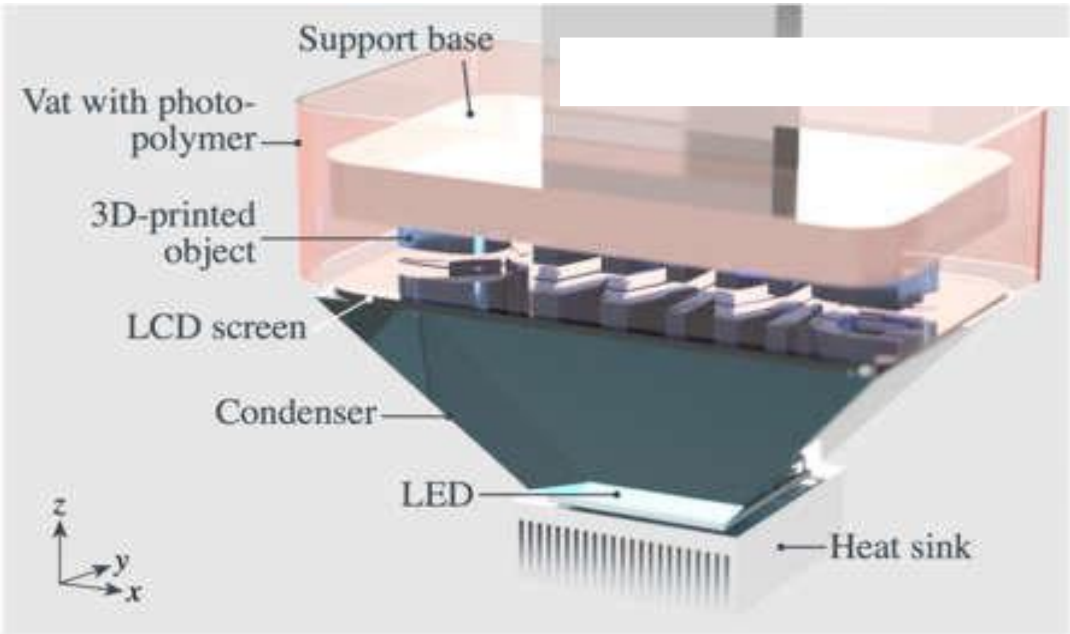

Fig.2.SLA printer layout

The limited surface method or bottom-exposure strategy (Fig 3) features a construction platform, which may be hung above the resin bath. Illumination from below, via the transparent floor, cures a layer of resin between building platform and vat floor. As the z-stage is elevated by a specific distance, this layer clings to the platform. The component grows hanging from the platform downward as the layer is bent, as illustrated in Fig. 4, and the construction platform with the attached part is raised.

The smooth surface is produced with a layer height that can be precisely controlled to within 0.1 to 1 mm thanks to the accurate z-stage movement. The layer may be produced more quickly than using the free surface method without the need of a mechanical sweeper, cutting down on the printing time. Cost is reduced since less resin is used because the specimen doesn't have to be totally submerged in the vat.

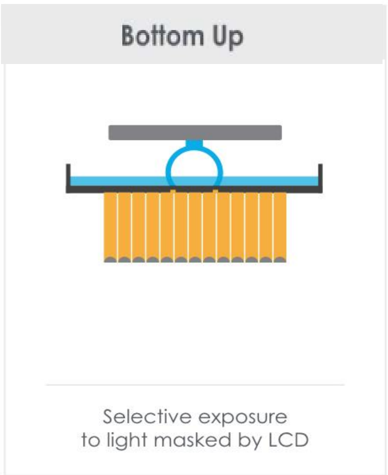

Fig.3

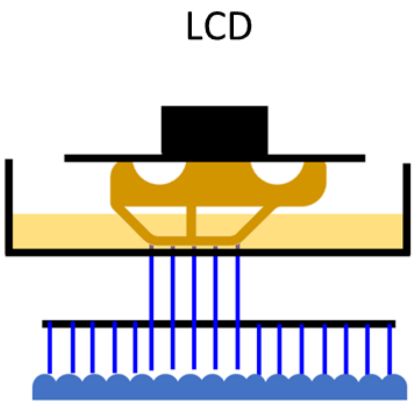

Fig.4

The CAD file is transformed to a.stl file format and then into a sliced format in order to build a structure utilising SLA. By using an ultraviolet (UV) laser to solidify a thin layer on the surface of a photocurable resin vat, these slices are orientated. By employing G-codes provided to the printer, the laser beam focuses on the platform bed and cures the resin, forming the object layer by layer. The platform will move after each layer is printed to give layer thickness, and as the platform moves higher, the layer will harden. Recent years have seen major advancements in the usage of stereolithography for production; the main goals of SLA are producing items with high resolution. excellent surface polish, too.

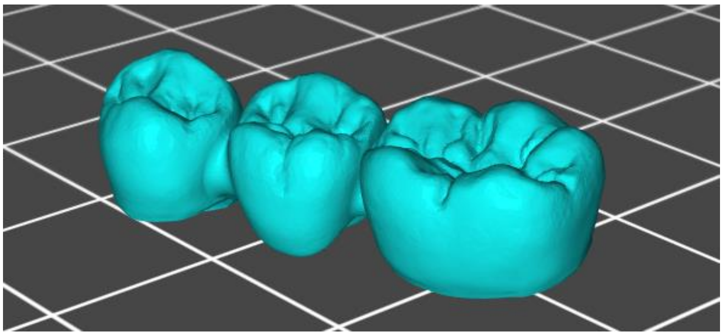

Fig.5 Dental Bridge of 3D Model

We will be concentrating on surface roughness and dimensional accuracy in this project, where we will print in many parameters like layer thickness and various angle orientations like (0˚, 45˚,, 75˚, 90˚). After printing is complete, the object is cleaned with alcohol for a short period of time, and then it is curled using UV light. The amount of time required for curving depends on the application, but it is essentially the same procedure for all SLA 3D printing technologies.

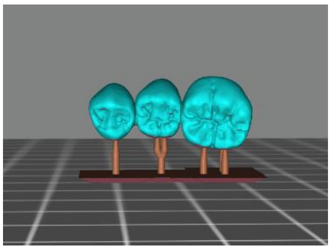

Fig.6.1. (0˚)

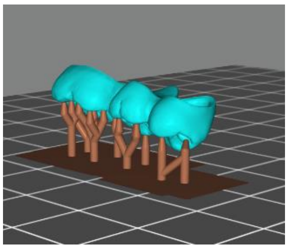

Fig.6.2. (90˚)

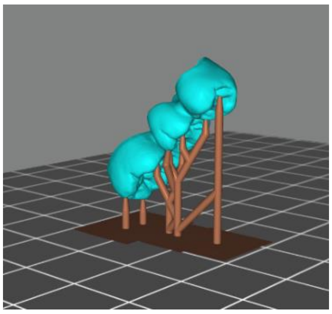

Fig.6.3. (75˚)

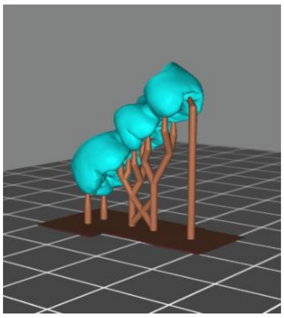

Fig.6.4. (45˚)

SAMPLE AND PRINTING ANGLE	PARAMETER CHANGE
SAMPLE 1 (0˚, 45˚, 75˚, 90˚)	Layer Thickness(mm) :0.035 Normal Exposure Time(s): 2.50 Off Time(s) : 0.50 Bottom Exposure Time(s): 40 Bottom layers : 6 UV power : 100%
SAMPLE 2 (0˚, 45˚, 75˚, 90˚)	Layer Thickness(mm) :0.030 Normal Exposure Time(s): 2.00 Off time(s) : 0.50 Bottom Exposure Time(s): 28 Bottom Layers : 4 UV power : 80%
SAMPLE 3 (0˚, 45˚, 75˚, 90˚)	Layer Thickness(mm) :0.030 Normal Exposure Time(s): 2.00 Off time(s) : 0.50 Bottom Exposure Time(s): 28 Bottom Layers : 6 UV power : 100%

Table 1

The three sets of data in the above mentioned table indicate the various printing settings use to print the dental design shown in Fig.6, and the final output of dental bridge after printing is shown below

Final output

Fig.7.1

Fig.7.2

Surface Roughness

The geometry of the 3D part and the raw material will decide what sort of surface finishing method can be used for a particular 3D printing component, therefore the surface finish of 3D printing is combined with a technique of raw material and the 3D printer to achieved. Roughness: Raised, Low, and Medium Roughness.

The surface roughness of items produced by 3D printers is one of the crucial elements in the 3D printing process since it has a major influence on the product quality and performance. Secondly, the primary goal of this study is to reduce surface roughness by altering the input.

Profilometer is used to test the surface quality of 3D printed objects. It is extremely sensitive equipment with a pointed, sharp probe/stylus that slides across a small pi ece of the surface to "scan" it.The stylus's nose captures the precise geometry of the surface during sampling, which is subsequently utilised to determine the surface roughness value (the quantitative equivalent of surface finish).

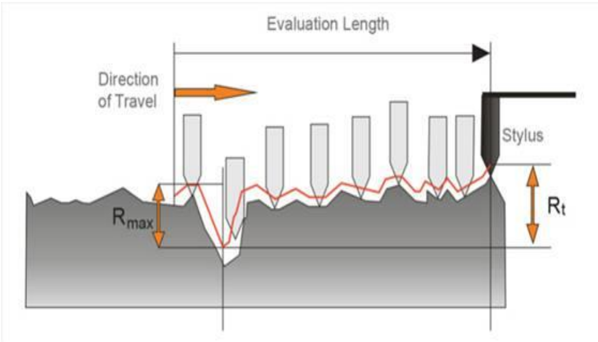

Fig.8

The Ra value is the gauge used most frequently to assess surface roughness. The arithmetic mean (average) of all measurements makes up this value. The figure below might help you understand this better.

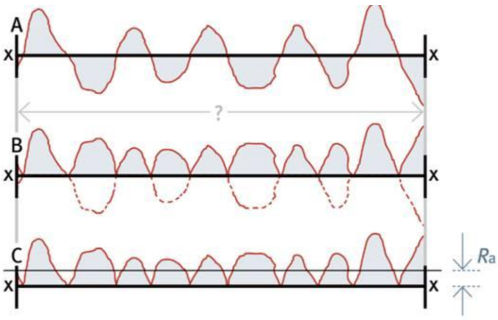

Fig.9

Result and discussion

The above sample is tester using surface roughness, from the average value (Ra) are found with the three different sample.

SAMPLE 1

ANGLE	Ra (value) In µm	Rq (value) In µm	Rz (value) In µm
0º	0.330	0.412	2.357
45º	0.873	1.078	5.792

75º	2.577	3.420	14.720
90º	2.007	2.393	11.388

Table 2

SAMPLE 2

ANGLE	Ra (value) In µm	Rq (value) In µm	Rz (value) In µm
0º	0.208	0.261	1.282
45º	1.061	1.311	6.185
75º	4.652	6.071	28.027
90º	1.312	1.631	7.322

Table 3

SAMPLE 3

ANGLE	Ra (value) In µm	Rq (value) In µm	Rz (value) In µm
0º	2.638	3.267	14.288
45º	0.479	0.647	3.570
75º	0.586	0.828	3.896
90º	1.290	1.656	8.405

Table 4

Discussion

From the above tables we have found that in the sample 2 with 0 degree having the low surface roughness value of Ra=0.280, Rq=0.261 and Rz=1.282 in(µm), The graph of that sample is adder below.

Result

ANGLE	Ra (value) In µm	Rq (value) In µm	Rz (value) In µm
0º	0.208	0.261	1.282

Table 5

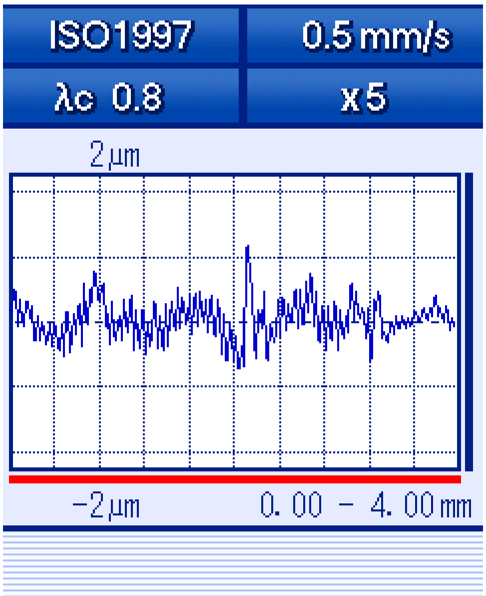

Fig.10

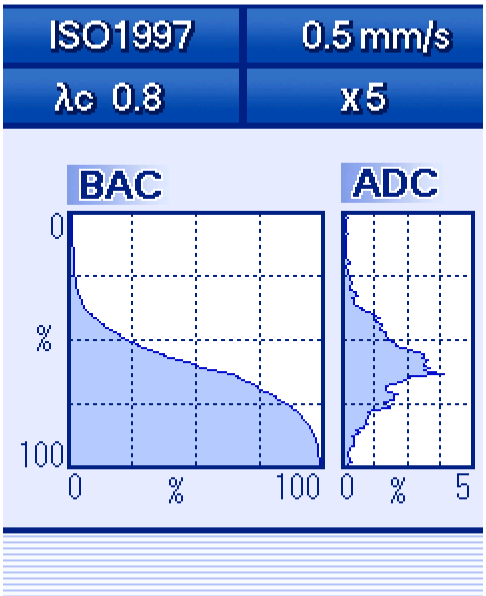

Fig 11

Conclusion

A study of surface roughness of dental bridge made by using Stereolithography (SLA) 3D printing has been conduced. We have print the dental bridge with different angle with different parameter, it has been found that in the sample 2 with the build angle of 0 degree has value of Ra=0.280, Rq=0.261 and Rz=1.282 values in (μm). we found that sample 2 build angle with 0 degree has a low surface roughness value by comparing other sample.

Reference

[1] Christian Brenes, Walter Renne, Tyler Toblert, Lincoln Fantaski, Don Mettenburg and Frederik Ruggerberg (2020). The effect of print angulation on the surface roughness of 3D Printed Models

[2] Lavecchia, F., Guerra, M. G., & Galantucci, L. M. (2021). Chemical vapor treatment to improve surface finish of 3D printed polylactic acid (PLA) parts realized by fused filament fabrication. Progress in Additive Manufacturing, 7(1), 65–75.

[3] Bridget O' Neal (2019). 3D printing dental prosthetics: The effects of parameters on Fit & Gap

[4] Maier, R., Bucaciuc, S.-G., & Mandoc, A. C. (2022). Reducing surface roughness of 3D printed short-carbon fiber reinforced composites. Materials, 15(20), 7398.

[5] Dikova, T. D., Dzhendov, D. A., Ivanov, D., & Bliznakova, K. (2018). Dimensional accuracy and surfaceroughness of polymeric dental bridgesproduced by different 3D

printingprocesses. Archives of Materials Science and Engineering, 2(94), 65–75.

[6] Dikova, T., Dzhendov, D., Katreva, I., & Pavlova, D. (2016). Accuracy of polymeric dental bridges manufactured by stereolythography. Archives of Materials Science and Engineering, 78(1), 29–36.

[7] Ji-Man Park, Jin Jeon, Jai-young Koak, Seong-kyun Kim &Seorg-joo Heo (2020) Dimensional Accuracy and surface characteritics of 3D Orinting dental cast

[8] Alharbi, N., Osman, R., & Wismeijer, D. (2016). Factors influencing the dimensional accuracy of 3D-printed full-coverage dental restorations using stereolithography technology. The International Journal of Prosthodontics, 29(5), 503–510.

[9] Osman, R., Alharbi, N., & Wismeijer, D. (2017). Build angle: Does it influence the accuracy of 3D-printed dental restorations using digital light-processing technology? The International Journal of Prosthodontics, 30(2), 182–188.

[10] Kim, J. H., Pinhata-Baptista, O. H., Ayres, A. P., da Silva, R. L., Lima, J. F., Urbano, G. S., No-Cortes, J., Vasques, M. T., & Cortes, A. R. (2022). Accuracy comparison among 3D-printing technologies to produce dental models. Applied Sciences, 12(17), 8425.

[11] Hazeveld, A, Huddleston Slater, J. J. R., & Ren, Y. (2014). Accuracy and reproducibility of dental replica models reconstructed by different rapid prototyping techniques. American Journal of Orthodontics and Dentofacial Orthopedics, 145(1), 108–115.