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Compression Testing of PLA in 3D Printing

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ABSTRACT

This article deals with the manufacturing aspect of 3D printing with the use of 3D deposition method. The material used for fabrication is PLA with Nozzle hot end size of 0.25mm. The 3D printing machine set up is Ultimakaer with cura as the slicer engine for setting up the print setting prior to the actual printing of the solid model designed. Parts manufactured by 3D printer are first analyzed efficiently with the characteristic features of print setting parameters for print. Specimen manufactured under evaluated settings is experimented for mechanical analysis of PLA printed parts. Compression strength, is obtained in this report bringing out the feasibility of PLA printed parts to be used in replacement of other materials being used all over in near future. Compressive strength obtained from the compression test is around 43.19×10^6 *Pascal.*

Keywords: *3D printing, extruders, PLA*

INTRODUCTION

A new era of 3D printing is a very important tool now a day to conceptualize the raw design into a final product and how it would be when actually brought in use. Manual prototyping has always been a regular practice by a skilled craftsman before the launch of any product in its full capacity in our early days of evolution of prototyping [3,4]

In all Rapid prototyping processes, the fabrication of product is achieved by the deposition of material layer by layer in 2D, x-y plane. Contouring pattern is used in deposition. The third dimension which the z direction is achieved by the pilling or stacking of the material layer over layer there by achieving the height or depth required. The z-coordinate doesn't work as a continuous element thus giving stepping like stairs effect to the model [4,2]. This effect can be fairly reduced by using the adjustment in printing properties and using very fine thin layers for deposition of material for fabrication, which is why the model is more precise to the actual model specifications [5].

Paper deals with fabrication and analysis of PLA 3D printed specimens .Printed specimen with fixed and variable properties are then exposed to loads to check for strength and properties .Compressive strength and analysis is stressed in this paper .Results obtained can be used as the base for the study of strength of PLA 3D printed materials with major application as replacement of many materials which are now being researched with full effect [1,5].

METHODOLOGY

Ultimaker Extended 2.0 is being used fabricate the standard specimen with print settings variable in approach. Print settings are of great importance in the research as they set the final properties induced in the material to be tested for strength properties. Testing specimen is made up of PLA. Compressive testing is done to analyze the compressive strength of PLA specimen to be used in future research for replacement of similar strength materials.

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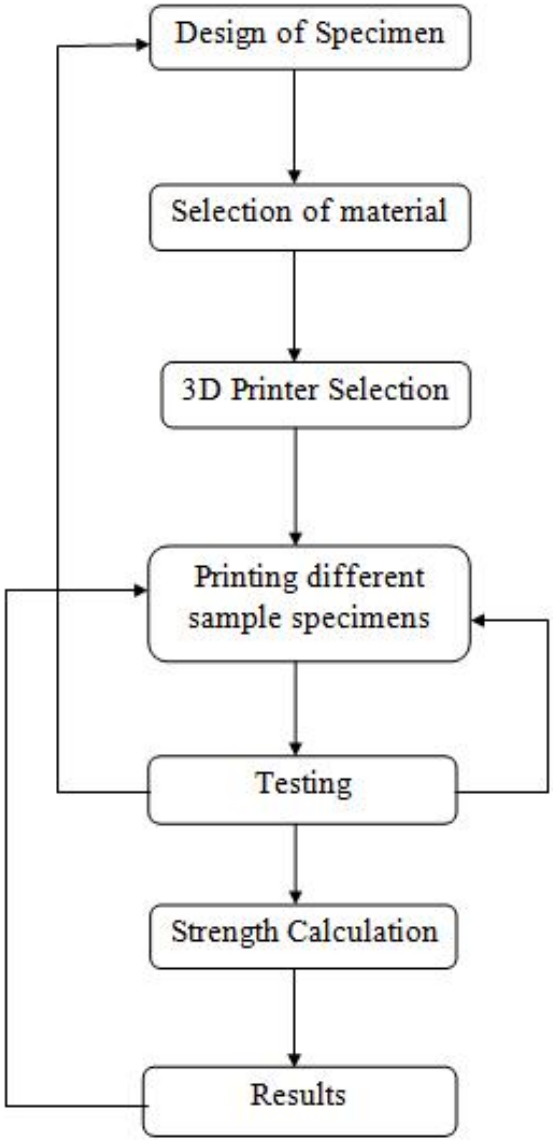

DESIGN AND EXPERIMENTATION

3D printers use layer by layer printing thus achieve the third axis though the deposition of layers on one above the other. Ultimaker extended 2.0 printing machine is used for the fabrication of specimen. Compressive strength of material in terms of compressive load is being experimented and tested with results with fixed parameters.

Process chain

J 3-D modeling of part

In this step the part to be fabricated is modeled in 3-D form by using software's like solid works with exact dimensions and characteristics. It is the first step in final development of product or part.STL file of this 3-D model is generated

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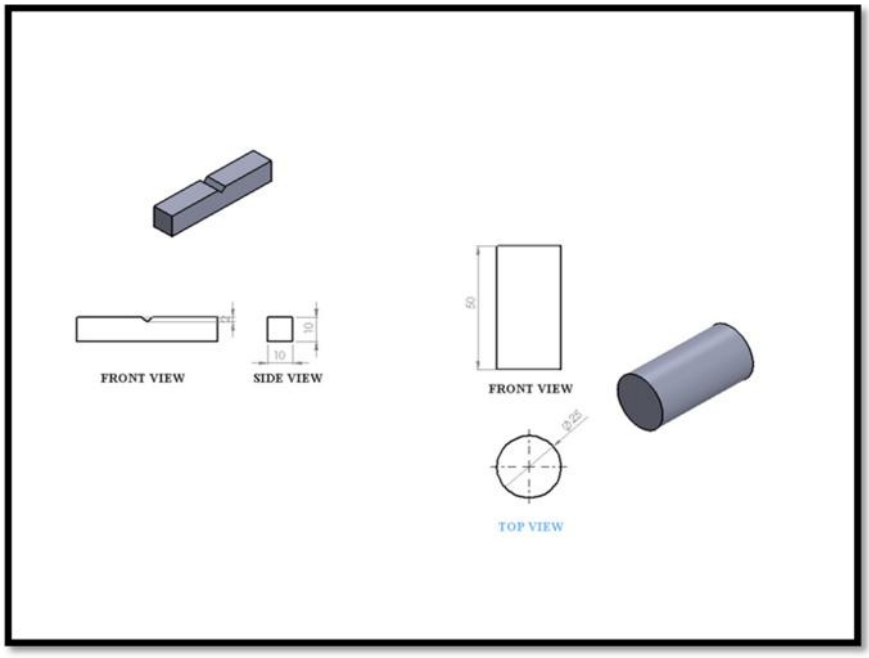
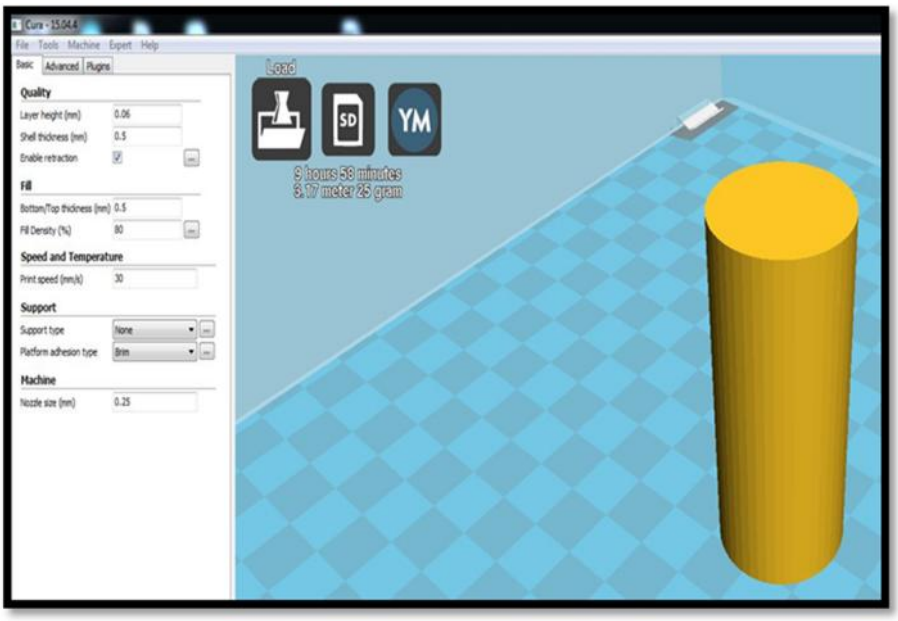
Figure1. Compressive test specimen



- The STL file generated in the above step is exported through proper tessellation process of 3-D geometric model
- Tessellation process

In this process chain the 3-D model part to be fabricated is meshed into several polygons which are placed side by side avoiding any overlapping between them. After this process is completed the whole 3-D design has to be sliced so that the printer can get the actual model printed through the layer by layer technique

Figure2. Cura slicer for print setting and orientation



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RESULTS

Testing for compressive strength

Dimension of the specimen: The specimen designed is of cylindrical shape with its diameter (d) as 25 mm and height (h) as 50mm. For compression testing the h/d ratio should be not less than 2, which is standard criteria for conducting compression test, and while selecting the dimension this factor is considered. Here three different specimens were fabricated with same dimension but with different print settings

Figure3. Advance and Basic settings for 3D printing of specimen

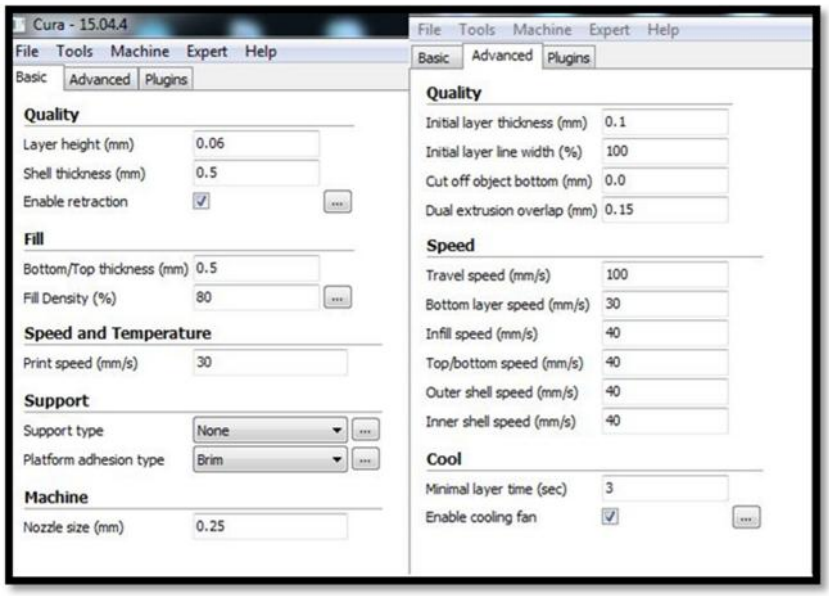
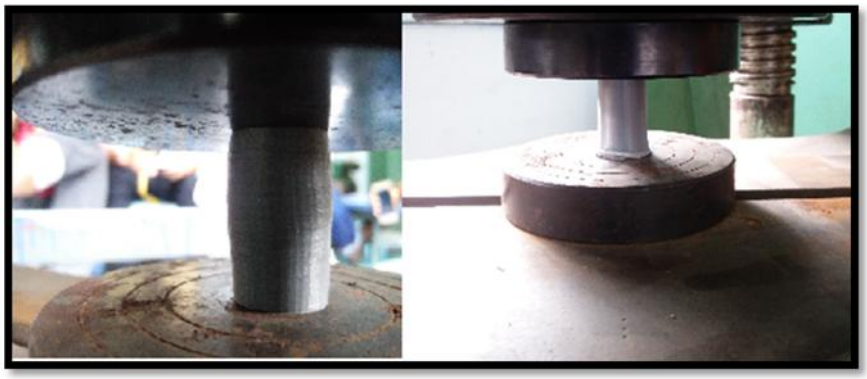


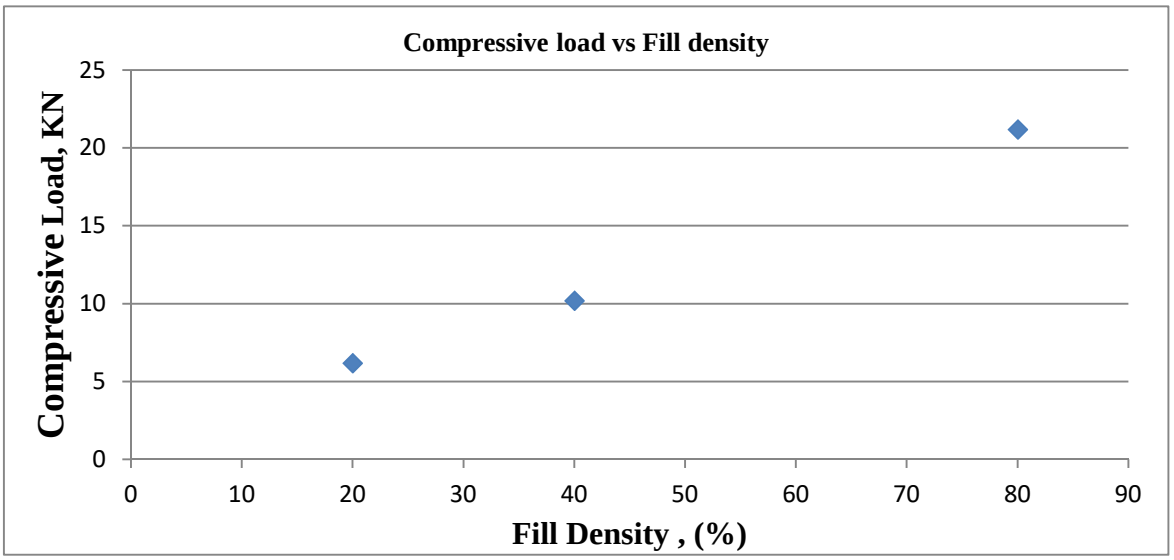
Figure 4. Compression test of test specimen



Sr. No.	Fill Density (%)	Layer Height(mm)	Printing Time(min.)	Weight (gm)	Breaking Load (KN)
1.	20	0.15	96	9.88	6.2
2.	40	0.1	209	13.65	10.2
3.	80	0.06	598	24.48	21.2

Table 1.Compression Test results of PLA

Figure 5: Compression Test results



CONCLUSION

Compressive load for a standard specimen with fill density of 80%, layer height 0.06 mm and shell thickness 0.5 mm was found to be 21.2 kN with the compressive strength of 43.19×10^6 Pascal. Compressive strength of PLA material increases with the increase in fill density percentage and with minimum layer height and shell thickness parameters. PLA Material strength (compressive) analysis can be used in applications in educational applications, biomedical engineering (Bone structures, biodegradable medical devices etc)

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