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ANALYSIS OF MECHANICAL PROPERTIES OF 3D PRINTED ABS PARTS BY VARYING PROCESS PARAMETERS

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Abstract- The paper work discusses analysis of mechanical properties of 3D printed objects by varying process parameters such as layer thickness and printing temperature. In the work two sets of specimens numbering each 1-9 were manufactured for both tensile and flexural testing. All the specimens were manufactured at different printing temperatures by varying their layer thicknesses through fused deposition modelling technique. Finally testing was done on the specimens with the help of universal testing machine. Results obtained were varying due to change in properties of material used for manufacturing specimens with the increase in printing temperatures at varying layer thicknesses.
Keywords – Fused Deposition Modeling, ABS Material, Tensile Strength, Flexural Strength

1. INTRODUCTION

3D printing machines that use FDM Technology build objects layer by layer from the very bottom up by heating and extruding thermoplastic filament. Firstly special software "cuts" CAD model into layers and calculates the way printer's extruder would build each layer. Then the printer heats thermoplastic till its melting point and extrudes it throughout nozzle onto base that can also be called a build platform or a table, along the calculated path. When the thin layer of plastic binds to the layer beneath it, it cools down and hardens. Once the layer is finished, the base is lowered to start building of the next layer.Then objects can also be milled, painted or plated afterwards.

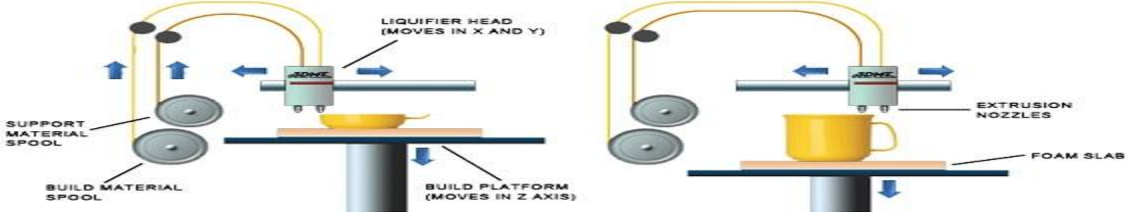

Figure 1. (a) Fused Deposition Modeling

2. METHODOLOGY

The aim of the study is to analyze the mechanical properties of 3D printed ABS parts by varying process parameters. Three different ranges of printing temperatures were taken with varying layer thicknesses. Standard size specimens were prepared through fused deposition modeling technique using ABS material. Manufactured specimens were then sent to laboratory for tensile and flexural testing.

2.1 Collection of ABS material in wire form

For the manufacturing of specimens we need approx. 150 grams of ABS material in the form of wire. The material grade which we used manufactures in between the printing temperature range of 210-240 ºC.


Figure 2. (a) ABS in wire form

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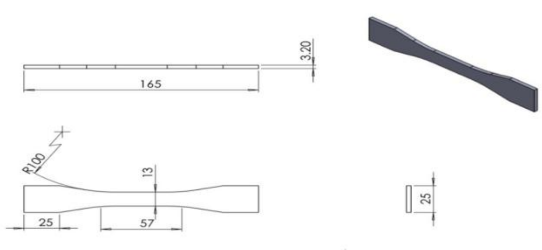
2.2. Manufacturing of ABS specimens by 3D printing.

The 3d printing machine consisted of gun holding ABS material filament operated by a robot. Solid material in the form of wire on the spool goes in one end, gets pushed through a hot nozzle in the gun, melts and is deposited in thin layers. This happens over and over until a three dimensional object emerges. In this way considering process parameters two different types of specimens were manufactured numbering from 1 to 9 each type. Specimen for tensile testing was in the shape of dumble whereas specimen for flexural testing was in the shape of strip.



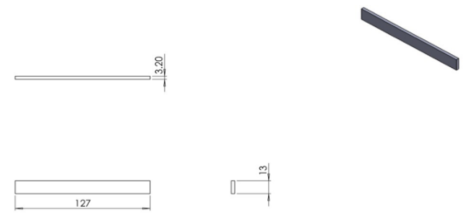
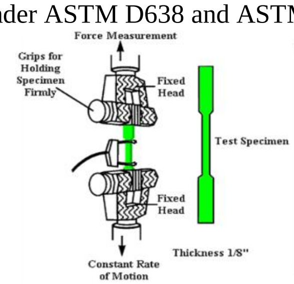


Figure 2. (b) Drawing of Specimen for Tensile Test Figure 2. (c) Drawing of Specimen for Flexural Test

2.3. Tensile and Flexural Testing

After manufacturing the specimens, they were sent for testing in laboratory. In the laboratory tensile testing and flexural testing were done under ASTM D638 and ASTM D790 standards respectively on universal testing machine.



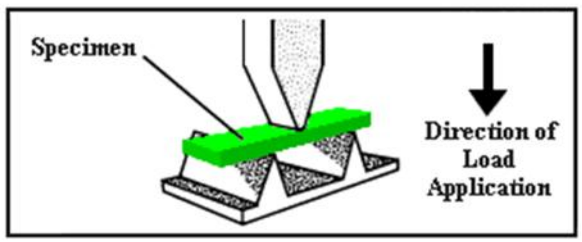


Figure 2. (d) Tensile Testing Figure 2. (e)Flexural Testing

3. RESULTS AND DISCUSSIONS

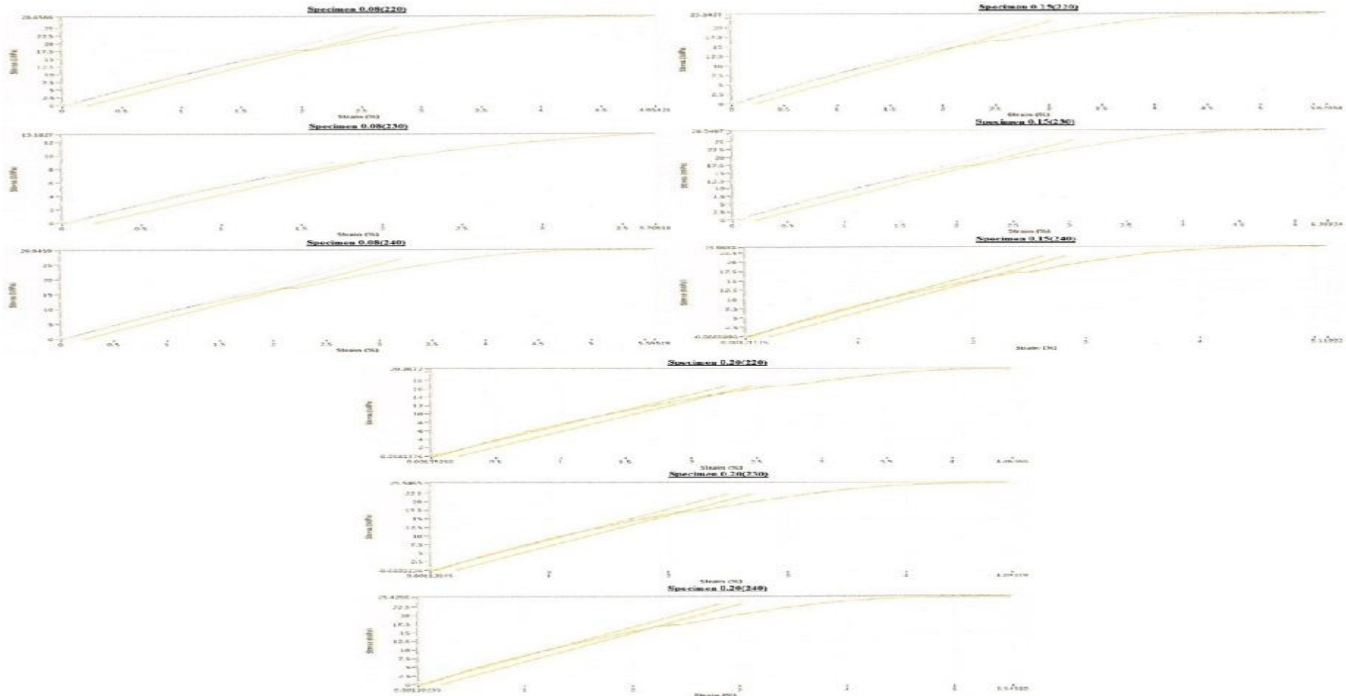
3.1. Results and Discussions of Tensile Testing specimens numbering from 1-9

Table 3. (a) shows the results of tested specimens on universal testing machine under standard ASTM D638. All the nine specimens were subjected to tensile load. There were three groups of specimens. Each group contains three specimens printed at three different printing temperatures 220 ºC, 230 ºC and 240 ºC respectively with same layer thickness. So all the three groups have different layer thicknesses. Fill density, bed temperature and printing speed were kept constant.

Fill Density: 30%, Bed Temperature: 60, Printing Speed: 60mm/s

Table 3. (a) Results of tensile strength test for specimens

S.NO.	Layer Thickness (mm)	Printing Temp. (ºC)	Peak Load (N)	Tensile Strength at Peak (MPa)	Break Load (N)	Tensile Strength at Break (MPa)	Elongation at Break (%)	Yield Point (MPa)	Young's Modulus (MPa)
1		220	1231	28.657	1144	26.631	4.887	18.25	967.78
2	0.08	230	678	13.183	628	12.211	3.629	8.85	535.28
3		240	1302	29.946	1290	29.670	5.545	16.64	898.61
4		220	1074	23.543	1069	23.433	5.578	14.04	772.77
5	0.15	230	1268	28.547	1255	28.254	5.222	17.71	902.28
6		240	1075	23.969	567	12.642	5.070	14.78	825.26
7		220	942	20.767	915	20.172	4.464	14.01	738.78
8		230	1144	25.547	934	20.857	4.857	15.85	892.50
9	0.20	240	1130	25.430	1119	25.182	5.546	15.37	831.70



Graph 3. (a) Stress Strain Graph for tensile tested specimens

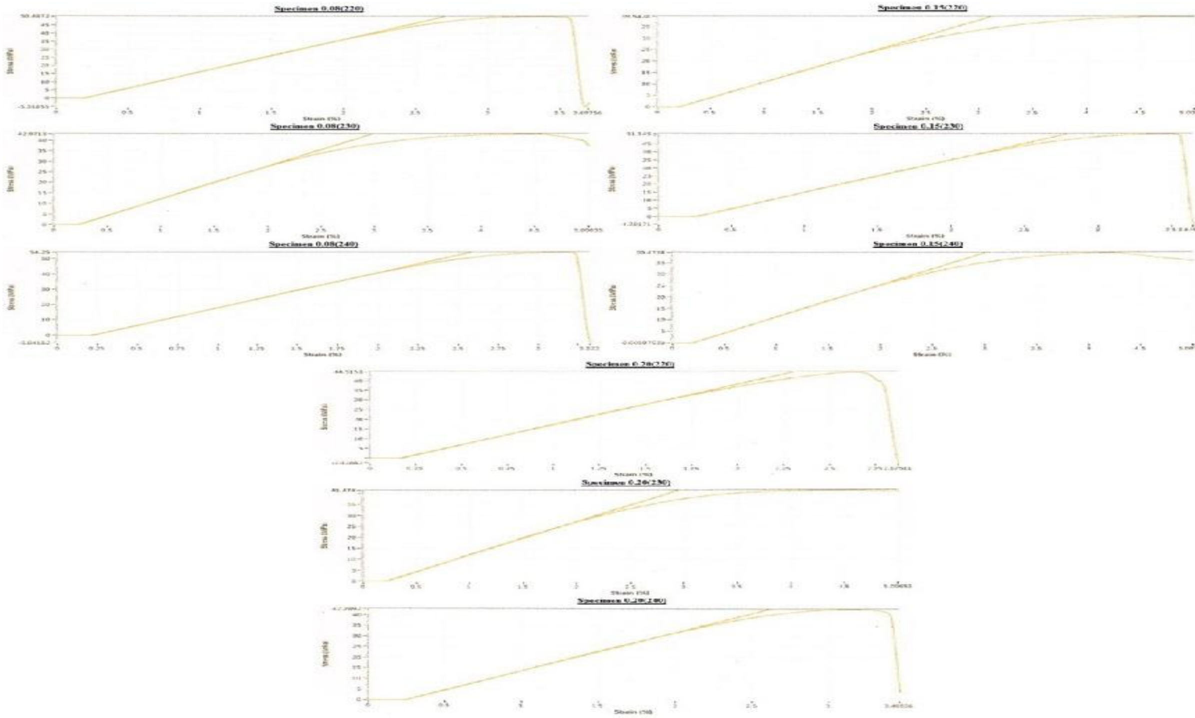
3.2. Results and Discussions of Flexural Testing specimens numbering from 1-9

Table 3. (b) shows the results of tested specimens on universal testing machine under standard ASTM D790. All the nine specimens were subjected to flexural load. Similarly there were three groups of specimens. Each group contains three specimens printed at three different printing temperatures 220 ºC, 230 ºC and 240 ºC respectively with same layer thickness. So all the three groups have different layer thicknesses. The only difference was the shape of specimen. Fill density, bed temperature and printing speed were kept constant.

Fill Density: 30%, Bed Temperature: 60, Printing Speed: 60mm/s

Table 3. (b) Results of flexural strength test for specimens

S.NO.	Layer Thickness (mm)	Printing Temp. (ºC)	Peak Load (N)	Flexural Strength at Peak (MPa)	Strain at Break (%)	Flexural Modulus (MPa)
1	0.08	220	91.36	50.487	3.698	2007.258
2		230	71.12	42.971	5.006	1560.004
3		240	92.26	54.250	3.322	2296.596
4	0.15	220	71.59	39.543	5.007	1361.430
5		230	90.85	51.145	3.650	2017.464
6		240	66.64	39.473	5.007	1400.520
7	0.20	220	78.59	44.515	2.875	2082.427
8		230	69.15	41.474	5.007	1512.314
9		240	73.39	42.789	3.460	1802.801



Graph 3. (b)Stress Strain Graph for flexural tested specimen

4. CONCLUSION

Analysis of mechanical behavior of 3d printed FDM specimens is conducted through experiments and following conclusions are obtained.

There are large variations in tensile and flexural strength of specimens with different layer thickness when printed at printing temperature 230 ºC as compared to specimens printed at printing temperature 220 ºC and 240 ºC.

A maximum tensile and flexural strength values are reported for specimens which has low layer thickness of 0.08mm and printing temperature of 240 ºC.

In both cases tensile strength as well as flexural strength there are variations firstly strength decreases keeping layer thickness constant with increase in printing temperature and then increases with further increase in printing temperature.

The variations are due to change in properties of material with increasing printing temperature.

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