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RESEARCHARTICLE OPENACCESS

"The Study of Effect ofProcess Parameters in Fused Deposition Modeling (3D Printing) for ABS Material"

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ABSTRACT
Additive Manufacturing Method is a method where components are manufactured by building material layer over layer. Fused Deposition Modeling is a common additive manufacturing method (commonly called as rapid prototyping) where solid material is melted with the help of heating coils and deposited on platform build the part by adding melted layer over another layer. While carry out this process some parameters to be set before manufacturing the component using FDM. The process parameters are fill density; fill pattern; temperature; layer height; layer thickness; etc. In this research for the study purpose we have selected one 100mmx100mmx100mm square block. The study has been carried out by considering the fill density, fill pattern, travel speed and print speed. The main aim of this research paper is study of effect of travel speed and print speed with change in fill density and fill pattern inFDM.

Keywords: Additive Manufacturing, Rapid Prototyping, FDM, Square Block etc.

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I. INTRODUCTION

Additive manufacturing is the one type of advanced manufacturing technologies where parts are built by adding layer by layer. The material addition of layer by layer is controlled by G codes by creating CAD models. Fused Deposition Modeling is the one of the advanced manufacturing technologies, where thermoplastic materials are used. The plastic material is inserted in an extruder which consists of heating coils, these heating coils melts the material and extruder nozzle make material out of the extruder and carry out layer by layer task. The basic step of FDM is creating a solid model using CAD software and converting that CAD model into STL format which is compatible for all AM machines. In a AM language plastic material is used to call as filament which is circular cross section with specified diameter for each FMD machines.

FDM process has its own advantages like we can build complex parts also with ease, no need of dies molds etc, most important feature of FDM is we can produce internal featured parts.

Several parameters involved and influence the mechanical properties of parts manufactured by FDM machines. So many researchers have focused on these parameters. Ala'aldin Alafaghani [1] investigated the effect of fill density, fill pattern, print speed, temperature of extruder and layer height on mechanical properties of a component and developed approach to model FDM parts using FEA. Aboma Wagari Gebisa [2] used five process parameters for his experimental investigation like air gap, raster width, raster angle, contour number and contour width. Among the parameters considered, the influence of raster angle was the highest. K.G. Jaya Christiyan [3] drawn a conclusionfromhisresearchthatlayerthicknessof 0.2 mm and printing speed 30mm/s will exhibit maximum tensile strength. He concluded that better tensile and flexural strength will be exhibited by maintaining low printing speed with low layer thickness gives a better bonding with the previous layer. Boddula Vikas [4] systematically experimented and investigated the influences of printing temperature, filling rate, layer thickness and printing speed on tensile properties were analyzed by L9 orthogonal array of four factors and three levels. He came to conclusion on normal varying filling ratio tensile specimen; the 100% filling ratio tensile specimen has more tensile strength. Jelena Zarko [5] concluded with his case of square and circular elements, reproduction was successful only for elements whose diameter or side is greater than 2 mm. This could represent a problem in reproduction of finer elements, such as typographical elements, especially types with serifs. It is necessary to find appropriate values for other variable printing parameters that would guarantee the optimal results in dimensional accuracy and surface quality,with the aim of finding optimal parameters for making finer and thinner elements of the 3D printed embossing tool.

II. MATERIALS ANDMETHODS

2.1 3DModel

For study purpose square block selected of dimensions 10x10x10 as shown in Figure 2.1 with the help of CATIA V5 software then model converted into STL format then this STL format file transferred to flash print software to make initial setup for printing process

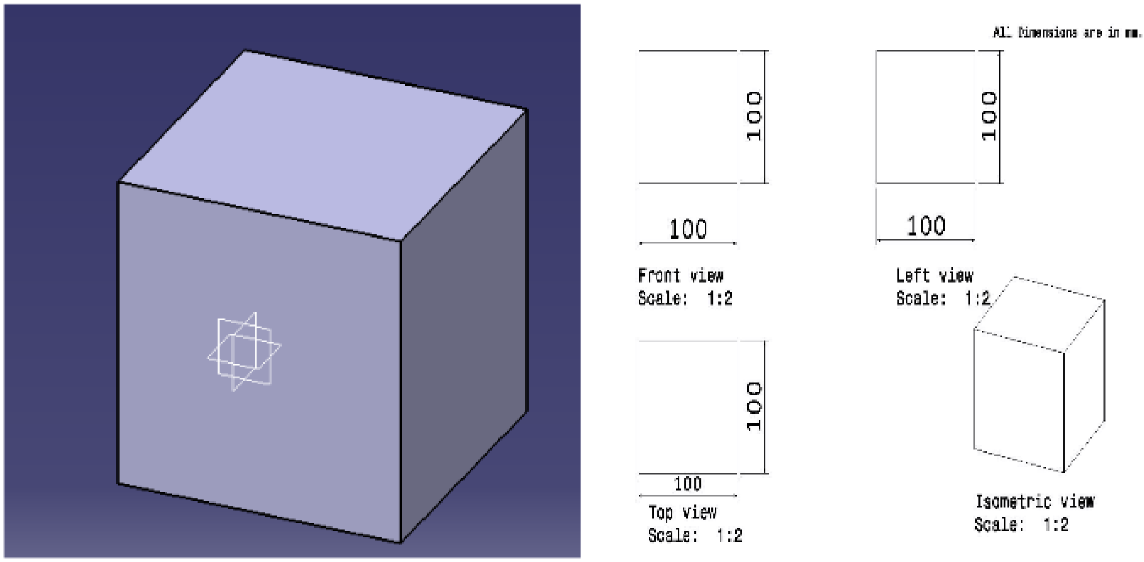

Figure No 2.1 Model and Drafting of Square Block

2.2 3D PrintingSetup

The parameters used for the study like fill density, fill pattern, print speed, travel speed. Two combination of speed of printing and travelling is chosen for the study in FDM machine. First speed combination has print speed as 50mm/s and travel speed as 70mm/s similarly second speed combination has print speed as 70mm/s and travel speed as 90mm/s. First layer height and each layer heightiskeptconstantforbothspeedcombinations i.e0.12mmand0.20mmrespectively.Temperature of the extruder and platform is also kept as per the requirements of ABS material i.e 230°c and 105°c.

2.3 Methodology

The effective study has been carried out by keeping temperature and layer height parameter constant. Three different fill pattern styles and two different speed combination were considered for the fill density 10% to 100%. The three filling pattern are line, hexagonal and triangle are shown in Figure 2.2

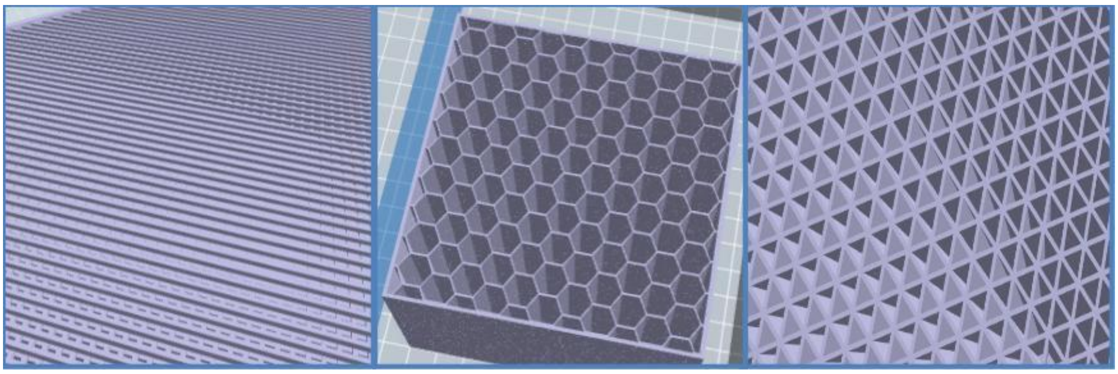

Figure No 2.2 Fill pattern styles Line, Hexagonal and Triangle

III. RESULT ANDDISCUSSION

Square Block of dimensions 10mmx10mmx10mm designed, modeled in CAD software after converting into STL file transferred to AM software where slicing of the model will be done. The total number of layers for the all three different filling parameters like line, hexagonal and triangle recorded and tabulated. First speed combination considered and values of time taken for printing, material usage, density of the material, weight of the model are recorded and tabulated for all three filling patterns with fill density increase of 10% line from 10% to 100% as shown in Table. In the same way for the second speed combination results are recorded and tabulated as shown in Table 3.1.a, b andc

Table No 3.1.a Results record for first fill pattern Line style

Line Fill Pattern Print speed 50mm/s , Travel Speed 70 mm/s					Line Fill Pattern Print speed 70mm/s , Travel Speed 90 mm/s				
Fill Density	**Time (Hr.Sec)**	**Material**	**Layers**	**Weight (gm)**	**Fill Density**	**Time (Hr.Sec)**	**Material**	**Layers**	**Weight (gm)**
10%	15.52	72.27m	833	180.78	10%	11.49	72.27m	833	180.78
20%	21.19	114.7		286.92	20%	16.1	114.7		286.92
30%	26.57	156.79		392.22	30%	20.4	156.79		392.22
40%	32.34	199.27		498.48	40%	24.12	199.27		498.48
50%	38.9	241.76		604.76	50%	28.2	241.76		604.76
60%	43.46	284.52		711.72	60%	32.28	284.52		711.72
70%	49.2	326.97		817.9	70%	36.35	326.97		817.9
80%	54.53	369.24		923.66	80%	40.4	369.24		923.66
90%	60.3	412.11		1030.9	90%	44.48	412.11		1030.9
100%	66.1	454.21		1136.3	100%	48.52	454.21		1136.3

Table No 3.1.b Results record for second fill pattern Hexagonal style

Hexagonal Fill Pattern Print speed 50mm/s , Travel Speed 70 mm/s					Hexagonal Fill Pattern Print speed 70mm/s , Travel Speed 90 mm/s				
Fill Densi ty	**Time (Hr.Sec)**	**Materia l**	**Layer s**	**Weight (gm)**	**Fill Density**	**Time (Hr.Se c)**	**Material**	**Layer s**	**Weight (gm)**
10%	17.8	74.36	833	186.01	10%	14.5	74.36	833	186.01
20%	26.4	119.29		298.41	20%	24.7	119.3		298.41
30%	37.47	163.21		408.26	30%	35.19	163.2		408.26
40%	49.14	203.7		509.56	40%	46.46	203.7		509.56
50%	61.5	246.74		617.22	50%	59.22	246.7		617.22
60%	NA	NA		787.92	60%	NA	NA		787.92

70%	NA	NA		915.53	70%	NA	NA		915.53
80%	NA	NA		1025.6	80%	NA	NA		1025.6
90%	NA	NA		1144.5	90%	NA	NA		1144.5
100%	66.1	454.23		1136.3	100%	48.52	454.2		1136.3

Table No 3.1.c Results record for first fill pattern Triangle style

Triangle Fill Pattern Print speed 50mm/s ,Travel Speed 70 mm/s					Triangle Fill Pattern Print speed 70mm/s , Travel Speed 90 mm/s				
Fill Density	**Time (Hr.Sec)**	**Material**	**Layers**	**Weight (gm)**	**Fill Density**	**Time (Hr.Sec)**	**Material**	**Layers**	**Weight (gm)**
10%	17.11	77.43		193.68	10%	12.54	77.43		193.68
20%	23.44	124.65		311.8	20%	17.53	124.65		311.8
30%	30.21	172.16		430.65	30%	22.55	172.16		430.65
40%	37.6	219.64		549.43	40%	27.59	219.64		549.43
50%	43.35	267.23		668.47	50%	32.52	267.23		668.47
60%	50.8	314.98	833	787.92	60%	37.49	314.98	833	787.92
70%	56.54	362.52		906. 84	70%	42.31	362.52		906. 84
80%	62.57	410		1025.6	80%	47.2	410		1025.62
90%	69.9	457.52		1144.5	90%	51.55	457.52		1144.48
100%	66.1	454.23		1136.3	100%	48.52	454.23		1136.25

IV. CONCLUSION

The current research study investigated the effects of fill density, fill pattern, print speed and travel speed in FDM for ABS material. From the results and discussion the following conclusion were drawn for ABS material square blockmodel.

a) There is no effect of print speed and travel speed on material consumption for building the part or you can say material usage for part build is independent of print speed and travel speed parameter.

b) For Hexagonal fill pattern, fill density 60%, 70%, 80% and 90% not possible due to shape of the filling pattern and because of the square model.

c) If 100% fill density parameter chosen for any filling pattern, the time taken for building the part is same for both combination ofspeed.

d) Time taken for second combination speed parameter is lesser than first combination of speed for 10% to 90% fill density for all three filling patterns like line, Hexagonal, Triangle.

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