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Analysis of process parameters of FDM made parts: A Review

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Abstract **The mostly used RP technique is Fused Deposition Modeling (FDM). In Fused deposition modeling process material filament is melted with the help of heating element and placed on the platform of printer to form a three dimensional part . The variable process parameters such as raster width, layer thickness, air gap, part orientation, raster angle on which the mechanical properties and part quality of FDM made parts depends. Therefore, parameter which are selected must be optimized one. Objective of this study is to determine the effect of this parameter on final part through the different research work done so far.**

Keywords —ABS, Fused deposition modelling (FDM), Mechanical properties, Process parameters, PLA, 3D printing, Rapid prototyping (RP)

I. INTRODUCTION

Rapid prototyping is an additive manufacturing process of making 3D solid parts from digital file. Now a days RP technology is mostly used technology in the industries, but still there are some limitation in the quality and mechanical properties of the final product due to effect of process parameter. At the time of manufacturing stage this limitation can be reduce by changing the process parameters. Then we are able to obtain a final product with better quality and mechanical properties. During the fabrication from RP technique by optimizing the process parameters we can achieve a better quality, accuracy and properties. Fused deposition modelling is a techniques in which a material filament is pass through heated moving head where the heating element is placed. Due to the heating element plastic material filament is melt and successively depositing material in layers, in the desired shape. A moving platform lowers after each layer, a new layer get deposited on previous layer. Diagram shows the FDM process working.

The quality, accuracy and mechanical properties of final part depend on process parameters. Hence, before fabrication of part from FDM it is much more important to study the effect of different parameters. This study gives the effect of different parameters [1].

The process parameters are

1. **Build orientation** specify the orientation angle of the product built on the platform.

2. **Layer thickness** is thickness of material which is deposited by the nozzle in the single pass.

3. **Air gap** it gives the space between the beads of material.

4. **Raster angle** is angle made by nozzle and X- axis of the printing platform.

5. **Raster width** is width of material deposited by nozzle which is related to tip size

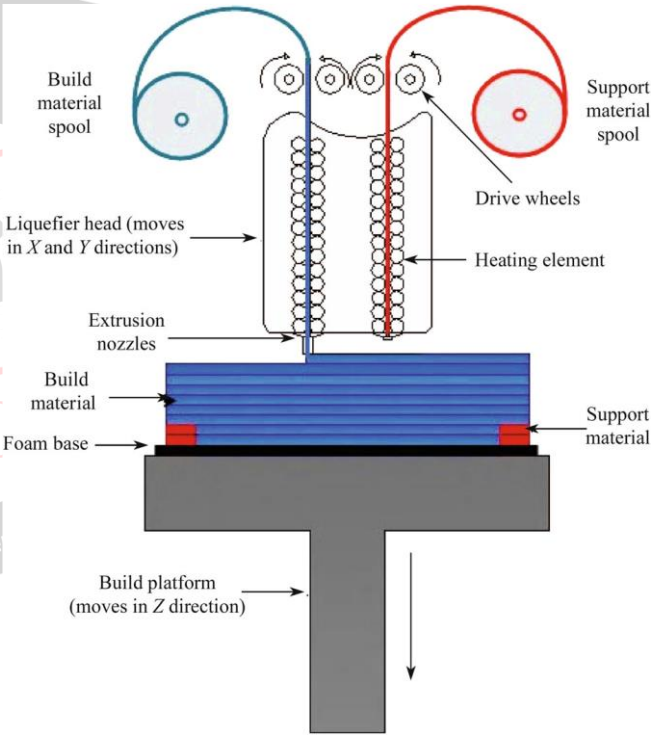

Figure: Principle of FDM process [1]

II. LITERATURE SURVEY

This literature survey contains the effects of process parameters which is given by many researchers.

C.S. Lee et al. [2] have given the anisotropic properties of RP parts fabricated by using three different process. In this study author uses three different process namely FDM, 3D printer, NCDS to make compression test specimens by using ABS, zp102(plaster powder) and acrylic- hydroxyapatite composite material. It was found that FDM parts had high compressive

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strength. As compare to other process 3D printer part shows less compressive strength.

Sandeep Raut et al. [3] studied the mechanical properties and total cost of FDM made part upon which the effect of built-up orientation is given. In this study tensile and Flexural specimens were prepared in a different built-up orientation and with three geometrical axes using ASTM standard. The results of their investigation shows that part made by FDM process had good tensile strength and minimum cost when there is a 0° built up orientation about y-axis. And when FDM parts made with 0° built up orientation about x-axis showed good flexural strength and minimum cost.

R. Srinivasan et al. [4] studied the parts made by FDM on which tribological properties was performed. In this study specimens are made up of ABS and CPFLA material. Author considered three type of parameter namely infill density, infill pattern and layer thickness. As considered wear strength for CFPLA and ABS infill pattern and layer thickness gives a major impact. Very low wear rate found at 80% of higher infill density with 0.075 of minimal layer thickness.

Syed H. Masood et al. [5] have studied tensile properties of FDM made partes by using polycarbonate material. Also studied effect on tensile strength due to process parameters. The parameters considered in this study are air gap, raster width and raster angle. The results shows that raster width 0.6064 mm gives the highest tensile strength. On tensile properties air gap is mostly affected.

B.H. Lee et al. [6] studied the effect of parameter on elastic performance of prototype which is made by using ABS as a material. Study gives maximum throwing distance by optimising the parameters. For this study Taguchi and ANOVA method is used. Results show that for 10° angle to get maximum throwing distance air gap is most affected parameter. And for 15° angle raster angle and layer thickness, and for 20° angle layer thickness are most affected parameters to get maximum throwing distance.

Dinesh Yadav et al. [7] have studied the effect of parameters on functionality, design quality and mechanical properties of final product. In this study test pieces are made using three different material and tensile test is carried out. ABS, PETG and Multi-material are used in this study. The effect on tensile strength due to infill density, extrusion temperature and material density is carried out. Most affected parameter on tensile strength is extrusion temperature. The PETG material shows maximum tensile strength up to 44 N/mm2 which is observed at extrusion temperature of 225℃ and 40% infill density.

Devesh K et al. [8] studied the compression and bending test for automobile application parts for which parts are made from FDM process by using ABS as a material. Bumper and pillar trim are considered as automobile components. Compression and bending properties are most affected by infill patterns and build orientation. Rectilinear infill pattern (i.e.45.39Mpa) at 0° orientation gives maximum bending strength. Gyroid infill pattern (i.e.24.47Mpa) at 0° orientation gives maximum compressive strength.

Mst Faujiya Afrose et al. [9] studied the dog-bone size specimens tested for tensile properties and made from material Polylactic Acid (PLA). From the results it is found that PLA parts are stronger when printed in X-build orientation than when parts printed in Y- and -45 build orientation.

Duraibabu R V et al. [10] Studied the pore shape made from ABS material to understand the energy absorption under compressive lodind. Four different type of pore shape are considered in this study. The different shape are hexagon, square, cylindrical and triangular. From this shape hexagonal pore absorb maximum energy under compressive loading.

Table- Summary of published work on FDM process

Author	*Material used*	*Process parameters*	*Measured output*	*Method*
C.S. Lee et al. [2]	ABS, zp102(plaster powder),acrylic-hydroxyapatite (40 wt%)	Build direction	Compressive strength	Three RP processes used in this study namely FDM,3D printer ,NCDS to form a specimens to measure compressive strength
Sandeep Raut et al. [3]	ABS	Built-up orientation	Total cost, Tensile and Flexural strength	STRATASYS FDM with CATALYST software machine used to form a specimens to take Tensile and Flexural test
R. Srinivasan et al. [4]	CFPLA, ABS	Layer thickness, Infill pattern , Infill density	Wear rate	Specimens of ABS and CFPLA are fabricated by using 3pro printer under ASTM standard.
Syed H. Masood et al. [5]	Polycarbonate	Raster angle, Air gap, Raster width	Tensile strength	A new FDM Vantage system is used to produce Polycarbonate parts on which tensile test are carried out
B. H. Lee et al. [6]	ABS	Layer thickness, Raster angle, Air gap, Raster width	Elastic performance	Part are made by using ABS as a material by using FDM process. ANOVA used to find out contribution of each parameter

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Dinesh Yadav et al. [7]	ABS, PETG	Extrusion temperature, Infill density, Infill pattern	Tensile strength	Test specimens are made by using three type of material. Tensile testing is done by using UTM.
Devesh K et al. [8]	ABS	Orientation, Infill pattern	Bending and compressive strength	A total of 12 specimens have been fabricated. SolidWork used for modelling. Testing done by using UTM.
Mst Faujiya Afrose et al. [9]	PLA	Build direction	Tensile strength	Specimen of shape dog-bone are created. For testing Zwick machine used
Duraibabu R V et al. [10]	ABS	Pore shapes	Compressive strength	Different type of pore shapes are used. Absorbed energy calculated.

III. Conclusion

All process parameters are taken part in output performance. From study we can conclude that;

- FDM parts had high compressive strength when build in Axial direction
- Cost can be reduce by optimizing the parameter.
- We are also able to minimize wear rate by optimizing the parameter
- Hexagonal pore is able to absorbed maximum energy under compression
- Maximum tensile strength could be obtain for Air gap of type solid normal

Scope for future work

There are also other parameters which are not considered in this study like humidity, part shrinkage. By study we can also find out effect of this parameter

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