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Literature Survey for Effect of Process Parameters on Surface Roughness of 3D Printed Parts with Fused Deposition Modelling

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Abstract: A current manufacturing scenario focuses on processes which can manufacture products at highest quality with minimum wastage of material. Additive manufacturing is one such technology which can fulfil demands of today's manufacturing organisation. Fused Deposition Modelling is a 3D printing process from additive manufacturing family to build polymer component accurately with almost negligible wastage of material.

***IndexTerms* - Additive manufacturing, Fused deposition modelling, Surface roughness, Build orientation, Layer thickness, Infill density.**

I. INTRODUCTION

The fabrication of components from a CAD model by stacking and merging layers to achieve the desired physical model is referred as additive manufacturing [1]. Among all the advanced manufacturing processes, additive manufacturing uses the required amount of material possible while maintaining the desired level of dimensional accuracy [2]. There are many AM processes which can manufacture any integrate shape from wide range of materials like polymers, resins and metal powder. Fused Deposition modelling (FDM) introduced by Stratasys in the year of 1991 it is one of the most widely used type of additive manufacturing process for polymers [3-4]. The steps in involved 3D printing are shown in Figure 1.1. The process of 3D printing starts with generation of CAD model of an object to be printed. The second step, convert the CAD file into STL format. This format is chosen from the name stereolithography (STL) which is the first additive manufacturing process. In third step pre-processing software slices the STL model into a number of thick layers. The thickness here may be defined depending on the application of model. Here a support is also generated which will support the model during the actual manufacturing. This is very important when manufacturing delicate parts. The last two steps are layer by layer construction of model and its cleaning and finishing [5-9].

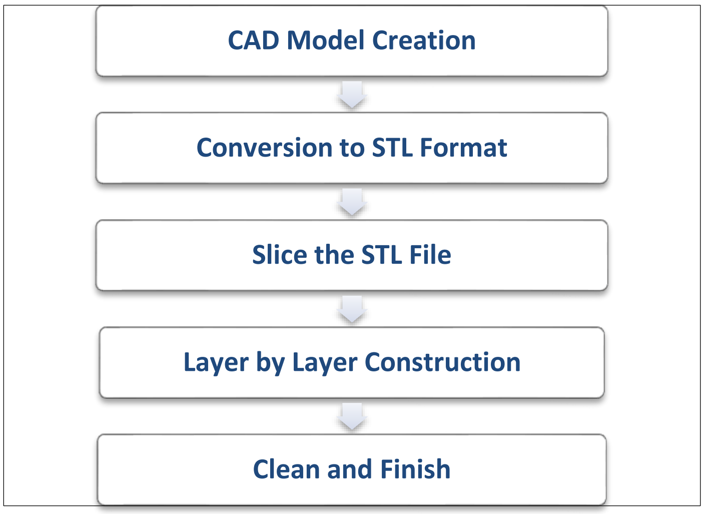

Fig.1.1. Steps in 3D printing [8]

In FDM raw material in wire form is fused in thermostat and deposited through a nozzle which follows the path defined by a computer program to create a 3-Dimensional object. After completing deposition of one layer the bed lowers or the nozzle kit raises to successfully fabricate the adjacent layer [10]. The performance of Fused Deposition Modelling depends on process parameters like layer thickness, raster width, air gap, build orientation, infill density, printing speed etc. The performance is measured in form of surface roughness, build time, material consumed and sometimes in form of strength of material.

To assess performance of FDM and quality of manufactured parts with FDM, apart from size and shape surface roughness is most important aspect. Altan et. al [11] in their study used L_{16} array with variation in layer thickness from 0.1 mm to 0.4 mm to fabricate PLA samples using FDM. For above layer thickness they found variation from 9.102µm to 10.275 µm in surface roughness. According to them, layer thickness and deposition head velocity are most influencing parameters in surface roughness. According to Gautham et al. [12] in the surface angle range40-90°, the rate of variation of surface roughness (Ra) is lesser than in the 0-40° surface angle range. With layer thickness of 0.2 mm, printing speed of 60 mm/s, and the extrusion temperature of 240 °C lowest mean of surface roughness can be found [13]. Akande et al. [14] found range of surface roughness varies from 2.46 to 22.48 µm with a layer height varying from 0.25 to 0.5mm. Vasudevarao et al. [15] sets different parameters to determine surface roughness and proved that Layer Thickness and Part Orientation the factors which has highest impact on the surface roughness. A layer thickness of 0.007 inches and orientation of 70° have best surface finish. Model Temperature, air Gap and Road Width did not have much influence on the surface finish of the part. Pandey et al. [16] considered side angles of 10°, 15°, 30° and 45° with layer thickness of 0.254 mm for the pyramid specimen for assessment of the surface roughness. They have derived a model for surface roughness based on layer thickness and build orientation. Smaller layer thickness indicates smaller layer height during printing therefore at smaller layer thickness better surface can be found [17]. Byun and Lee [18] studied several Rapid Prototyping techniques, they have found the best build-up direction when a part is created with variable layer thickness.

The procedure considers the average weighted surface roughness (AWSR) caused by the staircase effect, as well as the build time and part cost using variable layer thickness. According to Khan and Mishra, air gap has highest impact on surface of ABS printed parts [19]. Surface roughness can be improved by lowering the layer thickness [20]. The surface roughness of FDM printed specimens is investigated by Galantucci et al. [21] and found that slice height and raster width are particularly essential factors for surface roughness considerations, whereas the tip diameter is less important for surfaces that run parallel or perpendicular to the build direction.The optimum surface roughness can be found by combination of higher infill density and lower layer height [22]. According to Mendricky and Fris [23], layer height, top layer shape, and fill print speed are the most influential parameters on the surface roughness of the top layer whereas layer height and the orientation of the part on the base have influence on surface roughness of the side wall. Though a lot of research has been done on surface roughness of FDM printed Parts. Lot of scope is still there to make a detailed analysis of surface roughness to find out working range of process parameters for FDM.

II. ACKNOWLEDGMENT

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