A Review on volumetric error in Rapid Prototyping Fused Deposition Modeling

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A Review on volumetric error in Rapid Prototyping Fused Deposition Modeling

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Abstract : Rapid prototyping technology comes at the end of the 19th century. A 3D model in computer Aided Design (CAD) can be converted into a 3D Product. Rapid prototyping is one of the best technologies to fabricate complex and intrinsic parts.
In rapid prototyping part formed addition of layer by layer material. This paper reviews the volumetric error in rapid prototyping. The principle and classification of rapid prototyping presented. In this paper our main focus on to highlight issue occurs in rapid prototyping part fabrication in Fused Deposition Modeling (FDM)

***Keyword* - Rapid Prototyping, Computer Aided Design (CAD), 3D Product, Fused Deposition Modeling (FDM)**

I. Introduction

In today's manufacturing industry product development team focus on two important things i) To reduce manufacturing time & ii) To improve flexibility of manufacturing by assuring quality product to customer.

This leads to invention of additive manufacturing & subtractive manufacturing. In subtractive manufacturing to cut complex part or part having intrinsic feature is quite difficult and it is time consuming. In subtractive manufacturing required jigs, fixture and costly cutting tool which can be suitable for CNC machine and lathe machine.

In additive manufacturing the part can be fabricated by adding layer by layer material to complete part. It required less time and suitable for batch production.

Basic principal of Rapid Prototyping

Rapid Prototyping is an additive manufacturing process in which part is fabricated by deposition of material layer by layer. Part fabricated by deposition of layers contoured in (xy) plane and increment in Z direction is depends on layer thickness due to this stair-step effect is produced. In literature review it observed that smaller layer thickness leads to model toward original part & also reduces the surface roughness [1]. Actual part fabrication process steps are shown figure 1

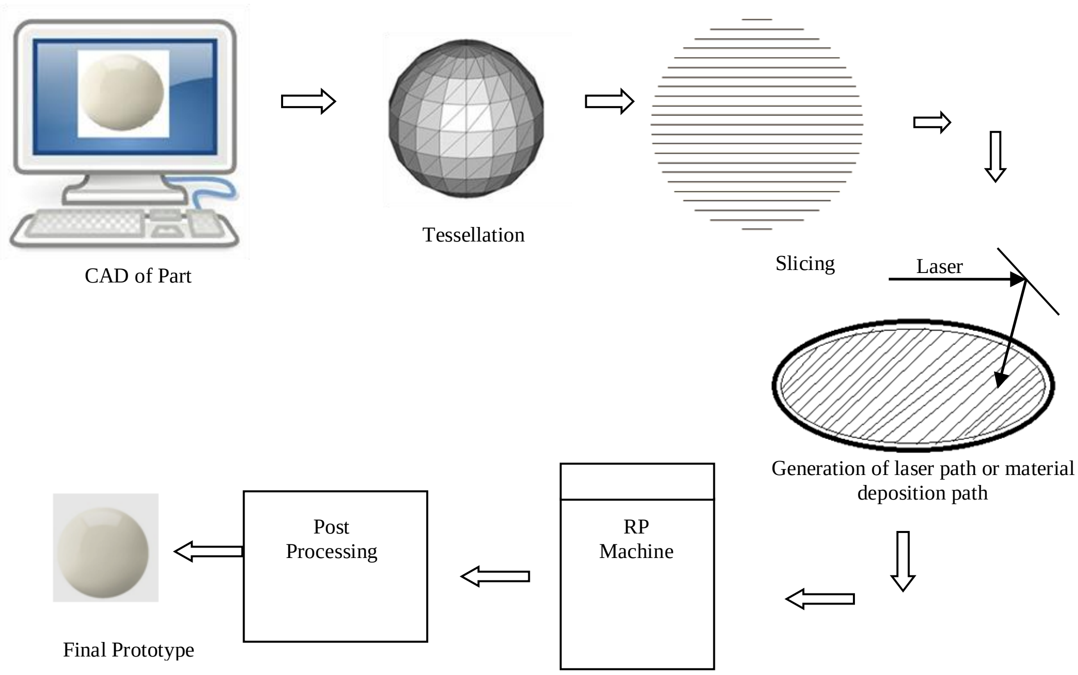
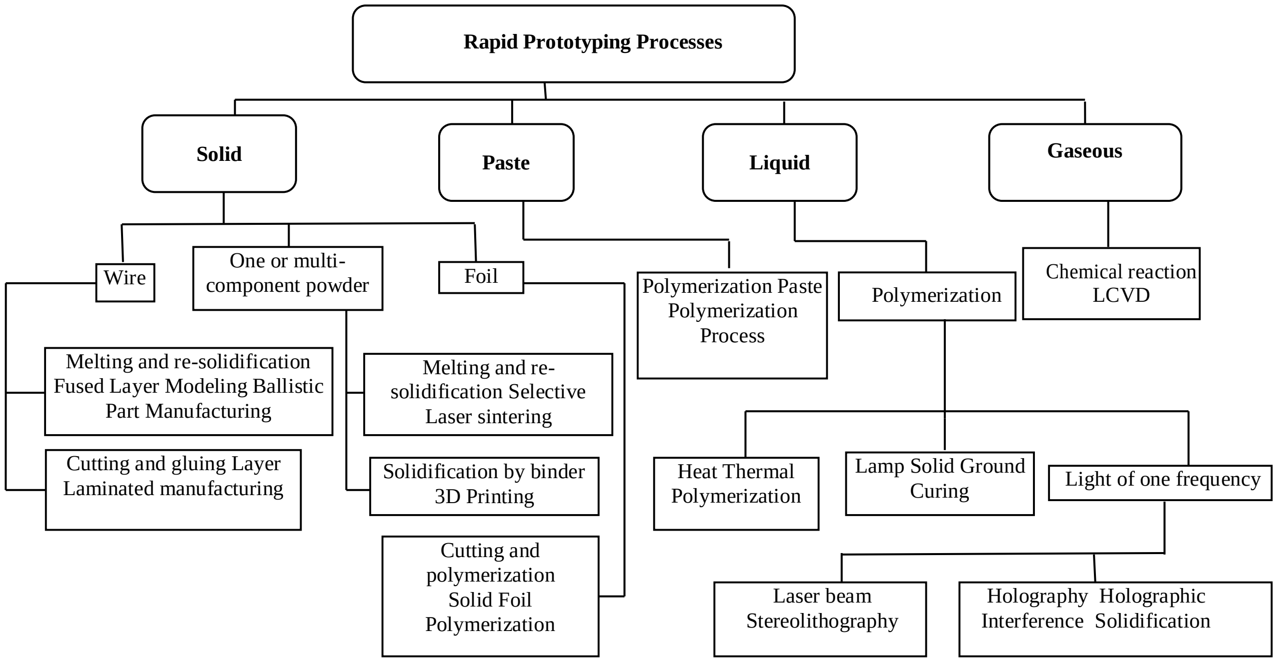


Figure 1 Rapid Prototyping Part fabrication Process

As process starts with generation of 3D Model then transfer that model to .stl file (stereolithography file format) that means tessellation of model takes place, after this tessellation this model is sliced as per desired layer thickness and on each slicing the SLC (stereolithography contour) is generated & store in standard format.

The rapid prototyping model is fabricated in RP machine. The physical model is made by one of the process like 3D printing, stereolithography, Selective leaser sintering, fused deposition modeling and Laminated Object Manufacturing. Classification of rapid prototyping process as shown in flow chart 1[2]



Flow chart 1

Rapid prototyping technology moves toward commercial rapid manufacturing. To get smooth surface or to improve surface roughness layer thickness plays an important role. If slicing thickness is small it gives smooth surface and reduce cost of post processing like sanding, filing, etc. In the finishing of model layer thickness, road width, air gap and model temperature plays an important role in Fused Deposition Modeling

II. EFFECT OF LAYER THICKNESS

Layer thickness decides the height of the stair step for example if layer thickness is large more stair-step effect produced in the following Figure 3 It illustrates the effect of various layer thickness on stair-step effect.[3]

This constant layer thickness produces more volumetric losses for curved shape product. As shape is more from linear to nonlinear the stair-step effect is dominated. Smaller the layer thickness better is the surface finish. So it is advisable to move towards adaptive slicing.

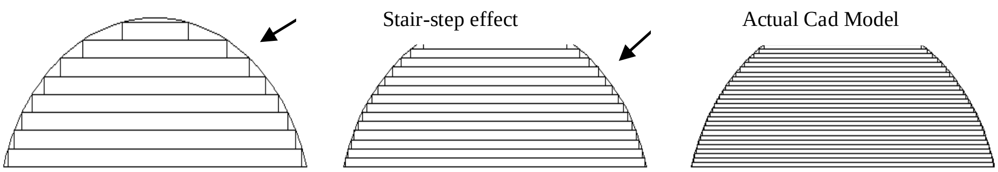


Figure 3 Part with different layer thickness a) Layer thickness 2mm, b) Layer thickness 1mm, c) Layer thickness 0.5mm

III. AIR GAP BETWEEN ROADS

Due to geometric constraint nozzle path in fused deposition model the air gap is produced. Figure shows a road width and layer thickness. The gap in the nozzle path shown in figure 4

Air gap between the two roads is also main factors which affect the surface roughness. Lesser the road gap better surface finish obtains [3].

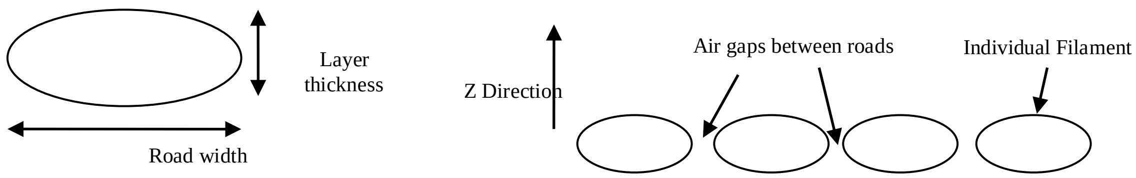


Figure 4 Air gap between roads in Horizontal plane

IV. MODEL TEMPERATURE

It is the temperature at liquefied chamber where model material is in melt condition. It varies material to material. The variation of model temperature for same material affects the surface roughness. If temperature of filament is high fluidity of material is good so rounding is pronounced as shown in figure 5. If model temperature low rounding is less pronounce.

a) Rounding at high temperature b) Rounding at low temperature

Figure 5 Effect of model temperature on the shape of filament deposition

V. INTERNAL DEFECTS

These defects are produced in FDM during formation of parts [5]. The following defects are mainly observed in FDM

I. Voids due to nozzle path-
In the raster nozzle path for the geometry is shown in figure 6 as there are some gap accrues during the material deposition.

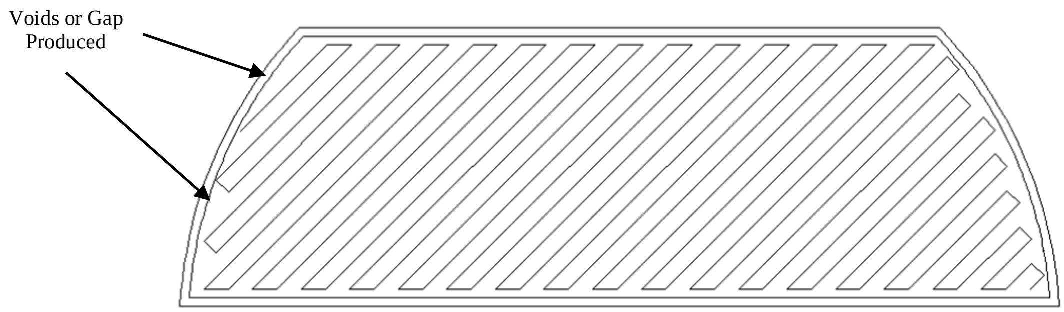


Figure 6 Voids due to nozzle path

II. Non uniform filament diameter-
Non uniform filament diameter is also one of the reasons for gap produced in material deposition path.

III. Non sequence of raster segment- In this case the material deposition path segment brakes and start as per convenient of path trajectory because of this gap has been produced

VI. CONCLUSION-

This paper provides an overview of errors produced during Fused deposition modeling Process also classification of rapid prototyping processes. Layer thickness affects the stair-step effect. Smaller the layer thickness lesser the stair-step effect and vice a versa. As the model temperature increases filament rounding is more pronounced so lesser the gap between two adjacent layers. The voids produced in FDM part is depends on the tool path strategy and filament cross section

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