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Design and Analysis Of FDM 3D printing nozzle

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ABSTRACT

FDM process is increase day by day in industrial sector. The purpose of this project is to find different geometrical shapes of nozzle outlet which can be used to make decorative products also to find strength of the product. Fused deposition modeling (FDM) is the low cost additive manufacturing (AM) process uses polylactic acid (PLA) materials to fabricate prototype parts from a CAD & solid works model. The melt flow through nozzle is studied in terms of the pressure drop, nozzle outlet velocity and axial temperature is studied by varying material property and nozzle geometry.

Keywords – FDM, PLA, nozzle geometry

1. INTRODUCTION

Additive manufacturing process is widely used in industrial sector. As there are many AM process such as, stereo lithographic (SLA), selective laser sintering (SLS), fused deposition modelling (FDM).

As FDM process is widely used because the FDM system has multiple operations as feeding a thermoplastic filament into a nozzle zone heating the filament using heating coils flowing the melt through a liquefier nozzle depositing the melt on a heated platform and finally cooling the deposited materials to make the final product[1]. FDM process are used in many sectors such as aerospace, biomedical application and also in automotive parts.

In FDM different material can be used as polylactic acid (PLA), Acrylonitrile Butadiene Styrene [ABS], plastic, high impact polystyrene, ceramic etc. The printing quality depends upon various factor as nozzle feed rate, heat release to nozzle, viscoelastic property of the polymer, melt flow rate, cooling rate of deposition material and bed temperature [2].

The FDM extruder is used to control the flow rate of the material and also archived high quality finished parts. The feed rate controls the amount of melt present in the liquefier, temperature of the melt, viscosity, and surface energy. As the geometrical shape of a nozzle is change the output gets differ in pressure drop, nozzle angle, nozzle diameter.[3]

If melt temperature is low in that case the output is not uniform and pressure drop increases which leads to buckling.

In this experiment we have to study different geometrical shapes such as triangle, circle etc., and to analysis the different output and check the flow rate. It means the cross section shape of melted polymer coming out of a nozzle will change depend on the nozzle geometry.

2. DESIGN OF NOZZLE

In this study we have design different shapes of nozzle by solid work software. We have design a equilateral Triangle of side 0.4mm. in this case nozzle is made up of brass.as material brass has low heat releasing capacity And size of the is standard as per the ultimaker machine. This tensile model is made up of PLA material. The small nozzle diameter and layer thickness will give good printing quality mainly in the precision of product. In this study we have used PLA with nozzle hole diameter 0.4mm and layer thickness is 0.1 mm. the use PLA material with printing temperature 220 degree Celsius and hole diameter of 0.4mm shows the decrease in the layer height and give good surface finish to the product.

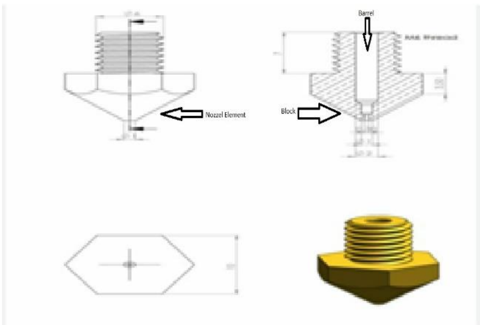

Fig. 1. Design of Nozzle

Our aim is to design a nozzle that will improve the extrusion speed, part quality, and process repeatability for a low cost 3d printer. The barrel is 0.4 mm diameter

As the small design and advanced control will contribute to faster and higher quality 3d prints for variety of material. The accurate control of the temperature, pressure, and the flow of plastic through the nozzle helps to maintain material uniformity at the outlet. Manufacturer use plastic pellet to create diameter spools of filament for deposition-based process, because the filament has to go extra manufacturing process.as these systems convert pellets into spools of filament used on FDM based 3d printer

The strength of the smaller is used to increase the resolution print. The nozzle element is brass material

3. NOZZLE ELEMENT

In all component of 3d printer nozzle comes the last part of 3d printer which helps extrude the melted filament and deposited on the build platform in the required geometry .nozzle is available in various size and shapes as per the requirement. The size and material determines the print quality and printing time, and the strength of 3d pint. The material used is brass which has low heat releasing capacity.

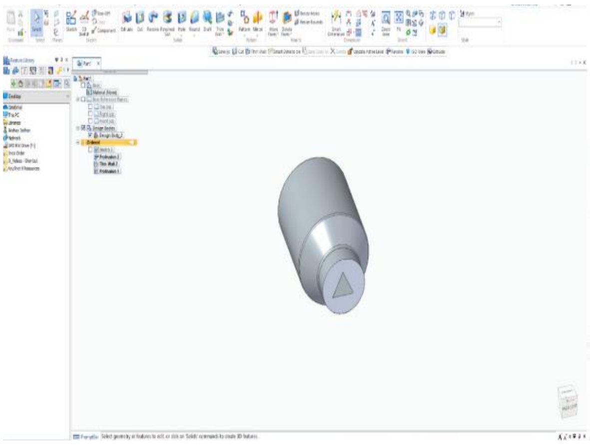

Fig. 2. Design model of triangle of side 0.4

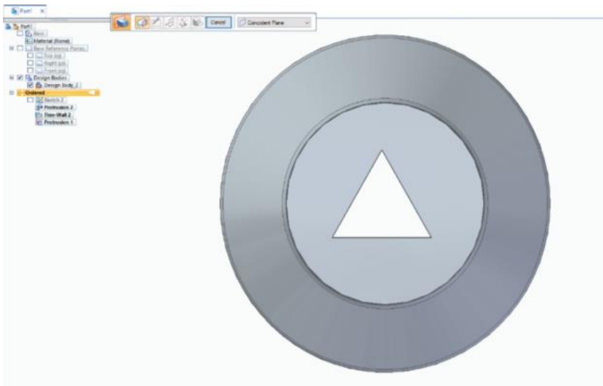

Fig. 3. Design of Triangular Nozzle

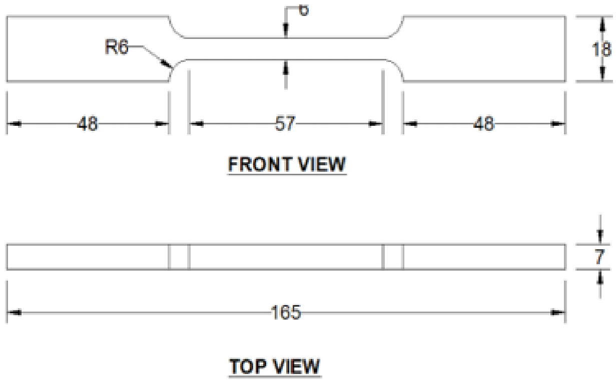

Fig.4.Tensile Test model

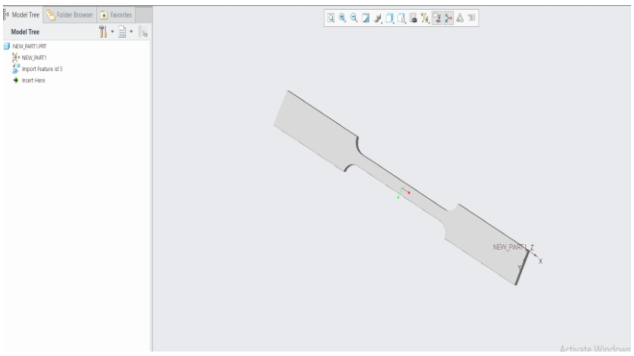

Fig.5.Tensile Test model in solidwroks

4. NOZZLE MANUFACTURING PROCESS

In this study we have manufacture the nozzle through micro laser cutting machine. In this laser cutting the mechanical component with thickness from 0.05 to 1.5 mm are machined. The micro laser cutting is mainly used where high geometric precision or very narrow opening is needed in relation to the material thickness, even smallest and very fine contour can be cut precise and with highest dynamic. Is has minimum heat impact and high speed. The laser cutting has maximum accuracy for difficult parts. For some application the fixed beam is use with part moving under the beam to create the desired design pattern .in this process various material are cut with precision such as brass, copper, aluminum, fiber glass and plastic material. This process comprises different mechanism as cutting, drilling, marking, turning, threading etc.

5. MATERIAL PROPERTIES

In this study it's important to select the material to get required output. In this case we are selecting polylactic Acid (PLA).As this material has good mechanical properties the most important property of this material is that it has greater Yield and tensile strength than ABS material. The thermal conductivity of PLA be constant as 0.195 W/m-K. Heat transfer coefficients. For barrel, block and nozzle are taken as 13.6, 18.6 and 22.9 W/m2-K. Respectively.to model the barrel, block and nozzle, material properties of aluminum and brass are used. The constant properties of density, specific heat and thermal conductivity for aluminum barrel and block were taken as 2719 kg/m3, 871 J/K-kg, and 202.4 W/m-K, respectively. The constants of density, specific heat and thermal conductivity for brass nozzle were 9490 kg/m3, 380 J/kg-K, and 109 W/m-K,

6. FINITE ELEMENT ANALYSIS

In thus study we have done FEA of nozzle to check the pressure drop, velocity of the material output through nozzle. The equilateral triangle has outlet of side 0.4 mm, FEA model demonstrating the equivalent stress Model is subject to a tensile load of 5,000N. The peak stress in red occurs adjacent to the

Bend radii. PLA reaches its melting point (175°C) after crossing two-third of the liquefier barrel and as soon as it enters the nozzle section, the PLA temperature is almost uniform and a fully developed melt flow is achieved. At the entrance of nozzle barrel, the temperature quickly rises to approximately 150°C and then it increases gradually to 220°C at the midsection of the block. At the nozzle tip, temperature again drops to 218°C. This shows a temperature variation of 70°C between the entrance of liquefier barrel and block. But PLA melt temperature reaches to 218°C and show uniform distribution in nozzle section.

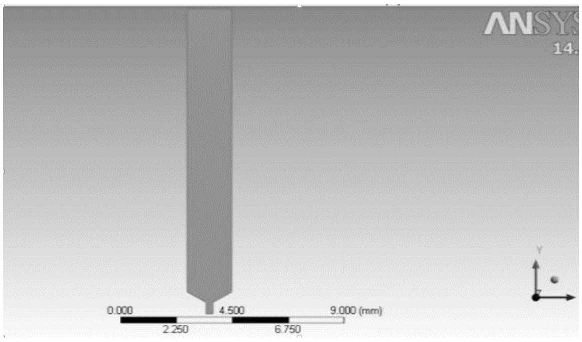

Fig.6.Nozzle Diagram

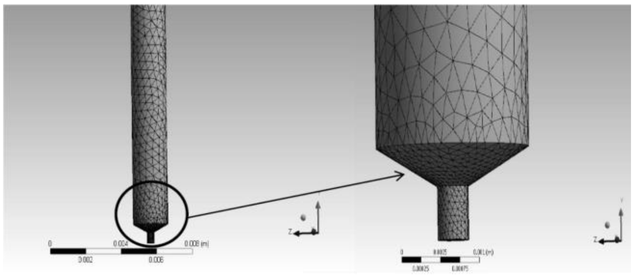

Fig.7.Meshing

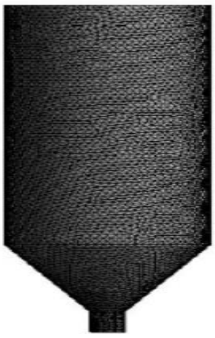

Fig.8.Meshing

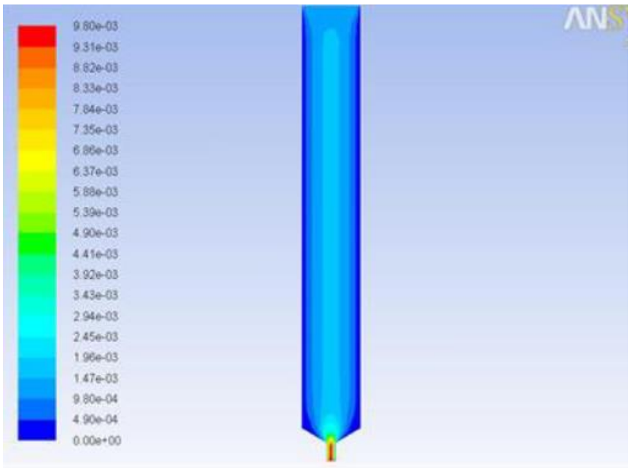

Fig.9.Velocity Analysis

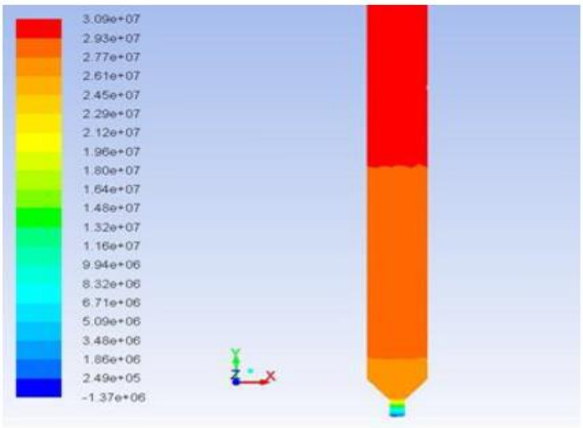

Fig.10.Pressure Drop

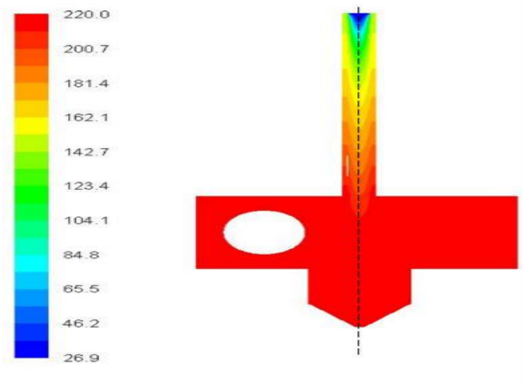

Fig.11.Temperature analysis

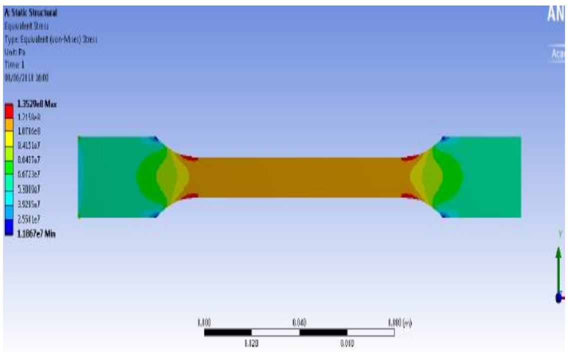

Fig.12.Analysis of tensile model

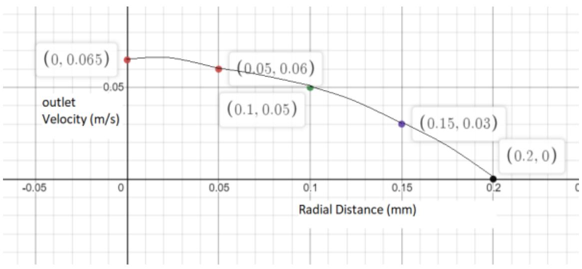

Fig.13. Velocity Gradient

Table 1:.Printing parameter:

Printing parameter	value
Nozzle temperature	218 degree Celsius
Bed temperature	40 degree Celsius
Printing speed	80mm/s
Layer thickness	7mm

Table 2: Property of materials: -

Property	PLA	ABS
Printing temperature ©	180-230	210-250
Biuld flatform temparature	20-60	80-110
strength	high	medium
flexibility	brittle	moderate
biodegradability	YES	NO

Table 3: Paramentre to produce tensile model by triangular & circlur shape

parameter	triangular	Circular
Time required	9 min 58sec	11min 10sec
Nozzle temperature	216℃	220℃
Bed temperature	180℃	195℃
Surface finish	Good	Not so good
Accuracy	more	Lesser than triangular
Material used	PLA	PLA
Nozzle material	brass	brass

6. RESULT & DISCUSSION

In this this study we have observed the time required for creating model By triangular outlet nozzle is less than the circular outlet nozzle, We also have observed that the accuracy is better than circular shape. And we can produce many decorative parts as per our requirement.

As time of production is reduced ultimately the cost of the product is reduced. And also, the quality of product is good compare to others. Surface finish is good compare to other nozzle. The strength of the part is strong.

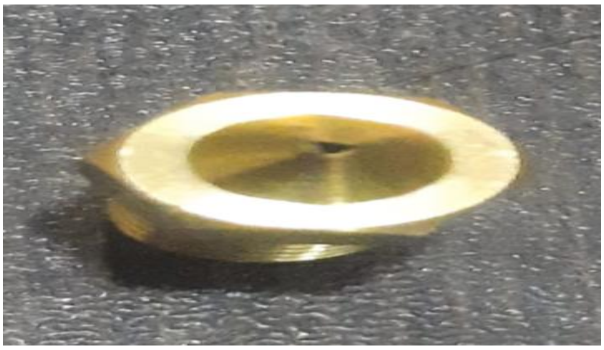

Fig.14.Triangular tip of the Nozzle

Fig.15.Actual Tensile Test model

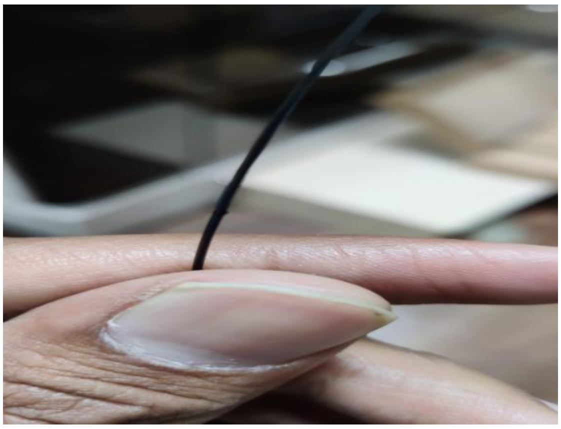

Fig. 16.Output wire of triangular shape nozzle

7. CONCLUSION

In this study we have successfully design the triangular shape nozzle and model is created also we have check The melt flow characteristics of thermoplastic PLA have been found by studying the thermos-fluidic model of complete FDM assembly. Pressure drops and velocity gradients were find for different geometrical shapes. The triangular nozzle shape reduces the time of production. Also, it helps to fabricate different shapes product. This nozzle helps to give better surface finish than other geometrical shapes. The tensile strength of the product is high compare to circular shape. As the time production is reduced it ultimately reduced the cost product.

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