Effect of Different Infill Shape Geometry on the performance of 3D Printed Components

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Abstract: **3D printing can provide the end-use product which reduces the different processes needed for conventional manufacturing techniques. With the help of FDM polymer prototypes which are basically used to simulate the actual condition of the components. The quality and strength of the FDM printed components depend on the different process parameters like built orientation angle, the material used, infill density, infill shape geometry, extrusion rate, rate of printing, and many others. This work is mainly focused on the effect of different infill shape geometry on the tensile strength of different materials. It also identifies the deformation behavior of different materials at different infill shape geometry. Through experiment, it is found that for different materials different infill shape geometry shows the maximum tensile strength. No, any particular infill shape geometry shows the optimum values for all the materials.**

***Keywords*: Fused deposition modeling, material, infill geometry, deformation behavior, tensile strength**

1. Introduction

Additive manufacturing is producing everything from human organ replacement to printing footwear and chocolates and many more example available in the market. Additive manufacturing products are vast and increasingly entering all unexplored segments. The additive manufacturing boundary is limitless and its ability to produce all sectors products with accuracy. Its adoption in the medical application, large-scale industrial applications with lightweight products, and lowers production cost. In 2014 Make in India was launched by the Prime Minister as a way to transform the Indian manufacturing sector into a global manufacturing and design hub. In the future companies in India are beginning to reorganize their work to incorporate additive manufacturing into their commercial manufacturing process by simulating the printing layer by layer in all the manufacturing sectors. Additive manufacturing solution provider companies are trying to meet this emerging requirement by targeting manufacturing engineering and several simulations which engaged with manufacturing hubs located in Hyderabad, Bangalore, Pune, Delhi, and Mumbai. There is an educational, aviation, defense, automobile, medical manufacturing organizations are encouraged to create and customize products in India.

Normally with the help of controlling or operating software, the infill percentage can be set from 0 (hollow) to 100% (completely solid). For non-functional prototypes application, mostly 20 % infill density was considered which is cost-effective, low weight and the main thing is effective printing time. In order to make 3D printed components stronger everyone knows that they have to print the component with 100% infill density. But with increasing the percentage of infill density the cost and time required for building the components should get increased. So, to reduce the cost and printing time of components it is necessary to first know the end requirements of users for which they are using the 3D printed components and according to that optimization of infill, density can be done. Many of the researchers have already studied the effect of infill percentage on different components. Here in this work, the infill density of the samples in each case remains constant that is 80%. This work is mainly focused on the effect of different infill shapes geometries that are used to fill the sample on mechanical properties of specimens and their deformation behavior. There different shape geometric pattern was considered in this work that is concentric, line, and triangular.

2. Different types of infill geometry shapes

2.1 Lines shape - In this case, the simple line at the 45-degree orientation is used to fill the inside portion of the specimen.

2.2 Concentric Shape - Here concentric shape pattern is used to fill the inside portion of the 3D printed specimen, the concentric shape pattern used for filling

2.3 Triangular shape pattern- In this case, triangular shape geometry is used to fill the specimen.

3. Experimental setup

Total nine sets of experiments were performed with three different materials having three different infill shapes. The design of the set of an experiment that was considered during specimen printing is mentioned in the table. J-hot end type FDM printer is used to build the specimens of different cases. for each case three- three samples were prepared and average data was coated in this report. in this works blue color filament represents the PLA material, White color represent the ABS material and black color represents the PETG material.

Table.1 Set of experiments considered during the work

S. No.	Material	Infill Density (%)	Infill pattern
1	PLA	80	Lines
2	PLA	80	Concentric
3	PLA	80	Triangular
4	ABS	80	Lines
5	ABS	80	Concentric
6	ABS	80	Triangular

7	PETG	80	Lines
8	PETG	80	Concentric
9	PETG	80	Triangular

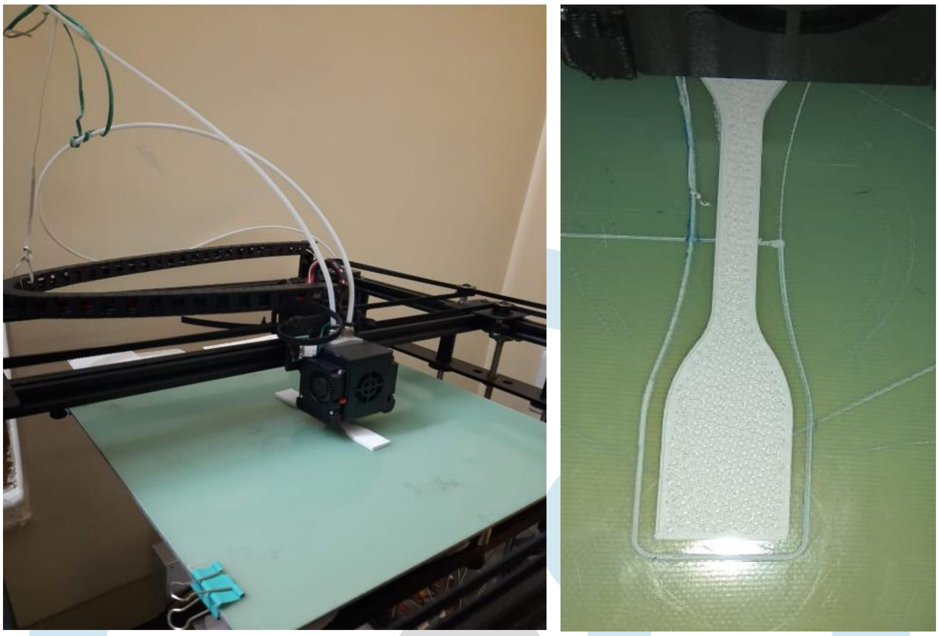


Fig.1 Shows the FDM printing of concentric shape fill ABS material specimen

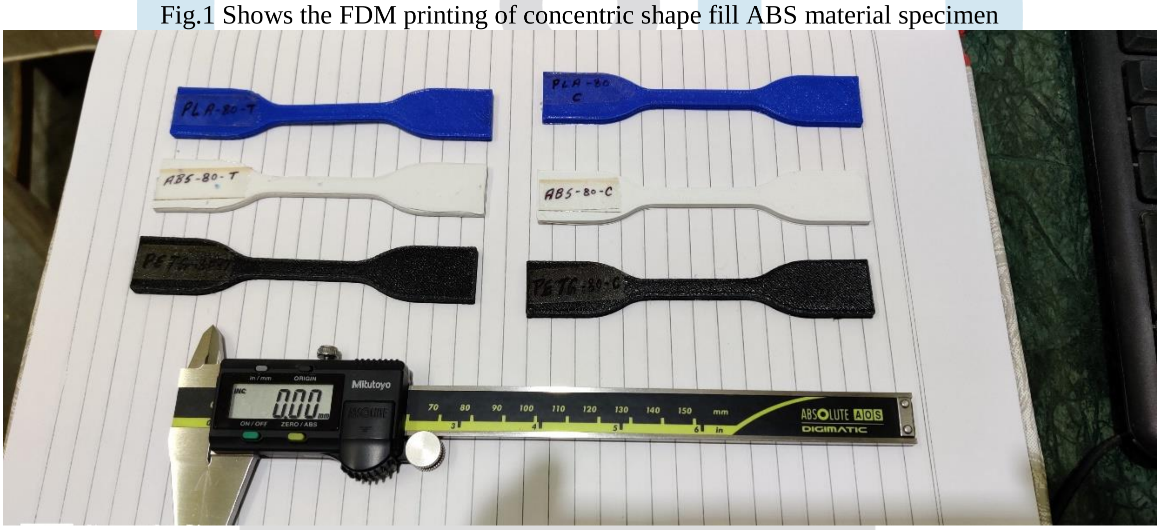
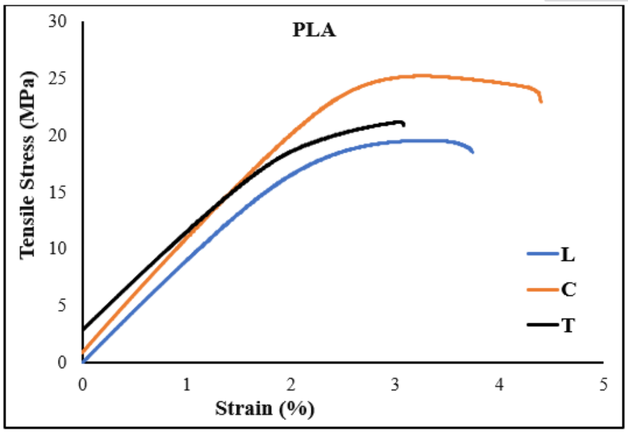
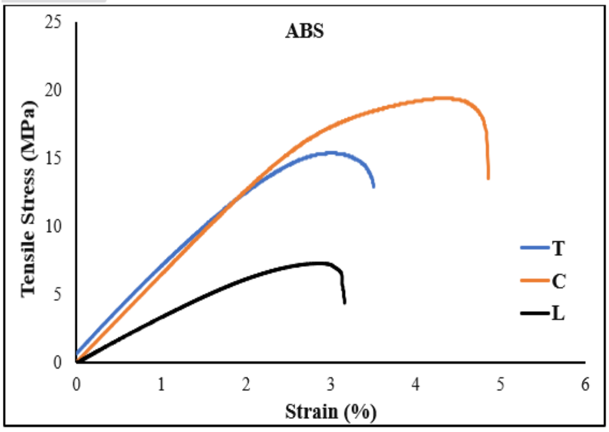


Fig.2 Shows the triangular and concentric set of samples for tensile testing

4. Result and discussion

After sample preparation and unidirectional tensile testing of each sample, the result was evaluated. The tensile strength of the FDM sample depends on the material used, infill density percentage, infill pattern, bonding in between two adjacent layers, and others. It mainly focuses on the deformation behavior and tensile strength of different materials having different infill shape geometry. The results are





categorized into two sections, first section considered the tensile strength and deformation behavior of the same material at different infill shape geometry, whereas in the other section tensile strength and deformation behavior of different material at the same infill shape geometry was evaluated.

Fig.3 Tensile stress-strain graph of PLA and ABS material having different infill structure geometries

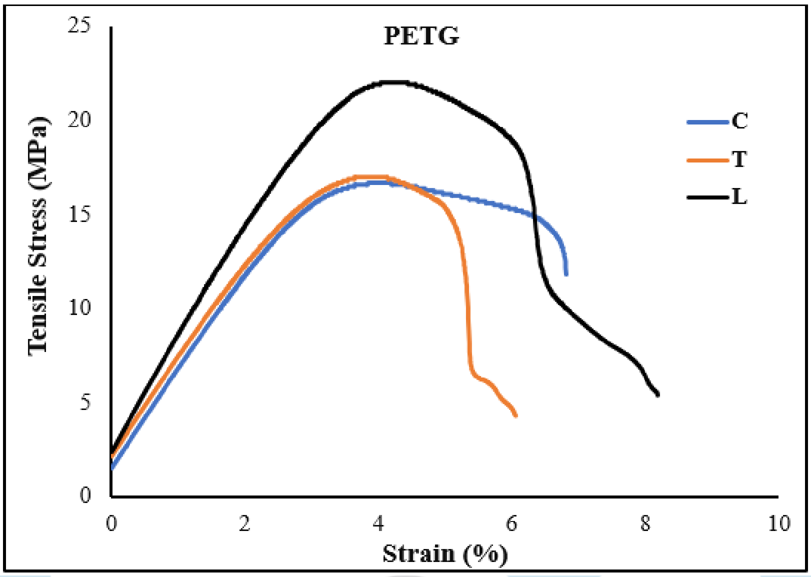


Fig.4 Tensile stress-strain graph of PETG material at different infill structures

From graph it is found that there is a marginal different of tensile strength in between lines and triangular shape of geometry. Whereas for PLA material concentric shape structure shows the highest compressive strength as compared to other infill structure geometry. Through graph it is analyzed that for each case of infill structure, the compressive stress increases with increase in strain and after reaching to yield stress it starts decreasing. Beyond yield stress gradual decrement of stress is found which shows the indication of permanent plastic deformation. Through graph it is found that for PLA material, the concentric shape of infill geometry shows the maximum strength as compared to another shape of infill geometries. From the stress-strain graph of ABS material, it is found that concentric structure infill geometry shows the maximum tensile strength as compared to triangular and lines shape structure geometry. The elongation of concentric material is also more as compared to other two materials. ABS material with different infill structures shows the plastic deformation behavior and after a certain percentage of elongation, it gets a break. In PETG material lines infill structure geometry shows the maximum tensile strength as compared to other geometries. There is a marginal difference in between concentric and triangular shape geometry specimens in terms of yield strength, whereas the yield strength of the line geometry is significantly high as compared to other. One thing that is also observed from the PETG graph that is beyond yield strength the plastic elongation of PETG material specimen is much more as compared to PLA and ABS material. This shows the more ductility behavior of PETG material as compared to PLA and ABS material.

5. Conclusion

The deformation behavior of the Specimen is mainly depending on the base materials and has less influence on infill shape geometry. For PLA material, the concentric shape of infill geometry shows the maximum tensile strength, whereas for ABS material the same thing is happing. In the case of PETG material, the line shape of infill geometry shows the maximum tensile strength as compared to the concentric and triangular shape of infill geometries. As the deformation behavior of the tensile specimen is mainly depends on the material, PLA and ABS material show less ductile nature as compared to PETG material. In the case of PETG, after reaching the yield point the value of stress starts decreasing gradually which shows the more plastic deformation behavior of the material. Whereas as in PLA and ABS material, after reaching the yield point sudden drop of stress value takes place which shows the less plastic deformation behavior nature of the material.

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