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# Effect of Print Speed, Infill Pattern and Infill Density on Tensile Strength of Part Produced by ABS Filament Using FDM 3D Printing Technology

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**Abstract**

A rapid emerging additive manufacturing technology for various engineering applications is fused deposition modelling (FDM). Several parameters affect the mechanical qualities of 3D printed materials using FDM technology. According to the literature, the density of infill, Infill Pattern and Print Speed, are the factors that directly affect the Tensile Strength of 3D printed materials. The effects of infill pattern and density and Print speed on tensile properties, and material used in 3D printing will all be examined and discussed in this article. There are a total of 16 different forms of infill pattern, and out of these 6 different types of infill pattern with varying infill densities from 20% to 100% and constant print speed of 80mm/min will be evaluated. To minimize the impact of other factors on the mechanical properties of the material, each specimen would be 3D printed using ABS material using the same color and 3D printing parameters, as well as in the same position on the printer bed. The results will provide us with a clearer idea of how to print objects in 3D as quickly as possible while still maintaining the necessary tensile qualities.

## INTRODUCTION

Additive Manufacturing (AM), known as 3D print, is a group of technologies and processes that produce objects from a CAD model by adding layers of material bottom-up. AM is used in the manufacturing of prototypes (Rapid Prototyping), tools (Rapid Tooling) and final functional parts (Rapid Manufacturing). These technologies provide the ability to produce complex product geometries without the need of complex tooling. AM is gaining importance in the industry 4.0, and producing parts via this method offers many advantages over traditional manufacturing technologies

The additive manufacturing technology is widely used in engineering for customized products, functional models, pre-surgical models and conceptual models. This technology finds its application in many fields of engineering and industry, such as automotive products (companies like Ford and Volkswagen), aircraft, Aerospace rocket, dental restorations, medical implants (prosthetics, bionics, and orthotics) and more. Today, designers and production engineers face the challenge of producing products faster than ever to meet customer requirements and fulfil their expectations [4], [5]. The increased use of 3D printing as a learning tool and to generate functional end-use parts in industry have generated need for a better understanding of the mechanical behavior of 3D printed parts and the development of analytical tools and design guidelines for engineers. Materials testing of 3D printed plastics were performed in order to provide both industrial and academic communities with new to improve mechanical and digital design in the context of additive manufacturing; specifically fused deposition modelling (FDM) [6].

There are many different AM technologies today, and one of the more representative AM technologies is FDM, layer forming technology by extrusion of wire-shaped materials. The FDM process is also known as "Material Extrusion" or FFF (Fused Filament Fabrication) process. First step in FDM process is to create STL file from 3D CAD model, and then in slicer software (e.g. Ultimaker Cura or Prusa) create G-code with 3D printing parameters for 3D printer. After the entire layer is applied, the pad is reduced by the thickness of the layer in the vertical axis and the gradual deposition continues again until the full product is formed.

Schematic model of FDM process is presented on Fig 1.1

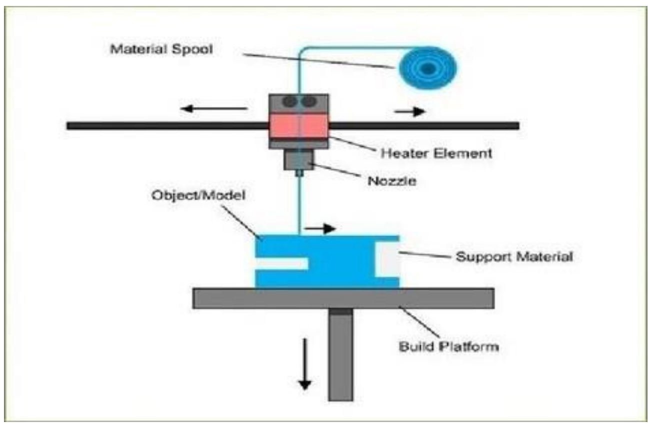


*Fig.1: Fused deposition Modelling (FDM), Machine*

**SCOPE OF PRESENT WORK**

This work aims to review the impact of infill pattern, print speed and infill density on mechanical properties of ABS material, also to analyze influence on tensile strength. A dogbone-type specimen will be chosen for the tests due to the simplicity of sample preparation and its suitability for FDM preparation.3D model of dogbone-type specimen, according to ISO 527-2, was designed in CAD, also 3D model in STL format is prepared (Fig1.2).

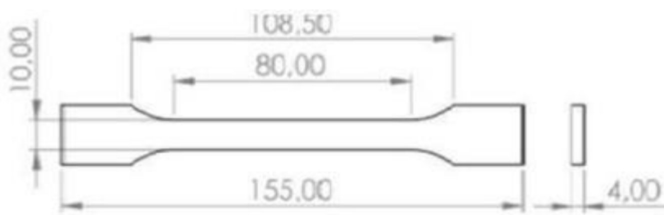


*Fig 2. Dog bone type specimen according to ISO527-2*

**Formulation Of Present Work**

**Problem Statement**

In 3D printing or additive manufacturing area a very vast work has been done in the past several years.

1) Most of the researches had worked on the various process parameters for defining the various mechanical properties of the parts manufactured by this technology.

2) But very less work has been done on the infill pattern and infill density for defining the tensile strength of the parts.
3) There are total 16 different types of infill patterns exist as per PRUSA 2.4.2Sliceris concern. Out of the 16-infill pattern most of the researchers had considered the Stars, Rectilinear, aligned rectilinear, Grid, Triangle, Cubic, Lines, Concentric, adaptive cubic and support cubic infill patterns, but very less work has been carried out by considering the Gyroid, Honeycombe,3D honeycomb, Hilbert Curve, Archimedean chord, Octa gram Spiral type of infill pattern.
4) So the aim is to check the tensile strength of the parts by considering the 6 different infill pattern as above with different infill densities between (20% to 100%) with constant print speed of 80mm/sec.

**Objectives**

The objective of this dissertation is:

1) To investigate the effect of different infill patterns on the tensile strength of the parts.
2) To investigate the effect of different infill % densities on the tensile strength of the parts.
3) To increase the tensile strength of the components produced with the 3D printing technology.
4) To provide the Optimized process parameters with the proper design of experimentation which can be used in the future studied is the area of 3D printing

**Methodology Of Proposed Work**

A series of specimens were produced using a Marks forged carbon fiber composite 3D printer. Regarding the software and printing configurations, the tool path calculation (G-code) was made with the Prusa, version 4.0.0.Printing parameters were set by selecting the predefined "Normal" profile provided by the Prusa. Methodology of preparing 3D model and 3D printing specimens is presented in Fig.3.1.

Our technique involves methodology of preparing 3D model and 3D printing specimens is presented in Fig. 3.1 Which reveals the information from material selection to the results.

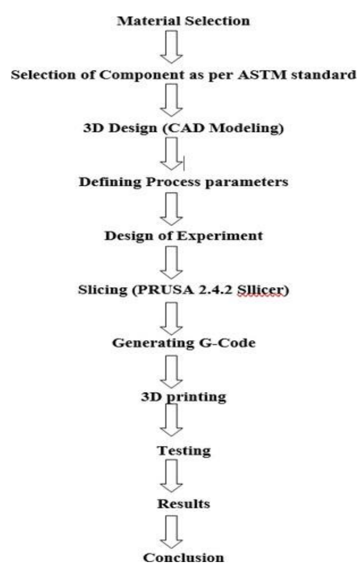


*Fig.3. Methodology of preparing 3D model and 3D printing specimens*

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**Design Of Experiment**

Main selected 3D printing process parameters like infill density, prints peed, and different selected infill pattern are presented in table 3.1

*Table 1. Shows the different process parameters*

| | | | | | |
|---|---|---|---|---|---|
| **Infill type** | **Honeycomb** | | | | |
| **Infill density** | 20% | 40% | 60% | 80% | 100% |
| **Print speed(mm/min)** | 80 | 80 | 80 | 80 | 80 |
| **Infill type** | **3D Honeycomb** | | | | |
| **Infill density** | 20% | 40% | 60% | 80% | 100% |
| **Print speed(mm/min)** | 80 | 80 | 80 | 80 | 80 |
| **Infill type** | **Archimedean chords** | | | | |
| **Infill density** | 20% | 40% | 60% | 80% | 100% |
| **Print speed(mm/min)** | 80 | 80 | 80 | 80 | 80 |
| **Infill type** | **Octagram spiral** | | | | |
| **Infill density** | 20% | 40% | 60% | 80% | 100% |
| **Print speed(mm/min)** | 80 | 80 | 80 | 80 | 80 |
| **Infill type** | **Gyroid** | | | | |
| **Infill density** | 20% | 40% | 60% | 80% | 100% |
| **Print speed(mm/min)** | 80 | 80 | 80 | 80 | 80 |
| **Infill type** | **Hilbert curve** | | | | |
| **Infill density** | 20% | 40% | 60% | 80% | 100% |
| **Print speed(mm/min)** | 80 | 80 | 80 | 80 | 80 |

**CAD MODEL**

*Fig.4. CAD Model of tensile test specimen as per ASTM ISO 527-2*

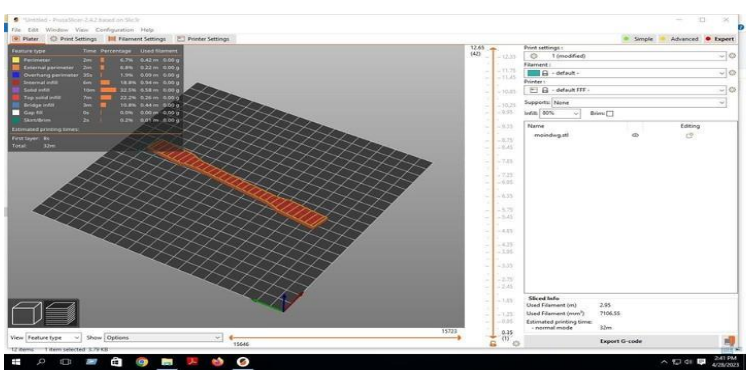

*Fig.5. Slicing with Infill Density 80%, Print speed 80mm/min, honeycomb infill pattern*

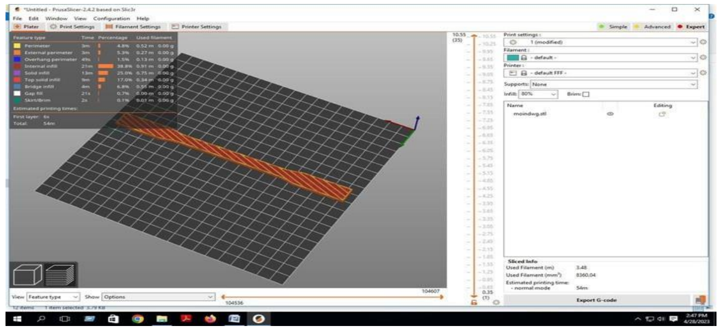

*Fig.6. Slicing with Infill Density 80%, Print speed 80mm/min, 3D honeycomb infill pattern*

## EXPERIMENTATION AND RESULTS

In this experiment total of 30 specimens of ABS material with different infill pattern and density are tested and all results are analyzed inexcel and presented. Experimentation and Testing is done at PARTH METALLURGICAL SERVICES MIDC, Hingna Road, Nagpur, Maharashtra, India

## Results

*Table 2: Shows the Result of Tensile Test.*

| | | Number of Run | | | | |
|---|---|---|---|---|---|---|
| | | T1 | T2 | T3 | T4 | T5 |
| Input | **Infill type** | **Honeycomb** | | | | |
| | **Infill density** | 20% | 40% | 60% | 80% | 100% |
| | **Prints peed(mm/min)** | 80 | 80 | 80 | 80 | 80 |
| Output | **Tensile strength(Mpa)** | 9.685 | 11.923 | **12.011** | 10.63 | 10.63 |
| | **% Elongation** | 0.56 | 0.7 | 1.06 | 0.98 | 2.4 |
| | **Maximum Force(KN)** | 0.72 | 0.93 | 0.9 | 0.81 | 0.81 |
| Input | **Infill type** | **3D Honeycomb** | | | | |
| | **Infill density** | 20% | 40% | 60% | 80% | 100% |
| | **Prints peed(mm/min)** | 80 | 80 | 80 | 80 | 80 |
| Output | **Tensile strength(Mpa)** | 12.315 | 12.528 | 12.646 | 12.747 | **13.128** |
| | **% Elongation** | 0.38 | 0.45 | 0.58 | 0.64 | 0.76 |
| | **Maximum Force(KN)** | 0.68 | 0.72 | 0.76 | 0.81 | 0.92 |
| Input | **Infill type** | **Archimedean chords** | | | | |
| | **Infill density** | 20% | 40% | 60% | 80% | 100% |
| | **Prints peed(mm/min)** | 80 | 80 | 80 | 80 | 80 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Input | Infill type | Archimedean chords | | | | |
| | Infill density | 20% | 40% | 60% | 80% | 100% |
| | Prints peed(mm/min) | 80 | 80 | 80 | 80 | 80 |
| Output | Tensile strength(Mpa) | 8.342 | 9.302 | 8.739 | 6.753 | 5.426 |
| | % Elongation | 0.34 | 1.24 | 0.38 | 3.34 | 0.76 |
| | Maximum Force(KN) | 0.63 | 0.72 | 0.66 | 0.51 | 0.42 |
| Input | Infill type | Octagram spiral | | | | |
| | Infill density | 20% | 40% | 60% | 80% | 100% |
| | Prints peed(mm/min) | 80 | 80 | 80 | 80 | 80 |
| Output | Tensile strength(Mpa) | 8.846 | 8.846 | 10.810 | 10.726 | 8.527 |
| | % Elongation | 1.84 | 3.42 | 0.62 | 0.86 | 0.40 |
| | Maximum Force(KN) | 0.69 | 0.69 | 0.81 | 0.81 | 0.66 |
| Input | Infill type | Gyroid | | | | |
| | Infill density | 20% | 40% | 60% | 80% | 100% |
| | Prints peed(mm/min) | 80 | 80 | 80 | 80 | 80 |
| | Tensile strength(Mpa) | 18.212 | 20.254 | 20.228 | 20.325 | 28.595 |

*Fig 5.2 3D printed specimen after testing*

## CONCLUSION

From the above results obtained after the performing of test on the different samples we are come to know that

1. Maximum Tensile strength for the Honeycomb Infill pattern is 12.011Mpa.
2. Maximum Tensile strength for the 3D Honey comb Infill pattern is 13.128Mpa.
3. Maximum Tensile strength for the Archimedean Chord Infill pattern is 9.302 Mpa.
4. Maximum Tensile strength for the Octagram Spiral Infill pattern is 10.810 Mpa.
5. Maximum Tensile strength for the Gyroid Infill pattern is 28.595 Mpa.
6. Maximum Tensile strength for the Hilbert curve Infillpatternis17.224Mpa.
7. Hence it is Conclude from the result that the Maximum Tensile strength of Gyroid is more than the other material.

## References

Pinero Vega D.;Batista PonceM.;Valerga PuretaA.P.;Vazquez Martinez J.M.& Fernandez Vidal S.P.A(2018). Comparison of Macro and Micro geometrical Properties of Specimens Made with a FDM Commercial Printer and its Open source Retrofit Version.

Polak R.;Sedlacek F.& RazK.(2017).“Determination of FDM Printer Settings with Regard to Geometrical Accuracy”

Hajdarevic S.; Obucina M.; Mesic E. & Martinovic S. (2018). Stress and Strain of the Frontal Parallel Joints With 3D Printed Connectors”

Farhad M.O.;Tahseen Fadhil A.& Hind B.A.(2018).Influence of Process Parameters on Mechanical Properties and Printing Time of FDM PLA Printed Parts Using Design of Experiment.
Baich L. (2016). Impact of Infill Design on Mechanical Strength and Production Cost in Material Extrusion Based Additive Manufacturing.
Farbman D.& McCoyC.(2016).Materials Testing of 3D Printed ABS and PLA Samples to Guide Mechanical Design
Cekic A.; Begic-Hajdarevic D.;Muhamedagic K. & Guzanovic N.(2018).Experimental Investigations of Process Parameters Influence on Dimensional Accuracy and Mechanical Properties of FDM Manufactured Parts.
Fernandez-Vicente M.; Calle Wilson.; Ferrandiz S. & Conejero A. (2016). ). Effect of Infill Parameters on 1.
Tensile Mechanical Behaviour in Desktop 3D Printing. 3D Printing and Additive Manufacturing.
Tahseen Fadhil A.; Farhad M. O. & Hind B. A. (2017). Effect of Infill Parameter on Compression Property in FDM Process.
Alvarez K.L.C.; Lagos R.F.C.& Aizpun M.(2016).Investigating the Influence of Infill Percentage on the mechanical Properties of Fused Deposition Modelled ABS Parts.
JapN.S.F.;PearceG.M.;HellierA.K.;RussellN.;ParrW.C .&WalshW.R.(2019). The Effect of Raster Orientation on the Static and Fatigue Properties of Filament Deposited ABS polymer.
FloorJ.(2015).Gettinga Grip on the Ultimaker 2– Tensile Strength of 3DPrinted PLAAbout the Authors