International Journal of Mechanical and Industrial Engineering

Volume 4 | Issue 3 Article 4

April 2023

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Recommended Citation

S, Raja and N, Rajeswari (2023) "Optimization of Acrylonitrile Butadiene Styrene Filament 3D Printing Process Parameters based on Mechanical Test," *International Journal of Mechanical and Industrial Engineering*: Vol. 4: Iss. 3, Article 4.
DOI: 10.47893/IJMIE.2023.1204
Available at: https://www.interscience.in/ijmie/vol4/iss3/4

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Cover Page Footnote

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ABSTRACT

This research paper's main goal is to improve the printing parameters that can be used in the 3D Printing Material Extrusion production method in order to get the best printing parameters for Acrylonitrile Butadiene Styrene (ABS) filament with the tensile test in the shortest possible time. The printing parameters that can be employed on 3D printing material extrusion machines include the extruder temperature, layer height, printing speed, and shell count. Also, tensile specimens in accordance with the ASTM (American Society for Testing and Materials) D638 standard were created utilising ABS filament and the aforementioned adjusted printing settings. The most effective printing settings for ABS products were established using the production time and the results of a post-production tensile test. As a result, this research can be used to determine the ideal ABS filament printing parameters and their timing.

Keywords- Additive manufacturing, 3D printing, FDM machine, process parameter selection, mechanical property.

1. INTRODUCTION

The ability of additive manufacturing (AM) to produce products with slightly more challenging geometrical designs has garnered interest in a number of manufacturing sectors. Additionally, AM is thought by researchers to be a potential replacement for the CM (conventional manufacturing) method in the future, and the production of an object using only digital data is thought to be sufficient in AM. A 3D printer uses digital data that has been converted to STL (Standard Triangle Language), sliced, and fed as input. The 3D printer creates the final object layer by layer using the input data. With little waste and in a short amount of time, it is simple to make the finished goods . [1-5].

Previous studies [6–9] provided descriptions of AM-based types, characteristics, policies, availability, and market potential. According to some studies, manufacturers only consider the time and cost of production. Different strategies are used for this. Manufacturers are interested in the ABS filament that can be used in FDM machines because of its low cost and wide availability.

Determining the best ABS filament printing parameters based on production effectiveness and tensile testing is the goal of this study (Mechanical property). Several researchers in the past have experimented with 3D printed materials. The characteristics of four photopolymer resins were studied by Fragassa, C., et. al. in [10].This study provided a guarantee for the tensile and bending strength's physical characteristics and nominal mechanical parameters. When considering other qualities, the authors of this research advocate utilizing personal assessment.

ABS (Acryionitrile Butadiene Styrene) and PLA filament are thought to be the two most widely used types of filament in the market, according to Talic, A et al. [11]. Comparing PLA and ABS filament, ABS has a little bit more strength and stiffness. ABS filament is regarded as a good PLA substitute and is thought to be a little bit simpler to print with than PLA filament. Previous researchers have thought about it [12–14].

The market is flooded with ABS filament, which is currently used extensively. The three monomers that make up the hazardous thermoplastic polymer known as ABS filament are acrylonitrile, butadiene, and styrene.After the 1940s, when the substance was first patented, it quickly became well-known. Because of its adaptability, moldability, and strength, ABS is used in a variety of industries today [15–17].

Prior researchers [18] considered Polyetheretherketone (PEEK) as a replacement for PLA and ABS filament. However, the 3D printing technology cannot immediately use this.

In their research, Galeta, T., et al. looked into how the processing variables in the 3D Prototype model affected tensile strength.

2. STANDARDS AND SPECIMENS

In this study, the same ASTM D638 tensile specimens are first produced, and the minimal production time is then determined by adjusting a variety of printing settings on the FDM machine that can be utilised for additive manufacturing (AM).

The five manufactured tensile specimens' breaking point, true strain at maximum load, and true strain at break percentage are all determined in this study. Printing characteristics were considered, including the extruder temperature, platform temperature, layer height, print speed, and shell count. The manufacturing machine was a Botzlab WANHAO Duplicator 4S, and the slicing software was Flash Forge.

The following is the process for creating ASTM D638 tensile specimens:

- Design model
- Creating an STL file from a design model (a standard format for 3D printers)
- The following slicing parameters (Table 1) were taken into consideration and changed during the.STL conversion for all 5 tensile specimens.
- Using an FDM machine to build a 3D physical model.
- Each specimen's production time was recorded in Table 1 as shown

2.1 Slicing in additive manufacturing

Table 1 lists the slicing parameters that are frequently taken into account in 3D printing by earlier researchers. Previous studies [15–19] discovered that the melting point of ABS filament was above 210 °C at the extruder temperature.

In this study, an extruder with a temperature range of 210 °C to 250 °C was used. The temperature of the platform is standard room temperature of 27 degrees Celsius. During production, first layer heights ranging from 0.10 mm to 0.24 mm were employed. Printing rates between 30 mm/s and 75 mm/s are used as a minimum and maximum. Extruder travel speeds range from 60 mm/s to 90 mm/s at their lowest and fastest points.

As far as 3D printing optimisation goes, infill (%) is regarded as the essential crucial slicing parameter. In this study, the infill was composed of the following patterns: hexagonal pattern (15%) for A, line pattern (15%) for B, triangle

35° pattern (30%) for C, 3D Infill pattern (20%) for D, and triangle 55 ° pattern (35%) for E.

Last but not least, the optimization parameter employs a minimum shell count of 2 and a maximum shell count of 3.

2.2 ASTM D638 type V

Figure 1 shows how the design for ASTM standards D638 type 5 polymers was initially chosen, which can be used to determine the mechanical properties of the selected ABS material.

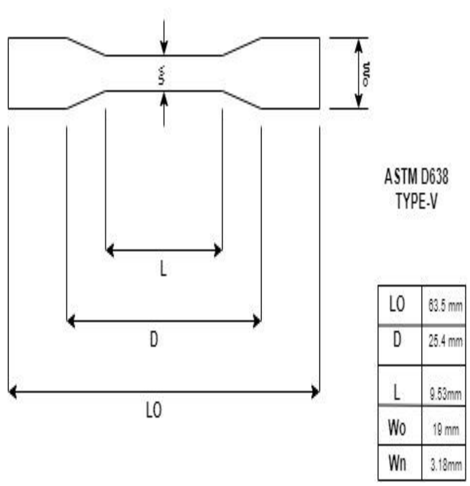

Fig 1. Standard dimension (open access)

3. EXPERIMENT

3.1 3D PRINTING

For printing thermoplastic polymers, material extrusion process, commonly referred to as fused deposition modeling (FDM) or free-form manufacturing, is the most trustworthy and economical AM technique (FFF).

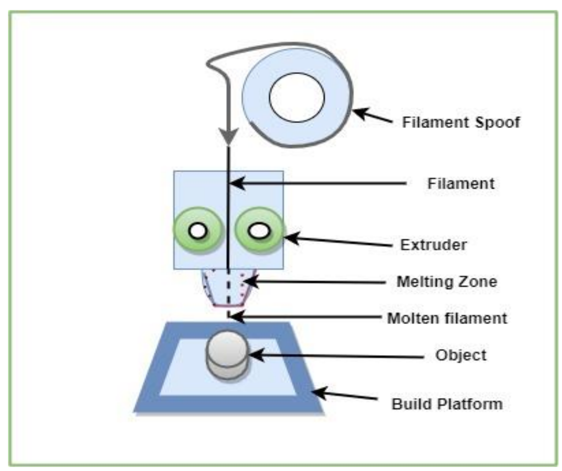

Fig 2. FDM machine components

The quality of the final model is influenced by a large number of process variables, but when these variables are effectively controlled, the process has a great deal of potential and viability. All 3D printing techniques entail building objects layer by layer, but FDM is unique in that material is added through a nozzle while being continuously streamed and under constant pressure. This pressure must be kept consistent to produce precise results. Chemical agents or temperature control of the material layers are both options as shown in Fig 2.

As depicted in the diagram, material is frequently added to the machine in the form of spools [21-33]

3.2 TENSILE TEST

At a speed of 5 mm/min, an INSTRON 5980 series tensile testing device was employed. Figure 3 depicts the setup of the tensile testing apparatus.

Fig 3. INSTRON 5980 series

4. RESULTS AND DISCUSION

The ideal ABS filament printing parameters are described in this experimental study. The printing settings and the time it took to create the specimen are shown in Table 1. The fastest specimen to produce is A (8 minutes), followed by D (9 minutes). B then requires 10 minutes. C and E were produced in 11 and 12 minutes, respectively.

Table 1. Printing parameters of specimens

Parameters/ Specimens	A	B	C	D	E
Extruder temperature	210ºc	220ºc	230ºc	240ºc	250ºc
Layer height	0.18mm	0.12mm	0.20mm	0.20mm	0.23mm
Printing speed	60mm/s	30mm/s	70mm/s	75mm/s	55mm/s
Time taken for fabrication (minutes)	**8**	**10**	**11**	**9**	**12**

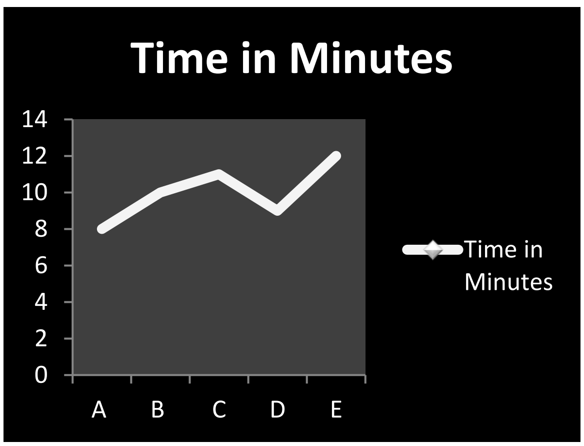

Figure 4. Printing time of each specimens

Figure 4 shows the printing times for each specimen, with the exception of specimen B, which shows all specimens to be slower than the average. The manufacturing industries also use this method to determine the average time, which is calculated for the final normal or shortest time of making anything. Equation 1 calculates the average time.

Average Time = (8+10+11+9+12)/5 = 10 minutes (Nearby obtained value)…. (1)

The maximum weight of the specimen is also displayed on the load extrusion diagram. Thus, specimen A is the heaviest at 364 N, followed by specimens C 362 N, specimen E 352 N specimen D at 341N, and specimen B at 326 N.

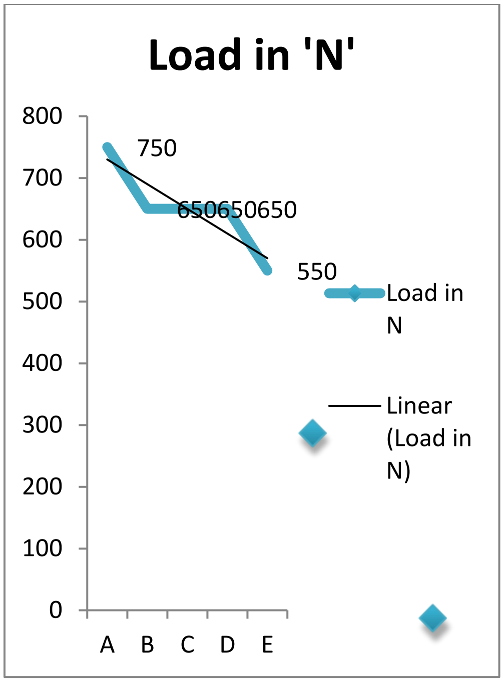

Figure 5. Tensile strength of each Specimen (based on load)

Finding the ideal slicing/printing parameter for the tensile and short time attributes is the primary objective of this study. It essentially considers shorter specimens, such as specimens C, E, D, and B.

Based on the results of these four specimens' tensile tests, the specimen A can withstand a weight of 364 N and an extension that is 13.573% longer than the specimens C, E, D, and B. As a result, the printing parameters for specimen A are determined to be the most efficient for ABS filament. The extruder is 210 degrees Celsius and the Platform is 27 degrees Celsius as a result. The layer height is 0.18 mm, and the printing speed is 60 mm/s. The most important printing parameters are infill pattern hexagonal, infill density of 15%, and shell count of 2. It is depicted in Figure 5.

5. CONCLUSION

The goal of modern manufacturers is to produce more finished goods in a shorter amount of time. Many strategies are employed to accomplish this. Based on a time and tensile test, this research paper seeks to identify the ideal ABS printing parameter. With the aid of a contemporary 3D printer, 5 ASTM D638 tensile specimens were created for this purpose, and a tensile test was conducted on them. The specimens B, C, D, and E are slower than the specimen A in terms of time.

In this research paper, only the specimen's production time was considered.
This is because slicing the model that the slicing software developed typicall y determines the time to change.As a result, the time available after using modelling software to slice the model can occasionally change.

The specimen A can withstand more weight and moderate extension than specimens B, C, D and E, according to the results of the tensile test. At the end of this study, it is determined that the printing parameter of specimen A is the best printing parameter for ABS.

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