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Study On the Mechanical Properties of Pla, Abs and Petg Filament Printed by Various Type of Infill Design Using 3d Printing Machine

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Abstract: The basic technique of 3D printing is to build a product layer by layer by adding or printing material. The mechanical properties of PLA, ABS and PETG filament printed using a 3D printer with various types of infill and different type of infill percentage such as line and hexagon, 50% and 100% infill are studied in this research in this study. Mechanical properties vary depending on the type of infill pattern and its percentage used. Tensile, flexural, and impact tests were performed as part of the mechanical analysis. The specimens are printed using a dog bone model created with Solidworks software and printing by Ender 3Pro, 3D printer. Based on the results obtained from tensile test, the PLA material, hexagon type of infill with 100% percentage of infill shows the highest tensile strength and modulus elasticity where the value recorded was 49.82 MPa and 7.56 MPa. Followed by PETG material, where the tensile strength and modulus elasticity value were 49.05 MPa and 5.31 MPa respectively. The lowest tensile strength was ABS material, where the tensile strength and the modulus elasticity value were 27.55 MPa and 4.89 MPa. As for the flexural strength and modulus, PLA material, the hexagon type of infill with 100% infill was recorded the highest where the values were 101.02 MPa and 29.60 MPa. Followed by the ABS material, where the flexural strength and modulus value were 83.67 MPa and 23.14 MPa respectively. The lowest flexural strength was PETG material, where the flexural strength and the modulus value were 72.54 MPa and 21.59 MPa. Next, for impact test, ABS material, hexagon type of infill with 100% of infill was the highest for impact strength where the result recorded was 1.136J/mm². Followed by PLA material, where the impact strength was 0.226 J/mm². The lowest tensile strength was PETG material, where the impact strength value was 021 J/mm². In conclusion, it can be concluded that hexagon type with 100% infill was the best compared to line type of infill as it shows the highest result for all mechanical test conducted.

Keywords: Additive Manufacturing, PLA, ABS, PETG, Hexagon, Infill percentage

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1. Introduction

3D printing is the most recent great innovation that has improved engineering, product design, and manufacturing, and it has the ability to revolutionize medical field. 3D printing enables the efficient transformation of data from digital 3D models into actual products. Other term for 3D printing includes additive manufacturing (AM), rapid prototyping (RP), solid free form fabrication, and layered manufacturing. This method has found widespread application in a variety of engineering and biomedical disciplines. [1]

FDM technology is quickly advancing and appears to have limitless promise in a variety of applications. The layer-by-layer technology of FDM has been used in medical applications to make prosthetics, medical equipment, and organ models. The potential of this technology is continually expanding with continuous improvements and discoveries, particularly in the materials and printers.[2]

The ability to print in only a few materials is a significant disadvantage in the FDM 3D printing industry. However, the strength capability of plastic varies and may not be suitable for all components. Plastic filament is used in popular and low-cost 3D printers. Metal is a material offered by several companies; however final product parts are frequently not totally dense. Other materials, such as glass, carbon fiber, and nylon, are being used but have yet to be commercialized. All these materials are constrained by machine size, and the larger they become, the more challenges with accuracy.[3]

The objectives of this research projects are to perform testing for different materials with different types of infill in 3D printing. Thus, to study the mechanical properties of different materials and in different infill of printing. The mechanical properties have been studied in this research in different type of infill of pattern which include line infill and hexagon infill. Other than that, mechanical properties in 50% infill and 100% infill for these three materials. For this study, tensile testing, flexural testing, and impact testing need to be performed to collect data.

2. Materials and Methods

2.1 Materials

The next stage is material preparation. This study used Polylactic acid or polylactide (PLA) 3D printing filament, which is a biodegradable thermoplastic aliphatic polyester developed from renewable resources. Other than that, Acrylonitrile Butadiene Styrene (ABS), a typical end-use engineering material that enables functional testing on sample parts. Polyethylene terephthalate glycol, PETG is the ideal filament for combining strength and ductility.[4]

2.2 Methods

The scoping study will begin with short planning and preparation of samples before the preliminary test is carried out. Figure 2.1 below shows the flowchart of the study.

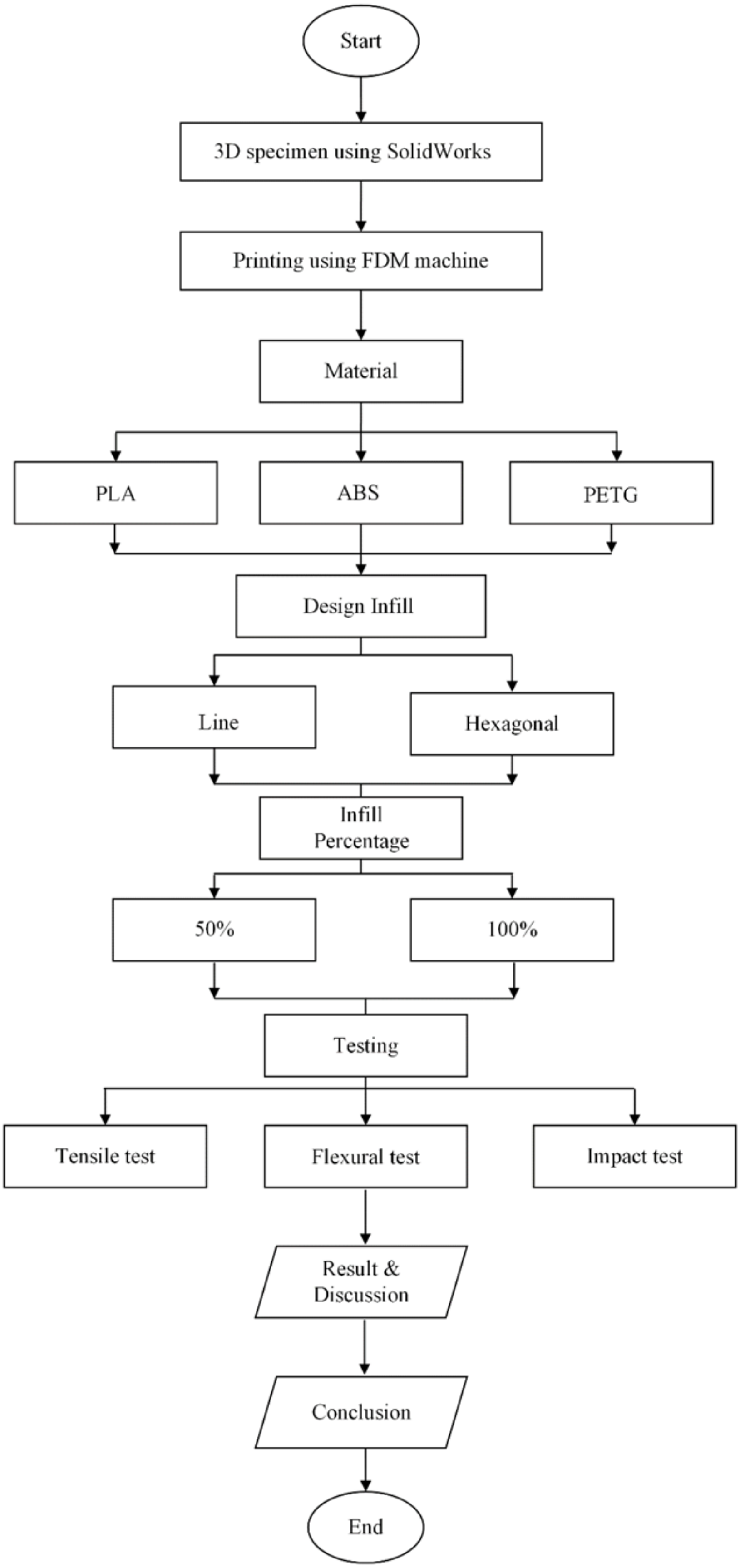

Figure 2.1: Flowchart of the study

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2.2.1 Parameter settings

In this study, the important parameter setting procedure to generate G-code. The variable parameter is set using the process manufacturer's software FlashPrint. Printing temperature, height decomposition, printing speed, and travel speed are examples of parameters used in this experiment. Table 2.1 depicts the parameter setting.

Table 2.1: Parameter setting

Material	PLA	ABS	PETG
Print temperature (ºC)	190	230	220
Height of deposition (mm)	0.2	0.2	0.2
Printing of speed (mm/s)	60	60	50
Travel speed (mm/s)	150	60	60
Infill percentage (%)	50, 100	50, 100	50, 100
Type of infill	Line, Hexagon	Line, Hexagon	Line, Hexagon

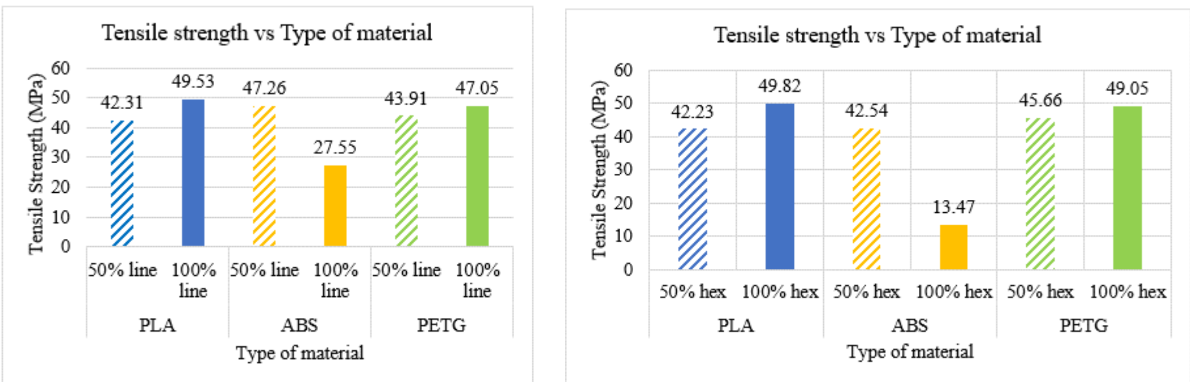
2.2.2 Mechanical testing

Tensile, flexural, and impact mechanical tests will be conducted as part of this study; therefore, ISO standards ISO 527-2, ISO 178, and ISO 179-1 must be applied to. All samples were tested using the Autograph Shimadzu Universal Testing Machine (AGS-J series) for tensile and flexural tests. The loading speed of the universal testing machine was set to 50 mm/min for all samples. Pendulum impact testing device for impact tests. The maximum degree of the Charpy impact test device is 160º. For every testing method included two types of infill, 50% and 100%, and two types of infill, line type and hexagon type, each one with three specimens.

3. Results and Discussions

This section presents all the results and discussions that the research produced in order to accomplish the key goals and scopes based on the four primary tests that were carried out.

3.1 Tensile Test

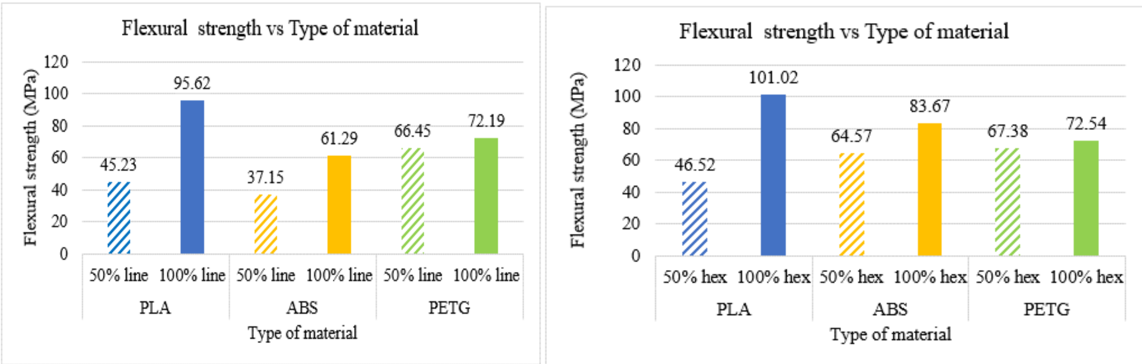


(a) (b)

Figure 3.1: (a) Tensile strength for line type of infill (b) Tensile strength for hex type of infill

Figure 3.1 illustrates the tensile strength derived from line type and hexagon type of infill for mechanical tests. The data shows that PLA material with 100% hexagon of infill have the highest tensile strength compared with the other two materials. PETG material shows similar data by obtaining the highest tensile strength when compared to ABS material. This result shows that PLA and PETG material have the ability of a material to withstand tearing caused by tension.

3.2 Flexural test

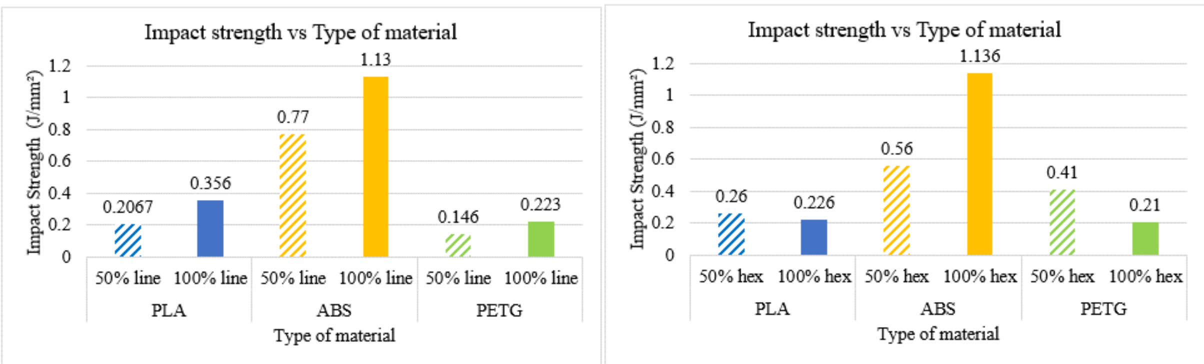


(a) (b)

Figure 3.2: Flexural strength for line type of infill (b) Flexural strength for hex type of infill

Flexural strength testing determines a material's ability to resist failure when bending and a load is applied. The data shows from figure 3.2 that PLA material with 100% hex of infill have the highest flexural strength. Followed by ABS material and PETG material. This shows that hexagon type of infill has the best flexural strength compared with line type of infill. The stiffness and material behaviors of PLA combined with 100% hexagon are excellent under static load.

3.3 Impact test



(a) (b)

Figure 3.2: Impact strength for line type of infill (b) Impact strength for hex type of infill

The data in table 3.2 shows that ABS material with 100% hexagon type of infill has the material's capacity to withstand a sudden application of load, expressed in terms of energy. At the other end of the notch, a pendulum struck the Charpy test sample. The absorbed energy required to generate two new fracture surfaces was measured in Joules. This can be seen that the hexagon type of infill shows the ABS material have outstanding shock resistance.

4. Conclusion

The various types of infill patterns and their percentages that were tested in this study to determine whether the best infill pattern for the materials PLA, ABS, and PETG can produce suitable mechanical properties for product manufacturing. The results of each specimen's tests were analysed as flexural, impact, and tensile. The objectives of this study were to investigate the mechanical properties of various infill specimens printed with a 3D printer) and to achieve these objectives through the results of the research on the specimens that were examined. Different types of infill and their percentages will produce different results, according to the mechanical test analysis. To be concluded, hexagonal type of infill is the best infill in terms of strength versus the material used. This shape is the most efficient infill and the quickest to print, making it the go-to infill for most applications. It will save you material, time, and energy while also providing high strength. For further experimentation, consider using a higher percentage of infill and other types of infill and also the proportion of specimen is more variable. Aside from that, tensile, flexural, and impact tests revealed that more samples are needed to eliminate inaccurate data and increase the likelihood of collecting reliable data.

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