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Influence of infill parameters on the tensile strength of ABS 3D printing filament

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ABSTRACT

This study aims to analyze the effect of infill parameters on the tensile strength of Acrylonitrile Butadiene Styrene (ABS) filament in the 3D printing process for the manufacture of prototype cat prosthetics. ABS filament was chosen because it has good mechanical strength, resistance to high temperatures, and the ability to be further processed after printing. The infill parameters studied include infill percentage, layer thickness, and print speed. The research methodology involved making test samples with varying infill percentages, which were then tested using a tensile testing machine to measure the maximum tensile strength. The infill percentage was varied between 25%, 50%, and 80%,. Tensile strength testing was conducted in accordance with ASTM D638 standards to determine the mechanical characteristics of the molded specimens and then the optimal infill parameters were applied in the design and manufacture of the cat prosthetic leg prototype, ensuring better load distribution and higher durability. The results show that the percentage density of infill has a positive correlation with the tensile strength of the specimen; an increase in infill density increases the tensile strength of the material. The findings provide practical guidance in the selection of infill parameters for tensile strength optimization in 3D printing applications using ABS filament so that it can be known that the influence of infill parameters greatly affects the strength of manufacturing.

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1. INTRODUCTION

Cats are popular pets all over the world because of their cuteness and beauty. This causes many cat lovers, especially in Indonesia. The popularity of cat lovers has encouraged the creation of cat communities where these communities rescue and feed stray or pet cats. Stray cats are common and are usually called village cats or house cats. Cats often have birth defects or congenital abnormalities, which are common in both wild and domestic cats. Injuries occur due to accidents (hit and run) caused by the owner's negligence or the cat's own negligence. The area most often affected is the legs, including the front and back, causing the cat to lose one of its legs. Therefore, the innovation that emerged from the application of rapid prototyping is the creation of prototypes of prosthetic legs for cats and other animals that have deficiencies in their limbs so that this

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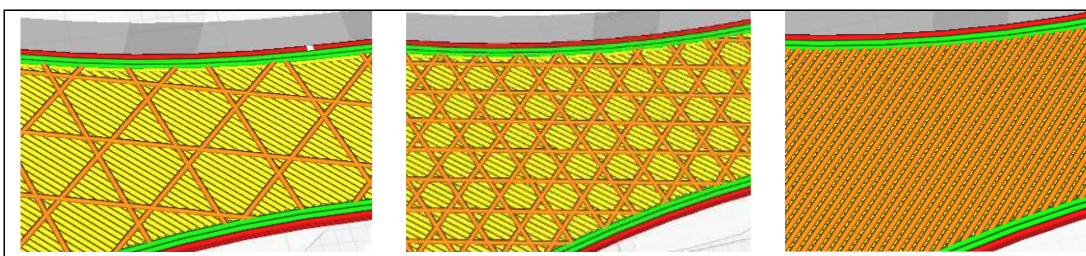
innovation can help animals that have deficiencies. The following is the anatomy of a cat's body parts in Figure 1 (Roharjo, 2023).

(a) (b)

Figure 1. (a) Anatomy of Cat Body Parts; (b) Description of Body Parts.

Rapid prototyping is the process of making models in physical form using design data supported by computer-aided design (CAD) software (Lubis et al., 2016). The software used to create the 3D design and simulate the thickness and strength of the designed product is Autodesk Fusion 360. The design that has been designed is continued with rapid prototyping using a 3D printer machine with ABS filament (Widyanto, 2007).

In the process of making prototype cat prosthetics, several steps are needed such as determining the material or filament that is suitable for use in designing prototype cat prosthetics. The material or filament used is ABS (Acrylonitrile Butadiene Styrene) because it has the characteristics of a combination of strength, durability, and good surface quality, so it is often used for prototyping (Dhinesh et al., 2021). In the printing process, 3D printing parameters are influenced, namely printing temperature, bed temperature, print speed, layer resolution level, and infill percentage level. In this study, the parameter used is the percentage of infill density. The infill pattern is the pattern of material used to build the volume of the printed part (Pernet et al., 2022). The infill percentage is the infill density that designates the volume ratio between the molded pattern part and the solid molded part. The process of filling the angle between the pattern line and the X/Y/Z axis as shown in Figure 2.



Persentase*infill* 25% Persentase*infill* 50% Persentase*infill* 80%

Figure 2. Infill percentage and infill angle

In this study, the tensile strength test results of ABS materials made using the 3D printing method are then analyzed for the design of a cat prosthetic leg prototype. Therefore, to determine the strength and elasticity that occurs in 3D printed ABS material, with 25%, 50%, and 80% infill percentage parameters will be made according to ASTM D638 standards. So based on this, this research was carried out to find out the ideal parameters for designing a cat prosthetic leg prototype as shown in Figure 3 by testing the tensile strength using the ASTM D638 standard, because ABS is a polymer material (Grant et al., 2021).

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Figure 3. Prototype cat prosthetic leg

Figure 3 is the result of the design that has been made using the Creality Ender-3 V3 SE 3D Printer machine at the Mechatronics Laboratory of Tarumanagara University.

2. RESEARCH METHOD

This research is an experimental study using a universal tensile machine by varying the percentage infill parameter to determine the tensile strength of ABS (Acrylonitrile Butadiene Styrene) filament material using ASTM D638 standards (Singh et al., 2020). The tensile strength test research begins with the CAD design process using Fusion 360 software followed by printing the design using a 3D printer. In the printing process, parameter settings are made using UltiMaker Cura software with settings shown in table 1. Then the tensile strength test data was collected using a Universal Tensile Machine at the Tarumanagara University Production Process Laboratory followed by data analysis to conclusion. The following are the stages of the tensile strength test.

Table 1. 3D printing process parameter settings

Specimen	Nozzle Tempature (°C)	Infill Density (%)	Layer Height (mm)	Printing Time
A1	250	25	0.2	41 minutes
A2	250	25	0.2	41 minutes
A3	250	25	0.2	41 minutes
B1	250	50	0.2	48 minutes
B2	250	50	0.2	48 minutes
B3	250	50	0.2	48 minutes
C1	250	80	0.2	59 minutes
C2	250	80	0.2	59 minutes
C3	250	80	0.2	59 minutes

The tensile test process was carried out three times with 3 different specimen parameters, namely the percentage of infill 25%, 50%, and 80% as in table 1 above and the total specimens tested were 9 specimens. In this study using several equipment tools as shown in Figure 4. The following equipment and materials were used as follows:

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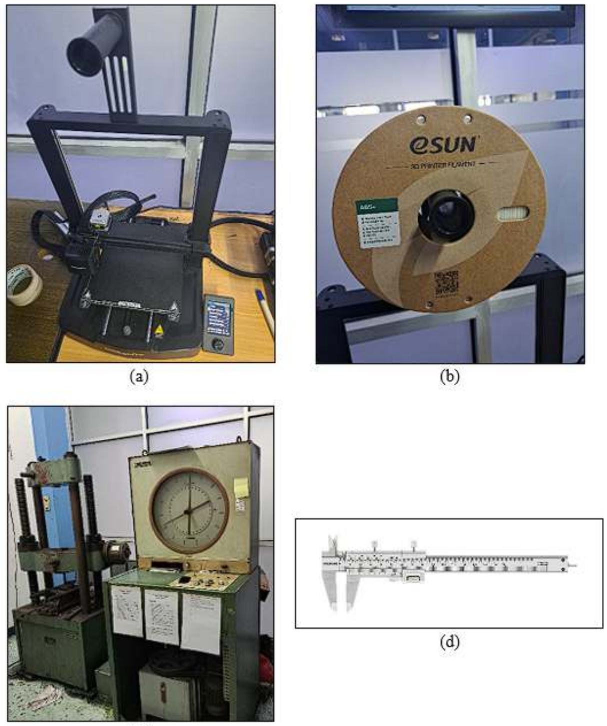
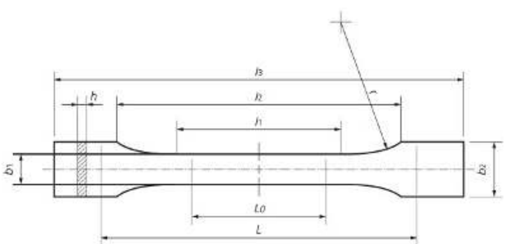


Figure 4. (a) Ender-3 V3 SE creality 3D printing machine, (b) ABS eSUN 3D printing filament, (c) Shimadzu universal tensile machine, (d) Vernier caliper.

The test uses the ASTM D638 type 1 standard. The following is an ASTM D638 design drawing that will be used in this study in Figure 5 (Raffik et al., 2024).



(a)

L_0 Gauge length	:	50 ± 0,25
L Grip-to-grip separation	:	115 ± 5
l_1 Length of the narrow parallel section/inner diameter	:	57 ± 0,5
l_2 Distance between the wide parallel section	:	
l_3 Total length / outer diameter	:	≥ 165
b_2 Specimen width in shoulder area	:	19 + 6,4
b_1 Specimen width in gauge length area	:	13 ± 0,5
h Specimen thickness	:	3,2 ± 0,4

(b)

Figure 5. (a) ASTM D638 type 1 standard design; (b) Design description

To support the data needs, the tensile stress value of the tested ABS filament specimen can be calculated by the equation (Mazlan et al., 2023):

(1)

where σ is the tensile strength (MPa), F is the maximum force (N), and A is the cross-sectional area (mm^2). The strain of the tensile test can be calculated by the equation:

(2)

where ε is the strain, ΔL is the increase in length (mm), and is the initial length (mm).
Meanwhile, to find the elastic modulus of a material, it can be calculated with the equation:

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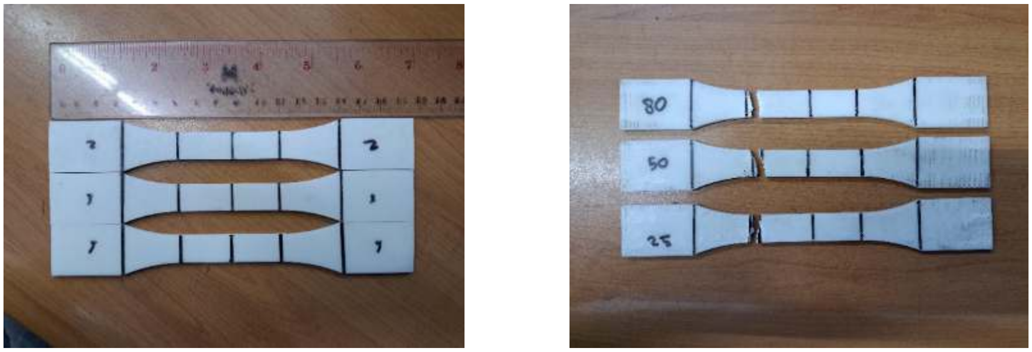
(3)

where E is the modulus of elasticity/young's modulus (GPa).



(a) (b)

Figure 6. (a) Specimen from 3D printing of ABS filament; (b) Specimen after tensile test.

In Figure 6 (a) is a specimen of 3D printing results with ABS material that will be used in testing with ASTM D638 standards while for Figure 6. (b) results after tensile testing. With specimen sizes l_3 = 180 mm, l_2 = 109 mm, l_1 = 50 mm, b_2 = 25.4 mm, b_1 = 13.5 mm, and h = 3.6 mm.

3. RESULT AND DISCUSSION

This study evaluates the tensile strength of 3D printed ABS specimens with various infill density percentages (25%, 50%, and 80%) with 3 trials using a universal tensile machine. The tensile strength test results are shown in Table 2 and analyzed to determine the effect of each parameter.

Table 2. Tensile strength (MPa) of specimens with various infill density parameters

Specimen	F (N)	σ (MPa)	Average (N)	Average (MPa)	Average (%)	Average (GPa)
A1	407.96	8.39				
A2	415.55	8.55	414.18	8.52	1	0.8361
A3	419.04	8.62				
B1	931.63	19.17				
B2	562.99	11.58	745.86	15.35	0.9	2.054
B3	742.95	15.29				
C1	1024.79	21.09				
C2	877.69	18.06	921.46	18.96	1.4	1.322
C3	861.91	17.73				

Based on the results of the test data shown in Table 2, the infill percentage parameter significantly affects the tensile strength (σ) and maximum force (F) of the ABS filament material. The test results reached a maximum strength of 21.09 MPa with 80% infill density and the lowest strength of 8.39 MPa with 25% infill density as in the study conducted by Alvarez et al. (2016) where with the increase in the percentage of infill density, the tensile force generated increases so that there is an increase in tensile stress. So the study conducted has a similar discussion with this research.

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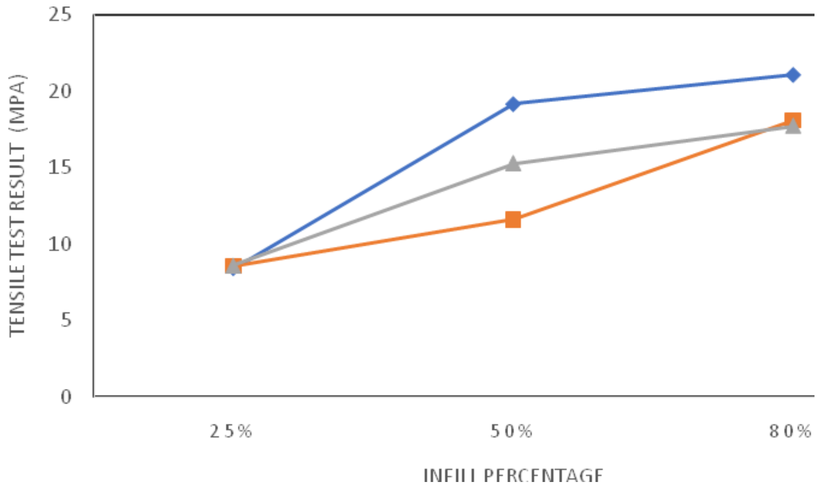

Figure 7. Tensile strength graph for each specimen with various infill percentage parameters

Figure 7 shows that the tensile stress strength increases with increasing infill density percentage. As in experiment one, the 25% infill percentage yielded a tensile stress of 8.39 MPa, the 50% percentage yielded a tensile stress of 19.17 MPa, and the 80% percentage yielded a tensile stress of 21.09 MPa. From the test results with three trials, it shows that the 25% infill density percentage produces the lowest tensile strength of 8.39 MPa while the 80% infill density percentage produces the highest tensile strength of 21.09 MPa. From the tensile strength results obtained, the greater the percentage of infill, the greater the tensile stress produced while the smaller the percentage of infill, the smaller the tensile stress results produced (Muslimin et al., 2024).

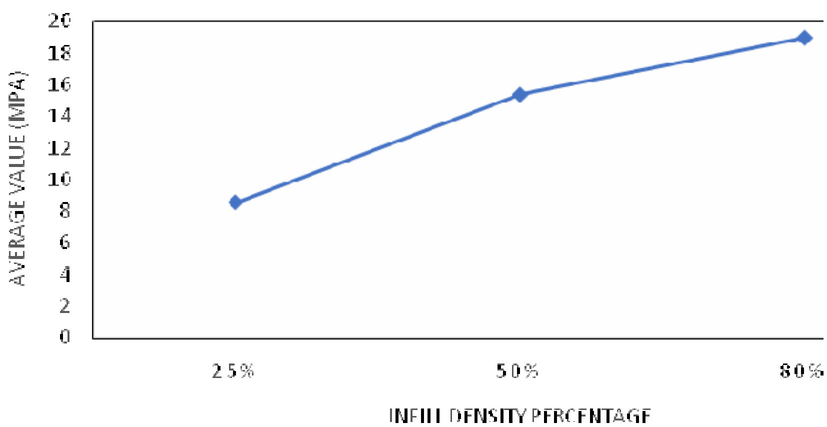

Figure 8: Comparison graph of the average value of each specimen parameter

Figure 8 shows the graph of the average comparison results from 3 experiments, where each experiment used 3 specimens with different variations of infill percentage parameters. From the comparison of the average values, the optimal value of each percentage of infill density is obtained, namely the 25% infill percentage, the average value is 8.52 MPa, the 50% infill percentage, the average value is 15.35 MPa, and the 80% infill percentage, the average value is 18.96 MPa. The average comparison can be seen that the percentage of infill density greatly affects the tensile stress results, if the greater the percentage of infill, the greater the tensile stress while the smaller the percentage of infill, the tensile stress results are also small. So that in the process of making a prototype of a cat's prosthetic leg using a larger infill density because it has a high tensile stress and has material efficiency. The results of the tensile test obtained are similar to the results that have been carried out by

Pranata et al. (2022) where the smaller the infill percentage, the smaller the pull result, while the larger the infill percentage, the greater the pull result.

4. CONCLUSION

The results of this study indicate that the infill density percentage parameter has a significant influence on the tensile strength of ABS filament printed using 3D printing. Where the higher the percentage of infill density the greater the tensile stress strength as in 80% the tensile strength result is 18.96 MPa and while the smaller the percentage of infill the smaller the tensile stress strength results such as 25% infill the tensile strength result is 8.52 MPa. Thus ABS filament can be used in the manufacture of cat prosthetics because it has characteristics such as strength, good durability, and resistance to moisture.

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NOTATION LIST

: Tensile strength (MPa)
F :Load/force applied (kN)
A :Cross-sectional area of the specimen (mm²)
:Strain
:Length gain (mm)
:Initial length (mm)
:Modulus of elasticity/young's modulus (GPa)

REFERENCES

Alvarez, K., Lagos, R.F.,Aizpun, M., Investigating the influence of infill percentage on the mechanical properties of fused deposition modelled ABS parts, Ingenieria e Investigacion, 36(3), 110, 2016.

Dhinesh, S.K., Prakash,A.S., Kumar,S.K.L., Megalingam, A., Study on flexural and tensile behavior of PLA, ABS and PLA-ABS materials, Mater. Today Proc., 45, 1175–1180, 2021.

Grant, A., Regez, B., Kocak, S., Huber, J.D., Mooers, A., Anisotropic properties of 3-D printed poly lactic acid (PLA) and acrylonitrile butadiene styrene (ABS) plastics, Results Mater., 12, 100227, 2021.

Lubis, S., Djamil, S., Yolanda, Y.,The influence of object orientation in the 3D printing process for PLA and ABSpolymer materials on tensile strength and product dimensional accuracysuy, Sinergi, 20(1),27, 2016.

Mazlan, M.A., Mustar, M.F., Abdullah, A.H., Zakaria, N.A.C., Hashim, N.M., Pangesty, A.I., Effects of printing parameters on the mechanical strength of thermoplastics 3D printed specimens, J. Mech. Eng., 12, 101–117, 2023.

Muslimin, Farhan, M., Muhammad, A.M., Characteristics of mechanical properties in 3D printing result for motorcycle controller cover fabrication, Journal Mekanika Terapan, 5(3), 168-175, 2024.

Pernet, B., Nagel, J.K., Zhang, H., Compressive strength assessment of 3D printing infill patterns, Procedia CIRP, 105, 682–687, 2022.

Pranata, Y., Hasdiansah, H., Arriyani, Y.F., Tensile strength testing of ABS material 3D printing products, Prosiding Seminar Nasional Inovasi Teknologi Terapan, 3(1), 2022

Raffik, R., Sivaguru, J., Parveen,S.A., Sabitha, B., Naveen, C., Murugajothi, T., Experimental investigation on stereolithography process parameter optimization and its influence on smooth surface finish for ABS accura-60 material, Mater. Today Proc., 2024.

Singh, S., Rajeshkannan, A., Feroz, S., Jeevanantham, A.K., Effect of normalizing on the tensile strength, shrinkage and surface roughness of PLA plastic,Mater. Today Proc., 24, 1174–1182, 2020.

Widyanto, S.A., Development of rapid prototyping technology for manufacturing multi material products, Rotasi, 9(4), 10–14, 2007.

https://doi.org/10.29303/dtm.v15i1.949