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ABLE TO PULL POLYLACTID ACID (PLA) MATERIAL ANET ET4 3D PRINTING MACHINE PRODUCT RESULTS

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ABSTRAK

Mesin 3D Printing merupakan mesin yang mampu mencetak benda dalam bentuk 3 dimensi, dibuat dengan cara lapisan per lapisan dengan melelehkan/mencairkan bahan yang telah ditentukan. Bahan yang digunakan untuk membuat spesimen dari filamen Polylactid Acid (PLA) yang memiliki kekuatan yang baik dan mudah terurai dilingkungan. Spesimen yang dihasilkan dilakukan uji tarik dengan dengan 3 variasi ketebalan yang berbeda yaitu 2 mm, 3 mm dan 4 mm. Hasil dari pengujian tarik menunjukkan bahwa benda uji dengan ketebalan 2 mm mempunyai kuat tarik paling tinggi yaitu 43,29 MPa, karena kepadatannya lebih tinggi dibandingkan benda uji 3 mm dan benda uji 4 mm.

ABSTRACT

A 3D Printing machine is a machine that is capable of printing objects in 3 dimensions, made layer by layer by melting/melting a predetermined material. The material used to make specimens is Polylactic Acid (PLA) filament which has good strength and is easily decomposed in the environment. The resulting specimens were subjected to tensile tests with 3 different thickness variations, namely 2 mm, 3 mm and 4 mm. The results from the tensile test results show that the specimen with a thickness of 2 mm shows the highest tensile strength, namely 43.29 MPa, because its density is higher compared to the 3 mm specimen and the 4 mm specimen.

1. INTRODUCTION

The increasingly rapid development of technology makes human work easier, such as making household appliances, industrial manufacturing and even technology capable of making human body parts. One technology that is able to do this and is most popular today is 3D printing.

The advancement of printing technology, known as 3D printing, allows for the single-unit production or design of complex structures. One of the Fused Deposition Modeling (FDM) manufacturing technologies is 3D printing, specifically Addtive Manufacturing (AM) technology, whose mechanism is to create objects by layering on material (Dattatray Agashe et al., 2020; Wicaksono et al., 2021).

Rapid prototyping processes have seen a notable growth in the contribution of 3D printing technology to both print quality and cost. 3D printing and other rapid prototyping techniques are useful tools for product development. Using programs like Solidworks, AutoCAD, Sketcup, Fusion 360, and others, a 3D Computer Aided Design (CAD) model is first created as part of the rapid prototyping (RP) process. Next, the production space is orientated to the valid model (Kunarto & Pratama, 2021; Lubis et al., 2016; Pratama et al., 2021)(Lubis et al., 2016; Pratama et al., 2021).

Materials generally used for 3D printing are plastic, Polylactic Acid (PLA), Acrylonitrile Butadiene Styrene (ABS), Polyethylene Terephthalate Glycolmodified (PETG), High Impact

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Polystyrene (HIPS) (Alika et al., 2023; Hadi Susilo et al., 2023; Lubis et al., 2016; Pranata et al., 2022).

Tests have been carried out using 3D printed Acrylonitrile Butadiene Styrene (ABS) material with dimensions of 115 mm x 19 mm x 4 mm, where the greatest value obtained from the tensile test was 30.46 MPa, and the lowest value was 25.31 MPa (Pranata et al., 2022). Rikky et al. carried out tensile testing using the ASTM D638-14 Type 4 tensile test standard using PLA filament material, producing the highest tensile strength value of up to 42.5 MPa (Ardiansyah et al., 2021). It is interesting to carry out tests on tensile test specimens according to the American Standard Testing and Material (ASTM) D638 TYPE I standard with different test specimen thicknesses using the Anet ET4 3D printing machine in Figure 1. The choice of the ASTM D638 TYPE I standard is due to its relevance in assessing properties plastic tensile is very possible, while the Anet ET4 3D printing machine was chosen because it has the advantages of precision and reliability.

Figure 1. Anet ET4 3D printing machine.

2. METHOD

In this research, the first step was to create a 3D printing specimen design using CAD software. The designs and sizes used for 3D printing specimens are shown in Figure 2 and Table 1 using the American Standard Testing and Materials (ASTM) D638 TYPE I tensile test standard (American Society for Testing and Materials, 2016).

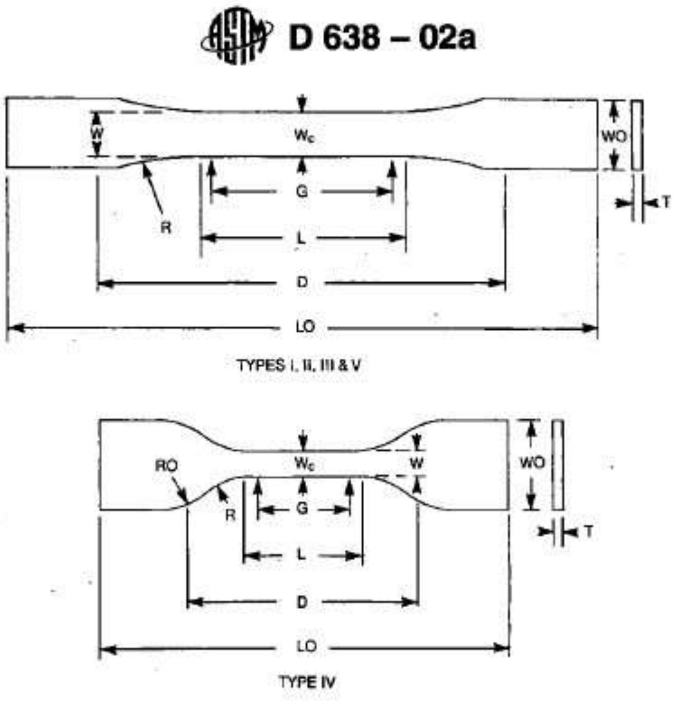

Figure 2. ASTM D638 standard shape size (American Society for Testing and Materials, 2016).

Table 1. ASTM D638 standard size (American Society for Testing and Materials, 2016). Specimen Dimensions for Thickness, T, mm(in)[A]

Dimensions (see drawings)	7 (0.28 or under		Over 7 to 14 (0.28 to 0.55)	4 (0.16) or under		Tolerances
	Type I	Type II	Type III	Type IV[B]	Type V[C,D]	
W-Width of narrow section[E,F]	13 (0.50)	6 (0.25)	19 (0.75)	6 (0.25)	3.18 (0.125)	±0.5 (±0.02)[B,C]
L-Length of narrow section	57 (2.25)	57 (2.25)	57 (2.25)	33 (1.30)	9.53 (0.375)	±0.5 (±0.02)[C]
WO-Width overall, min[G]	19 (0.75)	19 (0.75)	29 (1.13)	19 (0.75)	-	±6.4 (±0.25)
WO-Width overall, min[G]	-	-	-	-	9.53 (0.375)	±3.18 (±0.125)
LO-Length overall, min[H]	165 (6.5)	183 (7.2)	246 (9.7)	115 (4.5)	63.5 (2.5)	no max (no max)
G-Gage length[I]	50 (2.00)	50 (2.00)	50 (2.00)	-	7.62 (0.300)	±0.25 (±0.010)[C]
G-Gage length[I]	-	-	-	25 (1.00)	-	±0.13 (±0.005)
D-Distance between grips	115 (4.5)	135 (5.3)	115 (4.5)	65 (2.5)[J]	25.4 (1.0)	±5 (±0.2)
R-Radius of fillet	76 (3.00)	76 (3.00)	76 (3.00)	14 (0.56)	12.7 (0.5)	±1 (±0.04)[C]
RO-Outer radius (Type IV)	-	-	-	25 (1.00)	-	±1 (±0.04)

Polylactic Acid (PLA) material is a material used with a diameter of 1.75 mm in the form of filaments, shown in Figure 3, where this material has good strength and is easily decomposed in the environment (Biodegradable) (Sujana & Prasetyo, 2022). Apart from that, this filament is easy to print or process and does not require high temperatures (Setyawan & Ngadiyono, 2022). The specimens were made using 3 variations in thickness, namely 2 mm, 3 mm and 4 mm, where the tensile test used a machine with a capacity of 5 tons, as shown in Figure 4.

Figure 3. Polylactic Acid (PLA) filaments.

Figure 4. 5 ton capacity tensile testing machine.

3. RESULT AND DISCUSSION

Result

The specimens produced by the Anet ET4 3D printing machine with a thickness of 2 mm, 3 mm and 4 mm using the American Standard Testing and Material (ASTM) D638 TYPE I tensile test standard can be seen in Figure 5.

Figure 5. Tensile test specimens.

After the tensile test specimens were produced, tests were then carried out, where the test results for each thickness are shown in the table. 2 for a thickness of 2 mm, table 3 for a thickness of 3 mm and table 4 for a thickness of 4 mm.

Table 2. Tensile test results for 2 mm thick specimens.

	Width [mm]	Thickness [mm]	Max Load [N]	Tensile stress [MPa]	Tensile stress at Yield [MPa]	Tensile strain (Extension) at Break (Automatic load drop) [%]	Modulus (Automatic Young's) [GPa]	Code
1	13.69	1.74	968.60	40.69	29.88	6.25	1.36	2
2	13.29	1.75	1041.87	44.72	34.00	4.42	1.42	2
3	13.50	1.74	1046.46	44.47	33.30	6.62	1.43	2
Mean	13.49	1.74	1018.98	43.29	32.39	5.77	1.40	
Standard deviation	0.20	0.01	43.69	2.26	2.20	1.18	0.04	
Minimum	13.29	1.74	968.60	40.69	29.88	4.42	1.36	

Table 3. Tensile test results for 3 mm thick specimens.

	Width [mm]	Thickness [mm]	Max Load [N]	Tensile stress [MPa]	Tensile stress at Yield [MPa]	Tensile strain (Extension) at Break (Automatic load drop) [%]	Modulus (Automatic Young's) [GPa]	Code
1	13.50	2.69	926.19	25.53	19.31	6.63	1.02	3
2	13.52	2.67	926.35	25.63	19.52	5.96	0.99	3
3	13.42	2.72	904.77	24.80	19.05	6.25	0.94	3
Mean	13.48	2.69	919.10	25.32	19.29	6.28	0.98	
Standard deviation	0.05	0.02	12.42	0.45	0.24	0.34	0.04	
Minimum	13.42	2.67	904.77	24.80	19.05	5.96	0.94	

Table 4. Tensile test results for 4 mm thick specimens.

	Width [mm]	Thickness [mm]	Max Load [N]	Tensile stress [MPa]	Tensile stress at Yield [MPa]	Tensile strain (Extension) at Break (Automatic load drop) [%]	Modulus (Automatic Young's) [GPa]	Code
1	13.71	3.54	1044.61	21.53	10.64	6.13	0.76	4
2	13.46	3.50	1068.85	22.69	20.67	8.66	0.64	4
3	13.84	3.53	1069.66	21.88	16.00	4.61	0.78	4
Mean	13.67	3.52	1061.04	22.03	15.77	6.47	0.73	
Standard deviation	0.19	0.02	14.24	0.59	5.02	2.05	0.07	
Minimum	13.46	3.50	1044.61	21.53	10.64	4.61	0.64	

Discussion

Test results in table 2, table 3 and table 4, the results show that as the thickness of the specimen decreases, the tensile stress value increases. Specifically, for a thickness of 0.2 mm, the average tensile stress is 43.29 MPa; for a thickness of 0.3 mm, it is 25.32 MPa; and for 0.4 mm, it is 22.03 MPa. This trend can be attributed to the fact that thinner specimens have a higher layer density, thereby increasing their structural integrity and resistance to tensile forces. This finding is consistent with previous research (Pratama et al., 2021) which showed a similar inverse relationship between specimen thickness and tensile stress. However, further research is needed to explore the underlying mechanisms in more detail.

4. CONCLUSION

The results of testing the tensile strength of specimens made from Polylactic Acid (PLA) filaments, 2 mm specimens 43.29 MPa, 3 mm specimens 25.32 MPa and 4 mm specimens 22.03 MPa. The greatest result was the 2 mm specimen at 43.29 MPa because the layers of this specimen were denser than the 3 mm and 4 mm specimens.

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