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TENSILE TEST OF CARBON CLOTH COMPOSITE WITH MATRIX POLYPROPYLENE RECYCLING WITH WORKING TEMPERATURE PARAMETER OF 600 °C WITH METAL AND CERAMIC PRESS MEDIA

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Abstract

Right now the distribution of polypropylene in the environment has become more and more so that it can pollute the environment. Thus polypropylene waste can be converted into a composite matrix. In this study, the manufacture of composites from recycled polypropylene was carried out, to be further combined with carbon fiber. After that, tensile testing is carried out to find out the mechanical properties. As a variation, there are differences in press media, namely using metal and ceramics. This research method is carried out experimentally, where when polypropylene waste has been softened using a heat gun at a temperature of 600 °C, it is emphasized using aluminum metal and ceramics so that polypropylene can be solid. Then for the dimensions of its manufacture according to ASTM D 638 for recycled polypropylene and ASTM D3039 for recycled polypropylene matrix carbon fiber composites. From the tensile test results for ASTM D638, specimens with suppression treatment using metal press media have an average maximum tensile strength of 5.40 MPa. As for specimens with ceramic press media has an average value of 6.32 MPa. Tensile testing on recycled polypropylene matrix carbon fiber composite specimens showed tensile strength with a value of 7.53 MPa for the treatment of metal press media and for ceramic press media its strength value of 10.66 MPa. Thus ceramic press media in the polypropylene composite manufacturing process is better than metal press media.

Keywords: *polypropylene, ceramic, metal, ASTM, tensile*

Introduction

Waste of polypropylene spread out in our environment is increased, this is because many of thing that using polypropylene as a based material. From polypropylene can be used as a bottle, furniture, and electronic component. To decresead the waste of polypropylene can be used 3R process, that is reduce, reuse, and recycle, thus the waste of plastic can be reduced (Lokantara et al., 2018). At this time, many of way to process the waste from polypropylene plastic, for example is recycle the plastic into plastic pellets, so the plastic pellets can be used again to make something. But, there is another way to recycle the waste of polypropylene, that is change it to composite. Composite is material that build up from two or more material that have a different of mechanical properties. The advantage of composite is have a high corrosion resistance if compared with metal. Beside that the mass of composite is lighter and high durability (Rodiawan et al., 2016). Although the mechanical properties is lower dan metal, but composite is give enough strength at certain component. Another advantage of composites is have a light mass. Therefore, the potency of using composite to make some component is can be considered.

The topic from this research is make composite that from recycle of polypropylene. The waste of polypropylene will be recycle with heat treatment until soften and pressed with different media, the media that used in this research is from metal and ceramic. Then, the polypropylene that already soft combined with carbon fiber, so the polypropylene is used as a matrix and the carbon as fiber. To find out the mechanical properties of the composite, so the composite is tested with tensile test. The objective of this research is to know the raise of tensile strength from recycle polypropylene to composite polypropylene that reinforcement with carbon fiber. Another objectives is to find out the effect of diferrent press media that used in this research. With this research, it is hoped that waste of polypropylene can be decreased.

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Literature Review

Composite

Composite is material that consist two or more different material (Wahyudi dan Yuono, 2015). Typically, composite is arranged with matrix and fiber, matrix has a function as tied the fiber. According from Haezer (2016) matrix have ductile properties lower than the fiber, this is becase the purpose of matrix is just tied the fiber. While, the function of fiber is to be main structure on composite. Matrix on composite can be divided by type of plastic, that is thermoset and thermoplastic (Mardiyati, 2018).The different of the plastic is based on bond chain. Thermoset is plastic that have cross bond chain, so when the plastic is heat treated they will not melted, but will burnt. While thermoplastic is plastic that have straight bond chain, so while give heat treated they will melted and soften. Therfore, thermoplastic is plastic that can be recycle (Dantes et al., 2016). Example from thermoset plastic is resin, while example from thermoplastic is polypropylene.

Fiber can be found from natural and unnatural. For natural fiber can be found from plant that have fiber, to extract the natural fiber is with separated the flesh and fiber plant. The advantage of natural fiber is easy to get and have a low price (Setiajit et al., 2016). But, natural fiber have a shortage that is heterogeneous diameter of fiber, so they need special treatment. Unnatural fiber can be found from carbon, fiber or another fiber that through fabrication process. Fiber that came from fabrication process have better mechanical properties than natural fiber, this is because the mechanical properties of fiber can be controlled. But unnatural fiber have high prices if compared with natural fiber (Mulyo dan Yudiono, 2018). So, when make composite we must estimate the price, then we get enough mechanical strength for certain purpose.

Polypropylene

Polypropylene is one of types plastic that can be used on daily life. Generally polypropylene is used as material to make bottle, furniture, or electronic component. But when utilization of polypropylene is increased, for example bottle that have characteristic disposable. So, to decreased the spread of waste, we must recycle it. One of recycle process than can be done is melted the plastic then turn the melted plastic into another shape, for example is used as matrix composite. Characteristice of polypropylene is solid, strong and tough, so can be used as a composite matrix (Hakim et al., 2020). The properties of pure polypropylene can be shown on Table 1.

Table 1. Properties of pure polypropylene

Item	Values	Units
Density	$8.95x10^{-10}$-$9.2x10^{-10}$	Tonne/mm^3
Modulus Young	1300-1800	MPa
Tensile strength	35-40	Mpa
Elongation at Break	150-600	%

Source: Subagia et al. (2019)

Tensile Test

Tensile test is testing that pull the specimen until the specimen have fail. Tensile test is one of material test that destructed the specimen, the purpose of this test is to find out mechanical propertis from specimen. The mechanical properties that can be get from this test is maximum force, maximuml tensile strength, yield strength, stress, dan strain (Prayoga et al., 2018). Inside the tensile test equipment is based on stress and strain equation. The equation can be shown on Equation 1 (stress) and Equation 2 (strain).

$$\sigma = \frac{F}{A} \quad (1)$$

$$E = \frac{(L - L_0)}{L_0} \quad (2)$$

Research Methods

This research is make composite polypropylene specimen from waste of plastic. First step is prepare the tool and material that can be shown on Table 2.

Table 2. Research tool and material

Tool	Material
1. Heat gun 2. Ceramic 3. Metal 4. Tensile test equipment	1. Polypropylene plastic 2. Carbon cloth

The next step is soften the polypropylene plastic using heat gun at temperature 600 °C, after that press the soften polypropylene using ceramic and another variant using metal (aluminium). The thickness of specimen is based on ASTM, for recycle polypropylene specimen using ASTM D-638, while composite carbon fiber matrix recycle polypropylene specimen using ASTM D-3039. The dimension of each ASTM can be shown on Figure 1 and Figure 2.

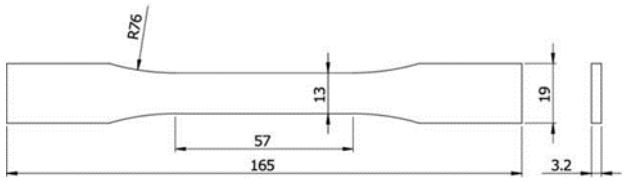

Figure 1. Dimensions of ASTM D-638

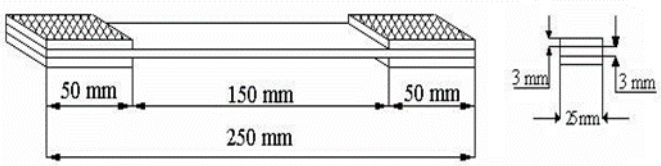

Figure 2. Dimensions of ASTM D-3039

After adjust the specimen with each ASTM, next step is perform tensile test to find out the mechanical strength from variant specimen that already done.

Result and Discussion

Tensile Test Recycle Polypropylene

From Tabel 3 is result of test recycle polypropylene that used press media metal and ceramic. From the tensile test can be determined, that the highest tensile strength is using metal press media that can be found at specimen DM with the value is 10.40 MPa. While specimen with lowest tensile strength is on specimen AM with the value 3.04 MPa. From average test result on this variant have tensile strength 5.40 MPa, maximum force 382.17 N and elongation 0.24 % from initial dimensions.

For ceramic press media, best specimen is CC, with the tensile strength 10.36 MPa. While for lowest tensile strength is specimen AC with have value 3.10 MPa. For average result on this variant is maximum force 438.80 N, tensile strength 6.32 MPa and elongation 0.09 % from initial length.

From table the difference of specimen is significant enough, this is because the constraint of test still manual using hand.

Table 3. Recycle polypropylene

Specimen	Max Force (N)		Tensile Strength (MPa)		Elongation (%)	
	M	C	M	C	M	C
A	216.21	228.77	3.04	3.10	0.36	0.23
B	353.55	393.68	4.91	5.22	0.12	0.03
C	211.70	659.62	3.24	10.36	0.16	0.04
D	747.23	473.14	10.40	6.59	0.31	0.04
Average	**382.17**	**438.80**	**5.40**	**6.32**	**0.24**	**0.09**
Difference	**13%**		**15%**		**170%**	

M = Metal, C = Ceramic

Figure 3 is bar diagram tha reprecentated the comparion average tensile strength between metal and ceramic press media for recycle polypropylene. From the result can be determined that the difference is 15 % between those press media, thus the best press media is ceramic.

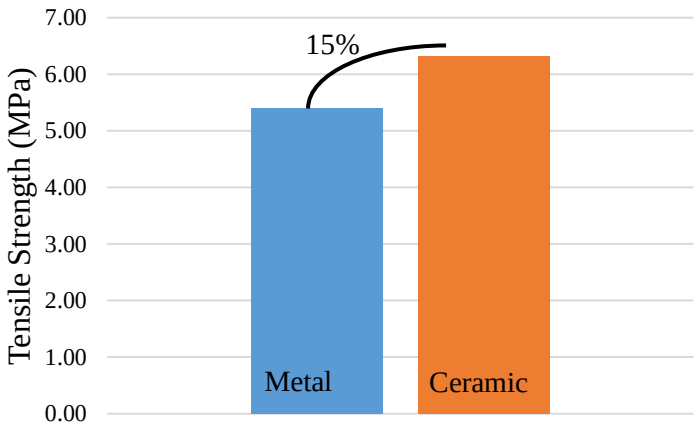

Figure 3. Comparison press media on recycle polypropylene

Tensile Test Composite Carbon Fiber Matrix Recycle Polypropylene

Table 5 is result from tensile strength composite carbon fiber matrix recycle polypropylene with metal and metal press media. From the result for metal press media shown that best specimen is ACM with tensile strength is 10.50 MPa. While for lowest tensile strength found on specimen BCM with tensile strength 4.81 MPa. For average result from this variant have maximum force 876.87 N, tensile strength 7.53 MPa and elongation 3.83% from initial length.

The best tensile strength variant ceramic press media is on specimen ACC with tensile strength 12.38 MPa. While for the lowes tensile strength is on specimen DCC with the value 7.25 MPa. Average result from this variant test is have maximum force 1182.45 N, tensile strength 10.66 MPa and elongation 4.14 % from initial length.

Table 4. Composite carbon fiber matrix recycle polypropylene

Specimen	Max Force (N)		Tensile Strength (MPa)		Elongation (%)	
	M	C	M		M	C
AC	1149.83	1388.21	10.50	12.20	4.77	4.38
BC	671.49	1197.31	4.81	12.38	1.71	3.96
CC	900.26	1110.39	7.85	10.80	3.70	2.79

Specimen	Max Force (N)		Tensile Strength (MPa)		Elongation (%)	
	M	C	M		M	C
DC	785.88	1033.88	6.97	7.25	5.12	5.43
Average	**876.87**	**1182.45**	**7.53**	**10.66**	**3.83**	**4.14**
Difference	**26%**		**29%**		**8%**	

M = Metal, C = Ceramic

From Figure 4 is shown difference of average tensile strength between metal and ceramic press media, with the difference is 29%. Thus, ceramic press media is better than metal press media.

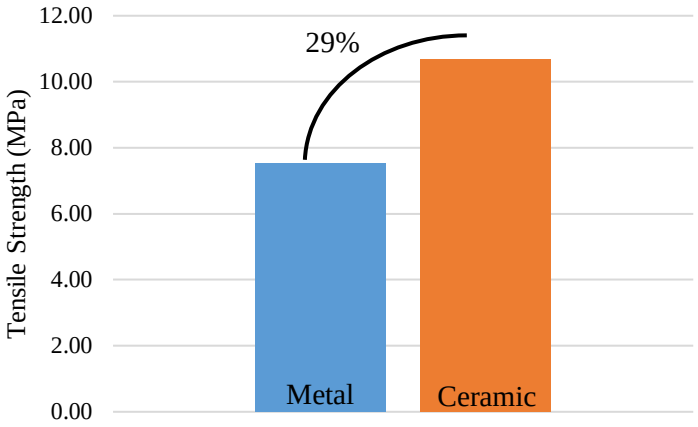

Figure 4. Comparison press media on composite carbon fiber matrix recycle polypropylene

Conclusion

From tensile strength test, can be conluded that ceramic press media is better than metal press media for make composite recycle polypropylene. From average result test at recycle polypropylene using metal press media have tensile strength 5.40 MPa, while ceramic press media 6.32 MPa. So, it give difference 15% higher using ceramic press media than metal. For composite carbon fiber matrix recycle polypropylene the best media press is also ceramic press media with the tensile strength 10.66 MPa while for metal press media is 7.53 MPa. There is difference 29% higher using ceramic media press than metal press media.

The reason ceramic press media is better than metal press media is have lowest heat conductor, so the heat can be hold at polypropylene surface while soften. With this condition the bond of particle inside polypropylene will adjusted well.

Notation

σ = Stress (MPa)
A = Area (mm^2)
E = Strain
F = Weight (N)
L = Final length (mm)
L_0 = Initial length (mm)

Speciment symbol

..C.. = Specimen using ceramic press media
..M.. = Specimen using metal press media
..C = Specimen composite carbon fiber matrix recycle polypropylene

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