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Full paper

Tensile Strength Matrix Composite Waste Glass Fiber Reinforced Plastics

A. Mataram

Mechanical Engineering Department, Sriwijaya University, Jl. Raya Palembang – Prabumulih KM 32 Inderalaya (OI) Tlp, Indonesia

*Corresponding author: Agungsini@gmail.com

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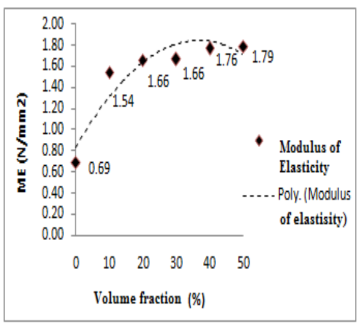
Graphical abstract



Abstract

Polypropylene (PP) including a type of plastic which ranks second on the most number of types of plastic waste after the type of High Density Polyethylene (HDPE). Glass fibers have superior mechanical properties of natural fibers. Because it has good mechanical properties, glass fibers currently plays an important role in the use of composite reinforcement. Mechanical properties of glass fiber owned and PP waste in environmental conditions that more conditions, it can be utilized as a composite reinforcement and matrix materials. This research was conducted by of injection molding method. The comparison between the volume fraction of the glass fiber matrix of type PP plastic waste with variation 0% fibers 100% matrixs, 10% fibers 90% matrixs, 20% fibers 80% matrixs, 30% fibers 70% matrixs, 40% fibers 60% matrixs, and 50 % fibers 50% matrixs. The optimum conditions obtained in this study was the comparison of variation occurs in 50% fibers volume fractions of 50% matrixs were: tensile stress was 24.30 N/mm2, tensile strain was 13.60%.

Keywords: Composites; waste plastic; fiber glass; tensile test

1.0 INTRODUCTION

One way of handling plastic waste is recycling, however, the quality of recycled products will not be as good as the quality of the new plastics processing. The other way to handling plastic waste beside recycle, is to modify the plastic waste into a new material with the addition of fillers or reinforcing a good alternative because it would improve the quality and usefulness. It could be called a composite material. One of the composite reinforcement which has been widely used in the industrial world is fiber glass. Fiber glass has also been used in industries such as the automotive vehicle body panels. In fact, almost the entire body of the motorcycle is now made of glass fiber Composite. This proves that the glass fiber is one fiber that has a superior effect in improving the mechanical properties of the composite.

Research on composite materials and components made of composite materials has been carried out, among others: Arbelaiz, *et al.* conducted a study comparing the composite joint between the PP matrix and natural fibers chemically treated with the PP matrix and glass fiber, have demonstrated the effect of glass fibers on the mechanical properties of composites are superior to natural fibers [1].

Furthermore, Zampaloni, *et al.* have proven the ability to successfully combine polypropylene into composite with natural fibers, that is kenaf fibers [11]. A method of how heat compression of the polypropylene powder and kenaf fibers with fiber volume fraction of 30% and 40% of the matrix has been shown to provide sufficient reinforcement to improve the mechanical strength of polypropylene powder. Meanwhile, Bourmad *et al.* conducted a study using polypropylene as matrix with 2 types of fiber, pandanus fiber and banana stem fiber, and concluded that it has better tensile strength compared with polypropylene fiber banana stems [3].

Bourmad, *et al*. also examined the polypropylene were carried out by making composites with 3 types of mixtures, first the pure polypropylene matrix (without fibers), second the polypropylene with 30% hemp fiber, third the polypropylene with 30% sisal fiber [3]. The research obtained that the best tensile strength are polypropylene fiber flax plus 30% then polypropylene sisal fiber and last the pure polypropylene. Based on the description and refer to some studies above, the researchers conducted a study to utilize optimally polypropylene plastic waste to make it as matrices in composites reinforced with glass fiber (fiberglass) with simple processing and searching for the best volume fraction between the matrix and the fiber towards tensile strength resulting from the composite and to assist the conserve of the environment.

2.0 EXPERIMENTAL DETAILS

2.1 Definition of Plastics

Plastic is one of the non-metallic material that can be printed. Plastic has unique and remarkable properties such as has light of weight, a resistance to dirt by wetness, low thermal conductivity and can also be penetrated by light (transparent). Plastic is also a material that is cheap but has a low melting point compared to metallic materials in general, but more flexible. Plastic is usually used as an electrical insulating material [4].

2.2 Definition of Composite Materials

Composite material is a material composed of a mixture or combination of two or more major elements that are different in shape and macro or material composition that essentially cannot be separated [5]. Composites consist of two (2) main parts, namely:

Matrix

Matrix has function as the adhesive or binder and protects the filler from external damage. Matrices are commonly used: aluminum, resin, ceramic, etc. The properties of the matrix according to Arbelaiz *et al.*: good mechanical properties, good bonding strength, good toughness, good resistance to temperature [2].

Filler

Filler (filler) serves as a reinforcement of the matrix. Fillers are commonly used: carbon, glass, aramid (Kevlar), silicon carbide, etc.

2.2.1 Fiber Composite Materials

There are two kinds of fiber composite material, the continuous fiber, and the short fiber or whisker. In this report we use fiber composite materials. Fiber composite material has the main advantage that is strong, stiff or tough, and more resistance to heat when in the matrix [6].

2.3 Polypropylene (PP)

Polypropylene is a crystalline polymer resulting from the polymerization of propylene gas. Polypropylene has a low density compared to other plastic types (Table 1). And polypropylene has a fairly high melting point (190˚C s / d 200°C), while the crystallisation point between 130˚C s / d 135°C. Polypropylene chemical resistances is high, but the impact strength is low [7].

Table 1 Density comparison of various polymers [7]

Polimer	Density (gr/cm^3)
Polypropylene (PP)	0,905
Low Density Polyethylene	0,925
High Density Polyethylene	0,959
Polystirene (PS)	1,05
Poly Carbonate (PC)	1,20
Polyvinyl Chloride (PVC)	1,30-1,58
Polyetheretherketone (PEEK)	1,31
Nylon	1,14
Epoxy	1,11-1,40
Phenolic	1,28

2.4 Fiber Glass

Fiberglass is molten glass which drawn into a thin fiber with a diameter of about 0.005 mm-0.01 mm (Figure 1). These fibers can be spun into yarn or woven into fabric, which is then impregnated with a resin material so that it becomes a strong and corrosion-resistant for used as car bodies and ship building. Fiber glass is widely used as a reinforcing material for many plastic products, Composite materials which produced by these fibers known as glass reinforced plastic or glass fiber reinforced epoxy (GRE). The most important use of this fiber is to use as reinforcement composites in the aviation industry, such as aircraft wings, fuselage. While in the furniture industry this fiber is also used in the manufacture of home, chairs, tables etc [8].

Figure 1 Fiberglass

Glass fiber is a synthetic fiber that has a fairly low density when compared with its strength. Tensile strength of glass fibers (tensile strength) is 1020 MPa and has a density of 2.58 g/cm^3 [8].

Table 2 Elastic modulus and density fiberglass, carbon fibers and epoxy [4]

Material	*Elastic Modulus* (GPa)	*Density* (g/cm^3)
Glass Fibers	72,5	2,58
Carbon Fibers (Standard Modulus)	230	1,80
Carbon Fibers (Medium Modulus)	285	1,80
Carbon Fibers (High Modulus)	400	1,80
Epoxy Resin	2,4	1,14

2.5 Mechanical Properties of Materials

After producing specimens of experiments comparing the volume fraction, the composite materials usually will do some testing in between load testing, drag, tap, slide or latitude, bending, and density to determine the physical and mechanical properties of the material examined. However, in this study only focused on the characters generated by the tensile test results.

2.5.1 Tensile Test

Tensile test is one test stress-strain (stress straintest) to find the stress and strain that aims to determine the tensile strength of the material. Composite tensile strength (ultimate tensile strength) is one of the important properties of a material. Step tensile test carried out by providing a tensile load on both ends of the test specimen is slowly increased until the specimen is split into two dropped out. With a tensile test we can determine tensile strength, yield load (creep) and modulus (Young's modulus) voltage, pull the complete profile of a curve, the curve is a graph of the results of the test load versus extension (elongation), and determine the extent to which material increases in length (Figure 2).

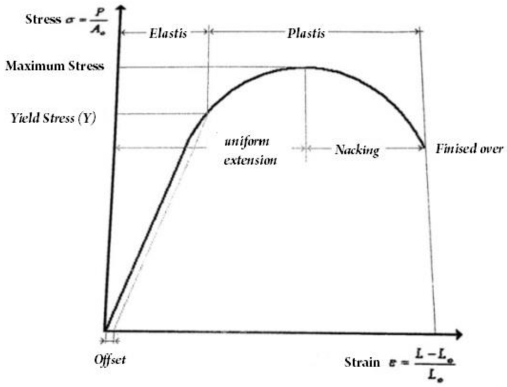


Figure 2 Graph stress versus strain

3.0 RESEARCH METHODOLOGY

This research was conducted with an experimental method in the laboratory is supported by literature research Metodologi can be seen in the Figure 3:

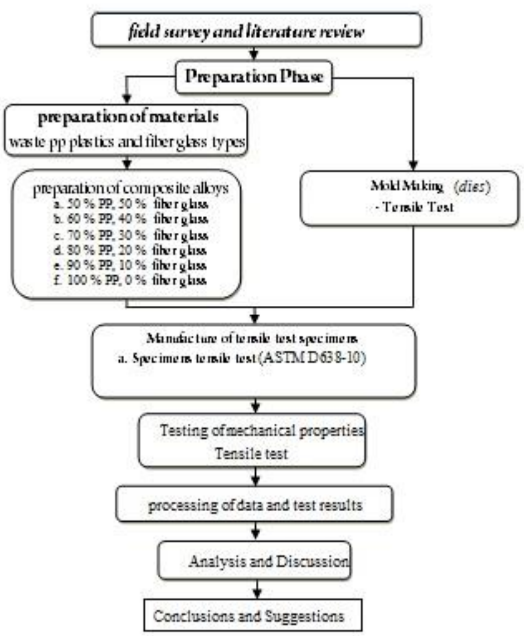


Figure 3 Scheme research methods

3.1 Equipment and Materials

Tool

The equipment used in this study are:
1. Tool test: tensile testing machine: Universal Material Tester Hydraulic.
2. Measuring devices: digital scales, bar, thermocouple and calipers.
3. Tools: milling tool is modified, spoon, wooden rollers, scissors, sandpaper, files, hand grinders, mixer, etc.

Materials

Materials to be used in this study are:
1. Matrix: the former type of polypropylene plastic waste
2. Reinforced: fiberglass
3. Water
4. Aluminum

3.2 Research Procedure

In carrying out the study, the research methodology used is as follows:

3.2.1 Preparation of Fiber Glass

The steps-glass fiber preparation steps are as follows:
a. Cutting
Cutting glass fibers made from an early form in the form of sheets into small parts but still the random fiber orientation.
b. Weighing
Once divided into small sections and then weighted according to fiber volume fraction of fibers that have been prescribed.

3.2.2 Moulding

Prints are made using aluminum formed to fit the standard ASTM D638-10 for tensile test.

3.2.3 Stages Pull Testing

Tensile testing performed using the Universal Material Tester Hydraulic machines. Composite materials made of samples tested by the shape and size refers to the standard ASTM D638-10 test (Figure 4).

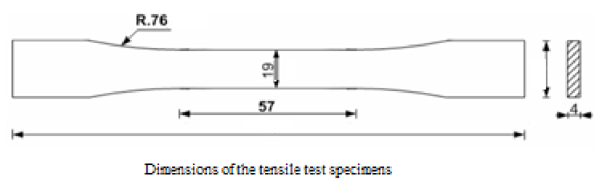


Figure 4 Dimensions of tensile test specimens standard ASTM D638-10

The steps of the tensile test on composite materials is as follows:
a. The test sample is mounted on a tensile testing machine.
b. Clamped with chucks on the edges.
c. Pulled to the longitudinal direction slowly.
d. During the withdrawal of the stress and strain are automatically recorded in the computer controller places available on the machine until the sample broke.
e. Record the force at the time and the length ultimate point of the test sample after the break.
f. From the data obtained will then be calculated and the data obtained composite tensile strength and strain are then used to calculate the elastic modulus.
g. From the test data have been obtained calculation, which calculates the amount of stress (σ), strain (ε), and modulus of elasticity (E).

Figure 5 Tensile test specimens

3.2.4 Analysis and Data Processing

After all testing is complete, the existing data compiled and then processed to analyze the tensile strength. Furthermore, the calculation result data arranged in tabular form is then displayed in graphical form.

■4.0 DATA ANALYSIS AND DISCUSSION

Making plastic matrix composite materials with the former type of glass fiber reinforced polypropylene done using hand lay-up method. Samples were prepared and then performed tensile testing. Tests performed on each - each different sample variation of the volume fraction, namely:

1. 0% = Matrix 100% with 0% reinforcement as much as 3 specimens
2. 10% = 90% matrix with reinforcement as much as 10% 3 specimens
3. 20% = 80% matrix with reinforcement as much as 20% 3 specimens
4. 30% = 70% matrix with reinforcement as much as 30% 3 specimens
5. 40% = 60% matrix with reinforcement as much as 40% 3 specimens
6. 50% = 50% matrix with reinforcement as much as 50% 3 specimens

4.1 Tensile Test

From the tensile test data obtained, and then viewed in graphical form, as follows:

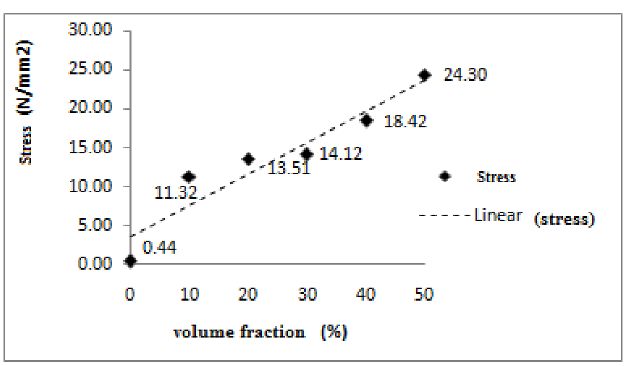


Figure 6 Graph showing the relationship between stress with a ratio of volume fraction variation

Based on the test results and test data processing tensile plastic matrix composite materials with the former type of glass fiber reinforced polypropylene obtained average value of the voltage-the highest average obtained from the variation of the matrix volume fraction 50% to 50% in the amount of reinforcing 24.30 N/mm^2, while the value average voltage-the lowest average obtained from the variation of the matrix volume fraction of 100% to 0% in the amount of reinforcing 0:44 N/mm^2.

The results of tensile testing as shown in Figure 6 shows that the addition of wt% reinforcement will affect the maximum tensile stress will rise from 0% up to 50% by weight of the amplifier. From the graph the relationship between the average stress-average ratio variation with volume fraction composites, explained that along with increasing the glass fiber composite materials used plastic bermatriks polypropylene, the tensile stress is also greater. In Figure 9 also shows that the use of glass fibers in a polypropylene matrix used plastic capable of providing a good influence on the tensile strength of the composite, it is seen from the glass fiber matrix berpenguat Plastic which has a much higher tensile strength than plastic without the use of glass fiber (0% amplifier).

The results of this study showed the same effect incidence between tensile stress and weight% reinforcement when viewed with the research using polypropylene as matrix and wood fibers as reinforcement, where the average tensile stress increases linearly with increasing percentage of amplifier 10% up to 50% [5].

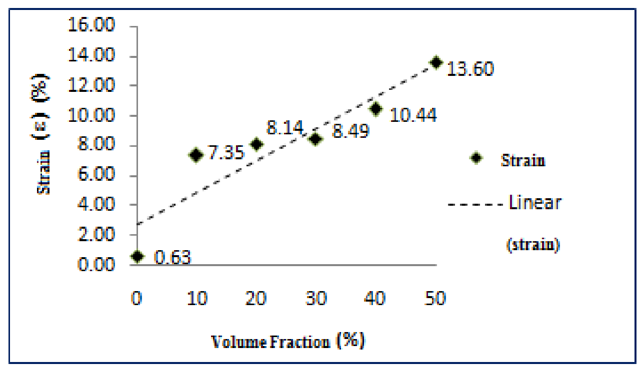


Figure 7 Graph showing the relationship between strain with a ratio of volume fraction variation

From the calculation of the value of the strain (ε) average-average used plastic matrix composites with the type of glass fiber reinforced polypropylene, obtained average value of strain-the highest average obtained from the variation of the matrix volume fraction 50% to 50% amplifier is equal 13.60%, while the value strain average-the lowest average obtained from the variation of the matrix volume fraction of 100% with 0% reinforcement is equal to 0.63%

Figure 7 is a graph the relationship between the strain average-average variation of volume fraction and comparison with matrix composites used plastic types of glass fiber reinforced polypropylene, explained that the addition of glass fiber composites can increase the value of the strain, and there is evidence of an increase in the value chart with increasing volume strain fiber glass. The addition of glass fibers in composite materials bermatriks used plastic polypropylene types also affect the length (ΔL), where the greater the length of the show that the material is ductile. In Figure 7 also shows that the use of glass fibers in a polypropylene matrix used plastic has a better strain of plastic without the use of glass fiber (0% reinforcement).

The results of the study showed that tensile stress and strain increased with increasing percentage versus unidirectional glass fiber reinforcement showed that glass fiber can act as a reinforcing material in plastics waste polypropylene. This is consistent with research [8], which produces the effect of increasing the glass fiber tensile stress and strain when added percentage of glass fiber reinforcement fiber 10% up to 40% Polyethylene fiber in the matrix. This incident caused the glass fibers have high strength and stiffness are able to donate to the polypropylene matrix used plastic that is resilient so as to provide value-added effect of tensile stress and strain in the composite.

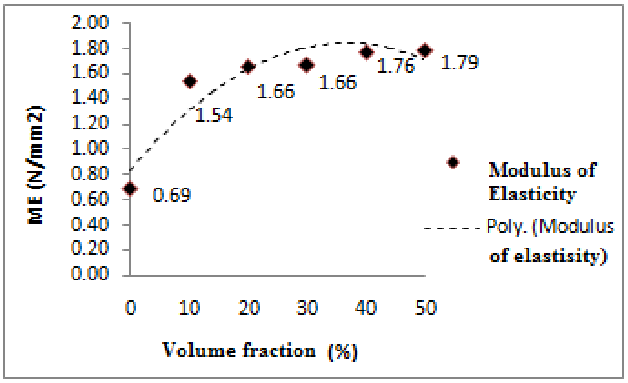


Figure 8 Graph showing the relationship between the modulus of elasticity (E) with a ratio of volume fraction variation

From Figure 8, graph the relationship between the modulus of elasticity of the average-average variation of volume fraction and comparison with matrix composites used plastic types of glass fiber reinforced polypropylene, obtained average value of modulus of elasticity-the highest average obtained from the variation of the matrix volume fraction 50% to 50% ie amplifier of 1.79 N/mm^2, while the average value of modulus of elasticity-the lowest average obtained from the variation of the matrix volume fraction of 100% with 0% reinforcement is equal to 0.69 N/mm^2 .

Explained that the value of the modulus of elasticity increased with increasing glass fiber. This suggests that, on the addition of glass fiber composite material used plastic bermatrik polypropylene types can increase the value of the modulus of elasticity. Modulus of elasticity of the variation of the volume fraction of 0% to10 % showed a considerable distance, this is in accordance with the conditions of stress and strain values on the variation of the volume fraction of 0% and 10% of those who have different values are much different and it also confirms that influence on the glass fiber composite plastic bermatrik former is much better than the old plastic matrix composite without glass fiber reinforcement.

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusion

Based on the research that has been conducted on composite materials bermatriks glass fiber reinforced plastic waste by hand lay-up method, it can be deduced as follows:

a. Composites were formed from the combination of used plastic matrix with glass fibers showed more percentage then the tensile strength of glass fiber produced, the better .
b. The maximum value obtained in this study is contained in the ratio 50% volume fraction variation matrix type of polypropylene plastic waste with 50% glass fiber reinforcement , ie at 24.30 N/mm^2 tensile stress, tensile strain at 13.60% .

5.2 Advice

Future studies are recommended to raise the glass fiber volume fraction above 50% in the composite mixture to find a limit on the effect of raising the value of mechanical fiber composite. Further testing is also recommended for SEM to see existing microstructure in composites using the hand lay up method, in order to see how much porosity is happening.

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