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New Performance with Matrix Composites of Used Plastic, Fiber of Red Pinang Sheath and Bamboo

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Abstract

Utilization of scrap plastic to composite, especially made polyproplene (PP) has to be done by adding fibers and sheaths Pinang Red Bamboo. PP matrix is heated in the heater melted then added to each of the natural bamboo fiber and red nut. Mechanical properties of the test results have been compared with the fiber-matrix without the addition of a fibrous matrix. Tests showed that the mechanical properties of kompisit has increased with the addition of natural fibers. Mechanical strength with the addition of bamboo fiber is greater than the addition of the Red Pinang fiber.

Keywords: *polyproplene, Bamboo fiber, fiber Pinang Merah, Composite, Mechanical Strength.*

1. INTRODUCTION

The Use of non-metallic material, which in this case does not include wood and stone, used in China for the local ceramic material. As for the non-metallic material was found during the development of material processing technologies [8].

The use of plastic as a derivative of the polymer has been growing rapidly after the 20th century. It could be argued that human life is inseparable from the use of plastic. As a material that is lightweight, inexpensive, and relatively strong, the use of plastics has become the main tool of human life.

Plastic waste has become an issue for every country in the world. Potential of municipal solid waste in Indonesia is very large as according to the data in year of 2000, it was 100.000 tons per day. The Plastic waste which is the major issue in this case, has contributed 2%, resulting 2000 tons in a single day production [10]. The composition of the waste or plastic waste disposed by each household was 9.3% of total household waste [2].

In general, some types of plastics have the physical, mechanical and chemical different from each other. Plastic is a polymer material that is commonly known in two groups, namely *thermoplastic* and *thermoset*. *Thermoplastic* can be easily reshaped by heating and processed into other forms, but the same treatment cannot applied to *thermoset italic* type.

At the level of plastics waste utilization, there are only a few researchers who have conducted research about it, especially research on the manufacture of plastic waste composite. Generally, the industry has been doing the *recycling* activities to process plastic waste to become new stuff (re-use).

The use of recycled plastics in the re-manufacturing of plastic goods has been growing rapidly. Almost all types of plastic waste can be used and processed back into the original item, although it must be done through the mixing of new raw materials and additives to improve quality.

2. LITERATURE REVIEW

Alexander Parkes, in 1862, discovered a new material called *Parkes.* It is an organic material derived from cellulose that once heated could be formed and maintained (its shape) when cooled [4]. In 1899, Arthur Smith received British Patent number 16,275, since "phenol-formaldehyde resin for use as an ebonite substitute in electrical insulation", the first patent was for processing formaldehyde resin. However, in 1907, Leo Hendrik Backeland increase the phenol-formaldehyde with reaction techniques and found the first fully synthetic resin that became commercially successful, it was called *Bakelitetradenamed*.

Plastics are polymers of long chain of atoms bind to each other. This chain molecules forming many repeated units, or monomers [5]. Utilization of plastics waste for recycling is generally done by the industry. Generally, there are four requirements for a plastic waste can be processed by the industry, such as waste must be in a particular form as needed (seed, pellets, powder, pieces), the waste must be homogeneous, not contaminated, and not oxidized. To overcome these problems, before the use of plastic waste, it is processed through a simple steps, they are separation, cutting, washing, and removal of substances such as iron and so on.

Looking at the number of people increases, it should be stated that the need of plastics will certainly tend to increase. Various types of plastics have been used by human nowadays. Various types of plastics have been developed. It can be concluded that, this type of plastic waste which is cannot be parsed will continue to grow every year. As a result, plastic waste is growing bigger every year, and this is a loss for mankind in the future.

As a matter of fact, plastic waste can be recycled. Recycling technology has long been used by people. The Re-use or recycling is an attempt to conserve natural resources and reduce the import of raw materials from abroad. Some examples of recycling are making plastic buckets, plastic bags, and gallon refill for drinking water, plastic broom fibers, and so forth.

Matoa (2010) submit articles on type and kind of plastic packaging material, which revealed that the recycling code for plastics was issued by The Society of Plastic Industry in 1998 in the United States and adopted by agencies that develop code systems, such as ISO (International Organization for Standardization). Various kinds of the plastic codes are PETE or PET (Polyethylene Terephthalate), HDPE (high density polyethylene), PVC (polyvinyl chloride), LDPE (low density polyethylene), PP (polypropylene) and PS (Polystyrene).

Recently, people started to use bamboo to make interesting bamboo plywood. It turned out that bamboo is pretty strong to be used as building block of plywood. The findings of Kliwon and Iskandar research (1994), shows the bonding strength of bamboo plywood and bamboo plywood multiplex meets Indonesian and Japanese standards. The firmness pull of bamboo plywood is higher than the pure plywood for both parallel and perpendicular direction of fiber. Bamboo composite products are not only used as a construction material for the floor and walls, but can also be used for a variety of special purpose such as furniture, container and truck. The purpose of bamboo composite board development is to use bamboo as a building material. To support the purpose, products as building materials panel with bamboo base material have been developed. The products have special conditions to be used in the very modest home residential sector (RSS), the products also have certain advantages for specific use and for export (Subiyanto et al., 1994).

Research on the development of several methods in processing of bamboo and composite materials structure studies have been conducted by Nugroho (2000) in various types of composite product which is known as the *Zephyr Bamboo Board* (BZB), *Bamboo Binderless Board* (BBB), *Laminated Bamboo Lumber* (LBL) and *Bamboo Reinforced Composite Beam* (BRCB). Research on board laminated bamboo rope as the core and plywood as face by Hendrawan (2005), showed that the laminated board with a distance of 0 cm core has the highest MOE value, because the bamboo core is denser than the core laminated board with the other distance. The MOR value also resulted better, the closer the distance of the bamboo core, the higher the value of the MOR will be. The findings of Purwito research (2005) on the multifunctional bamboo panels shows that the results of laboratory tests and tensile bending strength of bamboo panel is quite good as well soundproofed. Quality of the panel would be better if the bamboo to be used, preserved in advance so that the panel will be resistant to wood destroying powder.

The research on the product in the form of sandwich panels of bamboo has been done, as it was conducted by Setyo (2006) about the use of bamboo Apus on the composite rods (sandwich) of bamboo Sengon towards compressive strength and flexural, and Erniwati (2006) on the quality of coated woven bamboo composite board. The finding of the research showed that the use of bamboo wood combined with sengon bamboo to be composite rods can increase the strength and stiffness of the stem structure, both compressive strength and flexural strength.

Composite is material formed from a combination of two or more materials, which will form a better material than its constituent materials. Composite materials have many classifications, depending on the idea and concept of identification needed. Due to the different characteristics of the constituent, the new composite will be formed with different mechanical properties and characteristics of the constituent materials. Composite material is formed of two different types, namely: reinforcement (reinforcement) and the matrix as a binder.

Tampubolon (2010)[12], has classified the various composite as follows:

- **Fiber Composites**

Fiber composites is a composite of fiber and matrix (base material) produced through fabrications, such as adding resin as fiber adhesive. It is a kind of composite which consists only of a single lamina or layers using a fiber amplifier / fiber. Types of fiber that can be used are glass fibers, carbon fibers, armid fibers (poly aramide), and so on. This fiber can be arranged randomly (Chopped Strand Mat) or with a particular orientation can also be in the form of even more complex like webbing.

- **Laminated composite**

Laminated composite is a composite type consisting of two or more layers that are merged into one and each layer has its own characteristics. It is a type of composite consisting of fiber and matrix layers, layers which are reinforced with resin such as *plywood, laminated glass* which are often used in building materials and completeness. In general, macroscopic manipulation performed which is corrosion resistant, strong and resistant to temperature.

- **Flakes Composite**

Flake is defined as tiny particle that has been determined previously which is produced in special equipment with fiber orientation parallel to the surface. A flake composites consisting of shales that hold each other to bind the surface or incorporated into the matrix. Special properties that can be obtained from the flakes are large and flat shape so that it can be arranged tightly to produce a strong reinforcing material which for a particular cross sectional area.

- **Particles Composite**

Particles composite is composite consists of particles and the matrix grains (stone, sand) which is reinforced with cement as we have seen as concrete, complex compounds into complex compounds. Particle composite is a product produced by placing the particles and tie it with a matrix together with one or more elements such as heat treatment, pressure, humidity, and other catalysts. The composite particles with different types of random fibers that are isotropic. Fiber composite strength is affected by the coherent voltage between the matrix and particle phase that shows a good connection.

Aji et al (2009)[1] describes the nature of the fiber and polymer composites as follows: good surface treatment is needed to incorporate hydrophilic fibers and hydrophobic polymers to produce composites with excellent properties. Kenaf (Hibiscus cannabinus), is known as a source of cellulose fibers with economically profitable and ecologically, has a low density, non-abrasiveness during processing, high specific mechanical properties, and biode gradabilitas that can be used in combination with PE after treatment composite process which can help reduce the hydrophilicity of the fiber required for the production of composites.

The matrix is a material used to bind and unify the fiber without reacting chemically with the fiber that has the function among others, to protect the composite from mechanical damage and chemical damage, to divert/forwarding expenses from outside the fiber. This means that the matrix spread and separate the fibers so that the rift cannot be moved from one another and it also functions as a binder.

The mechanical strength of a composite is a thing to be taken into account. Scale is commonly used mechanical tensile strength, bending and impact. Some researchers have explained some of the mechanical strength in accordance with the conditions of usage and charging.

Purboputro (2006)[6], examined the fiber-reinforced composites of water hyacinth aims to find tensile strength, impact strength, bending strength fiber of water hyacinth composite with a length of 25 mm, 50 mm and 100 mm with 80% volume fraction of 20% fiber matrix polyesterdan water hyacinth. Based on the test, the value of the tensile strength of the composite with the highest fiber length of 100 mm is 11.02 MPa, with the modulus of elasticity of 11.023 GPa, the highest value impact is owned by composites with fiber length of 50 mm is 0.002344 J/mm2.

Palm fruit fiber and sawdust investigated by Sosu et all (2011)[9], who studied the possibility of using composite materials made from palm fruit fiber and sawdust building materials, modulus of elasticity, fracture load and the maximum deflection of the composite pieces of mahogany sawdust and fibers-kotolyn veneer has been determined using static bending test. Composite material made from 100% heavy crude measure sawdust recorded the highest fracture load and modulus of elasticity of 48.00 × 102 N and 106 Nm-2 2.23, respectively. Among composites containing fibers and sawdust, size 90 wt% wt% crude fiber recorded the highest fracture load and modulus of elasticity of 30.90 × 102 N and 1.07 × 106 Nm-2. Mechanical strength of the composite decreases with decreasing fiber content. The maximum deflection, however, increased with increasing fiber content. Incorporation of fiber into sawdust briquettes provide some degree of flexibility to the composite material with a decrease in strength and not make a good building material but can be used for finishing.

Tajan et all(2008)[11] presented some important properties of the experimental production of determined wood-plastic composite (WPC). Specimens had 30% Iron wood particles (Xylia Xylocarpa) mixed with cork recycled polypropylene (RPPF) and two different additives, glycerol as plasticizer and maleic anhydride grafted polypropylene homopolymer (MAPP) which is a compatibilizer. Thermal and mechanical properties of the composites were analyzed and compared with the non-additive composite. Compared with RPPF, iron wood / composite RPPF has higher melting point and crystallization temperatures, but crystallization level is lower. Their thermal stability is lower than RPPF because of degradation of wood powder. The experimental results showed that the addition of wood powder increased tensile modulus, but the decline in the values of tensile strength and elongation at break of the composites.

Research on bending resistance of composite with hybrid coconut trunk fibers/fiber glass with urea formaldehyde matrix, has been carried out by Sari et al (2011)[7], concluded that the highest hybrid composite bending strength on the variation of fiber volume fraction of 10% coconut trunks and 20% glass fiber that is average of 22.7 N/mm2.

3. RESEARCH PROCEDURES

The research will be done through the utilization of used plastic bottles as the matrix, and the fiber will be several kinds of organic fibers such as; leave fiber of red pinang sheath and bamboo. Used plastic is washed and then dried to remove excess water, and then cut into pieces. Fiber, sheath and bamboo will be soaked a few days, then beaten with wood to ease the separation of the fiber.

The research started with studying the literatures on studies and journals relating to the title before the study, and at the same time carrying out field survey, and then after all the data is collected, the next step is to do the material preparation that begins with the collection of plastic waste, collection of organic fiber material which are fibers of red pinang sheath and bamboo fiber. Mold making is done using the standard size aluminum specimens in each test, after that all the specimens were made using the mold.

Once the specimen is completed, then the testing of the mechanical properties of the specimens will be applied using the tensile testing, impact testing and arch testing. The resulting data is then made in the form of a table and then displayed using graphs. Then the data are discussed and conclusions drawn.

The independent variables which are measured in this study are:

- Organic fiber weight fraction of 10%, 20%, 30%, 40% by weight of the plastic fraction of 90%, 80%, 70%, 60%. (Using the balance sheet).
- Orientation of the fibers which will be used is Random.

4. DATA ANALYSIS AND DISCUSSION

Composite using plastic waste which is reinforced with bamboo fiber is tested through mechanical characteristic testing and the results is as follows:

Tensile testing

In the process of tensile testing, specimens were made in accordance with ASTM standard sizes. Accuracy in making this specimen must be met as slightly deviant size will provide measurement results of the tensile test with big error rate. Activity in the manufacturing process specimens in attachment 1. Tensile test carried out at the Polytechnic of Sriwijaya Palembang laboratories, equipment used is *Hydraulic Universal Material Tester 50 kN*. At the time of testing, tensile testing machine used can plot graphs directly. This machine can directly indicate the amount of the maximum tensile stress (ultimate strength) on the monitor. Tensile testing measurement results obtained from the tensile testing machine is a big load, F (Newton), beginning with the final length difference, ΔL (mm), tensile stress, σu (N/mm2). The amount of strain is calculated by using the existing formula.

Number of specimens for each test is 3 (three), so it can be taken the mean of the test and calculation. Examples of tensile test specimens in this study shown in Figure 1 below.

Figure 1. Specimen of Tensile Testing

The results indicate the magnitude of the measured maximum tensile stress σu, strain ε measurable, scalable and large load F length difference ΔL measured tensile testing, while the cross-sectional area A is the input value of the cross-section of the specimen. Tensile testing of a material can directly generate the amount of tensile stress and strain, where the amount of strain is the total strain.

Pull tension and strain with a mean value for the composite without and with bamboo fiber can be created pictures such as Figure 2 and 3 below.

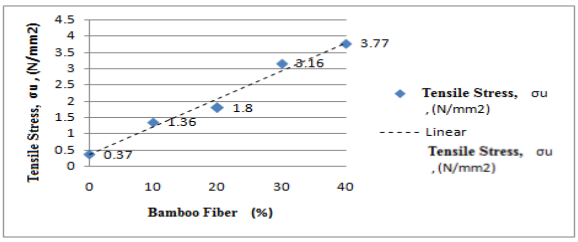

Figure 2. The maximum tensile stress of the composite with and without Bamboo fiber

Figure 2 shows that the addition of bamboo fiber in the parent matrix PP has increased the value of tensile stress. This is indicated by the line inclination (trend lines) is uphill and has made the regression line equation y = 0.86 x - 0.488 with R ² = 0.980. Variability toward the pieces of bamboo fibers during manufacture specimens have been made for each tensile stress variability. Another cause for this inconsistency is probably there are sheaths that does not blend with the fiber matrix.

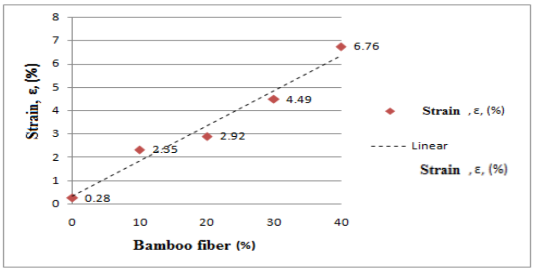

Figure 3. Strain for composites without and with Bamboo fiber.

Figure 3 shows that bamboo fiber composites with 10 and 40% greater than the trend in the regression line y = 1.509x - 1.167 with R ² = 0968, while for the 20 fiber and 30% less than the fulfillment of these equations. It is also due to variability from fiber direction. For fibers 10 and 40%, likely due to the persistence of the fiber composite interested and hold while the matrix has undergone a process of tensile test termination.

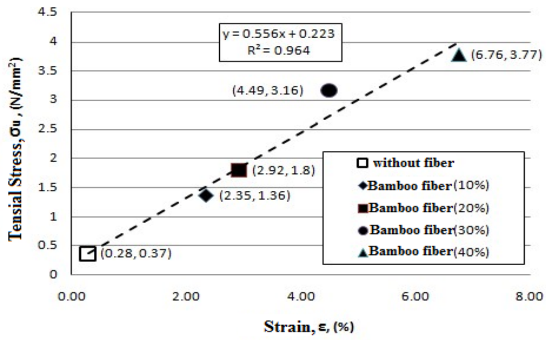

Figure 4. The maximum tensile stress and strain for composites without and with Bamboo fiber

The relationship between tensile stress and strain usually described as a relationship that occurs in the process of withdrawal of certain materials testing, in this case, it describes the relationship between variations of the bamboo fiber content for each of the tensile stress and strain (see Figure 4). With R2 value = 0.964 or R = 98%, then the high level of confidence shown by the equation y = 0.556 x + 0.223.

This equation shows a linear relationship between the additions of bamboo fiber which is followed by the increase of tensile stress and strain. Relatively, large deviation is indicated by the percentage of bamboo fiber composite by 30%. But this relatively credible as an advantage because with 30% of fiber, it has achieved an increase in tensile stress greater than the percentage of other fibers.

This image also shows that the greater the tensile load to the specimen with increased percentage in fiber, will increase the amount of material strain. Thus, it looks bamboo fiber composites has increased the ability of the receiving load pull.

Bending Three Point Testing

In testing the implementation of the arch, graphs tensile test cannot be plotted due to the small weight given to the specimen. So that the readings were taken on the monitor, where the figures shown are the load, F, and voltage arcing, σb. Measurement of the load F, and voltage arcing, σb done by observing specimens will momentarily cracked, the way to stop loading. Unreadable monitor the amount of F and voltage arcing and by manual measurement of the specimen measured deflection δ scale.

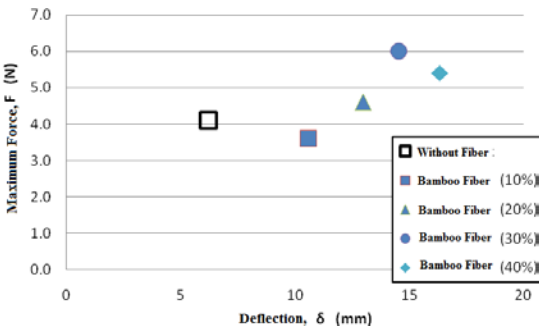

Figure 5. Maximum Load and Deflection Relationships for Composite without and with Bamboo Fiber

From Figure 5 it can be seen that the increase in the value of deflection, necessarily diiukuti with maximum force given on arch testing. This proves that great style with 3 Newton for each composite with bamboo fiber will cause a greater deflection than the deflection for the composite without bamboo fiber. It is understandable that the composite effect of bamboo fiber composites has increased the ability of the receiving load arch.

With the data that has been obtained, it will be calculated magnitude elasticity composite modulus for each specimen. Relationship modulus of elasticity, E and Deflection shown by the following equation:

$$\delta = \frac{F\,l^3}{48\ \mathrm{EI}}$$

$$I = \frac{\mathrm{b\ h}^3}{12}$$

Where l is the length, I is the moment of inertia bend test specimen with long dimension of each side of the specimen is the same, namely b = 20 mm and h = 20 mm. So therefore, the magnitude of the elastic modulus can be calculated and the results can be seen in Table 1.

Table 1. Elasticity Modulus of Composites with Bamboo Fiber

Specimen	Deflection, δ	Maximum Force F	Lenght L	Moment of Inertia, I	Modulus of Elasticity, E
	(mm)	(N)	(mm)	mm^4	(N/mm^2)
Without Fiber	6.2	3	100	13333.33	0.756
Bamboo Fiber (10%)	10.6	3.6	100	13333.33	0.531
Bamboo Fiber (20%)	13	4.6	100	13333.33	0.553
Bamboo Fiber (30%)	14.6	6.0	100	13333.33	0.644
Bamboo Fiber (40%)	16.3	5.4	100	13333.33	0.517

Modulus of elasticity for each specimen are not as great. This depends on the percentage of bamboo fiber which is added to the matrix. Larger elastic modulus cannot reflect that it is more elastic because it depends on the yield stress and the yield strain of the material.

Impact test

The impact test performed on specimens without fibers and with bamboo fiber. Tests carried out at the Laboratory of Material Department of Mechanical Engineering, Faculty of Engineering of University of Sriwijaya. Impact test results have earned the amount of corner swinging a hammer after the specimen, θ, α is the angle while swinging a hammer or mallet before the load is released and the specimen. With a swing of the hammer was taken the same style for all testing specimens of 251.921 N and the long arm hammer at 0,649 m, and the angle α = 90 0, then the energy released when the hammer is uniform in the amount of 163.5 Joules. While the energy behind after the specimen is broken by E2 and each depends on the magnitude of the angle θ measured on the needle tool impact test. The difference of the energy, E = E1-E2, is the maximum energy that can be accepted by the specimen.

Based on the mean score taken from the table, impact loads of each specimen can be described as shown in Figure 6 below.

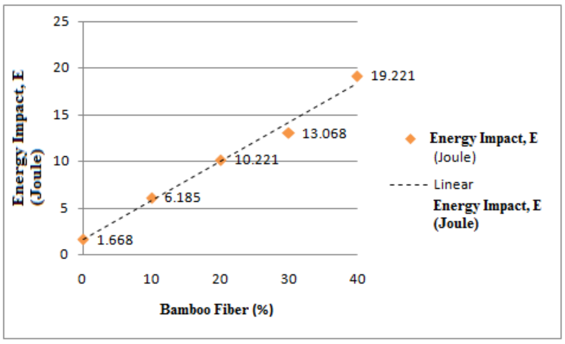

Figure 6. Energy Impact of Composite without and with Bamboo Fiber

The magnitude of the impact energy will show resilience of the material in receiving shock loads. Figure 6 shows that kopsit with bamboo fiber 30% below the regression line y = 4.199 x - 2.524 with R2 = 0.988. Whereas with 40% bamboo fiber, composites exceeded the regression line. This means that the specimens with 30% fiber needs further strengthening, while the composite with 40% bamboo fiber is more resilient than other specimens.

Composites using waste plastic reinforced with red Pinang Fiber are tested through Mechanical characteristic test, and results as follows:

Pull Testing

Fiber composites with red Pinang sheath is made just like the bamboo fiber, specimens used for the tensile test. Red Pinang sheath fiber short cut to size 1 (one) cm. Tensile tests performed at the same place and the tool.

Based on the result obtained from the test, picture is made to show tensile stress and strain relationship using the mean score of each. Figure 7, shows that only 30% composites with fibers that do not touch the linear regression line y = 0.663 x - 0.317 (with a confidence level of 0.985), while the three other specimens of the touch line. This means that the tensile strength of the fibrous specimens of 20% is not sufficient, but the tensile stress increases.

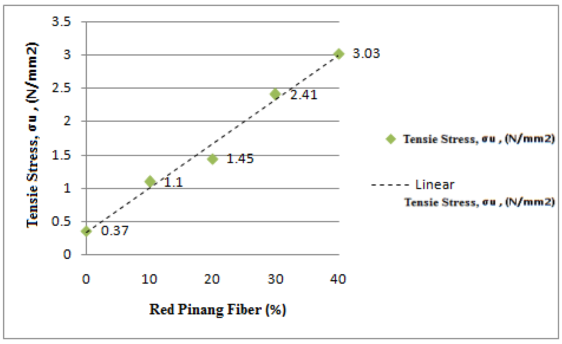

Figure 7. Maximum Tensile Stress of composite without and with Red Pinang Fiber

From Figure 8, with the linear regression equation y = 1.366 x -1.388 (with R2 = 0.951), shows that the fiber content by 20 and 30%, the composite does not touch the line equation. But with 40% red areca fibers, composites have exceeded the strain based on the line equation. This means that the effect of fiber orientation and arrangement of fiber and plenty of fiber in the composite is very influencing against strain. This condition is not much different from the tensile stress caused by the pull of the load on the specimen.

The relationship between the tensile stress and strain for composite using red Pinang sheaths can be drawn as Figure 9. Interpretation of the results of the study of the relationship between tensile stress and strain in the figure shows the relationship of each fiber composition.

Composite without fiber has tensile stress 0.37 N/mm2 with a strain of 0.28%, for 10% composite fiber has tensile stress of 1.1 N/mm2 and a strain of 1.6% and so on for each fiber. Linear regression line can interpret the linear relationship, so that the percentage increase in the number of fiber will be followed by a straight increase in tensile stress. Linear regression equation formed is 0.469 x + y = 0.375 with R2 = 0.97.

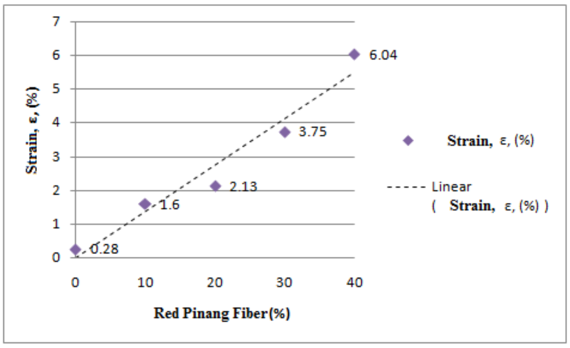

Figure 8. Strain for composites without and with Red Pinang fiber

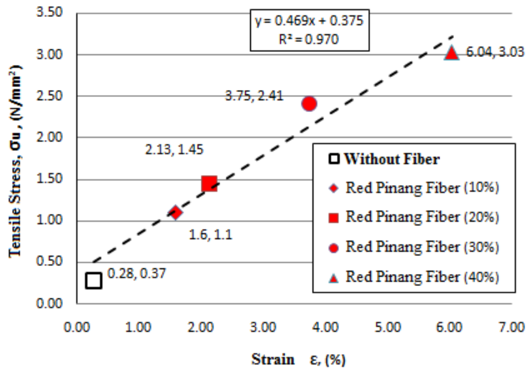

Figure 9. The maximum Tensile Stress and strain for composites without and with Red Pinang fiber

Bending Three Point Testing

Bending Three Point Testing for composite specimens with fiber sheaths of red Pinang is done with the same tools and the place for bamboo fiber composite. The mean of the maximum force and deflection can be described and shown in Figure 10.

As it was with bamboo fiber composites, fibers with a percentage of 10% has a lower maximum force than the specimens without fiber. So is the case for fibers with a percentage of 40%, which has a relatively low maximum force than the specimens without fibers, fibers 20 and 30%. In this condition, it is seen that the specimen without fiber has the lowest maximum force and the composite with 30% having the largest maximum force. Interpretation that can be given to this situation is the addition of red areca fiber composites has provided the ability to be able to accept loads with large deflections.

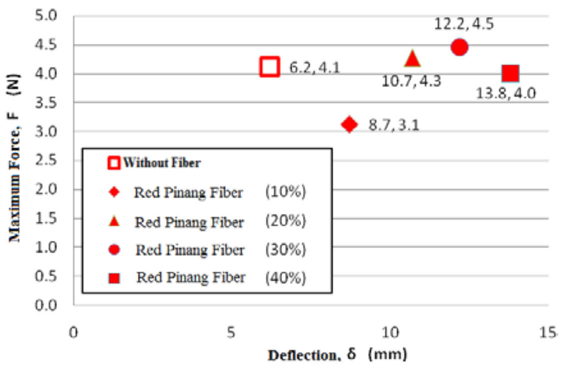

Figure 10. The Relation of Maximum Force and Deflection for Composites without and with Red Pinang Fiber

Table 2. Elasticity Modulus of Composites without and with Red Pinang Fiber

Specimen	Deflection, δ	Maximum Force, F	Length, L	Moment of Inertia, I	Modulus of Elasticity, E
	(mm)	(N)	(mm)	mm^4	(N/mm^2)
Without Fiber	6.2	4.1	100	13333.3	1.033
Red Pinang Fiber (10%)	10.6	3.6	100	13333.3	0.531
Red Pinang Fiber (20%)	13	4.6	100	13333.3	0.553
Red Pinang Fiber (30%)	14.6	6	100	13333.3	0.642
Red Pinang Fiber (40%)	16.3	5.4	100	13333.3	0.518

Just as is the case with bamboo fiber composite, the modulus of elasticity for each specimen for fiber composites with red Pinang sheath is not as great. This depends on the percentage of red pinang fiber which is added to the matrix. Larger elastic modulus cannot reflect that it is more elastic because it depends on the yield stress and the yield strain of the material.

Impact test

Impact test for composite specimens with red areca fiber also performed in the laboratory of Department of Mechanical Engineering, Faculty of Materials Engineering, University of Sriwijaya. Test results and Impact Energy calculations made in tabular form is then displayed in graphical form below.

Impact energy Figure 11 for the red Pinang composite has increased similar to the linear addition of red pinang fiber. With the addition of fiber as much as 20%, the specimen is able to withstand greater impact energy. But with as much as 10% fiber, the specimen has the ability to impact energy lower than the percentage of other specimens.

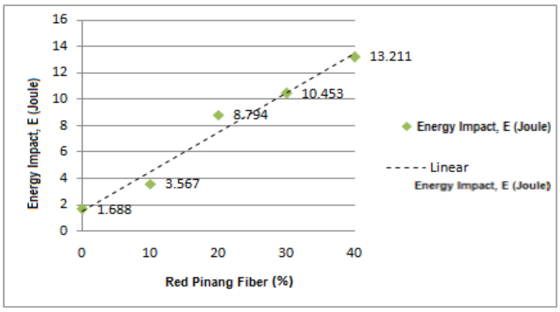

Figure 11. Energy Impact of Composite without and with Red Pinang Fiber

5. CONCLUSION

The Research conducted and the findings obtained have been discussed in the previous chapter. The conclusion that can be stated are:

1. According to the hypothesis made, it can be said that in general, the addition of fiber to matrix Polypropylene (PP) has increased the material's mechanical properties compared to without using fiber.
2. It also has been proved that the greater the weight fraction of reinforcement (fiber), the relatively good mechanical properties will be and has reached the optimal point.
3. Composites with the addition of bamboo fiber have increased tensile stress and strain which are relatively bigger compared to composites with red pinang fibers.
4. Judging from the tensile stress, bamboo fiber is more able to withstand the load pull and strain compared to the addition of fiber with red pinang sheath.
5. Judging from the arc stress, the addition of bamboo fiber in the matrix, the result is relatively better compared with the addition of red pinang fiber.
6. The addition of bamboo fiber has also given the ability to withstand shock loads greater than the polypropylene matrix with the addition of red betel nut fiber.

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