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The Influence of Matrix Banana Stem Fiber Volume Fraction *R*ecycled *P*olypropylene (RPP) toward Bending Test

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Abstract

Natural fiber was proof to be a strong material capable to substitute synthetic fiber. Natural fiber from banana stem having tensile strength of 68.44 MPa with average diameter of 0.698 mm maybe used as reinforcement for polymer composite materials. In a composite material of recycle polypropylene (RPP) matrix reinforced by fiber of banana stem, the fiber then should carry a big portion of applied load working on the composite materials. The RPP should act as a bonding for the fiber of banana stem, also protect fiber from damage. The optimum of volume fraction for bending test was 35% fiber : 65% matrix where bending stress 127.35 N/mm^2, modulus of elasticity 3209.75 MPa, shear stress 2.83 N/mm^2 and flexed stress 66,48Mpa, undergo a significant and optimum change. Using SEM observation, it was seen that 35% fiber : 65% matrix volume fraction and matrix was the optimal proportion in which bonding of matrix and fiber became strong. It maybe concluded that the influence of volume fraction of fiber of banana stem as reinforcement (fiber) and RPP as bonding (matrix) in a composite materials should result in a strong and brittle material. From all the tests done, it was found that the almost optimum of volume fraction was 35% fiber and 65% matriks.

Keywords: *Composite, Recycled Polypropylene (RPP), Banana Stem Fiber, Bending Test, SEM*

1. 1 INTRODUCTION

Utilization of natural fibers as reinforcement of composite components is already in great demand, because in addition to the strength and stiffness of high fiber and no lost than synthetic fibers. One's of the problems of the environment in the world especially in Indonesia is regarding plastic waste. In terms of benefits is to address the problem of waste plastics and waste banana stems. With the above problems is necessary to study the utilization of natural fibers as reinforcing filler in composite plastic or *recycled polypropylene* (RPP) and can be used for the corresponding components usefulness.

Natural fibers are a group of fibers produced from plants, animals and minerals [5]. The use of natural fibers in the textile and paper industries are widely available in the form of silk fibers, cotton, kapok, flax coarse (flax), jute, flax leaves and fiber. Fiber is what primarily determines the characteristics of composite materials, such as stiffness, strength, ductility, brittleness and other mechanical properties. Fiber also serves to hold the most the forces acting on the composite material.

Table 1. Chemical composition of various natural Fibres [6]

Types of Fiber	Cellulose (%)	Hemiselulosa (%)	Lignine (%)	Water Concentrate (%)
Banana	60-65	6-8	5-10	10-15
Abaca	56-63	20-25	7-9	10-15
Flax	70-72	14	4-5	7
Jute	61-63	13	5-13	12,5
Hemp	80-85	3-4	0,5	5-6
Sisal	60-67	10-15	8-12	10-12
Cotton	90	6	-	7

Composite with reinforcing fibers (*fibrous* composite) is very effective, because the material in the form of fiber is much stronger and stiffer than the same material in solid form. Matrix in the composite structure and the binding fiber serves to protect in order to work properly. Matrix must be able to pass on the burden of outer fibers. Generally, the matrix is made of soft materials and clay.

Plastics (*Polymers*) are a common material used. Matrix are also generally selected from it is ability to withstand heat. One of very important factor in determining the characteristics of the composite material is the ratio/percentage between the matrix and fibers. Before performing composite molding process, for the first step is comparing both calculations [4]. In determining the ratio between matrix and filler components (*fiber*) composite material is usually determined by the volume fraction. This method is used if the weight of the components of the matrix and reinforcement (*fiber*) composite material is much different. To determine usually used the following formulas[2]:

Composite volume

$$V_c = p.l.t \quad (1)$$

Composite fiber volume

$$V_{FC}=\frac{V_c.F_V}{100\,\%} \quad (2)$$

$$M_{fc}=\text{Volume fraction}\ _c.\rho_{fc} \quad (3)$$

Composite fiber volume

$$V_{MC}=\frac{V_c(100\%-F_V)}{100\,\%} \quad (4)$$

Elasticity

$$E_{cl} = E_m\ V_m + E_f\ \text{Volume fraction} \quad (5)$$

Mass matrix composites

$$M_{Mc}=V_{Mc}.\rho_M \quad (6)$$

The purpose of the study was to test the composite bending banana stem fiber amplifier as follows:

a. Generate bending strength with banana fiber composites Recycled Polypropylene (*RPP).*
b. Produce the effect of RPP matrix banana stem fiber volume fraction due to bending strength.
c. Function for environmentally friendly alternative materials by utilizing waste Recycled Polypropylene (*RPP)* as the matrix.
d. Knowing the structure of the bond between matrix and filler components of banana fiber composites with observations photo SEM (*Scanning* Electron Microscope*).*

2. METHODOLOGY

The steps to produce the fiber as follows: Hexanes extracted in solution which aims to eliminate impurities. Extraction process in H_2SO_4 solution is for cellulose tissue damage. Extraction process is in Na-OH solution to gain fiber. Composite manufacture by hot press process is by preparing composite molds. Fiber insert in the mold composite average once is compiled in a composite mold. Enter into the matrix of the composite mold and flatten below and above the fiber matrix. Mold is closed and ready to enter the hot press machine with the temperature 200° C and a pressure of 2 bars as shown in Figure 2.

b

Figure 1. . Hot press machine (STP-BPPT)

Information:

a: Hot Press Machine
b: Matter Composite

Bending Test

Bending test with hard and brittle materials is the best way to determine the strength and brittleness. Failure caused by bending test, the composite will be broken at the bottom is caused by unable to withstand tensile receive. The amount of bending depends on the strength of the material and the type of loading [7].

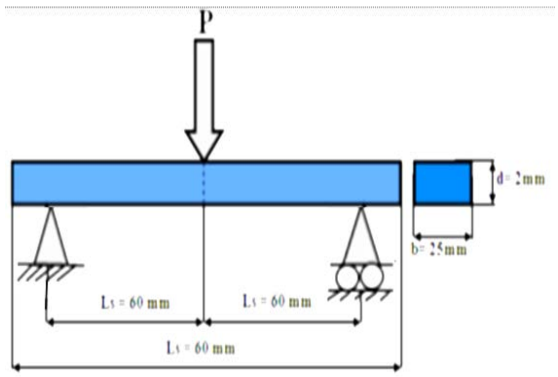

Figure 2. Testing of three point bending [7]

SEM observations

An observation with a Scanning Electron Microscope (SEM) was used to observe the orientation of the fibers in the matrix together with some properties of the bond between the matrix with reinforcements. How to get a reader micro structure with the electron beam, the electron beam in the SEM is generally a small stain on the surface of the specimen 1 μm repeatedly investigated [3].

3. RESULTS AND DISCUSSION

Table 2.Average score of bending test results

Volume fraction	Table: Average Bending Examination				
	Modulus of Elasticity (MPa)	Flexural Strength (MPa)	Maximum Load (N)	Shear Stress (N/mm^2)	Bending Strength (N/mm^2)
RPP	1375.25	2.14	85.53	2.41	95.53
15%	2544.00	2.54	101.68	2.86	114.39
20%	2685.00	2.57	102.96	2.90	115.83
25%	2808.25	2.62	104.78	3.06	117.87
30%	3029.25	2.80	112.18	3.16	126.20
35%	3209.75	2.83	113.20	3.20	127.35

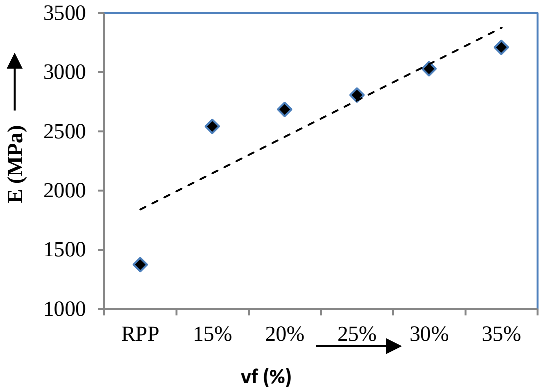

Figure 3. Modulus of elasticity curve

Bending modulus of elasticity tests tend to have the highest average increase in volume fraction of 35% is 3209.75 MPa while the lowest at 15% volume fraction is 2544.00 MPa. Variation of the elastic modulus of each specimen due to the spread of banana stem fiber composite materials in the printing process evenly mold using hot press machine. The volume fraction of variation will affect the strength of the elastic modulus will increase the holding capacity equal to the fiber matrix.

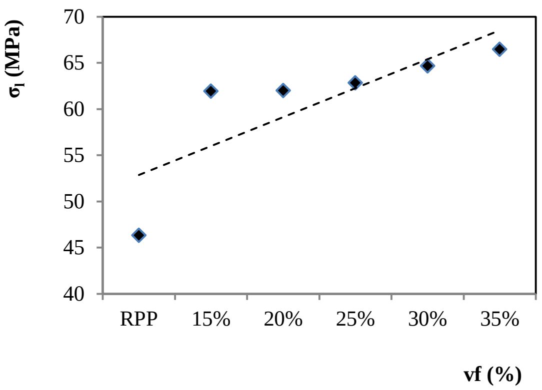

Figure 4. Curve of bending strength

Average bending stress is the highest at 35% fiber volume fraction is 66.48 MPa the lowest was on 15% fiber volume fraction is 61.94 MPa. When viewed as a whole the volume fraction apparent differences bending stress. This is due to a spread of banana stem fibers in the molding process of composite material to be evenly matched volume fraction.

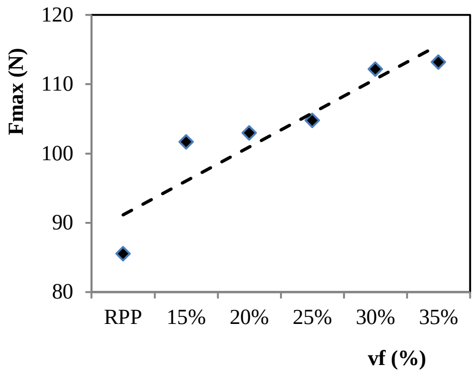

Figure 5. Maximum load curve

The maximum load average is highest at 35% fiber volume fraction is 113.20 N, the lowest was on 15% fiber volume fraction is 101.68 N. The increase of maximum load is caused by a perfect bond between the fiber and matrix. By the time given outside the first load of dropped out of the matrix. Followed by fiber and the fiber is gradually broken/not at once but there is still partly intact so that no visible curves drop gradually.

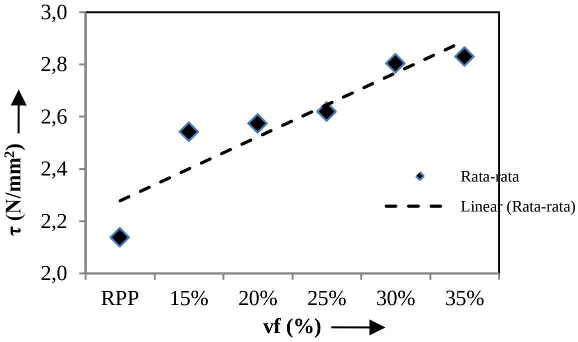

Figure 6. Shear stress

The highest average of fiber at 35% volume fraction is 2.83 N/mm^2 and the lowest was at 15% fiber volume fraction is 2.14 N/mm^2. Spread of banana stem fibers in a composite material molding process evenly. and *lignin* and *hemicellulose* content of the fiber is still there so it can affect the bending test. The increase of bending moment is caused by a perfect bond between fiber and martiks. The increased of bending moment is caused by the increase of load working while the moment of inertia is constant, to obtain the results obtained from the calculation of bending moment load (P) is multiplied by the load span length (Ls) divided by the moment of inertia and the bond between fiber and matrix is bonded well.

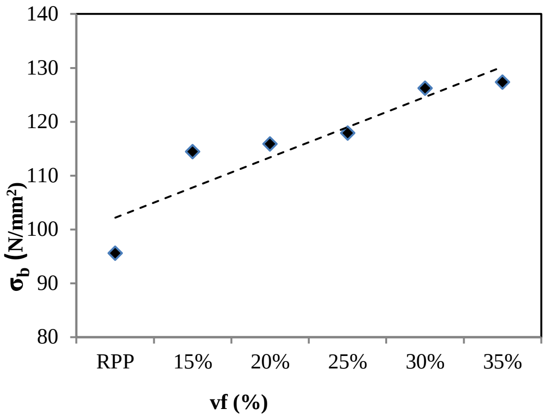

Figure 7. Results tension bending

The highest of average bending Strength at fiber 35% volume fraction is 127.35 N/mm^2, the lowest fiber 15% volume fraction is 114.39 N/mm^2. Because of the spread of banana fiber in material molding process becomes composite by using hot press machine. Bending stress calculations derived from testing burden while increasing material has changed shape so that the load will be increased in accordance with the volume fraction of the large volume fraction of the power will increase.

On RPP matrix is seen at the strength of the material received loads continue to increase until the end of material. Brittle materials generally do not show a clear yield limit, it happens because there is lignin in the fiber and irregular arrangement of fibers.

SEM observations Fiber

Analysis by Scanning Electron Microscope is important to know the differences in the fiber cross-sectional diameter of the fiber is shown as the cutting of about 1 cm, then coated with platinum elements for 60 seconds. Subsequently the samples were analyzed by means of SEM with 50 times magnification (Figure 8).

SEM pictures of composite Fl 35% : Mt 65% (Figure 9) shows about the strength of bond between matrix and filler appropriately, because of the strength of fiber and matrix causes the fiber is not released from the matrix which can causes pore. Nevertheless deal with the load delude working increase continuously therefore forces matrix and fibers is broken but it does not cause pore.

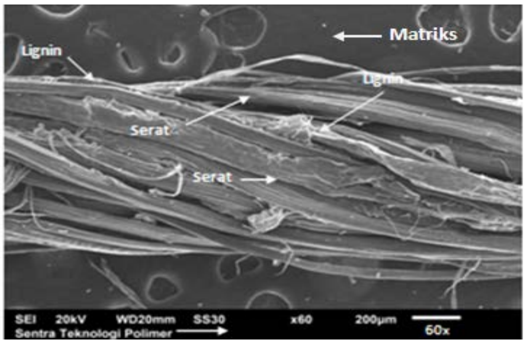

Figure 8. Fiber before testing

After SEM observation Bending Test

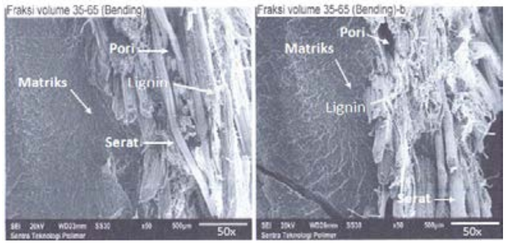

Figure 9. SEM observation of the highest composite bending stress

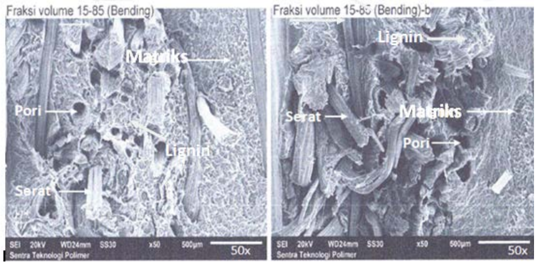

Figure 10. SEM observation of the lowest composite bending stress

SEM pictures of composite Fl 15%: Mt 85% (Figure 10) appeared to be bending test of fiber fracture. This shows the strength of the bond between the matrix and the reinforcements are low, because the bond regardless of the matrix to the matrix and fibers that cause pore broken. Mechanism of damage caused bending strength, modulus of elasticity and bending moment decreases which means the fibers uprooted not fused with the matrix which can cause pores. Something like this should be avoided.

4. CONCLUSION

a. The greater of fraction volume. the strength and toughness of composite materials is increasing and matrix and fiber are attached well. it shows that there is strength of bond between the matrix and its reinforce is higher. It is on fraction volume Fl 35%: 65% Mt.
b. Moisture content. lignin and cellulose of the fibers greatly affect the mechanical properties and physical properties of composite materials.

c. The greater of volume fraction, the higher bending strength, bending moment, flexural strength and elastic modulus were found on Fl 35%: 65% Mt.

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