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Effect of Composite Composition on Mechanical Properties of Banana Fiber Composites with Epoxy Matrix for Functional Materials

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A B S T R A C T

Technological developments and the influence of globalization have an impact on increasing the need for the amount of material for industry. The many disadvantages of metal materials due to their large mass, difficult manufacturing processes, corrosive properties, and high production costs have resulted in reduced use of metal materials in various products. Nowadays, there are many replacement materials with mechanical properties that can resemble metal materials such as composites. The role of composites is very important in the development of today's industrial world. This study wanted to determine the effect of the composite composition of rias banana fiber and teak sawdust with epoxy resin on the mechanical properties of the composite. The results showed that the comparison of the composition of the composite using rias banana fiber and teak sawdust with an epoxy matrix had an effect on the mechanical properties. Increasing the percentage of resin composition increases the value of the surface hardness of the composite. The highest level of Rockwell hardness with a value of 117 HRB in sample D and the lowest 109 HRB in sample A. While the highest max strength value was produced by sample C with a composition of teak sawdust: rias banana fiber: epoxy is 20% : 40% : 40 %. The conclusion of this research is the more resin composition will increase the composite hardness test value.

Keywords: Composite, Rias Banana Fiber, Epoxy, Mechanical Properties

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1. Introduction

Technological developments and the influence of globalization have an impact on increasing the need for the amount of material for industry. Various kinds of natural, synthetic, and composite materials continue to be produced to meet domestic material needs. The many weaknesses of metal materials due to their large mass, difficult manufacturing processes, corrosive properties, and high production costs have resulted in reduced use of metal materials in various products [1].

Nowadays, replacement materials are widely developed with mechanical properties that are able to resemble metal materials [2] but can cover the weaknesses of metal materials such as low production costs and ease in the manufacturing process. One of the superior materials is composite-based materials.

Composite is a combination of matrix or binder with reinforcement which is formed in a number of multi-phase systems with combined properties [3]. Composites are materials formed from two or more materials that have different mechanical properties with the aim of obtaining new and better properties of the composite constituent materials [4]. Composites are materials composed of two or more materials that remain separate so as to produce new materials that have better properties than their constituents [5]. Composites consist of a matrix as a filler binder as a composite filler.

Each composite will produce different properties depending on the matrix, filler and reinforcing material used [6]. The fibers used consist of synthetic fibers and natural fibers [3]. The advantages of natural fiber composites are because they are abundant, environmentally friendly, and the price is relatively cheaper than glass fiber [7]. Kusumastuti also stated that natural fiber is easy to obtain at a lower price, easy processing, low density, environmentally friendly, and biodegradable [8]. Composites have low density, high specific mechanical properties, performance comparable to metals, resistant to corrosion and easy to fabricate [9].

One of the abundant natural fiber wastes is the former cutting of banana trees which are usually only taken for the fruit, then the trunk is discarded. Rias banana fiber is the inner part of the banana trunk which is covered by a layered pile of pseudo trees. Rias banana fiber extends from the roots to the stem of the banana fruit.

According to data from the Center for Horticulture Production, the number of banana production ranks highest. The same goes for the waste generated. Banana production shows a figure of up to 6,862,558 tons or about 34.65 percent of the total fruit production in Indonesia.

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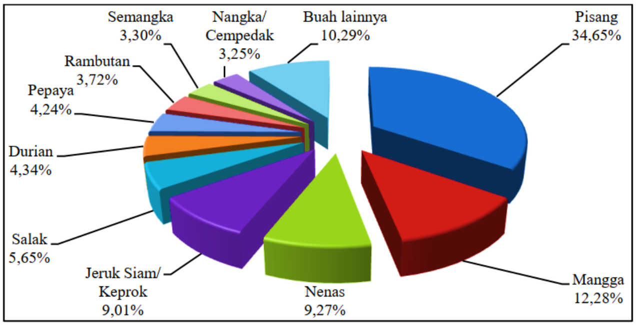

Figure 1. Percentage of fruit production in Indonesia in 2014 [10]

In addition to banana fiber waste, the availability of wood sawdust is also abundant in nature. The high demand for wood for furniture, plywood, and various other needs results in a large amount of wood waste remaining. One form of waste is sawdust. So far, this waste is underutilized because most of it is only used as firewood or left alone so that it pollutes the environment. Sawdust is also a natural fiber in the form of particles with a density of about 1.3 – 1.4 g/cm3. The density is almost the same as the fiber density [11].

The presence of abundant waste of banana fiber and sawdust must be utilized as functional materials. Utilization of Rias banana fiber can be done by mixing alkaline materials (NaOH) to remove the existing lignin [12]. The carbonization process can be carried out on wood sawdust so that it cannot be decomposed again.

a. b. c.

Figure 2. (a and b) Wet banana fiber (c) Dry banana fiber

2. Material and Methods

The main focus of this research is to study the mechanical properties of composites with the composition of rias banana fiber and teak sawdust with an epoxy matrix.

2.1. Related work

Mamur L.O., et al, conducted a study on the mechanical properties of sago stalk fiber composites combined with teak sawdust with a polyester matrix where the lowest bending strength was found in the 50:30:10 mixture composition of 118,87844 N/mm and the highest at composite mixture 40:30:30 that is 278.1268 N/mm2. Meanwhile, the lowest tensile strength was obtained at 40:10 mixture composition of 18,136 N/mm2 and the highest at 30:30 composition of 31,059 N/mm2 [13].

Diharjo et al, used kenaf fiber and sea sengon wood as materials for making acoustic panels and sandwich composite panels [14]. And Nopriantina and Astuti found that the compressive strength value of polyester was 12.16 N/mm2 and the compressive strength value increased after adding banana midrib fiber with a thickness of 0.70 mm by 12.92 N/mm2 [15]. PVC-CaCO3 composite using banana stem fiber powder as a filler can meet the requirements of SNI 15-0233-1989 Quality and Test Method of Fiber Cement Sheet [16]. Based on the results of previous studies, banana stem fiber and wood sawdust have the opportunity to be developed into composite materials.

2.2. Methodology

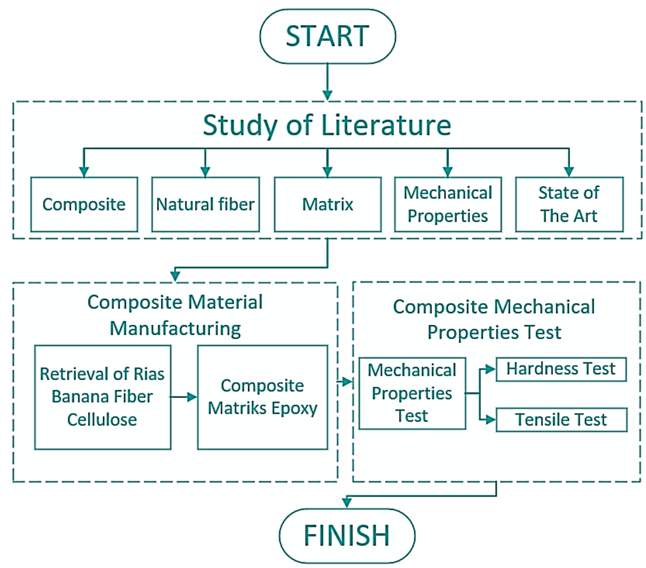

Figure 4. Flow chart

In this study, it is divided into four steps as the foundation of the research, namely as follows.

- **Study of literature**

In this section, an in-depth study of composites, fibers, matrices, mechanical properties and several scientific studies on similar studies that have been conducted previously is carried out.

- **Composite Manufacturing**

This stage is the main part in the whole research process. The composite material was made using rias banana fiber and carbonized teak sawdust. Then all these natural materials are mixed with an epoxy matrix with varying compositions to obtain several composite materials.

Table 1. Composite composition

Composite Composition			Sample Label			
Teak Sawdust (%)	Rias Banana Fiber (%)	Epoxy (%)	1	2	3	Average
20	50	30	A1	A2	A3	A
20	45	35	B1	B2	B3	B
20	40	40	C1	C2	C3	C
20	35	45	D1	D2	D3	D

Information:

- Sample A is a composite composition with a ratio of teak wood sawdust: rias banana fiber: epoxy is 20:50:30%.
- Sample A is a composite composition with a ratio of teak wood sawdust: rias banana fiber: epoxy is 20:45:35%.
- Sample A is a composite composition with a ratio of teak wood sawdust: rias banana fiber: epoxy is 20:40:40%.
- Sample A is a composite composition with a ratio of teak wood sawdust: rias banana fiber: epoxy is 20:35:45%.

After all the compositions are made and mixed according to the dose, the sample is printed using a mold according to ASTM D 3039.

- **Composite mechanical properties test**

Tensile test and hardness test are tests of mechanical properties in this study. The composites were made using the hydraulic compression molding method on the basis of ASTM D 3039 for the geometry of the specimen. The test equipment used is WDW-20 E for tensile test and Rockwell TH550 for hardness test.

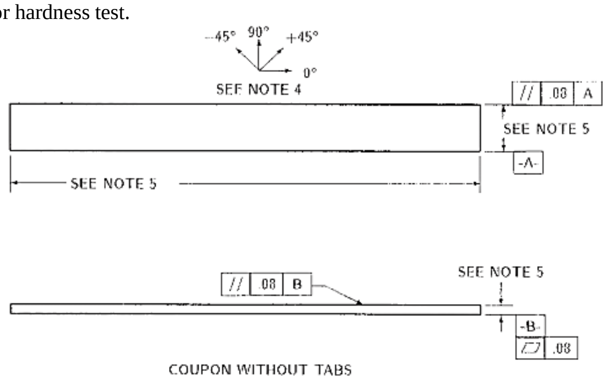

Figure 4. ASTM D 3039 specimen without indentation

A B

Figure 5. (a) WDW-20 E (b) Rockwell TH550

3. Results and discussions

The samples used were four samples with three replications in each sample composition according to Table 1. The purpose of replication was to obtain results that were close to the truth. In the hardness test, each replication was tested three times and then the average was taken, while for the tensile test the test was carried out once for each replication, because the specimen would immediately break.

Figure 6. Composite specimen example

The surface texture of each sample looks different because of the effect of the comparison of the composite composition used. Sample A has a rougher texture because the composition of the epoxy is lower than the other specimens, and vice versa. The texture of sample D is smoother because the composition of the epoxy is higher than that of the other samples.

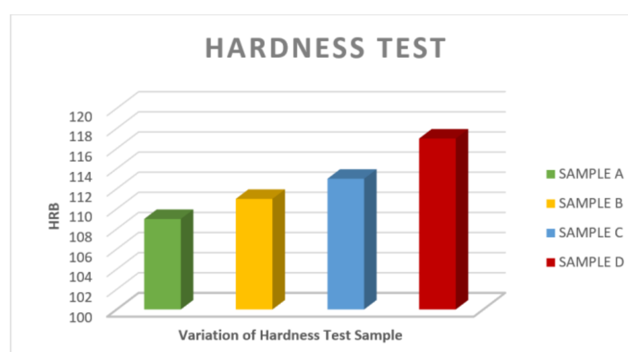

Figure 7. Rockwell hardness test results

Figure 7 describes the results of the Rockwell hardness test with the following description.

- The lowest Rockwell hardness level is in sample A with a value of 109 HRB
- The Rockwell hardness of sample B is 111 HRB
- Rockwell hardness of sample C is 113 HRB
- The Rockwell hardness of sample D is 117 HRB and is the highest

Table. 1, shows that the percentage of epoxy sample D is the highest compared to other samples. This offers a hypothesis that the higher the percentage of resin can increase the value of the surface hardness of the composite because the particles become denser and the gaps between the particles are filled with resin so that the hardness increases.

Next is a tensile test with the aim of knowing the maximum tensile strength of the composite. The test is carried out with the standard ASTM D 3039. The results of the tensile test are shown in Figure 8 below.

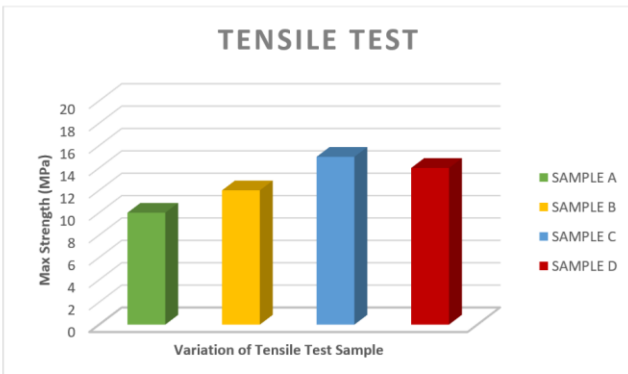

Figure 8. Tensile test results

4. Conclusion

Comparison of the composition of the composite using rias banana fiber and teak sawdust with an epoxy matrix has an effect on the mechanical properties. Increasing the percentage of resin composition increases the value of the surface hardness of the composite. The highest level of Rockwell hardness with a value of 117 HRB in sample D and the lowest 109 HRB in sample A. While the highest max strength value was produced by sample C with the composition of teak sawdust: rias banana fiber: epoxy was 20% : 40% : 40 %. The conclusion of this research is the more resin composition will increase the composite hardness test value.

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