MECHANICAL PROPERTIES OF THE PALM FIBERS COMPOSITE *(Arenga Pinnata)*

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Abstract – Composite is a combination of two or more materials of reinforcement and matrix in which the carrier properties of the constituent materials still exist. The developing composite technology can be supported by constituent materials, reinforcing materials such as fibers that are most widely used to give new properties of composites. One type of fiber that can be developed is natural fibers. Natural fibers commonly used to form composites are palm fibers because these materials are still abundant and easy to obtain. In this research, the fabrication and characterization of mechanical properties of fibers reinforced composites were carried out. The test parameters were used tensile test and bending test on 2 mm composites with fibers 0%, and 2.5% fiber volume fraction. The results of the tensile test are stress and strain values. The stress results in the 2 mm composite of tensile test with 0% and 2.5% fiber volume fraction was 2.64 MPa and 6.29 MPa.The strain results are 1.06% and 4.59%. The results obtained in the bending test are the stress value and the deflection value. The value of stress in the 2 mm composite bending test with 0% and 2.5% fiber volume fraction is 6.35 MPa and 10.85 MPa. The deflection values obtained were 1.45 mm and 7.35 mm. Based on the results obtained, it can be concluded that the composite with 2.5% fiber volume fraction has the optimum value.

Keyword: *composites, mechanical properties, stress, strain, natural fibers, deflection*

1. INTRODUCTION

Composite is a combination of two or more materials that still has their constituent properties [1]. Composite formation elements consist of reinforcement and matrix, both parts have their own characteristics. Combination of both materials is expected to complete each constituent material properties so it produces an improved material. The benefit of composite is light weight, rigid, and high durability [2]. The uses of fiber as a reinforcement can make composite that has a maximum strength and rigidity. The matrix functions as a fiber barrier so the fibers are united, distribute the weight and be a wrapper [1,2].

Fiber function as a power buffer in composite structure, the initial weight that go through a matrix pass the fiber, so that the fiber must have a higher tensile strength and elasticity than the matrix [3]. The fiber uses as a composite reinforcement material is expanding, especially those that are being developed are natural fibers. The benefit of natural fiber is cheap, light weight, have a good thermal properties, high toughness, not irritating, have relatively high specific mechanical properties and biodegradable. Natural fiber such as palm fiber (*Arenga pinnata Merr*) is one of fiber that is potential to be developed as composite reinforcement [4].

Palm fiber has a high mechanical properties and abundant availability make this fiber potential to develop as a reinforcement composite [4]. Palm fiber production nationally reaches 14.000 tons per month or 165.000 tons per year [5]. Palm fiber has a diameter range starting from 99 μm to 400 μm, often in 250 – 400 μm. Palm also has an advantage is high durability, slow down the weathering, resistance to acids and sea salt water and can prevent termite [5,6]. High mechanical properties and the advantages in palm fiber make it potential as reinforcement composite.

Fiber-reinforced composite structure can be divided to: continuous fiber composites, woven fiber composites, chopped fiber composites, and hybrid composites. Composite in general used for many needs such as automotive, aviation, marine, and architecture. Composites are also widely used in consumer products such as skis, golf clubs, and tennis rackets [1].

Previous research conducted by Sudarisman (2020) about pressure and impact test for palm fiber-reinforced polymer composite soaked in NaOH 5% resulted in bending strength with polyester resin 25,17 MPa and epoxy resin 16,43 MPa. The strain values obtained were 55.8 percent and 34.0 percent for polyester resin and epoxy resin.

Next research was conducted by Ilham *et al*. (2019) about the tensile strength test of hybrid composite material palm fiber reinforced with random fiber orientation. Test result obtained the tensile strength test of hybrid composite with fiber fraction volume (30% palm fiber : 0% coconut fiber) is 21,06 MPa, fraction volume (20% palm fiber : 10% coconut fiber) is 18,10 MPa, fraction volume (20% palm fiber : 10% coconut fiber) is 21,64 MPa and fraction volume (0% palm fiber : 30% coconut fiber) is 17,19 MPa. The maximum value is owned by a composite with a fiber volume fraction of 15%: 15% with a value of 23.48 MPa [7].

This study aims to determine and find the maximum value of the mechanical properties of the composite with a variation 0% and 2.5% fiber volume fraction with a thickness of 2 mm. Mechanical tests carried out are tensile tests and bending tests.

2. EXPERIMENT

a. Research Design

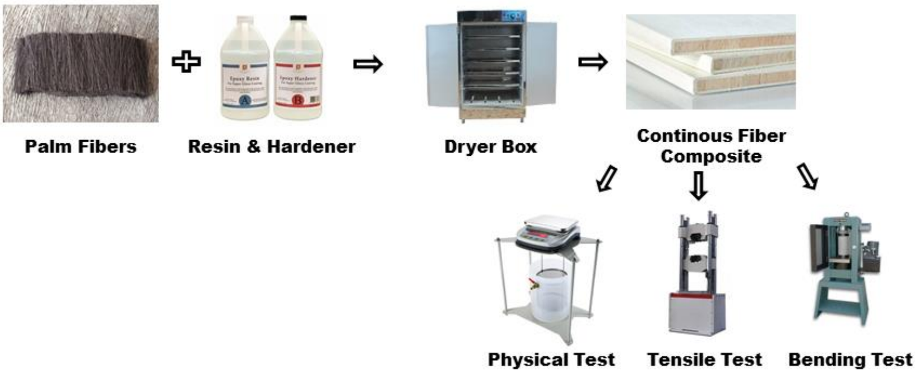

Figure 1. The Design of Research

b. Composite Preparation

The composite to be made is a type of continuous fiber composite with a long and straight fiber arrangement. The process of making composites begins with the selection and cutting of fibers, epoxy resin, and a catalyst as the constituent materials of the matrix, mixed and stirred until homogeneous. Then the matrix is poured into the mold until half the volume and the fibers are arranged on top of the matrix, the remaining matrix is poured to cover the entire fiber. The variation of fiber volume fraction used is 0% and 2.5% with a thickness of 2 mm.

c. Characterization

The mechanical characteristics of the composites that have been made then tested, the tests carried out are tensile tests and compression tests with standard specimen ASTM D 638-02 for tensile tests and ASTM D 790-02 for compression tests. The test was carried out at the Technical Materials Laboratory of the Vocational School of Gadjah Mada University using a TN20MD type UTM tester with a tensile test standard of ASTM D 638-01 and a compression test standard of ASTM D 790-07 [10,11].

d. Analysis

Based on the results of testing the mechanical properties of the composites, data on the tensile strength and bending strength of the composites were obtained. At this stage, each data is compared from each variation of the fiber fraction and it can be seen that the variation of the fiber volume fraction produces the most optimum mechanical properties.

3. RESULTS AND DISCUSSIONS

a. Composite Tensile Strength Analysis

The results of the tensile test obtained maximum force data (P) and elongation (ΔL), and then processed to obtain composite stress and strain values with the equation:

Stress

$$\sigma = \frac{P}{A} \tag{1}$$

Strain

$$\varepsilon = \frac{\Delta L}{L_0} \quad (2)$$

where P is the maximum force (KN), A is the composite area (mm^2), L is the increase in length (mm) so that the resulting data as in table 1.

Table 1. *Results of tensile test composites*

Samples	P (KN)	Stress (MPa)	Strain (%)
2 mm 0%	0,05	2,64	1,06
2 mm 2,5%	0,11	6,29	4,59

The comparison of fiber volume fraction and tensile stress is shown in graphical form in Figure 2.

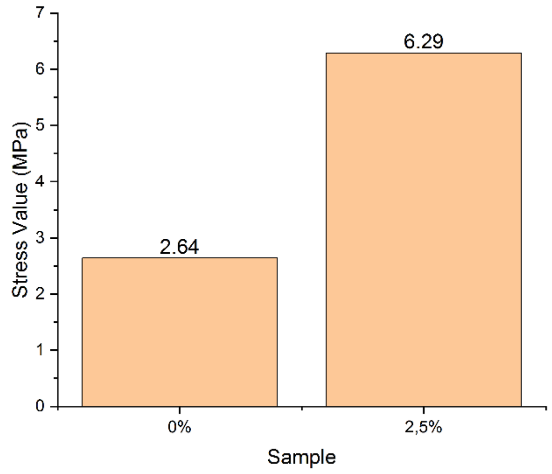

Figure 2. Stress Values of Tensile Test Composite Palm Fibers

The highest tensile strength value is 6.29 MPa owned by the composite with a 2.5% fiber volume fraction. The lowest value is 2.64 MPa owned by the composite with a 0% volume fraction. A comparison of strain and stress values is shown through the graph in Figure 3.

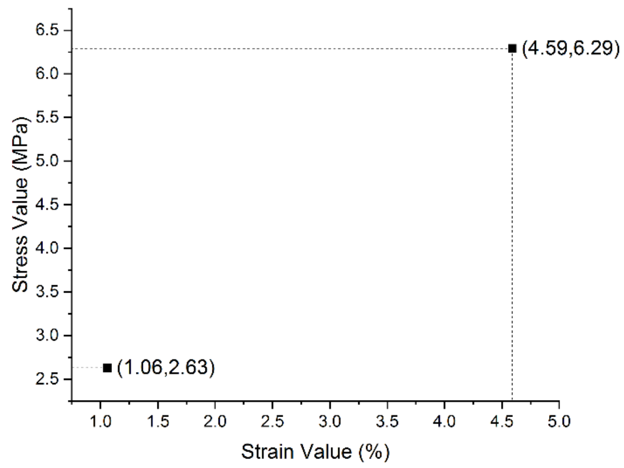

Figure 3. Stress-Strain Values of Composite Palm Fiber

The value of the strain that is owned by the composite is linear with the stress value. The highest strain is owned by the composite with a fiber volume fraction of 2.5 percent at 4.59 percent and the lowest value is owned by a composite with a fiber volume fraction of 0 percent at 1.06 percent.

From Figure 2 and Figure 3 it can be concluded that the fiber as reinforcement can increase the tensile strength and also the strain strength of the composite. The composite stress value increases when the composite is reinforced with fiber, it is seen that the composite that is not fiber-reinforced has the lowest tensile strength value coMPared to the fiber-reinforced composite. However, the addition of a lot of fiber can affect the bond between the matrix and the fiber or the interface of the composite. Composites with low interfaces will reduce the strength of the composites, the stronger the composite interface, the higher the tensile strength value [7].

The value of strain and stress has a linear relationship, the higher the stress, the greater the composite strain. Strain is the relative change in the size and shape of a composite [1]. The more distributed the stress on the composite, the greater the strain value [8].

b. Composite Bending Strength Analysis

The results of the compression test obtained data for the maximum force (P) and deflection, and then processed to obtain the stress value with the equation:

Stress

$$\sigma = \frac{3Pl}{2ba^2} \tag{3}$$

Where P is the maximum force (KN), l is the length of the span (mm), b is the width of the composite (mm), and a is the thickness of the composite (mm) so that the resulting data as in table 2.

Table 2. *Results of bending test composites*

Samples	P (KN)	Stress (MPa)	Deflection (mm)
2 mm 0%	0,03	6,35	1,45
2 mm 2,5%	0,04	10,85	7,35

A comparison of fiber volume fraction with composite bending stress is shown in the graph in Figure 4.

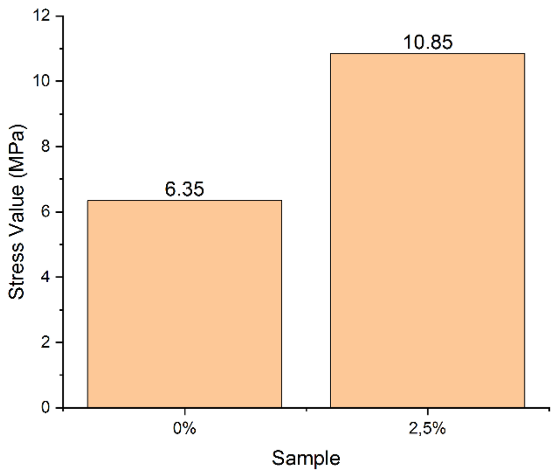

Figure 4. Stress Values of Bending Test Composite Palm Fiber

The highest tensile strength value is owned by the composite with a fiber volume fraction of 2.5 percent of 10.85 MPa. While the lowest value is owned by the composite with a volume fraction of 0 percent or without fiber of 6.35 MPa. These results are linear with the results in the tensile test where the composite with a volume fraction of 2.5 percent has the highest value. The composite deflection value is shown through the graph in Figure 5.

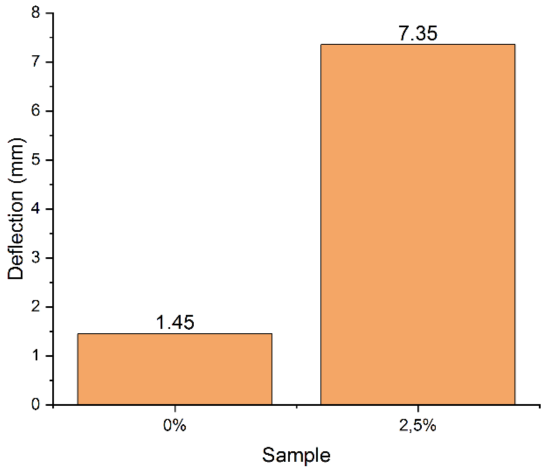

Figure 5. Deflection of Composite Palm Fiber

The highest deflection value is owned by the composite with a volume fraction of 5 percent of 8.47 mm. While the lowest value is owned by the composite with a volume fraction of 0 percent or without fiber reinforcement is 1.45 mm.

The results of the bending stress and deflection of the composite in Figure 4 and Figure 5 can be concluded that the reinforcement in the composite greatly influences the value of the bending stress and deflection. Fiber can distribute stress before the stress is received by the matrix [3]. Even the distribution of fiber can increase the bending strength of the composite because the stress will be distributed throughout the fiber [8]. In addition, the number of voids or air bubbles in the composite can also reduce the value of the bending strength, this is because air voids can cause breaking forces to lead to hollow areas and the force is not perfectly distributed [7].

Deflection is the bending of a rod caused by the force received by the rod. Deflection is useful for knowing the flexibility of a composite [9]. Linear deflection with the number of fiber volume fractions, the more fibers added to the composite, the greater the deflection. Fiber is useful for spreading the force to minimize the force received by the composite.

4. CONCLUSION

The results of the study obtained several conclusions as follows:

1. The addition of dense palm fiber can add value to the mechanical properties of the composite. Factors that influence this value are the bonding strength between matrix and fiber, fiber distribution, and voids or air bubbles in the composite.
2. The palm fiber-reinforced composite with a volume fraction of 2.5 percent has an optimal value coMPared to other composite variations.

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CERTIFICATE

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Dean The Faculty of Mathematics and Natural Sciences

Drs. Sunardi, M.Si

Conference Chair

Jamrud Aminuddin, Ph.D

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