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Effect of Polyester Resin Fraction and Sisal Fiber on Composite Tensile Strength

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Abstract— *Sisal fiber is a hard fiber produced from the extraction process of the leaves of the sisal plant. In this study, sisal fiber was used as a composite reinforcing material. This research aims to determine the effect of the composition of polyester resin and sisal fiber on tensile strength. This type of research is experimental research carried out by mixing polyester resin and sisal fiber. The dimensions of the tensile test specimens were made according to the tensile testing standard ASTM D 638 with three types of volume variations for polyester resin and sisal fiber, namely 90%: 10% for three specimens, 85%: 15% for three specimens, and 80%: 20% for three specimens. The number of specimens in this study was 9 specimens. The tensile testing equipment used is a Universal Testing Machine with type RF-2425. The tensile test results for a composition of 90% polyester resin and 10% sisal fiber showed a maximum stress of 22.993 N/mm2 and a strain of 2.245%. In a comparison of 85% polyester resin and 15% sisal fiber, a maximum stress of 37.931 N/mm2 and a strain of 2.342% were obtained. And in a comparison of 80% polyester resin and 20% sisal fiber, a maximum stress of 39.317 N/mm2 and a strain of 2.692% were obtained. So it can be concluded that the more the mixture of sisal fibers in the composite, the higher the tensile strength value of the composite*.

Keywords— *Composite, Polyester Resin, Sisal Fiber, Tensile Strength*.

I. INTRODUCTION

The use of materials applied as components in a structure is based on a high increase in mechanical properties. Engineers always carry out various research studies to engineer new materials that have better mechanical properties, such as new composite materials. Fiber-reinforced composites are the most widely developed type of composite. (Fahmi, et al, 2014).

The Sisal plant (*A. Sisalana L*) is a plant whose stems and leaves are fused, has strong fibers, can live on thinly cultivated land (lots of surface stones) or is classified as critical land.

The strength of sisal fiber is stronger than other fibers, and is resistant to high salt levels. Sisal plants mostly grow on chalky hillsides and dry climates.

This plant is produced by Brazil as the largest producer of sisal in the world, China, Kenya, Tanzania, Managaskar, Indonesia and Thailand. Sisal plants in Indonesia are developed in Bali, Madura Island, South Malang, and in Sumbawa Regency. Farmers plant sisal plants on the sidelines with secondary crops such as corn, peanuts or soybeans. (Basuki, T. et al., 2017).

A composite is an engineered material consisting of two or more materials where the properties of each material are different from each other, both chemical and physical properties and remain separate in the final result of the material. Composite materials have many advantages, including low specific gravity, higher strength, corrosion resistance and cheaper assembly costs. (Yunus et al. 2020).

According to (Widodo et al. 2022) Composites are materials produced from mixtures made of two or more materials that combine different chemical and physical properties to produce new materials with different properties.

The properties of composite materials are a combination of the properties of its constituents, namely matrix and fiber (reinforcement). These two properties have different functional roles, the fiber functions as a material reinforcement, and is called reinforcement, while the matrix functions as an adhesive for the fibers and assembles them into a solid material unit, because the fibers are bonded to each other. The mixture of the two produces a material that is hard, strong and light. Fiber has the property that it can be easily changed in shape by cutting or molding according to needs.

The matrix material is generally resin, which binds the fiber material and forms a strong material. The main point of making composite materials is to improve the properties, especially the mechanical properties of the matrix.

In making composites, fiber and matrix are needed. Fiber functions as a reinforcing element that determines the mechanical properties of the composite because it transmits the load transmitted by the matrix.

Along with the increasingly rapid development of technology, it has encouraged the discovery of several alternative technologies as a way to meet society's needs, especially in materials, the materials needed are high quality materials and have high mechanical properties. Therefore, composite materials are being reintroduced using synthetic fibers combined with polymer materials as a matrix, the aim of which is to obtain high strength and stiffness.

Based on the background of the problem, the researchers conducted research on the effect of the composition of polyester resin fractions and sisal fibers on the tensile strength of composites.

II. RESEARCH METHOD

The material used in the composite manufacturing process is a mixture of polyester resin and fiber.

1) Sisal fiber
2) Polymer fluid
3) Catalyst

Determining variations in test specimens. Specimen variations used in this research, namely

1) 90% polyester resin : 10% sisal fiber

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2) 85% polyester resin : 15% sisal fiber
3) 80% polyester resin : 20% sisal fiber

Three specimens were made each with one fiber direction, therefore 9 tensile test specimens were obtained, namely, 3 specimens for a ratio of 90:10, 3 specimens for a ratio of 85:15 and 3 specimens for a ratio of 80:20. Next, the 9 specimens were subjected to tensile tests using ASTM D 638 standards.

Keterangan :	W (Width)	13
	L (Length)	57
	WO (Width Overall)	13
	LO (Length Overall)	165
	G (Gage Length)	50
	D (Distance Between)	115
	R (Radius of Fillet)	76

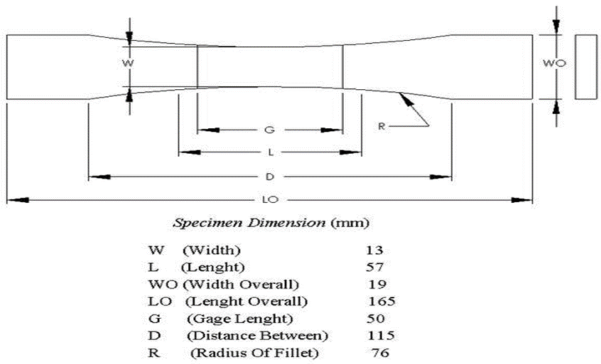

Figure 1. Tensile Test Specimen (ASTM D 638)
Source: Wahyu Ramadani Safitrah (2022)

III. Result And Discussion

1. Tensile Test Results

The data obtained from testing is as follows:

TABLE 1. Preliminary Tensile Test Data for Sisal Fiber Composite

No	Preliminary Tensile Test Data for Sisal Fiber Composite		
1	The initial width of the specimen (W_o)	=	13 mm
2	Initial thickness of the specimen (B_o)	=	10 mm
3	Initial length of the specimen (L_o)	=	165 mm
4	Test Specimen	=	Sisal Fiber Composite

a. Calculate the initial cross-sectional area (A_o)

$$A_o = W_o \cdot B_o$$

Where :
A_o = Initial cross-sectional area
B_o = Initial thickness of the specimen
W_o = The initial width of the specimen

$$A_o = W_o \cdot B_o$$
$$= 13\,m \;.\; 10\,mm$$
$$= 130\ \text{mm}^2$$

b. Calculating Maximum Voltage (σ_m)

$$\sigma_m = \frac{F_m}{A_o}$$

Where :
σm = Maximum stress
Ao = Initial cross-sectional area
Fm = Maximum Force

$$= \frac{2989{,}1}{130}$$

$$= 22{,}993\ \text{N/mm}^2$$

c. *Calculating strain (ε)*

$$\varepsilon = \frac{\Delta L}{L_0} X\ 100\%$$

Where:
ε = Strain (%)
L_0 = initial length of the specimen (mm)
Δ_L= increase in length (mm).

$$\varepsilon = \frac{\Delta L}{L_0} X\ 100\% = \frac{3{,}7}{165} X\ 100\%$$

$$= 2{,}245\%$$

2. Stress and Strain Data from Tensile Test Results with a Comparison of 90% Polyester Resin and 10% Sisal Fiber

TABLE 2. Calculation Results of Stress and Strain Tests for Tensile Tests of Sisal Fiber Composite 90% Polyester Resin and 10% Sisal Fiber.

No.	A_0 (mm^2)	Force (Fm)	ε max (%)	σ max (N/mm^2)	Information
1	130	2989,1	2,245	22,993	Specimen 1
2	130	2819,7	1,412	21,690	Specimen 2
3	130	2827,5	1,630	21,750	Specimen 3
	Average value		1,762	22,144	

3. Diagram and analysis of stress and strain in tensile tests with a comparison of 90% polyester resin and 10% sisal fiber.

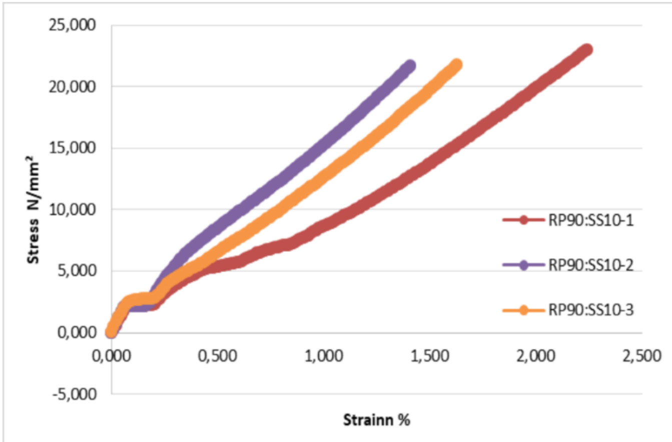

Figure 2. Stress – Strain Diagram of Specimens with a Comparison of 90% Polyester Resin and 10% Sisal Fiber

Based on Figure 2 diagram and stress strain analysis of the tensile test of the connection between polyester resin and sisal fiber with a ratio of 90% polyester resin and 10% sisal fiber above, it can be seen that each specimen tested produces different stresses and strains.

In the tensile test of the sisal fiber composite with a ratio of 90% polyester resin and 10% sisal fiber, it was found that specimen 1, the sisal fiber composite, produced a maximum stress of 22,993 N/mm2 and a maximum strain of 2,245% and specimen 2 produced a maximum stress of 21,690 N/mm^2 and maximum strain of 1.412%. And specimen 3 produces a maximum stress of 21,750 N/mm^2 and a maximum strain of 1,630%.

From the graph above, the relationship between a mixture of polyester resin and sisal fiber on tensile strength, the higher the stress, the resulting strain will increase and after the specimen reaches maximum tensile strength, the strength will decrease until it reaches the breaking point. In the graph above,

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it can be seen that each specimen tested produces different stresses and strains.

This is because during the styling process the fiber thickness is not even.

4. Stress and Strain Data from Tensile Test Results with a Comparison of 85% Polyester Resin and 15% Sisal Fiber

TABLE 3. Calculation Results of Tensile Test Stress and Strain with a Comparison of 85% Polyester Resin and 15% Sisal Fiber

No.	A_0 (mm^2)	Force (Fm)	ε max (%)	σ max (N/mm^2)	Information
1	130	4059,8	2,306	31,229	Specimen 1
2	130	3015,5	1,666	23,169	Specimen 2
3	130	4931,0	2,342	37,931	Specimen 3
Average value			2,135	30,776	

5. Diagram and Analysis of Stress and Strain in Tensile Tests with a Comparison of 85% Polyester Resin and 15% Sisal Fiber.

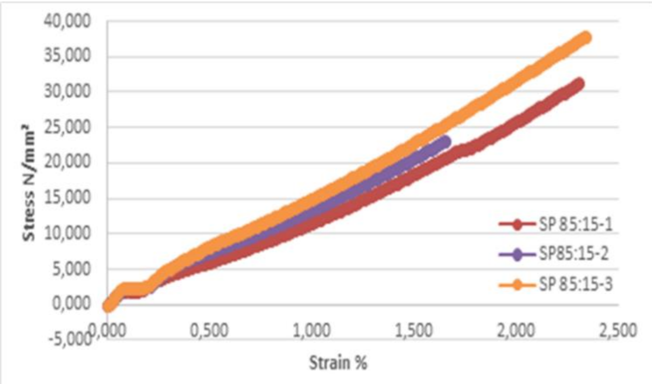

Figure 3. Stress – Strain Diagram of Specimens with a Comparison of 85% Polyester Resin and 15% Sisal Fiber.

Based on Figure 3 diagram and stress strain analysis of the tensile test of the connection between polyester resin and sisal fiber with a ratio of 85% polyester resin and 15% sisal fiber above, it can be seen that each specimen tested produces different stresses and strains.

In the tensile test of the sisal fiber composite with a ratio of 85% polyester resin and 15% sisal fiber, it was found that specimen 1, the sisal fiber composite, produced a maximum stress of 31,229 N/mm^2 and a maximum strain of 3,306% and specimen 2 produced a maximum stress of 23,196 N/mm^2 and maximum strain of 1.666%. And specimen 3 produces a maximum stress of 37.931 N/mm^2 and a maximum strain of 2.342%.

From the graph above, the relationship between a mixture of polyester resin and sisal fiber on tensile strength, the higher the stress, the resulting strain will increase and after the specimen reaches maximum tensile strength, the strength will decrease until it reaches the breaking point. In the graph above, it can be seen that each specimen tested produces different stresses and strains.

This is because during the arrangement process the fiber thickness is not even.

6. Stress and Strain Data from Tensile Test Results with a Comparison of 80% Polyester Resin and 20% Sisal Fiber

TABLE 4. Stress and Strain Calculation Results for Tensile Tests of Sisal Fiber Composite with a Comparison of 80% Polyester Resin and 20% Sisal Fiber.

No	A_0 (mm^2)	Force (Fm)	ε max (%)	σ max (N/mm^2)	Information
1	130	4180,1	2,885	32,145	Specimen 1
2	130	5111,2	2,680	39,317	Specimen 2
3	130	4655,5	2,209	35,811	Specimen 3
Average value			2,595	32,758	

7. Diagram and Stress and Strain Analysis of Tensile Tests with a Comparison of 80% Polyester Resin and 20% Sisal Fiber.

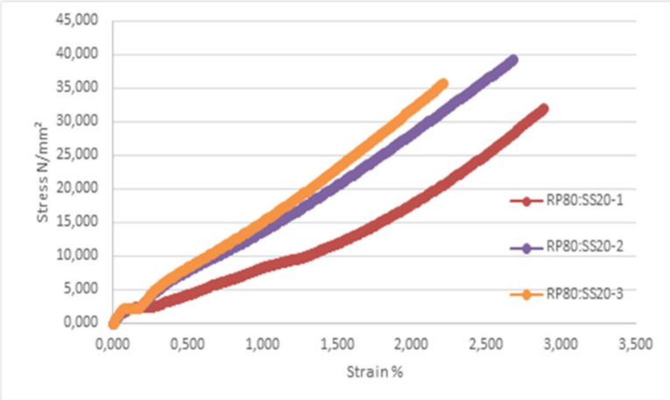

Figure 4. Stress – Strain Diagram of Specimens with a Comparison of 80% Polyester Resin and 20% Sisal Fiber.

Based on Figure 4 diagram and stress strain analysis of the tensile test of the connection between resin and sisal fiber with a ratio of 80% polyester resin and 20% sisal fiber above, it can be seen that each specimen tested produces different stresses and strains.

In the tensile test of the sisal fiber composite with a ratio of 80% polyester resin and 20% sisal fiber, it was found that specimen 1, the sisal fiber composite, produced a maximum stress of 32,145 N/mm^2 and a maximum strain of 2,885% and specimen 2 produced a maximum stress of 39,317N/mm^2. and maximum strain of 2.692%. And specimen 3 produces a maximum stress of 35.811 N/mm^2 and a maximum strain of 2.209%.

From the graph above, the relationship between the mixture of resin and sisal fiber on tensile strength, the higher the stress, the resulting strain will increase and after the specimen reaches maximum tensile strength, the strength will decrease until it reaches the breaking point. In the graph above, it can be seen that each specimen tested produces different stresses and strains. This is because during the styling process the fiber thickness is not even

8. Comparative Analysis of Tensile Strength of Polyester Resin Fractions and Sisal Fiber

From the three specimen ratios between 90:10, 85:15, and 80:20, the largest stress value was obtained, namely in the ratio of 80% polyester resin and 20% sisal fiber where the stress value was 32,758 N/mm^2 and the strain was 2,595%, 85 % polyester resin and 15% sisal fiber where the stress value is 30.776 N/mm^2 and the strain is 2.135%, while the sisal fiber

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composite with the smallest value is obtained in a comparison of 90% polyester resin and 10% sisal fiber where the stress value is 22.144 N/mm^2 and the strain is 1.762%. This is influenced by the fact that there is less fiber in the ratio of 90:10 and 85:15 compared to 80:20.

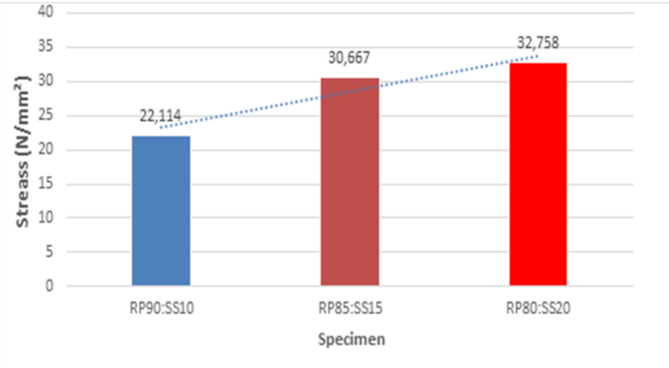

Figure 5. The average tensile strength diagram in various fraction variations

Therefore, it can be concluded that the more of the sisal fiber mixture given to each composite comparison, the greater the strength value of the specimens subjected to tensile tests.

a. *Discussion of Tensile Test Results*

From the graphic image above, it can be seen that each specimen tested produces different stresses and strains. Several things cause differences, such as the influence of room temperature during printing, the size of the sisal fibers in different specimens, the number of fibers for each specimen is different even though the fiber weight is the same.

In the tensile test of the sisal fiber composite, the relationship between stress and strain at a ratio of 90% polyester resin and 10% sisal fiber showed a maximum stress of 22,993 N/mm^2 and a strain of 2,245%. In a comparison of 85% polyester resin and 15% sisal fiber, a maximum stress of 37.931 N/mm2 and a strain of 2.342% were obtained. And in a comparison of 80% polyester resin and 20% sisal fiber, a maximum stress of 39.317 N/mm^2 and a strain of 2.692% were obtained.

Based on the data above, it shows the difference between the three comparisons, where the largest stress and strain are obtained at a ratio of 80:20 and the smallest stress is obtained at a ratio of 90:10. So it can be concluded that the more sisal fibers that are given, the greater the stress produced and after the specimen reaches maximum tensile strength, the strength will decrease until it reaches the breaking point.

IV. CONCLUSION

The results of the analysis of the influence of the composition of the mixture of polyester resin and sisal fiber on the tensile strength of the composite can be concluded that the composition of the mixture of polyester resin and sisal fiber can influence the tensile strength of the composite, the greater the percentage of sisal fiber used in making the composite, the stronger the tensile strength of the composite. produced, the highest value produced in this tensile test was a composite with a composition of 80% polyester resin: 20% sisal fiber with a stress result of 39,317 N/mm^2 and a strain of 2,860%

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