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Impact of Grain Size and Volume Fraction to the Mechanical Properties and Water Absorption of the Polyester-Palm Powder-Based Composite

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Abstract: In this study, bending strength and impact value of palm fiber grain infill in polyester is measured, using variation of specific grain size 80,180, 280 and powder composition or volume fraction 10%, 20% and 30 %..Bending strength of the composition material decrease due to palm fiber powder mesh size decreament and volume fraction increment with maksimum bending strength is 92 N/mm2 at grain mesh size 80 and volume fraction 10%. Impact value reach maksimum 0.002683 J/mm2 with mesh size 180 dan volume fraction 30%. Palm grain size affects bending strength and impact value significantly. Water absorption value of powder composition and powder size mesh also measured. Water absorption increase due to powder composition rate increament also mesh size increament and at rest after 192 hours of immersion.

Keywords: About five key words in alphabetical order, separated by comma

1. Introduction

Driven by the need for material with excellent properties, study dealing with utilization of Arenga Pinnata as promising composite material is recently increasing. Composite is a material formed from a combination of two or more forming materials through an inhomogeneous mixture, with the mechanical properties of each of the constituent materials being different (Matthew and Rawlings, 1994). With its abundance in the amount of Arenga Pinnata trees in Indonesia, it is becoming important to investigate the mechanical properties of Arenga pinnata as promising filler in composite material. Several earlier studies have investigated mechanical properties of palm fiber powder of matrix composites.According to (Umboh, 2019), it was found that the bending strength and impact of composite materials decreased with the increase in the mesh size of the fibers and weight composition of the fibers. Widodo (2008) found that the maximum mechanical properties of composite is achievable at 40% palm fiber weight fraction. Mahumda et al. (2013) found that the highest tensile strength and strain were achieved in the composite with a fiber length of 90 mm. Extending of those previous researchers, this research uses Palm fiber as an additive to the composite. The goal of this study is to determine the impact of grain size and volume faction of the palm fiber as a filler or reinforcement in the polyester matrix composite immersed in water.

2. Methods

The research procedure carried out according to the following stages.

Stage 1. Sample preparation.

Stage 2. Producing Sample testing.

This is performed by soaking the palm fiber powder in an alkaline solution with an immersion time of 2 hours, which is then drained and dried, mixing materials such as resin, catalyst and powder, with a volume fraction of 100% vs 0%, 90% vs 10%, 80% vs. 20%, and 70% vs 30% are then put into the mold and then dried.

Stage 3. Preparation of test specimens. For the bending test, the thickness of the sample test is 5 mm, the width is 15 mm, and the span length is 60 mm, for the impact test, the thickness is 5 mm, the width is 5 mm, and the specimen area is 25. Meanwhile, the immersion test has a specimen size of 100 x 100 mm.

Stage 4. Specimen testing; In this process, mechanical testing is carried out. This test includes a bending test using a Tensile/Brinell Test Machine MT 3017, an impact test using an Impact Tester MT 3016 and a composite immersion test.

Stage 5. Sample testing data analysis and conclusions

3. Result and Discussion

3.1 Bending Strength

Composite bending strength is determined using equation (1) and the result of appraising the bending strength is presented in Figure 1 according to varying grain sizes.

$\sigma b = \frac{3PL}{2bd^2}$N/mm^2 ……………………………………………….(1)

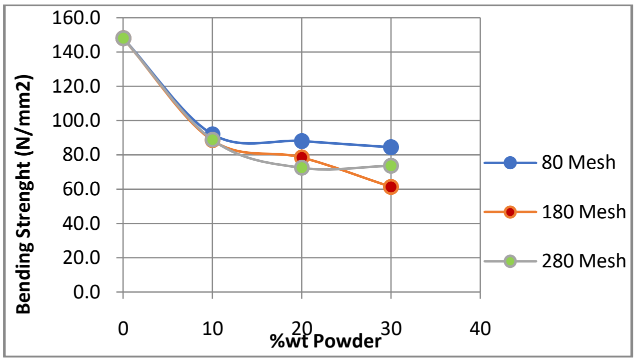

Figure1. Curve depicting average composite bending strength against varying grain size

Figure 1 show curve depicting the relationship between the average bending strength and the percentage of powder weight composition at various grain sizes of 80 mesh, 180 mesh, and 280 mesh.The result presented in figure 1 show that the composite bending strength will decrease along with increasing grain size when Palm fiber is added. The increase in the percentage of powder weight composition and the increase in the mesh size of the fibers also decreased the bending strength of the composite material. However, for the grain size of 280 mesh, the bending strength of the composite material is actually higher than the grain size of 180 mesh when viewed at 10% and 30% powder weight.

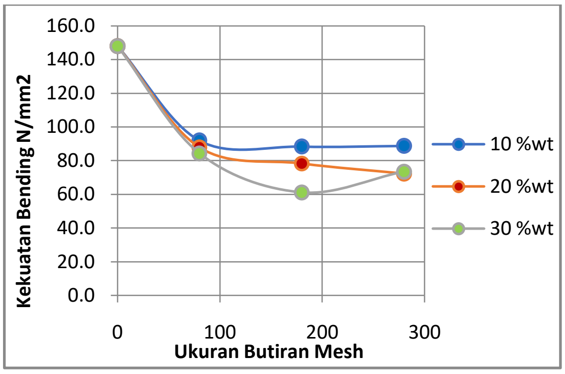

Figure2. Chart depicting average composite bending strength against varying grain size.

The results presented in figure 1 show that the bending strength will decrease if palm fiber powder is added. The increase in the percentage of powder weight composition and the increase in the mesh size of the fibers (decrease in particle size) also decreased the bending strength of the composite material. However, for the grain size of 280 mesh, the bending strength of the composite material is actually higher than the grain size of 180 mesh when viewed at 10% and 30% powder weight. After getting the results of the average bending strength for each variation of the mesh size, also getting the results of the average bending strength for each composition of the existing powder weight.Figure 2 shows relationship between bending strength and variations in grain size at the composition of 10% by weight of powder, 20% by weight of powder, and 30% by weight of powder. In can be seen that increasing in the mesh size of the fibers did not significantly affect the bending strength, and the increase in the weight composition of the powder actually decreased the bending strength of the composite material.

3.2. Impact Strength

Calculation of impact value from the equation of absorption energy and impact value, arm length (R) 0.3 m, Gravity acceleration (g) = 9.81 m/s2, Pendulum weight (m) = 2 kg, Angle = 30° and the result of the impact test shown in Figure 3.

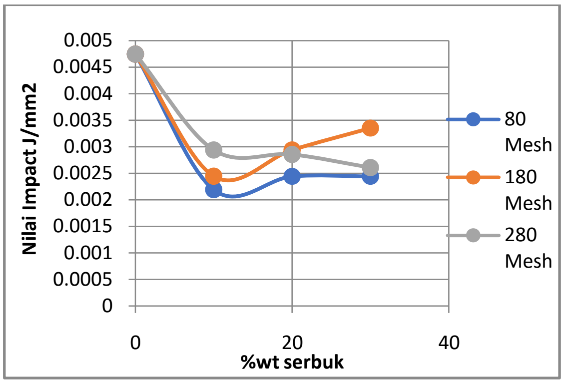

Figure 3.Curve depicting the average Impact Value on Powder Weight against percentage on Variation in Grain Size

Figure 3 shows relationship between the impact value and the percentage of powder weight composition at grain sizes of 80 mesh, 180 mesh, and 280 mesh. The test results showed that the addition of palm fiber powder decreased the impact strength of the composite material.

In can be observed from figure 3 that increasing in powder weight composition affecting the impact strength of the composite material at a grain size of 180 mesh. Also the increase in the grain size of the mesh has an effect on increasing the impact value, but the composition of 20% by weight of powder for the size of 180 mesh and 280 mesh tends to be the same, and at the composition of 30% powder weight the impact value for the size of 180 mesh is actually higher than the size of 280 mesh.

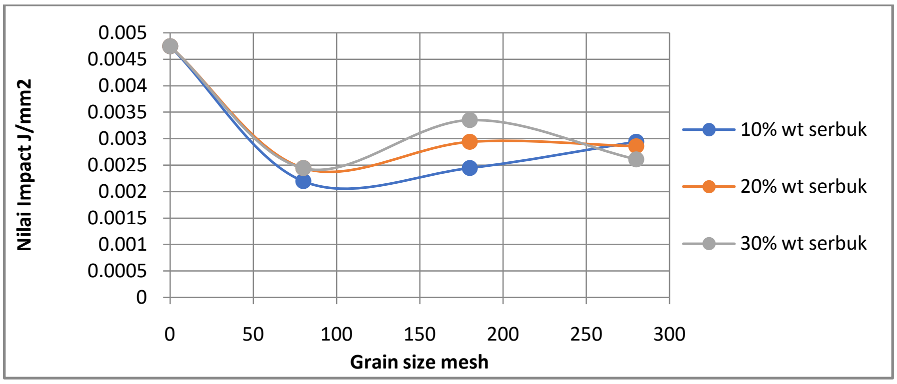

Figure 4. Relationship between grain size average to the percentage of composite powder.

Figure 4 shows relationship between the average impact values on variations in grain size with the addition of 10%, 20%, and 30% powder weight percentages. Based on Figure 4, it is observable that the addition of palm fiber powder reduces the impact value of the composite material. The increase in grain size increases the impact value to a size of 180 mesh and then decreases again to a grain size of 280 mesh, but for 10% by weight of powder the impact value continues to increase to a grain size of 280 mesh. The addition of powder weight composition also has an effect on increasing the impact value of the composite material, but at the grain size of 80 mesh and 280 mesh the impact value of the composite material tends to be the same. In other words, the grain size of 80 mesh and 280 mesh powder composition is having insignificant influence.

3.3 Composite Water Absorbing Capacity

The absorption value was calculated based on the equation W (%) = (Wt− W0)/ W0 x 100%, for W the percentage value of the composite weight after immersion, Wt the weight of the composite every 24 hours and W0 the weight of the initial composite before immersion.

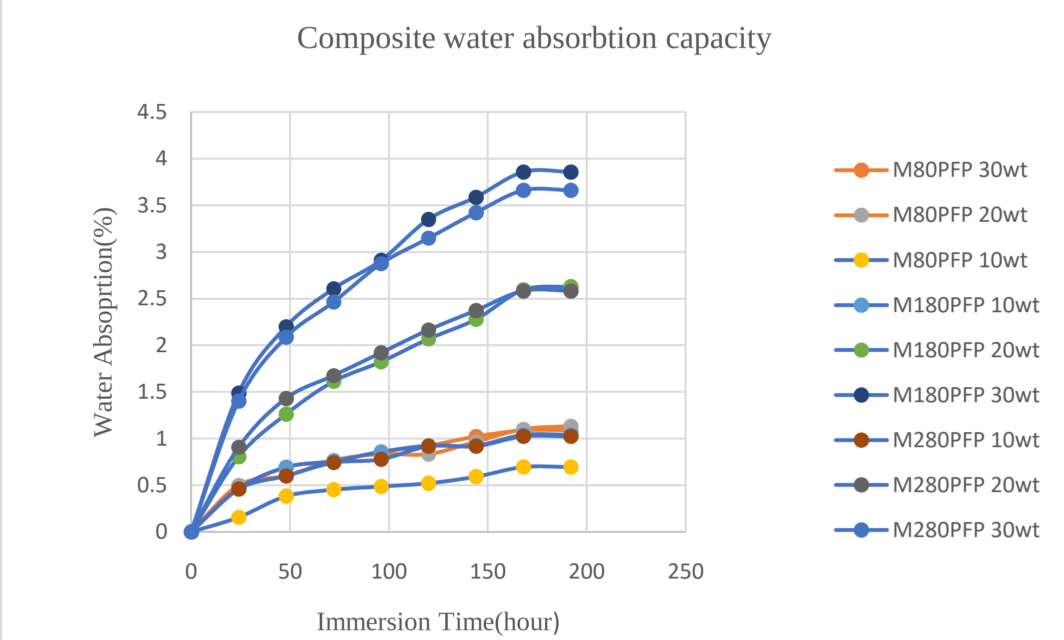

Figure 5. Curve depicting Composite Water Absorption Against Immersion Time

Based on Figure 5, the composite with grain size of 80 mesh and powder composition of 10% is having the lowest composition with the smallest water absorption, while the composite with grain size of 180 mesh and powder composition of 30% is the composition with the highest water absorption when immersed 192 hours.

4. Conclusions

Driven by the distinct characteristics of the Arenga Pinnata as promising composite filler material, this study investigates the influence on the grain size and volume fraction to the mechanical properties of the Polyester-Palm Powder-based Composite. This study reveal that the bending strength of the composite material decreases with increasing mesh size or decreasing particle size of palm fiber powder. Increasing the composition of the fibers also reduces the bending strength of the composite material. This study found that increasing grain size will increase the impact strength up to 180 mesh and then decreases back to a grain size at 280 mesh, but for 10% by weight of powder the impact value continues to increase to a grain size up to 280 mesh. The addition of powder weight composition will increase the impact value of the composite material, but at the grain size of 80 mesh and 280 mesh the impact value of the composite material tends to be the same. The addition of palm fiber powder as a filler in the composite material will reduce the mechanical properties of the composite material. The water absorption capacity of the composite will increase along with increasing powder composition and it was stable at 192 hours of immersion time.

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