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By Maryudi Maryudi

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Maryudi [a,1], Farrah Fadhillah Hanuma,[2,*], Oktaza Loundi Vidinda [b,3], Arif Dwi Anto [b,4]

[a] Magister of Chemical Engineering, Universitas Ahmad Dahlan, Bantul, Yogyakarta, Indonesia, 55191
[b] Chemical Engineering, Universitas Ahmad Dahlan, Bantul, Yogyakarta, Indonesia, 55191
[1] maryudi@che.uad.ac.id; [2]*farrah.hanum@che.uad.ac.id; [3] oktaza1800020092@webmail.uad.ac.id;
[4]arif1800020075@webmail.uad.ac.id
*corresponding author

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ABSTRACT

Advancements in science and innovation in the modern world have led to a growing demand for materials in the production of goods. The utilization of materials in the manufacturing process has been reduced. This is due to the heaviness, costliness, susceptibility to corrosion, and complex assembly systems of metal materials compared to natural fibers. One of the materials currently under development is composites. Composites are a mixture of at least two materials that vary in shape, chemical structure, and are non-disintegrating. The aim of this study is to explore the fabrication and influence of rice husk volume fraction in epoxy composites, as well as to test their tensile strength and composite characteristics. The methodology involves preparing the raw materials (rice husk charcoal, epoxy resin, epoxy hardener, and silicon spray), rice husk charcoal preparation, epoxy production from resin and epoxy hardener, and composite manufacturing with volume fractions of 10%, 20%, and 30% following ASTM D-638 standards. The testing of composite characteristics through tensile tests yields varying tensile strengths. The highest tensile strength is found in composites with a volume fraction of 10%, while the lowest tensile strength is found in composites with a volume fraction of 30%.

1. Introduction

In recent years, there has been a growing interest in the development of sustainable and eco-friendly materials for various applications, including the field of composites. Composites, which are materials composed of two or more distinct components, offer a wide range of advantages such as high strength, low weight, and improved mechanical properties[1-2]. To further enhance the sustainability of composites, researchers have been exploring the incorporation of natural fillers or reinforcements derived from agricultural waste materials [3-4].

One such agricultural waste material that has gained attention is rice husk charcoal. Rice husk charcoal is obtained from the carbonization of rice husk, a byproduct of rice milling [5-6]. It is abundant, renewable, and possesses unique properties that make it a promising filler material for composites. Rice husk charcoal is composed mainly of carbon, with a complex microstructure that includes pores and a hierarchical arrangement of particles [7].

The mechanical characteristics of composites are crucial for their performance and suitability for various applications. The addition of rice husk charcoal as a filling material in composites offers the

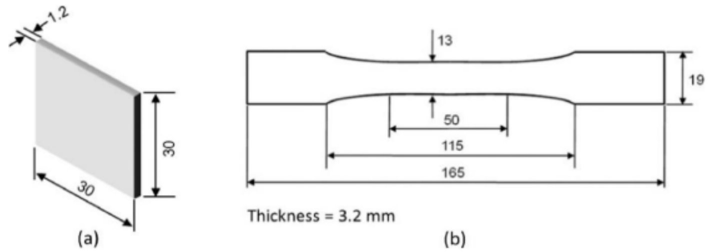

Figure 1. Specimens with standard size ASTM D-638-4

2.1.3. Composites

Determining the density of rice husk charcoal particles and epoxy. After calculation, the bulk density value of rice husk charcoal was 0.3729 g/ml and the epoxy density was 1.15 g/ml. Calculates a composite of rice husk charcoal particles, hardener, and epoxy resin based on the mold volume and specified variations. Where the ratio between resin and hardener is 1 : 1. Here is the formula used to find the amount of charcoal used:

$$charcoal = \frac{volume\ fraction(\%)}{100\% \ \times V\ cetakan\ \times charcoal\ density}$$

While the formula used to calculate the amount of epoxy used:

$$epoxy = \frac{volume\ fraction(\%)}{100\% \ \times V\ cetakan \times epoxy\ density}$$

Epoxy resin and rice husk charcoal were combined in a beaker glass and stirred the mixture thoroughly with a glass stirrer for approximately 15 minutes. Then, the epoxy hardener was added to the mixture and stirred using a glass stirrer for five minutes. The composite is then produced by coating the mixture with silicone spray for easy removal of the dried composite material and using a brush to flatten the silicone spray. Carefully pour the composite material mixture into the mold and cover it with a glass plate before securing it with a paperclip. Leave the mold to sit undisturbed for approximately 24 hours. Once the composite has cured, carefully remove it from the mold and use sandpaper to smooth the edges of the composite in accordance with the ASTM D-638 testing standard.

3. Results and Discussion

1. Effect of particle size of the rice husk into composite tensile strength

Tensile strength is used to determine the maximum load a material can withstand when stretched or pulled before it breaks. Testing of rice husk charcoal-based composites and epoxy using the Tensile Testing Machine tool with the tool type, namely retro Line tC II for Z020 TN. The tensile testing machine tool was carried out under operation conditions as the Table 1 below.

Table 1. Operation condition for tensile testing machine tool

Test Load Fmax	20 kN
Test Area Height	1058 mm
Test Area Widht	440 mm
Tensile Speed	5 mm/min

Based on the tensile strength data in Table 1, the addition of rice husk charcoal to the composite turned out to be an increase and decrease in tensile strength. Therefore, we chose to use trend analysis for forecasting where variables are non-free (dependent) and variables are free (independent). Linear trend analysis is an analysis that is shown to make an estimate or forecast of the future and find out the tendency of the data to rise or fall [6]. The data obtained from the composite tensile strength test of rice husk charcoal and epoxy are presented in Table 2 below.

Table 2. Composite tensile strength test in variations particle size of rice husk charcoal

No	Particle Size (N/mm2)									
	No Rice Husks	40 Mesh			60 Mesh			100 Mesh		
	0%	10%	20%	30%	10%	20%	30%	10%	20%	30%
1.	24,36	15,68	16,44	6,38	21,9	15,92	5,23	14,42	12,38	19,99
2.	25,69	11,21	11,60	12,55	21,90	10,94	4,60	16,05	10,96	18,76
3.	19,77	13,12	17,45	15,55	18,69	17,30	5,60	16,32	19,59	16,95
Σ	23,27	13,34	15,16	11,49	19,54	14,72	5,14	15,60	14,31	18,57

The value of tensile strength can be represented by standard deviation. Standard deviation is a reflection of the deviation of the average value data that describes how much variation the data has. In this case, the standard deviation is lower than the normal value, this indicates that the normal value can be used as a general informational picture. However, if the standard deviation value is higher than the normal value, it indicates that the normal value is a depiction of general information that should not be used. Here is the formula for finding the standard deviation value:

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(xi-\bar{x})^2}$$

Where: s^2 = variety or variation of the sample
s = Standard deviation
N = Number of data
i = I-th data number (I = 1,2,3,... N)
xi = I-th data (1,2,3,... N)
$\bar{x}$ = Sample average

Using the equation formula, the results of the standard deviation of composite tensile strength with variations in rice husk charcoal size of 40 mesh, 60 mesh, and 100 mesh as well as variations in volume fractions of 0%, 10%, 20%, and 30% are presented in the following figure (Fig. 1.).

The largest standard deviation value is found in the charcoal size of 40 mesh with a volume fraction of 30% with a standard deviation value of 4.6754 while the lowest standard deviation value, it is found in the charcoal size of 60 mesh and a volume fraction of 30% with a standard deviation value of 0.4128. Because the standard deviation value is lower than the average value, it can be concluded that the average value of tensile strength can be used as a representation of the overall data.

Generally, larger particles have higher tensile strength due to stronger bonding between the particles. However, if the particle size is too large, there may be a tendency for lower tensile strength due to gaps or empty spaces between the particles [9-10]. On the other hand, at the nano scale, phenomena such as surface effects and size effects can influence this relationship. Nano-sized particles tend to have a larger surface area per unit mass, which can result in a more dominant surface effect and significantly affect tensile strength.

According to the graph above, each particle size 40, 60, and 100 mesh with 0% rice husk charcoal added to the composite have the same value of tensile strength which is 23.27 N/mm2. Then, the data also explain that the more rice husk charcoal added, the smaller the tensile strength value, on the contrary, the smaller the composition of the husk charcoal, the greater the tens2 strength value or it can also be mentioned that the variation in charcoal addition has no effect on the tensile strength of the composite. This is due to the large amount of charcoal in the composite which causes the easy trapping of air bubbles so that the bond between charcoal and resin does not occur properly.

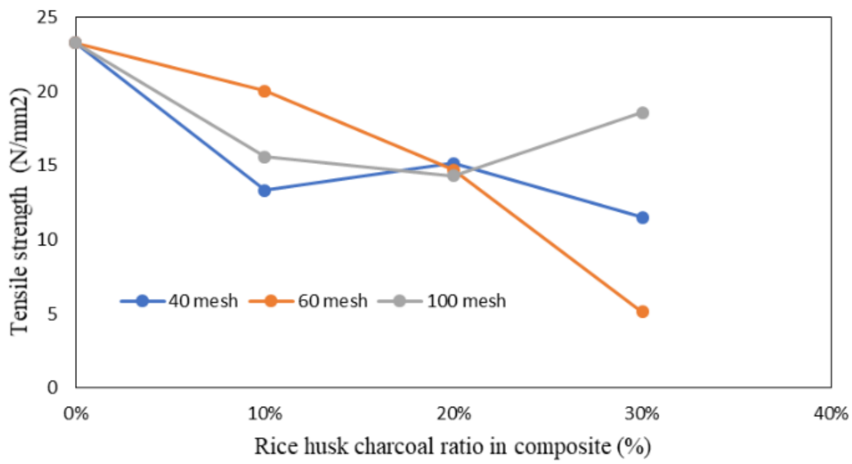

Figure 2. The relationship between tensile strength and particle size of rice husk charcoal for 0, 10, 20, and 30 % ratio charcoal in composite

The data for the charcoal size variations of 40, 60, and 100 mesh experienced ups and downs due to samples made separately or it can be said that when making samples as many as 3 pieces in one process there were broken during the collection from the mold so that the composition in the sample was different. Composites with a volume fraction of 0% give the greatest value of tensile strength. This is due to the homogeneous interaction of epoxy resins which leads to the occurrence of better bonding due to the slightly trapped air bubbles.

When compared to previous studies [11] the smaller the comparison between teak sawdust charcoal and the epoxy matrix, the greater the tensile test results obtained, and vice versa. This result is the same as the research we have done, namely the less the comparison between rice husk charcoal and the epoxy matrix, the greater the tensile test results obtained.

2. Elongation Break

An elongation break is a material strength testing method used to determine the percentage of elongation or change in length, a material undergoes before it breaks under tension. Elongation at break, also known as elongation to failure, is the measure of the percentage change in length of material before reaching the point of fracture or failure in a tensile test [12]. Elongation at break is commonly used in characterizing the mechanical properties of materials, especially in tensile testing or tensile strength evaluation[13-14]. This parameter provides information about how much a material can stretch or undergo deformation before ultimately failing or breaking.

It is often performed in conjunction with a tensile strength test. During a tensile strength test, a sample of the material is subjected to a slowly increasing tensile load until it breaks. While the material is being stretched, the change in length is measured continuously until the point of failure. Elongation break is the percentage increase in the length of the material at the point of failure compared to its original length.

The analysis of the elongation break for the composite was obtained in the variations of particle size of the rice husk charcoal and the additional volume of the charcoal into the composite. The result was described in the Figure below.

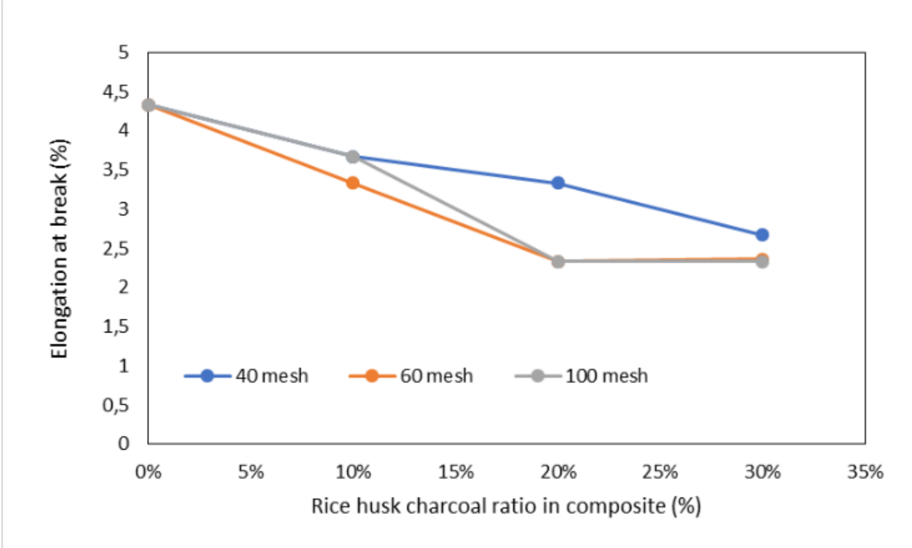

Figure 3. The relationship between elongation break of rice husk charcoal for 0, 10, 20, and 30 % ratio charcoal in composite

For charcoal size 40 mesh based on the graph above the highest elongation break value was obtained at a variation in the charcoal composition of 0% and 10% with a value of 4.33 and the lowest elongation break value was found in a variation in the composition of 30% with a value of 3.33. For the charcoal size of 60 mesh based on the graph above, the highest elongation break value was obtained at a variation in the charcoal composition of 30% with a value of 23.67, and the lowest elongation break value was found in a 20% composition variation with a value of 2.33. For the charcoal size of 100 mesh based on the graph above the highest elongation break value was obtained at a variation in the charcoal composition of 0% with a value of 4.33 and the lowest break extension value was found in a composition variation of 20% and 30% with a value of 2.33. Then by using trend analysis, the chart shows an increasing line it can be interpreted that with more charcoal used, the elongation of the predicted composite break will increase.

Based on the percentage of elongation break analysis, that composite made from a mixture of epoxy and rice husk charcoal has the greatest break elongation value found in the 30% volume fraction at a size variation of 60 mesh. the largest break elongation value is found in composites with a size of 60 mesh with a volume fraction of 30% and the smallest break elongation values are found in composites with sizes of 60 mesh (20%) and 100 mesh (20% and 30%). This happens because the smaller the size of the rice husk charcoal will produce a composite with a larger density of rice husk charcoal compared to the larger size of the rice husk charcoal. It can be concluded that the addition of rice husk charcoal with the volume fraction has no effect on the value of the elongation of the composite break because the results obtained are not constant.

4. Conclusion

In general, the utilization of rice husk charcoal in varying volume fractions has a significant impact on the tensile strength and elongation at break of the composite. This can be attributed to the increased reinforcement provided by the charcoal and the reduced presence of the binder. However, the dimensions of the composite sample remain unchanged within the 0%-30% fraction range. The strength of fiber composites is greatly influenced by the constituents, concentration, and distribution of the fibers. Furthermore, the relatively low value obtained in the tensile test may be attributed to the mixing process employed.

References

[1] H. Fahmi and N. Arifin, "Effect of Variations in Composite Composition of Epoxy Resins/Glass Fibers and Pineapple Leaf Fibers on Toughness," J. Tek. Mesin, vol. 4, no. 2, pp. 84–89, 2014.

[2] N. Imam and D. Widjanarko, "Composite Characteristics of Acacia Wood Charcoal Particle Epoxy As An Alternative to Non-Asbestos Brake Linings," Rotation, vol. 22, no. 1, pp. 7–13, 2020.

[3] Arjmandi, R. et al. (2015) 'Rice Husk Filled Polymer Composites', International Journal of Polymer Science, 2015. doi:10.1155/2015/501471.

[4] Laftah, W.A. and Wan Abdul Rahman, W.A. (2021) 'Rice waste–based polymer composites for packaging applications: A review', Polymers and Polymer Composites, 29(9_suppl), pp. S1621–S1629. doi:10.1177/09673911211046775.

[5] M. T. Sembiring and T. S. Sinaga, "Activated charcoal (its introduction and manufacturing process)," USU Digit. Libr., pp. 1–9, 2003.

[6] Bisht, N., Gope, P.C. and Rani, N. (2020) 'Rice husk as a fibre in composites: A review', Journal of the Mechanical Behavior of Materials, 29(1), pp. 147–162. doi:10.1515/jmbm-2020-0015.

[7] Bisht, N., Gope, P.C. and Rani, N. (2020) 'Rice husk as a fibre in composites: A review', Journal of the Mechanical Behavior of Materials, 29(1), pp. 147–162. doi:10.1515/jmbm-2020-0015.

[8] Arjmandi, R. et al. (2015) 'Rice Husk Filled Polymer Composites', International Journal of Polymer Science, 2015. doi:10.1155/2015/501471.

[9] Farah Nordyana, A.R., Romli, A.Z. and Abidin, M.H. (2013) 'Effect of rice husk particle size on tensile and density of recycled PPVC composite', Advanced Materials Research, 812, pp. 145–150. doi:10.4028/www.scientific.net/AMR.812.145.

[10] Yiga, V.A. et al. (2021) 'Optimization of tensile strength of PLA/clay/rice husk composites using Box-Behnken design', Biomass Conversion and Biorefinery [Preprint], (0123456789). doi:10.1007/s13399-021-01971-3.

[11] Nasruddin, "Characteristics of solid tyre mechanical properties with local natural resource-based fillers and softening materials," J. Din. Penelit. Ind., vol. 28, no. 1, pp. 20–31, 2017.

[12] Das, O. et al. (2022) 'Natural and industrial wastes for sustainable and renewable polymer composites', Renewable and Sustainable Energy Reviews, 158(January). doi:10.1016/j.rser.2021.112054.

[13] Nandiyanto, A.B.D. et al. (2021) 'The effects of rice husk particles size as a reinforcement component on resin-based brake pad performance: from literature review on the use of agricultural waste as a reinforcement material, chemical polymerization reaction of epoxy resin, to experiments', Automotive Experiences, 4(2), pp. 68–82. doi:10.31603/ae.4815.

[14] Bolcu, D. and Stănescu, M.M. (2020) 'A study of the mechanical properties of composite materials with a dammar-based hybrid matrix and two types of flax fabric reinforcement', Polymers, 12(8), pp. 1–20. doi:10.3390/POLYM12081649.

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