JEMMME (Journal of Energy, Mechanical, Material, and Manufacturing Engineering)
Vol.x, No. xx, Xxx xxxx

ISSN 2541-6332 | e-ISSN 2548-4281
Journal homepage: http://ejournal.umm.ac.id/index.php/JEMMME

SOUND ABSORPTION COEFFICIENT FROM COMPOSITES MADE FROM COCONUT FIBER, PAPER AND STYROFOAM

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Abstract

Noise is an unpleasant/undesirable sound. Apart from noise, environmental problems are often faced by the community in the form of organic and inorganic waste resulting from several small/large industrial activities. Organic waste often encountered is young coconut fiber from activities in traditional markets. Paper waste comes from teaching and learning activities/offices. Styrofoam waste is included in the category of inorganic waste, which is very difficult to decompose, so it has a bad impact on the environment. An experiment using a composite of young coconut fiber, sawdust and styrofoam with varying thicknesses was carried out by (Nur Yulianti H, et al, 2021). To reduce the mixture of composite materials, researchers tried to conduct research with coconut fiber, paper and styrofoam materials so that it could be used as a sound absorber. Cylindrical composite specimens were made with different variations in composition and analyzed the differences in sound dampening ability in various compositions. The sound absorption capacity of the composite was measured at frequencies of 125 Hz, 250 Hz, 500 Hz, 750 Hz, 1,000 Hz, 2,000 Hz and 4,000 Hz. The composite acoustic test results obtained for samples A, B and C showed that the highest absorption energy was 49.57 dB at a frequency of 750 Hz for sample C. Meanwhile, the lowest absorption energy was 1.15 dB at a frequency of 500 Hz for sample A. The sound absorption coefficient values were obtained for all variations. The frequencies of samples A, B and C have good absorption coefficient values, namely ≥ 0.2. The lowest absorption coefficient value was 2.01 at a frequency of 750 Hz for sample C and the highest was 46.67 at a frequency of 500 Hz for sample A. So a good sample to reduce noise is sample C (15 grams of glue: 4 grams of fiber: 3 grams of styrofoam: 8 grams of paper).

***Keywords**: Acoustics, Noise, Absorption Coefficient, Composites*

1. INTRODUCTION

Air pollution that is of concern to many researchers is noise. Noise is a sound or sound that is unpleasant or unwanted (Gabriel, 2001). Noise itself is an environmental problem that is often faced by people in urban areas, such as construction activities, music concerts, traffic jams on highways, and so on. In physics, noise levels can be expressed in terms of sound intensity levels in decibel (dB) units (Giancoli, 2001). The noise threshold limit based on Republic of Indonesia Minister of Health Regulation No. 1405 of 2002 is 85 dB, however the noise felt by urban communities is far above the permitted threshold limit.

Apart from noise problems, environmental problems that are often faced by the community are in the form of organic and inorganic waste from the results of several types of small and large industrial activities. The organic waste that is often encountered is young coconut fiber which can be obtained from buying and selling young coconuts in traditional markets. Paper waste can come from teaching and learning activities or offices. Meanwhile, inorganic waste which is also a problem is the use of Styrofoam. Styrofoam, which is often used as packaging for electronic goods, is a material made from expanded polystyrene and has a very light unit weight, namely around 13 kg/m3 to 16 kg/m3 (Satyarno, 2004). Experiments on the use of composites from young coconut husks, sawdust and styrofoam with varying thicknesses have been carried out by (Nur Yulianti H, et al, 2021). Styrofoam waste is included in the category of non-organic waste which is very difficult to decompose and so far there has been no known recycling of Styrofoam so that scavengers do not pick it up. This has quite a bad impact on the environment. Based on the presentation of environmental problems, researchers want to conduct research on making composites from coconut fiber, waste paper and styrofoam so that they can be used as sound/noise absorbers.

2. Methods

This research method used was an experiment in the laboratory. The composite material will be made by mixing coconut fiber, paper and styrofoam with PVC glue as a binder, then molded and dried. Cylindrical composite specimens are made with different variations in composition. To analyze the differences in sound dampening ability in several composition variations. The value of the sound absorption capacity of composite specimens was measured in the laboratory using frequencies of 125 Hz, 250 Hz, 500 Hz, 750 Hz, 1,000 Hz, 2,000 Hz and 4,000 Hz.

The following are the materials needed to make a composite from coconut fiber, waste paper and styrofoam:

1. Hydraulic Press Tool. This tool will be used to press the specimen with a mold. This equipment already exists in the Industrial Engineering Laboratory at Bojonegoro University.
2. Mold. The mold used is a paralon pipe connection with a diameter of 4 inches.
3. Caliper. Vernier calipers are used to measure composite specimens.
4. Scales. This tool is used to weigh the mass of coconut fiber, paper pulp and styrofoam.
5. Mixers. A mixer is used to mix the material to be printed as a test specimen.
6. Basin. Used as a place to mix materials that will be formed into test specimens.

After the preparation of tools and materials is complete, the test specimen is made, which consists of the following stages:

1. Preparation of materials, namely used paper, styrofoam and coconut shells.
2. Cut or grate the Styrofoam and coconut fiber into small pieces.
3. Mix all the materials and put them into a mold made from a pipe connection with a diameter of 4 inches.
4. Dry the specimen by drying the specimen in the sun for seven days until completely dry.

3. Result and Discussion

The authors' manuscripts should be completed with title, abstract, keywords and the main text. Furthermore, the authors should present tables, figures, and equations in good order.

3.1 Specimen Making Process

The stages of making a composite made from coconut fiber as a noise reducer are as follows:

1. Preliminary treatment stages for fiber

   At this stage, researchers took coconut fiber from the surrounding environment, apart from reducing waste, they also used materials that came from nature and developed it into a composite material that would be used as a sound absorber. In the initial stage, the fiber is prepared and is given pretreatment, namely by taking the fiber from the coconut, cleaning the fiber and drying it. The coconut fiber chosen was old coconut fiber because the water content in the coconut fiber was very low. This is because young coconuts contain high levels of water and when drying, weathering occurs. Peeling coconut fiber still uses a manual system, namely by using a hammer and by hand. This manual method makes work slow. To overcome this, it is necessary to develop or make a tool to peel coconut fiber.

2. Stages of fiber cutting

After the process of separating the coconut fiber from the coconut, it is then cut manually with scissors.

Figure 1. Fiber Cutting Process

The coconut fiber has been cut, then the fiber is cleaned from the fiber remaining on the surface of the fiber, then the material is soaked in water for approximately 10 minutes as in Figure 1. After that, it is drained and dried in the hot sun for 1 day. After the coconut fiber is completely dry, then mix it with NaOH.

Figure 2. Soaking coconut fiber with water

3. Stage of soaking with NaOH

The completely dry coconut fibers are then soaked in a mixture of 5% NaOH for approximately 4 hours, then drained and dried in the sun until dry. This soaking aims to minimize the amount of extractive substances such as a layer of wax on the fiber in the form of lignin and dirt in the fiber (Alamsyah, 2023).

Figure 3. Soaking fiber with NaOH

Figure 4. Drying fiber under the heat of the sun

After obtaining the coconut fiber, it was mixed and mixed to see the effect of the fiber composition of the composite material on the sound dampening ability.

4. Stages of Paper and Styrofoam Treatment

This stage begins with cutting the waste paper into small pieces and weighing them according to needs.

Figure 5. Cutting waste paper

Meanwhile, the Styrofoam material is shredded to a small size, then weighed as needed.

Figure 6. Cutting Styrofoam

5. Mixing stages between matrix and filler

The matrix used in this research is "Rajawali" brand glue. The mixture ratio between matrix and filler (coconut fiber, waste paper and styrofoam) was varied to see the effect of the composite content on the mechanical properties and the magnitude of the influence on the sound dampening characteristics of the sample. Variations in the ratio of matrix and filler used are:

- Sample A = 15 grams of glue: 4 grams of fiber: 1 gram of styrofoam: 10 grams of paper
- Sample B = 15 grams of glue: 4 grams of fiber: 2 grams of styrofoam: 9 grams of paper
- Sample C = 15 grams of glue: 4 grams of fiber: 3 grams of styrofoam: 8 grams of paper

Before the mixing process, the matrix and filler are weighed to obtain the desired ratio. Then stir until evenly mixed in a mixing container with the specified ratio.

6. Pressing stages with a hydraulic press machine

After mixing thoroughly, the matrix and filler mixture is poured into the base of the mold and then leveled, then the plastic on the top of the mold is trimmed until it completely covers the top of the matrix mixture and filler. After that, the mold is closed and pressed using a hydraulic press machine.

Figure 7. Composite pressing process with a hydraulic press machine

After the pressing process, the composite is first dried under the heat of the sun until the composite part becomes hard, then the composite mold is broken using a saw or grinding machine so that the composite that has been made can be taken out and then dried again under the heat of the sun until the composite is completely dry.

3.2 Sound Absorption Coefficient Measurement

Testing the damping ability of composite boards is carried out using an audio frequency device which functions to provide sound at the desired frequency and a sound level meter which functions to measure noise or sound levels in decibels (dB). This impedance tube will later be able to calculate the sound absorption coefficient of a medium (Yulianti, 2021).

Sound absorption coefficient is the sound absorption efficiency of a material at a certain frequency against the sound that comes to that material. This coefficient is expressed in α. The α value can be between – and 1. The smaller the sound absorption coefficient value, the more sound is reflected and the greater the sound absorption coefficient value, the better the sound absorption. The absorption coefficient of an acoustic material will depend greatly on its characteristics, including: The density of the material, the modulus of elasticity, the water content and the speed of sound hitting the material. If the value of this coefficient is large (more than 0.2), then the material will be called a sound-absorbing material. On the other hand, if this coefficient is small (less than 0.2), it will be called a reflecting material (Istri, 2016).

There are 3 composite samples to be tested, namely sample A (15 grams of glue: 4 grams of fiber: 1 gram of styrofoam: 10 grams of paper); sample B (15 grams of glue: 4 grams of fiber: 2 grams of styrofoam: 9 grams of paper) and sample C (15 grams of glue: 4 grams of fiber: 3 grams of styrofoam: 8 grams of paper). The sound frequencies given are 125 Hz, 250 Hz, 500 Hz, 1,000 Hz, 2,000 Hz and 4,000 Hz. The test was carried out by measuring the noise level in the chamber before and after the composite material was installed. The loss value is obtained by reducing the sound level entering the chamber before the acoustic media is installed and the sound received/reflected after the acoustic media (composite sample) is installed (Firmansyah, 2023). The test equipment and testing process can be seen in Figure 8.

Figure 8. Test Equipment (Impedance Tube)

The sound absorption coefficient test results are in the form of test data from specimens with composite compositions with input frequencies of 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz. Loss = sound/energy arrives (before) – sound/energy is received/reflected (after). Meanwhile, the sound/sound absorption coefficient is obtained by:

$$\propto = \frac{Wa}{Wi} = \frac{Bunyi\ atau\ energi\ yang\ diserap}{Bunyi\ atau\ energi\ datang} \qquad (1)$$

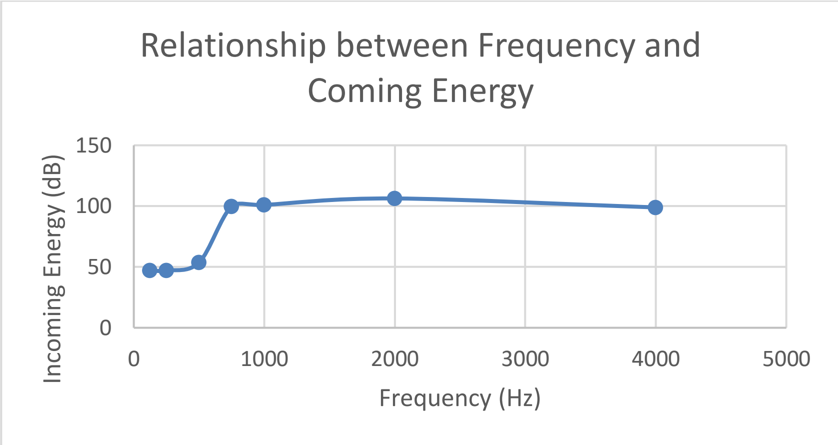

Figure 9. Incoming Energy based on Sound Frequency

The sound dampening ability results show varying values for each test specimen. The highest incident sound/energy after averaging was 106.3 dB at a frequency of 2000 Hz, while the lowest incident sound/energy after averaging was 47.08 dB at a frequency of 250 Hz. Meanwhile in Figure 4.10 it can be seen that the highest sound/energy absorption (loss) (average value) is 49.57 dB at a frequency of 750 Hz in sample C. Meanwhile the lowest sound/energy absorption is 1.15 dB at a frequency of 500 Hz in sample A.

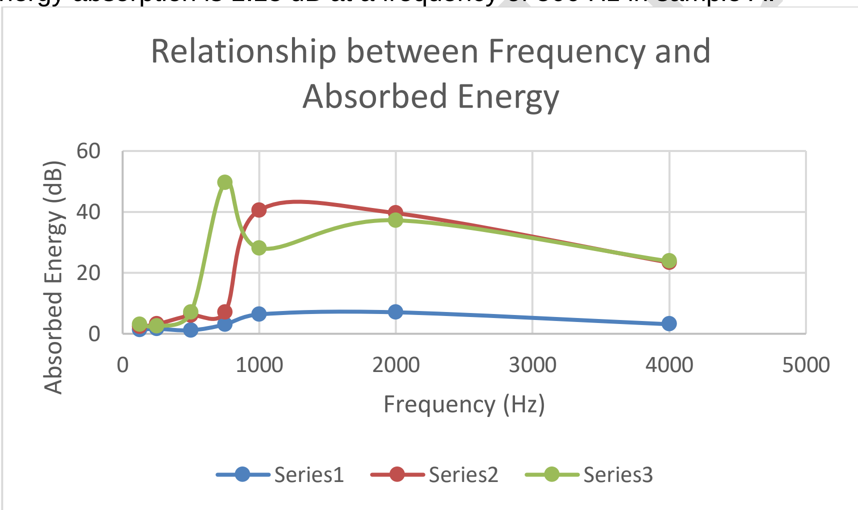

Figure 10. Absorbed Energy based on sound frequency

Clearer results can be seen in table 1 below:

Table 1. Average value of damping ability (loss)

Frekuensi	Energi Datang	Energi Serap (loss)			Koefisien Serap		
		A	B	C	A	B	C
125	47.12	1.27	2.37	3.08	37.2	19.91	15.28
250	47.08	1.63	3.13	2.53	28.83	15.03	18.59
500	53.67	1.15	6.08	7	46.67	8.82	7.67
750	99.72	3.05	7.13	49.57	32.69	13.98	2.01
1000	101.03	6.38	40.53	28.13	15.83	2.49	3.59
2000	106.3	7.05	39.6	37.25	15.08	2.68	2.85
4000	98.92	3.13	23.37	23.78	31.57	4.23	4.16

The absorption coefficient values show varying results, this is because the specimens tested are not homogeneous. What influences the non-homogeneity of composite materials can be caused by several factors, namely in theory composites are made from two or more constituents that do not dissolve in each other, the inhomogeneous mixing process causes the results to be not uniform throughout all parts so it tends to produce large porosity. The louder the sound, the more likely a material with a high density to reflect it (Rimantho, 2019).

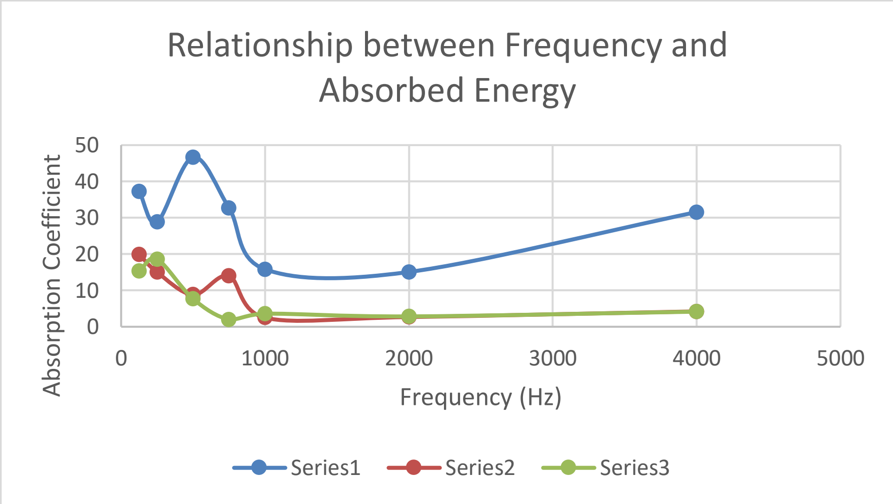

Figure 11. Sound Absorption Coefficient based on Frequency

Based on table 1, it shows that the sound absorption coefficient values obtained at all frequency variations from samples A, B and C have good absorption coefficient values (≥ 0.2). The results of this composite acoustic test obtained for samples A, B and C show that the lowest sound dampening ability/absorption coefficient (α) is 2.01 at a frequency of 750 Hz in sample C and the highest is 46.67 for sample A at a frequency of 500 Hz.

4. Conclusion

Based on the results of data processing and discussion, the following conclusions can be drawn: the results of this composite acoustic test obtained for samples A, B and C show that the highest sound dampening ability/absorptive energy (loss) (average value) is 49.57 dB at frequency of 750 Hz in sample C. Meanwhile the lowest absorption energy is 1.15 dB at a frequency of 500 Hz in sample A. Based on the sound absorption coefficient value obtained at all frequency variations from samples A, B and C, the absorption coefficient value is good, namely ≥ 0.2. Meanwhile, the lowest absorption coefficient value obtained was 2.01 at a frequency of 750 Hz in sample C and the highest absorption coefficient value was 46.67 for sample A at a frequency of 500 Hz. So a good sample to reduce noise is sample C (15 grams of glue: 4 grams of fiber: 3 grams of styrofoam: 8 grams of paper).

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