PERJ Vol. 4 No. 1 (2022), 29-34

Physics Education Research Journal
ISSN 2685 - 6190 (p)
ISSN 2714 - 7746 (e)
Department of Physics Education
Faculty of Science and Technology
UIN Walisongo Semarang-Indonesia

The Natural Composite of Sawdust Teak as a Sound Absorption Material Using The Resonator Space Method

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ARTICLE INFO

Article history:
Submitted : July 15th, 2021
Revised : December 8th, 2021
Accepted : February 15th, 2022

Keywords:
Absorption; sound; composite; *resonance space;* teak sawdust.

ABSTRACT

The development of science and technology has resulted in the increasing use of sophisticated equipment that can produce unwanted sounds, resulting in noise. Acoustic materials are a solution that can reduce noise. This study aims to determine the sound absorption coefficient of a composite of teak sawdust and polyester resin as an environmentally friendly acoustic material. The sample was made in the form of a cylinder using a press of as many as six samples with a comparison of the mass fraction of teak sawdust and the mass fraction of polyester resin, namely sample 1 (30:70), sample 2 (40:60), sample 3 (50:50), sample 4 (60:40), sample 5(70:30), sample 6(80:20). The samples that have been made were tested using a resonance space and sound level meter to measure the value of the sound absorption coefficient (α) at frequencies of 500 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 2500 Hz, and 3000 Hz. The optimal acoustic material sample in sample 1 with a fiber mass fraction of 30% and a sound absorption coefficient of 0.707 at a frequency of 3000 Hz.

Introduction

The rapid development of technology makes the human need for the equipment used is increasing. The use of equipment used by humans for means of communication, transportation, information, production, and entertainment cannot be separated from the noise produced (Rohim et al., 2020). Equipment that uses increasingly sophisticated technology produces unexpected sounds that cause noise and discomfort to human hearing (Astika & Dwijana, 2016). Noise problems in the community can cause discomfort in daily activities, reduce work productivity, and health problems, especially in the hearing system.

Noise is sound that comes from various kinds of human activities and equipment (Astika & Dwijana, 2016). Noise is an unwanted sound. Frequencies between 125Hz, 250Hz, 500Hz, 1000Hz, 2000Hz, and 4000Hz are often used in environmental acoustic measurements. While the frequencies that can be heard by humans include 500Hz, 1000Hz, and 2000Hz. Noise is very disturbing and harmful to humans, so the materials are needed to absorb intense sound (Bahri et al., 2016). One technique to minimize noise is to use acoustic materials (Milawarni, 2017). Acoustic material is a material that can soak sound to reduce production (Muhammad Munir, 2015). Acoustic materials can absorb sound with different strengths in each material (Yuliantika & Elvaswer, 2018).

Composites are materials formed from two or more materials mixed with a synthetic or natural adhesive (Erwan et al., 2015). Composites are produced by mixing the forming materials to produce a new material with different characteristics and mechanical properties from the previous material (Hadi et al., 2016). Composites from natural materials are an alternative sound-dampening material because natural fibers generally can absorb sound, especially indoor noise, which is expected to be used as a sound absorber (Sunardi & Sari, 2014). The natural fiber is a

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doi: 10.21580/perj.2022.4.1.8601

good choice to be researched as a material for making acoustic materials. It is useful as a filler/reinforcing reinforcement in composite materials from natural materials (Pratiwi et al., 2017).

Acoustic materials from natural materials are environmentally friendly. The use of natural fibers as composite reinforcement in recent years has experienced very rapid development. In recent years, the development of composites has led to the use of natural materials such as fibers and particles. Fibers and particles can be obtained from stem fibers, bark, leaves, midribs, and roots. One of the stem fibers that can be used as a composite is teak sawdust. The availability of teak sawdust is currently very abundant, this is related to the many Mabel industries that are often found in the community. Teak wood contains natural oils that can protect itself from wet and cold weather. Teak wood is stronger than other types of wood because it has a closed-grain structure (Deenadayalan et al., 2018). Sawdust is a waste from the Mabel industry in society; generally, it is just thrown away. Waste of various natural materials can be used as composite reinforcement (Masturi et al., 2021).

In recent years, the development of composites has led to the use of natural materials such as fibers and particles. Fibers and particles can be obtained from stem fibers, bark, leaves, midribs, and roots. As reinforcement for fiber and particle composites, it is more desirable because the manufacturing process is easier, environmentally friendly, does not endanger health, has low production prices, and abundant raw materials availability.

Composites applied to soundproof rooms made of natural fibers are not harmful to human health and are more environmentally friendly than synthetic fibers (Arenas & Crocker, 2010). Due to their biodegradable, lightweight, cheaper, non-toxic, and non-abrasive qualities, natural fibers are receiving a lot of attention in composites as a substitute for synthetic fibers for acoustic absorption purposes (Mamtaz et al., 2016). Wood particles are one of the components of processed products from sawmill industrial activities (Ganesan & N.Valarmathi, 2014). Waste composite technology is widely used as wood or building material to minimize deforestation (Masturi et al., 2020). These particles are easy to obtain and even tend to become waste and pollution if they are not handled properly.

The utilization of waste teak sawdust as a composite material for acoustic materials aims to absorb noise to reduce interference with human hearing. The research has made a composite from a mixture of teak sawdust waste used as a composite filler with polyester resin (matrix) for acoustic material.

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Methods

This research is a laboratory experiment with a resonator space tube and a sound meter level as a measuring tool to determine the absorption coefficient. This research was conducted at the Physics Laboratory of the Faculty of Mathematics and Natural Sciences, Semarang State University. The tools and materials used in this research are press, mold, resonator space, audio frequency generator (AFG), sound level meter (SLM), digital balance, screw micrometer, plastic cup, stirrer, polyester resin, teak sawdust, and vaseline. The variables used in this study were the dependent variable: sound absorption coefficient test and independent variables: variations in the mass fraction of fiber (teak sawdust) and matrix mass fraction (polyester resin) which are shown in Table 1.

Table 1
Comparison of the Mass Fraction Percentage of Teak Sawdust and Polyester Resin

Sample	Teak Sawdust Mass Fraction (%)	Polyester Resin Mass Fraction (%)
1	30	70
2	40	60
3	50	50
4	60	40
5	70	30
6	80	20

Research Stage

The stages of making composite materials from teak powder and polyester resin are as follows:

1. Taking teak sawdust at a furniture factory around the house in Tanjungrejo village, Jekulo sub-district, Kudus district. Teak sawdust used as a composite filler is clean, not mixed with dirt, and dry. The powder taken is then sieved using a sieve.
2. Weigh the raw materials according to the composition of the mass fraction ratio of teak sawdust powder and polyester resin.
3. Glue teak sawdust with resin. After gluing, the mixture of materials is put into a mold with an inner diameter of 4.26cm and pressed using the available press for 5 minutes. Then repeated with a different composition of ingredients.

4. After being pressed with a printing press, the sample was left at room temperature to dry for approximately 24 hours.
5. After the sample is dry, the thickness is measured using a micrometer screw.
6. The measure of the absorption coefficient on 6 samples alternately using a resonator space connected to a sound level meter, and AFG as a sound source at frequencies of 500 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 2500 Hz, and 3000 Hz.

Result and Discussions

The test results of this study were obtained by measuring sound absorption from the comparison of the intensity before and after passing through the sample using the Formula 1.

$$\mathrm{I} = \mathrm{I_0} \mathrm{e}^{-\alpha x} \quad (1)$$

where I am the transmitted sound intensity after passing through the sample, I_0 is the intensity of the sound before passing through the sample, α is the sound absorption coefficient, and x is the thickness of the sample. Acoustic impedance is a measure of the resistance value of a certain fluid or medium to the propagation of sound waves and affects the value of the sound absorption coefficient (α). The propagation of sound waves that hit the barrier medium will experience reflection, absorption, and transmission which affect the sound energy which is determined by the sound absorption coefficient. A sound absorption coefficient that shows the ratio between the sound energy that is not reflected (absorbed) by the limiting medium and the overall sound energy that hits the barrier medium.

The sound absorption coefficient is influenced by the frequency of the sound source. The frequency is divided into three namely, the low-frequency value is less than 1000 Hz, the medium frequency value is between 1000 Hz to 4000 Hz, and the high-frequency value is more than 4000 Hz (Rohim et al., 2020). Measurements were made at frequencies of 500 Hz, 1000 Hz, 1500 Hz, 2000 Hz, 2500 Hz, and 3000 Hz with absorption coefficient in Table 2.

Each acoustic material has different acoustic properties. Each composite has an optimum sound absorption capability at a certain frequency. The acoustic properties of the material as a sound absorber are very good at a frequency of 1000 Hz (Rohim et al., 2020). This is because at this frequency there is a waste of energy which increases the value of the sound absorption coefficient. After reaching the optimum point, it will decrease because the composite material will experience a decrease in acoustic properties at a certain frequency.

Table 2
Sound absorption coefficient

Frequency (Hz)	Sample	I_0 (dB)	I (dB)	x (cm)	α
500	1	90,2	77,9	0,47	0,312
	2		76,8	0,50	0,322
	3		73,7	0,59	0,342
	4		71,5	0,67	0,347
	5		68,0	0,79	0,358
	6		65,1	0,88	0,371
1000	1	87,3	74,5	0,47	0,337
	2		73,5	0,5	0,344
	3		71,1	0,59	0,348
	4		67,7	0,67	0,379
	5		64,5	0,79	0,383
	6		61,9	0,88	0,391
1500	1	87,8	74,8	0,47	0,341
	2		73,9	0,50	0,345
	3		71,3	0,59	0,353
	4		67,9	0,67	0,384
	5		64,6	0,79	0,388
	6		61,8	0,88	0,399
2000	1	88,1	70,1	0,47	0,486
	2		69,9	0,5	0,463
	3		67,5	0,59	0,451
	4		65,6	0,67	0,440
	5		63,2	0,79	0,420
	6		61,5	0,88	0,408
2500	1	99,9	76,1	0,47	0,579
	2		77,2	0,5	0,516
	3		74,7	0,59	0,493
	4		72,8	0,67	0,472
	5		71,1	0,79	0,430
	6		69,6	0,88	0,411
3000	1	94,4	67,7	0,47	0,707
	2		66,9	0,50	0,689
	3		67,3	0,59	0,574
	4		65,6	0,67	0,543
	5		65,6	0,79	0,461
	6		64,9	0,88	0,426

Table 2 shows the sound absorption coefficient (α) of each teak wood composite sample at certain frequencies. At a frequency of 500Hz, 1000Hz, and 1500Hz, samples that are close to the ideal absorption coefficient are sample 6 with an absorption value of 0,371; 0,391; 0,399. At the frequencies of 2000Hz, 2500Hz, and 3000Hz samples that have absorption values close to the ideal sound absorption coefficient are samples 1 of 0,486; 0,579; 0,707.

The quality of the sound-absorbing material is determined by the value where the value is expressed in the numbers 0 to 1. If the value of the sound absorption coefficient is smaller, the more sound is reflected. If the greater the value of the sound absorption coefficient, the more sound will be absorbed, meaning the better the ability to absorb sound. A good damping material has a sound absorption coefficient value greater than or equal to 0,3 $(\alpha \geq 0{,}3)$. A material that has a minimum sound absorption coefficient value of 0,15 can be categorized as a sound absorber (ISO 116541997). After analyzing that teak sawdust can be used as a natural sound-absorbing material because it has a sound absorption value above the minimum value.

Figure 1
Graph of the effect of the comparison of sample composition on the sound absorption coefficient

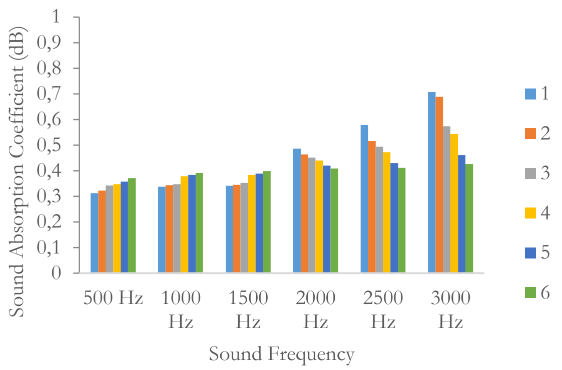

Figure 1 shows the varying sound absorption values of the teak wood composite material. The value of the highest sound absorption coefficient in sample 1 is a 30% mass fraction at a frequency of 3000Hz of 0,707. Meanwhile, the lowest absorption coefficient value is found in sample 1 of the 30% fiber mass fraction at a frequency of 500Hz. The sound absorption coefficient tends to increase due to an increase in sound frequency. At a frequency of 500 Hz, it can be seen that the distribution of absorption coefficient values is included in the lowest sound absorption coefficient, while at 3000Hz frequency, the distribution of absorption coefficient values is included in the highest sound absorption coefficient.

The value of the sound absorption coefficient is influenced by the inhomogeneity of the composite material caused by several factors, namely theoretically the composite is made of two or more insoluble constituents, the mixing process is not homogeneous so that the results are uneven. uniform. The louder the sound of a material with a high density, the material tends to bounce.

The addition of teak sawdust powder in the manufacture of composites with a polyester resin matrix will increase the value of the sound absorption coefficient at certain limits and conditions. Based on the research results, at frequencies of 500Hz, 1000Hz, and 1500Hz, the greater the mass fraction of the fiber, the greater the value of the sound absorption coefficient, while at the frequencies of 2000Hz, 2500Hz, and 3000Hz, it can be seen that the greater the mass fraction of the fiber, the lower the value of the sound absorption coefficient. . This is because the addition of teak sawdust causes high composite density because the teak sawdust particles will be forced to fill the deepest recesses due to the pressure of molding time, so that the surface of the composite material becomes solid. The surface of the composite material that is too tight or tight will tend to turn into reflected sound energy when it hits the surface of the test object. On the other hand, if only a small amount of teak sawdust is added, the density of the test object will be small or loose (hollow). The cavity formed in the composite specimen will absorb higher sound because the sound energy that hits the surface of the specimen as a whole will be absorbed more.

At the frequencies of 2000Hz, 2500Hz, and 3000Hz the properties of the composite material will affect the mass fraction of the fiber. The sound absorption value tends to decrease along with the increase in teak powder particles. This is because the incoming sound is propagated through the heat in the specimen generated by molecular friction between the air molecules and the fiber structure, causing fiber damage at the micro-scale. These fibers are damaged due to very high frequencies, so the given sound will be absorbed and transmitted out.

Conclusions

After analyzing the results of this study, it can be concluded that at frequencies of 500Hz, 1000Hz, and 1500Hz, the absorption value is 0.371; 0.391; 0.399 with 80% fiber mass fraction (sample 6). At frequencies of 2000Hz, 2500Hz, and 3000Hz with an absorption value of 0.486; 0.579; 0.707 obtained 30% fiber mass fraction (sample 1). Based on the results of the study, the frequency will affect the properties of the composite material to the mass fraction of the fiber. The sound absorption coefficient value is 0.3, so that it can be concluded that teak sawdust is eligible to be used as a sound absorbing material.

References

Arenas, J. P., & Crocker, M. J. (2010). Recent trends in porous sound-absorbing materials. *Sound and Vibration*, *44*(7), 12–17.

Astika, I. M., & Dwijana, I. G. K. (2016). Karakterstik Serapan Suara Komposit Polyester Berpenguat Serat Tapis Kelapa. *Dinamika Teknik Mesin*, *6*(1), 8–14. https://doi.org/10.29303/d.v6i1.19

Bahri, S., T.N. Manik, & Suryajaya. (2016). Pengukuran Sifat Akustik Material Dengan Metode Tabung Impedansi Berbasis Platform Arduino. *Jurnal Fisika Flux*, *13*, 148–154.

Deenadayalan, Sivakumar, S., Vishnuvardhan, R., & Sathish Kumar, R. (2018). Fabrication and characterization of B-H-G fiber with teak wood particles reinforced hybrid composite. *International Journal of Engineering and Technology(UAE)*, *7*(2), 208–211. https://doi.org/10.14419/ijet.v7i2.31.13442

Erwan, Faryuni, I. D., & Wahyuni, D. (2015). Sintesis Dan Analisis Sifat Fisik Dan Mekanik Papan Komposit Dari Limbah Pelepah Sawit Dan Sabut Kelapa. *Prisma Fisika*, *III*(3), 93–100.

Ganesan, M., & N.Valarmathi, T. (2014). Tensile Strength of Teak Wood Saw Dust – Cashew nut shell liquid resin composites. *International Journal of Engineering Development and Research*, *2*(1), 196–199.

Hadi, T. S., Jokosisworo, S., & Manik, P. (2016). Analisa Teknis Penggunaan Serat Daun Nanas Sebagai Alternatif Bahan Komposit Pembuatan Kulit Kapal Ditinjau Dari Kekuatan Tarik, Bending Dan Impact. *Jurnal Teknik Perkapalan*, *4*(1), 323–331.

Mamtaz, H., Fouladi, M. H., Al-Atabi, M., & Namasivayam, S. N. (2016). Acoustic absorption of natural fiber composites. *Journal of Engineering (United Kingdom)*, *2016*. https://doi.org/10.1155/2016/5836107

Masturi, Alighiri, D., Drastisianti, a., Susilawati, Fathurachman, Y., Maesaroh, S., & Sunarno. (2021). Surface morphology of composite from mahogany leaves waste with citronella oil (Cymbopogon winterianus Jowitt) as a natural coating for antifungals of Pleurotus ostreatus. *Journal of Physics: Conference Series*, *1918*(2). https://doi.org/10.1088/1742-6596/1918/2/022045

Masturi, Alighiri, D., Susilawati, & Sunarno. (2020). Mechanical strength of quartz reinforced polyvinyl acetate/leaves-waste composite. *Journal of Physics: Conference Series*, *1567*(3), 4–9. https://doi.org/10.1088/1742-6596/1567/3/032065

Milawarni, dan S. (2017). Pembuatan Plazore dari Plastik Bekas dengan Media Minyak Jelantah dan Aplikasi sebagai Peredam Bunyi. *Jurnal Teknologi Kimia Unimal*, *2*(718), 52–62.

Muhammad Munir, D. (2015). Pemanfaatan Fluk pada Styrofoam sebagai Bahan Dasar Peredam Suara dengan Metode Tabung Impedansi. *Jurnal Inovasi Fisika Indonesia*, *04*, 41–47.

Pratiwi, P., Fahmi, H., & Saputra, F. (2017). Pengaruh Orientasi Serat Terhadap Redaman Suara Komposit Berpenguat Serat Pinang. *Simetris : Jurnal Teknik Mesin, Elektro Dan Ilmu Komputer*, *8*(2), 813. https://doi.org/10.24176/simet.v8i2.1617

Rohim, A. M., Fianti, F., & Nurbaiti, U. (2020). Potensi Sekam Padi dan Jerami sebagai Alternatif Material Akustik. *Physics Education Research Journal*, *2*(1), 35. https://doi.org/10.21580/perj.2020.2.1.4883

Sunardi, & Sari, K. (2014). Sifat Optik dari Material Fiberglass dengan Filler Serat Sansiviera Trifasciata dan Polystyrene sebagai Panel Akustik (Halaman 36 s.d. 39). *Jurnal Fisika Indonesia*, *17*(50), 36–39. https://doi.org/10.22146/jfi.24422

Yuliantika, S., & Elvaswer. (2018). Impedansi Akustik dari Limbah Serat Kayu Meranti Merah (Shorea pinanga) dengan Menggunakan Metode Tabung. *Jurnal Ilmu Fisika*, *10*(1), 28–37.