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The Effect of Sample Density of Mixed Husk and Bran on Reflection and Transmission Coefficient of Acoustic Waves

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Abstract

Noise is a sound that is not desired because it is not in accordance with the context of activity, space, and time so it can cause disturbances to comfort and even human health. Twoof the basic ingredients of a silencer are husk and bran. This research aimed to determine the effect and model of the relationship of the density of the sample mixture of husks and bran on acoustic waves' reflection coefficient and transmission coefficient. The method used in this research is experimental, using a mixture of husk and bran samples whose density consists of 5 variations. The results showed that the husk and bran mixture's sample density strongly affected the reflection coefficient (r = 0.947 to r = 0.966) and the transmission coefficient (r = -0.962 to r = -0.999). These resultsshow that the greater the sample density of the husk and bran mixture, the greater the absorption intensity fraction produced. Statistically, the level of influence is indicated by the correlation coefficient, whose value is around r = 0.95 to r = 0.99. Based on the results, the reflection and transmission coefficients are influenced by the density of the mixture of husk and bran samples.
Keywords: *density; husk; bran; reflection; transmission*

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INTRODUCTION

The development of science and technology today has driven the development of the industry so rapidly. In both the manufacturing and service industries, the use of machines and work tools can help make work easier and faster. However, almost all machines have the potential to make noise [1]. Noise is unwanted sound from activity within a certain time level that can cause disturbances to human health and environmental comfort. Noise can negatively affect workers' communication, productivity, and social behavior who are continuously exposed to noise above the threshold value [2]. Minister of Manpower Regulation Number 13 of 2011 states that the threshold value for noise is 85 dB with an exposure time of 8 hours a day and 40 hours a week [3].

Noise in the workplace can cause emotional disturbances and impaired communication. This phenomenon can lead to misunderstandings in communicating and not hearing the signals given, leading to accidents due to work. Noise can also cause temporary or permanent hearing loss [4], decreased employee performance, cognitive impairment in children, and cardiovascular disease. In addition to affecting hearing (auditory effects), noise can also cause non-auditory effects [5], and air circulation system [6]. The World Health Organization (WHO) report says that Europeans lose at least one million healthy life years each year due to disability or disease caused by traffic noise [7].

Several alternative solutions for environmental problems include treating pollution to reduce negative environmental effects generated by industrial activities, using clean technologies, and developing new products using industrial waste [8]. One of the efforts to reduce noise, especially in the room, is to install noise-absorbing materials [9].

Sound-absorbing materials such as glass wool, mineral fibers, foam, and their composites used for noise control are distinguished due to their high efficiency insound absorption. However, many of these materials cannot be disposed of directly in nature because they have a long or indefinite decomposition time. In addition, if they are used as fuel in industrial furnaces, they can generate toxic gases that are harmful to human health and the environment. Natural fibers can replace these materials applied in acoustic insulation or acoustic treatment of ambient [10].

Some researchers have made breakthroughs in developing natural fibers and wood as new sound absorbers. Bamboo fibers are developed as a sound absorbent whose quality is as good as glasswool. Natural fibers such as coconut fibers, banana stalk fiber, bagasse, okra, tempeh pulp, tofu, and pineapple fiber are also used as a base for absorbing noise [11].

Indonesia is an agricultural country, where during the rice milling process, the husks will separate from the rice grains and become waste. The rice mill will produce about 65% rice, 25% husks, and 10% bran. Twenty totwenty-five percent of the husk's total weight is recovered as ash afterburning [12]. If rice husk is burned, it will produce rice husk charcoal which can be used as raw material for the chemical industry, building materials, and also as an adsorbent for heavy metals such as Pb, Cd, and Cr in water [13]. However, many husks and bran accumulate in rice mill locations without being used optimally, so they only become unused agricultural waste. The process of natural waste destruction is slow, so accumulated waste can indirectly endanger the health and the environment [14]. The husk is very light and has a bulk density of 90–50 kg m^{-3} [15].

The use of agricultural residues for particleboard production offers a sustainable solution to disposal challenges posed by the ever-increasing volume of agricultural residues in the environment. Key agricultural residues include bagasse, rice straw, rice husks, maize cobs, oil palm, and almond shells. Out of these, rice husk is one of the most promising and suitable raw materials for producing particleboards. Besides being readily available, tough, abrasive, and resistant to weathering, rice husk has basic components similar to wood, though in different proportions, as reported elsewhere. Consequently, it would be expected that rice husk behaves similarly to wood in particleboard production. However, because of its typically porous structure and low bonding strength, rice husk-based particleboards exhibit lower physical and mechanical properties than wood-based particleboards. More specifically, the strength of rice husk particleboards has been reported to be only 1/3 that of wood-based particleboards [16].

The absorption coefficient for rice husk bricks has the highest value of 0.42, so it can be said that these rice husk bricks meet ISO 11654 acoustic damping material standards [17]. Rice straw fiber can also be used as a sound absorber [18]. Rice husk hasa sound absorption capacity of 0.034 dB, and straw has a sound absorption capacity of 0.030 dB [19]. Data obtained from acoustic studies showed that the highest value of sound absorption coefficient of 6400 Hz was noticed for composite specimens developed using rice husk and saw dust reinforced with hybridized polymer composites [20].

Rice husks are not easily composted or useful as animal feed. However, when combusted at high temperatures, ricehusks will give a 20% yield of rice husk ash (RHA). RHA has a highamorphous silica content, making it an ideal pozzolan or cementreplacement [21]. Building materials like cement, husks, and bran can be used as sound absorbers. Rice husk has a reasonably good damping value, namely at a frequency of 1000 Hz, with the impedance tube method. The absorption coefficient value reaches 0.9, where the value is close to perfect [22]. Sound absorption coefficientlevels increase for compounds with more rice husk NPs [23]. A concrete block having 5%of rice husk ash with 0.05% aluminum powder contributes more strength than other concrete blocks [24].

Because the noise caused by sound can be overcome with a material that can absorb relatively high sound, and the density of a medium influences the speed of sound propagation, there is still no research that reveals the value of the reflection and transmission coefficient of husks and bran as sound absorbers, then a study was conducted on "The Effect of Mixed Husk and Bran Sample Density on the Reflection and Transmission Coefficient of Acoustic Waves".

METHOD

There search uses experimental methods using tools such as Pasco Scientific WA-9303 (8 Ohm), Oscilloscope, Function Generator, Microphone, husk, and bran mixture material samples. There are five variations in the density of samples of mixed husk and bran material, namely sample A with a density of 0.31 gr/cm^3, sample B with a density of 0.35 gr/cm^3, sample C with a density of 0.42 gr/cm^3, sample D with a density of 0.45 gr/cm^3 and sample E with a density of 0.50 gr/cm^3. At the same time, the data collection technique was done through each sample marked with a marker into 25 equal parts with 16 dots. The division can be seen in Figure 1.

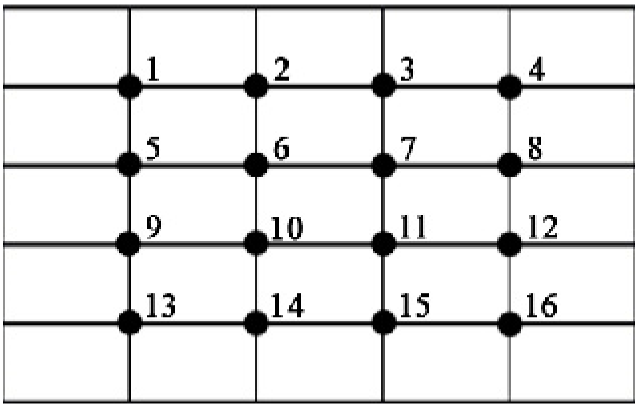

Figure 1. Distribution of 16 Observation Points.

The reflection coefficient value on the sample density of the husk and bran mixture uses the Equation 1

$$R = \frac{I_r}{I_0} \tag{1}$$

Information:

R = Reflection Coefficient

I_r = Intensity of Reflected Wave

I_0 = Intensity of Incoming Wave

The value of the transmission coefficient on the sample density of the husk and bran mixture uses the following Equation:

$$T = \frac{I_t}{I_0} \tag{2}$$

Information:

T = Transmission Coefficient

I_t = Intensity of Waves Leaving Sample

I_0 = Intensity of Incoming Wave

RESULTS AND DISCUSSION

By using Equations (1) and (2), the reflection coefficient and transmission coefficient are obtained as shown in Table 1.

Table 1. Average Value of Reflection and Transmission Coefficient

No.	Frequency (Hz)	Density (gr/cm^3)									
		0.31		0.35		0.42		0.45		0.50	
		R (10^{-1})	T (10^{-1})	R (10^{-1})	T (10^{-1})	R (10^{-1})	T (10^{-1})	R (10^{-1})	T (10^{-1})	R (10^{-1})	T (10^{-1})
1	200	7.06	2.60	7.10	2.14	7.25	1.72	7.30	1.20	7.40	1.00
2	250	6.35	3.13	6.57	2.64	6.76	2.26	6.92	1.84	7.04	1.04
3	300	3.60	3.05	6.80	2.61	6.90	2.03	7.03	1.70	7.20	1.21
4	350	7.66	2.03	7.76	1.77	7.83	1.47	7.90	1.25	8.00	1.02
5	400	5.81	3.49	5.97	3.23	6.01	2.92	6.32	2.14	6.45	1.77

Information:

R = Reflection Coefficient

T = Transmission Coefficient

The relationship between the density of the husk and bran mixture sample with the reflection coefficient is shown in Figure 2. In contrast, the relationship between the sample density of the husk and bran mixture and the transmission coefficient is shown in Figure 3.

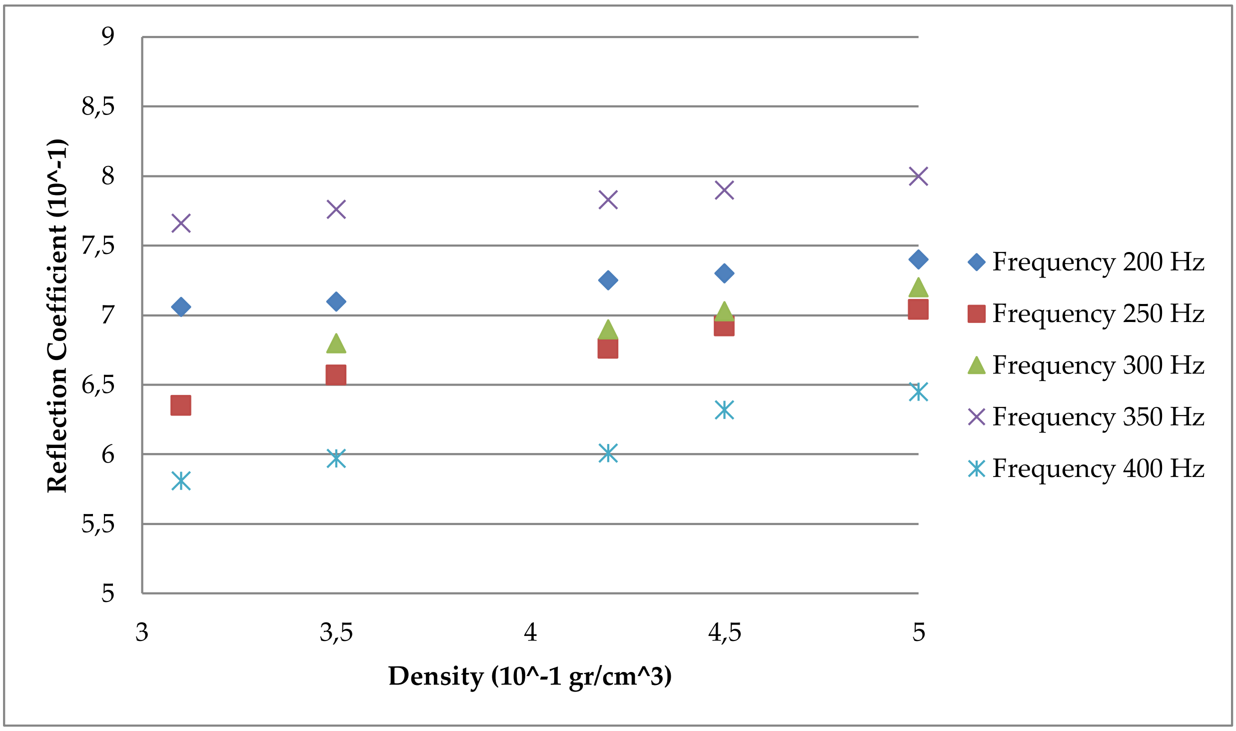

Figure 2. The Relationship between the Density of the Mixed Husk and Bran Samples with the Reflection Coefficient.

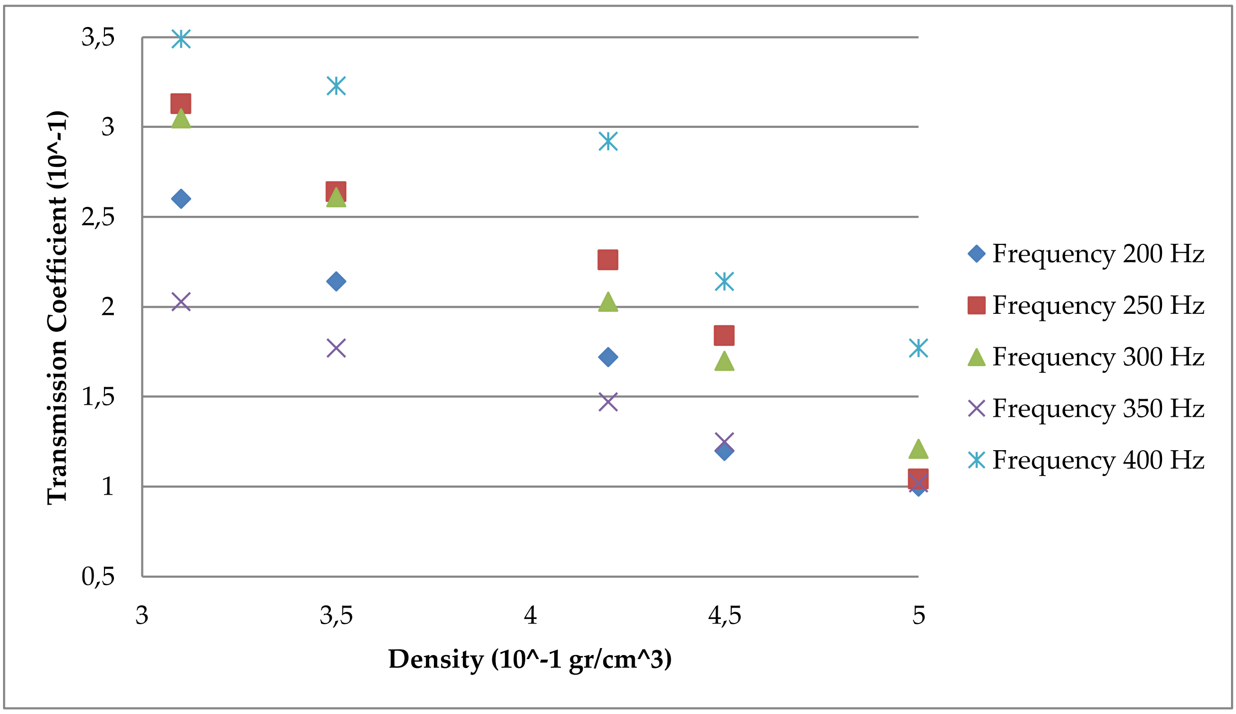

Figure 3. The Relationship between the Density of the Mixed Husk and Bran Samples with the Transmission Coefficient.

Figures 2 and 3 show a simple regression curve with two parameters for the frequencies of 200 Hz, 250 Hz, 300 Hz, 350 Hz, and 400 Hz. The regression equation obtained mathematically is written as follows:

$$Y = a + bx \tag{3}$$

Where a and b are the regression parameters. This regression equation is taken based on the data obtained, then the regression model with the most significant correlation coefficient is seen. The values of the regression parameters and the correlation coefficients are listed in Table 2 and Table 3.

Table 2. Parameter Value of Reflection Coefficient of Regression on Sample Density of Mixed Husk and Bran and its Correlation Coefficient

Frequency (Hz)	Parameter		Correlation Coefficient
	A	B	
200	0.474	0.184	0.996
250	5.277	0.358	0.992
300	5.717	0.293	0.984
350	7.146	0.169	0.989
400	4.781	0.328	0.947

Table 3. Parameter Value of Transmission Coefficient of Regression on Sample Density of Mixed Husk and Bran and its Correlation Coefficient

Frequency (Hz)	Parameter		Correlation Coefficient
	A	B	
200	5.189	-0.852	-0.966
250	6.345	-0.102	-0.979
300	5.989	-0.952	-0.999
350	3.641	-0.526	-0.997
400	6.444	-0.919	-0.962

Table 4. Parameter Value for Linear Regression Fraction of Absorption Intensity on the Density of Mixed Husk and Bran Samples

Frequency (Hz)	Parameter		Correlation Coefficient
	A	B	
200	-0.166	0.067	0.975
250	-0.148	0.063	0.957
300	-0.170	0.066	0.999
350	-0.074	0.035	0.995
400	-0.123	0.059	0.966

Values and parameters for each sample with different densities can be seen in Table 5.

Table 5. Parameter Value of Absorption Intensity Fraction Regression over Frequency for Various Densities.

No.	Density (gr/cm^3)	Parameter					Determination Coefficient
		a	b	c	d	e	
1	0.31	-0.250	-0.013	0.237	-0.107	0.013	1.000
2	0.35	-0.720	0.920	-0.340	0.040	-0.014	1.000
3	0.42	8.050	-11.67	6.288	-1.470	0.127	1.000
4	0.45	10.87	-15.40	8.140	-1.880	0.160	1.000
5	0.50	5.980	-9.170	5.290	-1.320	0.120	1.000

Regression-Correlation Analysis of Reflection Coefficient on the Density of Mixed Husk and Bran Samples

In Figure 2, it can be seen that the larger the density of the sample mixture of husk and bran, the larger the reflection coefficient. Numerically, for example, at a frequency of 200 Hz, the reflection coefficient increases by 0.184 units for each increase of one gr/cm^3 in the sample density of the husk and bran mixture.

The density of the sample mixture of husk and bran has a strong effect on the reflection coefficient, and this level is indicated by the correlation coefficient whose value is around r = 0.947 to r = 0.966 (Table 2), so the coefficient of determination is between 89% to 99%. In contrast, others are determined by variables of thickness, pore properties, and so on. These results show that the greater the density of the sample mixture of husk and bran, the greater the reflection coefficient produced.

The results of this research are in accordance with the theory that the size of the reflection coefficient depends on the density of the medium through which it passes. The greater the density of a medium, the greater the resulting reflection coefficient [25].

Regression Analysis-Correlation of Transmission Coefficient on the Density of Mixed Husk and Bran Samples

Figure 3 shows that the larger the density of a sample of a mixture of husk and bran, the smaller the transmission coefficient. Numerically, for example, at a frequency of 200 Hz, the transmission coefficient of the husk and bran mixture decreases by 0.852 units for each increase of one gr/cm^3 in the sample density of the husk and bran mixture.

The density of the sample mixture of husk and bran strongly affects the transmission coefficient. Statistically, this level is indicated by the correlation coefficient, whose value is around r = -0.962 to r = -0.999 (Table 3), so the coefficient of determination ranges from 92% to 99%. This result indicates that the greater the sample density of the husk and bran mixture, the smaller the resulting transmission coefficient.

The results of this research are in accordance with the theory that the greater the density of a medium, the smaller the resulting transmission coefficient [25].

Regression-Correlation Analysis of Absorption Intensity and Frequency Fractions on the Density of Mixed Husk and Bran Samples

The density of the sample mixture of husk and bran strongly affects the absorption intensity fraction. Statistically, the level of influence is indicated by the correlation coefficient, whose value is around r = 0.95 to r = 0.99 (Table 4), so the coefficient of determination ranges from 91% to 99%. This data shows that the greater the density of the sample mixture of husk and bran, the greater the absorption intensity fraction produced. Table 5 shows the pattern of the relationship between the absorption intensity fraction and frequency, with the strength of the relationship indicated by the coefficient of determination, which is around 1.000.

The results of this research are in accordance with the theory that the absorption coefficient depends on the chemical properties, density, thickness, temperature, and frequency. In addition, the figures obtained in this research are close to the absorption rate for stone wall materials of 0.03 and rugs of 0.30 [26].

The highest reflection coefficient value for all sample density values is at a frequency of 350

Hz. This fact shows that the mixture of husk and bran effectively reduces sound at a frequency of 350 Hz. The highest transmission coefficient value for all sample density values is at a frequency of 400 Hz. This data shows that the mixture of husks and bran effectively dampens sound at a frequency of 400 Hz. The use of rice husk and artificial waste can represent gains in the efficiency of impact noise acoustic insulation for subfloors when used in larger proportions [27].

Based on the above, it can be said that rice husk and bran as agricultural waste have added value for human life by using them optimally as one of the needs, namely making agricultural waste as a building material that can absorb sound. This phenomenon is because the husks and bran can absorb some of the transmitted wave energy. Rice husk ash can be used as a material replacement in concrete and reduces pollution that originates from cement production and the open burning of rice husk [28]. It was found that those that contain rice husk are suitable for coating acoustic barriers since it offers good mechanical, durability, and acoustic performance. It was also found that rice husk cement-based composites can be used as a thermal insulation layer.

The LCA further demonstrated the excellent performance of the rice husk composites compared with those containing treated wood and rubber granules [29]. Rice husk is one of the abandoned agriculture waste materials that can be obtained in large quantities which has the potential to applya sound absorber [30]. The limitation of this study is the lack of literature that discusses the relationship between the frequency and density of a mixture of husk and bran on the reflection coefficient and transmission of acoustic waves.

CONCLUSION

The reflection and transmission coefficients are affected by the density of the sample mixture of husk and bran. The larger the sample density of the husk and bran mixture, the larger the reflection coefficient and the smaller the resulting transmission coefficient. The density of the sample mixture of husk and bran influenced the absorption intensity fraction. The larger the density of the sample mixture of husk and bran, then linearly, the larger fraction of the resulting absorption intensity. The level of influence is indicated by the correlation coefficient, whose values range from $r = 0.975$ to $r = 0.999$.

AUTHOR CONTRIBUTIONS

Tirtawaty Abdjul: Conceptualization, Methodology, and Validation; Septiana Kurniasari: Writing - Original Draft, Article Template, Project Administration; Nancy Katili: Methodology, Formal Analysis, Resources; Citron Supu Payu: Data Curation, Resources.

DECLARATION OF COMPETING INTEREST

The authors declare that we have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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