

## EXPERIMENTAL STUDY OF THE SOUND ABSORPTION COEFFICIENT OF SAWDUST AND INSULFLEX USING KUNDT'S TUBE

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**Abstract.** Noise generated by machine vibrations during production processes is a significant issue in industry, as it can reduce workplace comfort and potentially accelerate structural damage to machinery. Therefore, vibration damping materials are required, either installed directly on machines or within the rooms where the machines operate. This study aims to analyze the performance of damping materials, namely sawdust and insulflex, as acoustic absorbers using the Kundt's Tube method within frequency ranges of 100–200 Hz and 500–5000 Hz. Sound absorption effectiveness was measured using the Noise Absorption Coefficient (NAC), where a material is considered highly absorptive when the NAC value equals or approaches 1, and non-absorptive when the NAC value is 0. The test results indicate that at low frequencies (100–200 Hz), sawdust exhibited an NAC range of 0.34–0.37, while insulflex showed an NAC range of 0.145–0.201. At medium to high frequencies (500–5000 Hz), sawdust achieved an NAC range of 0.68–0.99, whereas insulflex ranged from 0.84–0.99. These findings suggest that both materials have strong potential as sound-absorbing materials, with insulflex demonstrating greater effectiveness at higher frequencies, while sawdust provides stable performance across a broader frequency range.

**Keywords** Wave, Sound, Sound Intensity Level, Sound Intensity, Wave Propagation Speed, Noise Absorption Coefficient.

### INTRODUCTION

Industrial machinery and production equipment generally generate vibrations that have the potential to cause serious problems, both for machine performance and worker health. Excessive vibration can lead to material fatigue that accelerates component failure, while noise can reduce comfort and productivity and even cause permanent hearing loss ([Mohammadi et al., 2024](#)). Therefore, workplace noise has become a critical risk factor that must be controlled within the framework of occupational health and safety (OHS).

The Indonesian government has established permissible noise exposure limits through the Decree of the Minister of Manpower and Transmigration No. KEP-51/MEN/1999, setting the threshold at 85 dB(A) for an 8-hour workday. Meanwhile, the acceptable vibration limit for the human body is 4 m/s<sup>2</sup>. These regulations emphasize the importance of noise control in industrial environments to prevent health impacts as well as economic losses resulting from reduced machine service life ([Rusjadi, 2015](#)).

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One widely used method for reducing noise is the application of sound-absorbing materials. Porous materials have been proven effective in absorbing acoustic energy by converting sound wave energy into heat ([Tudor et al., 2021](#)). However, the effectiveness of such materials is strongly influenced by their physical characteristics, including density, porosity, and thickness ([Tiuc et al., 2019](#)).

Previous studies have demonstrated that wood-based materials exhibit promising sound absorption performance due to their natural porosity and structural characteristics ([Guiman et al., 2023](#)). Furthermore, sawdust, a byproduct of the wood processing industry, has attracted attention as an environmentally friendly and cost-effective acoustic material ([Yuliita & Nurbaiti, 2022](#)). In contrast, synthetic elastomeric foam insulation materials are widely utilized in noise control applications due to their strong sound-damping performance, particularly at medium to high frequencies ([Tiuc et al., 2022](#)).

Nevertheless, further investigation is still required to compare the sound absorption capabilities of these two materials across different frequency ranges. Therefore, this study focuses on analyzing the ability of sawdust and insulflex to attenuate sound using the Kundt's Tube method. Experiments were conducted at low frequencies (100–200 Hz) and high frequencies (500–5000 Hz). The objective of this research is to obtain empirical data on sound intensity, sound propagation speed, and the Noise Absorption Coefficient of both materials. The findings are expected to contribute to the development of cost-effective, environmentally friendly sound-absorbing materials that are relevant to industrial needs in Indonesia.

## **LITERATURE REVIEW**

### **Sound Waves**

Sound is a longitudinal mechanical wave that propagates through solid, liquid, and gaseous media ([Sarojo, 2011](#)). The characteristics of sound are determined by frequency, amplitude, wavelength, intensity, and propagation speed. Humans typically perceive sounds within the frequency range of 20–20,000 Hz ([Rusjadi, 2015](#)), while frequencies below 20 Hz are classified as infrasonic and those above 20 kHz as ultrasonic ([Guiman et al., 2023](#)). The speed of sound depends on the medium; in air at temperatures between 20–30 °C, it ranges from approximately 340–345 m/s, whereas it is higher in solid and liquid media ([Nyumutsu et al., 2023](#)).

## **Reflection, Refraction, and Sound Absorption**

When a sound wave encounters the boundary between two different media, part of the energy is reflected, part is transmitted, and the remainder is absorbed. Hard surfaces tend to reflect sound, whereas porous materials are capable of absorbing energy significantly ([Tudor et al., 2021](#)). The effectiveness of sound absorption is influenced by material density, thickness, and porosity ([Tiuc et al., 2019](#)).

### **Sound Absorption Coefficient**

A material's ability to absorb sound is expressed by the Noise Absorption Coefficient ( $\alpha$ ), which ranges from 0 (total reflection) to 1 (perfect absorption) ([Rusjadi, 2015](#)). Measurement methods include the impedance tube, also known as Kundt's Tube, where standing wave patterns are utilized to calculate absorption values ([Nyumutsu et al., 2023](#)).

### **Kundt's Tube**

Kundt's Tube is an experimental acoustic instrument used to determine wavelength, sound propagation speed, and the absorption coefficient of a material. Its working principle involves generating standing waves inside a tube so that nodes and antinodes can be analyzed ([Trisnobudi, 2000](#)). This method remains relevant today due to its simplicity and accuracy and is widely applied in modern acoustic studies ([Mohammadi et al., 2024](#)).

### **Sound-Absorbing Materials**

Sound-absorbing materials function by reducing the energy of propagating sound waves. Sawdust, a byproduct of the wood processing industry, possesses porous properties that make it effective for attenuating sound waves ([Wibowo et al., 2013](#); [Tiuc et al., 2019](#); [Guiman et al., 2023](#)). Recent research has also demonstrated the potential of teak sawdust as a natural composite with relatively high absorption performance within the mid-frequency range ([Yuliita & Nurbaiti, 2022](#)). Additionally, other local studies report that the density of waste-based materials, including sawdust, significantly influences their acoustic performance ([Wicaksono, Djafar, & Kusno, 2025](#)). The utilization of sawdust is not only cost-effective but also environmentally friendly ([Zou et al., 2021](#); [Theodorou et al., 2024](#); [Priya et al., 2025](#)).

On the other hand, insulflex, a synthetic material, is widely used in acoustic insulation systems. Its closed-cell structure enables noise reduction across various frequencies, particularly at higher frequencies ([Insulflex, 2022](#)). Research findings also indicate that polyurethane foam-based synthetic materials combined with sawdust can be developed into new composites with competitive acoustic performance ([Tiuc et al., 2022](#)).

### **Noise Control**

Noise control in industrial contexts can be implemented through three approaches: (1) control at the source, such as designing quieter machinery; (2) control along the transmission path, such as installing noise barriers; and (3) control at the receiver, such as using personal protective equipment ([Rusjadi, 2015](#)). Recent studies emphasize the importance of developing sound-absorbing materials based on sustainable natural fibers that are environmentally friendly while maintaining strong acoustic performance ([Mohammadi et al., 2024](#); [Kassim et al., 2023](#)).

## **METHODS**

### **Research Design**

This study employed an experimental method using a Kundt's Tube as the primary testing apparatus. The acoustic tube was utilized to observe standing waves and measure the ability of damping materials to absorb sound within specific frequency ranges. Two types of materials were tested: sawdust (bio-composite) and insulflex (reference material).

### **Instruments and Materials**

The instruments used in this study included an acrylic Kundt's Tube, a tone generator (100–200 Hz and 500–5000 Hz), an amplifier, a loudspeaker, two microphones, visual analyzer software, and a sound level meter. The materials used were:

1. Camphor sawdust was mixed with epoxy resin and hardener at a composition of 30% sawdust and 70% resin (total volume of 200 ml). The mixture was molded in a 4-inch diameter PVC pipe, cured for three days, and then machined to obtain a final diameter of 70 mm with a thickness of 10 mm.
2. **Insulflex** was used as the reference material for comparison..



**Figure 1.** Mixture of Sawdust and Resin



**(a)**

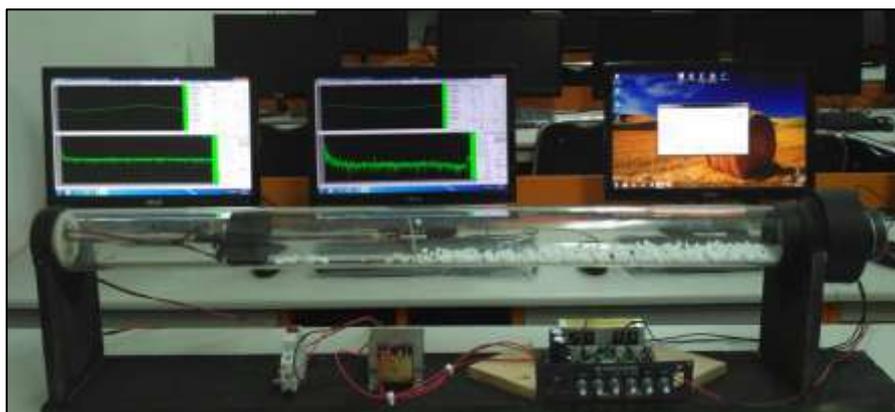


**(b)**

**Figure 2.** Sound-Absorbing Specimens: (a) Sawdust and (b) Insulflex

### Research Procedure

1. **Field Observation:** Noise measurements were conducted on five chiller units with a capacity of 400 TR using a sound level meter to obtain actual operating condition data as a reference.
2. **Laboratory Testing Using Kundt's Tube:**
  - a. The equipment was assembled with the following configuration: *tone generator* → *amplifier* → *speaker* → *Kundt's Tube* → *microphone 1 & 2* → *visual analyzer*.
  - b. The test material (sawdust or insulflex) was placed at the end of the tube.
  - c. Input frequencies were applied within the ranges of 100–200 Hz (10 Hz increments) and 500–5000 Hz (500 Hz increments).
  - d. Microphone 1 recorded the signal before passing through the material, while Microphone 2 recorded the signal after transmission through the material.
  - e. The output data were displayed via the visual analyzer.



**Figure 3.** Kundt's Tube Configuration

### **Data Processing Techniques**

The recorded signal data were used to calculate::

- a. Sound intensity,
- b. Speed of sound propagation,
- c. Noise Absorption Coefficient (NAC).

The calculation of the Noise Absorption Coefficient was performed using acoustic formulas based on the ratio between transmitted sound energy and incident sound energy.

## **RESULTS**

### **Field Measurement Results**

Noise level measurements were conducted in the chiller room housing five chiller units with a capacity of 400 TR. Based on measurements obtained using a sound level meter, the average recorded noise level exceeded 85 dB(A). This value surpasses the permissible noise threshold established in KEP-51/MEN/1999, indicating that the chiller room poses a potential noise hazard to workers.

### **Sawdust Test Results**

Testing of the sawdust material using the Kundt's Tube demonstrated an increase in the Noise Absorption Coefficient at low frequencies (100–200 Hz):

- At 100 Hz, sound absorption was relatively low.
- As the frequency increased to 200 Hz, the absorption value rose significantly.
- At higher frequencies (500–5000 Hz), the absorption value of sawdust declined, although it still exhibited measurable sound absorption.

Graphical data from the visual analyzer revealed a clear difference in amplitude between the signals before and after passing through the sawdust material, particularly at low frequencies.

### Insulflex Test Results

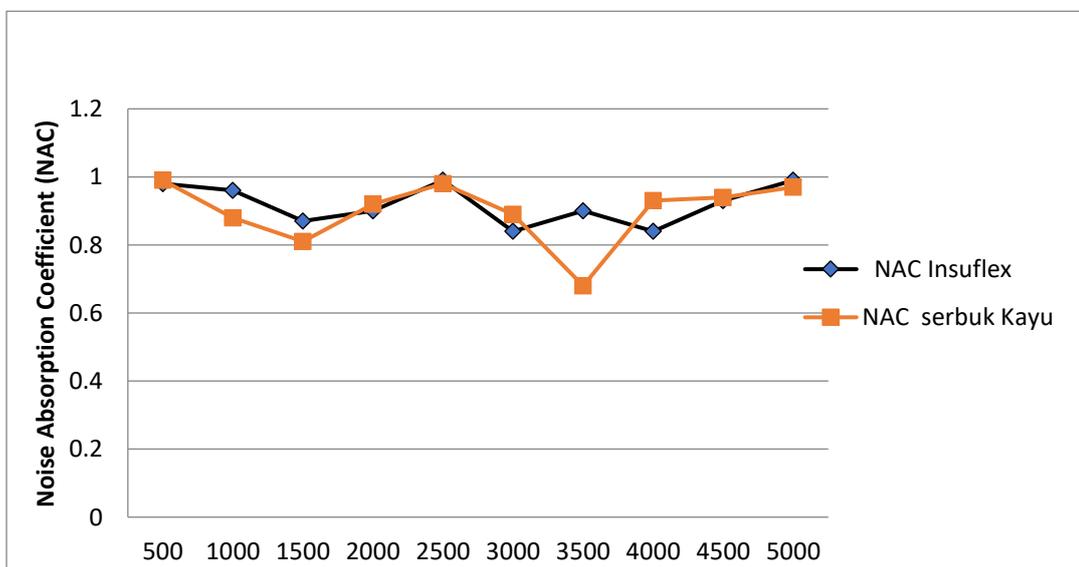
The test results for insulflex indicated that:

- At low frequencies (100–200 Hz), insulflex absorbed sound but with a lower absorption coefficient compared to sawdust.
- At higher frequencies (500–5000 Hz), insulflex exhibited a higher Noise Absorption Coefficient than sawdust, achieving optimal performance in the mid-to-high frequency range.

### Comparison Between Sawdust and Insulflex

Based on the test results:

- Low frequencies (100–200 Hz): sawdust outperformed insulflex.
- High frequencies (500–5000 Hz): insulflex was more dominant than sawdust.
- Both materials demonstrated distinct absorption capabilities depending on their frequency characteristics.



**Figure 4.** Comparison of NAC Between Sawdust and Insulflex

## **DISCUSSION**

Laboratory test results indicate that sawdust is more effective as a sound-absorbing material at low frequencies (100–200 Hz). This effectiveness is influenced by the porous nature of sawdust, which enables the conversion of long-wavelength sound energy into heat. These findings are consistent with fundamental acoustic theory, which states that porous materials are more effective in absorbing low-frequency sound waves ([Rusjadi, 2015](#); [Tiuc et al., 2019](#)).

In contrast, insulflex demonstrated superior performance at higher frequencies (500–5000 Hz). Its denser and more insulating physical structure makes this material more effective in reducing short-wavelength sound waves. This result aligns with the study by Tiuc et al. (2022), which reported that polyurethane foam-based synthetic materials combined with sawdust exhibit strong acoustic performance at medium to high frequencies.

The findings of this study are also consistent with local research by Yuliita and Nurbaiti (2022), which reported that teak sawdust composites possess significant absorption capabilities at medium frequencies. Similarly, the study by Wicaksono, Djafar, and Kusno (2025) emphasized that the density of waste-based materials influences the Noise Absorption Coefficient, highlighting the importance of considering material density variations in practical applications.

Recent studies further emphasize that the orientation of wood particles and the internal structure of materials significantly affect acoustic performance ([Guiman et al., 2023](#)). This supports earlier findings by Wibowo et al. (2013), which identified sawdust as a cost-effective and environmentally friendly alternative acoustic material.

From a practical perspective, these results underscore the importance of selecting sound-absorbing materials according to the frequency spectrum of the noise source. For industrial machines such as chillers and generators, which predominantly produce low-frequency noise, sawdust can serve as an environmentally friendly, inexpensive, and readily available damping material. Meanwhile, insulflex is more suitable for reducing noise at medium to high frequencies. A combination of both materials also has the potential to produce a composite with balanced absorption across a wide frequency range, as recommended by Mohammadi et al. (2024) in their study on natural fiber-based acoustic materials.

## CONCLUSION

This study demonstrates that sawdust and insulflex exhibit different sound absorption characteristics depending on the frequency range. At low frequencies (100–200 Hz), sawdust proved to be more effective, with a Noise Absorption Coefficient ranging from 0.34 to 0.37, whereas insulflex ranged only from 0.145 to 0.201. This finding confirms that the porous structure of sawdust is more capable of attenuating long-wavelength sound waves. Conversely, at higher frequencies (500–5000 Hz), insulflex showed superior performance, with absorption coefficients between 0.84 and 0.99 compared to sawdust, which ranged from 0.68 to 0.99. Therefore, this synthetic material is more effective for reducing high-pitched noise. Each material thus possesses specific advantages within certain frequency ranges, and their combination has the potential to produce a composite material with balanced absorption from low to high frequencies.

Based on these findings, future studies are recommended to incorporate variations in composition or alternative materials that may offer higher sound absorption coefficients, enabling further comparisons of effectiveness. Additionally, the use of more advanced analysis software could improve data visualization quality. During data collection, researchers should wear hearing protection to prevent auditory disturbances caused by noise exposure. This study is expected to serve as a foundation for the development of cost-effective, environmentally friendly sound-absorbing materials that are relevant to industrial needs.

## LIMITATION

This study has several limitations that should be acknowledged to provide a balanced interpretation of the findings. First, the experiment evaluated only two sound-absorbing materials, namely sawdust and insulflex, which limits the extent to which the results can be generalized to other natural or synthetic acoustic materials. Second, the testing was confined to frequency ranges of 100–200 Hz and 500–5000 Hz; therefore, the acoustic performance of the materials at very low, intermediate, or ultra-high frequencies was not examined. Third, the specimens were produced using a single composition and thickness, meaning that the influence of material variations such as density, porosity, particle orientation, and structural configuration was not investigated in depth.

Furthermore, the measurements were conducted under controlled laboratory conditions using a Kundt's Tube. While this method provides reliable acoustic characterization, it may not fully replicate real industrial environments where sound propagation is affected by room geometry, multiple noise sources, temperature, and humidity. Potential measurement uncertainties related to instrument sensitivity, calibration, and experimental setup may also have contributed to variations between input and transmitted signals.

Therefore, future studies are recommended to incorporate a broader range of materials, vary specimen compositions and geometries, and evaluate performance under real-field conditions. The integration of advanced acoustic analysis tools and numerical modeling is also encouraged to improve measurement precision and expand the practical applicability of sound-absorbing materials for industrial noise control..

## REFERENCES

- Guiman, M. V., Stanciu, M. D., Roșca, I. C., Georgescu, S. V., Năstac, S. M., & Câmpean, M. (2023). Influence of the grain orientation of wood upon its sound absorption properties. *Materials*, *16*(17), 5998. <https://doi.org/10.3390/ma16175998>
- Insulflex. (2022). *Insulflex product catalogue* (technical catalogue). Insulflex Corporation.
- Kassim, D. H., Putra, A., & Ramlan, R. (2023). Enhancement of sound absorption of coir fiber using thin layer of kapok fibers. *Journal of Natural Fibers*, *20*(1), Article 2164103. <https://doi.org/10.1080/15440478.2022.2164103>
- Mohammadi, M., Taban, E., Tan, W. H., Din, N. C., Putra, A., & Berardi, U. (2024). Recent progress in natural fiber reinforced composite as sound absorber material. *Journal of Building Engineering*, *84*, Article 108514. <https://doi.org/10.1016/j.job.2024.108514>
- Nyumutsu, J., Oppong Tawiah, P., Andoh, P. Y., & Asaaga, B. A. (2023). The potential of sawdust and coconut fiber as sound reduction materials. *Journal of Applied Engineering and Technological Science*, *4*(2), 73–81. <https://doi.org/10.37385/jaets.v4i2.624>
- Theodorou, V., et al. (2024). Eco-friendly, sound-absorbing materials based on fir sawdust and PU foam. *Macromolecular Materials and Engineering*. <https://doi.org/10.1002/mame.202400863>
- Tiuc, A.-E., Borlea, S. I., Nemeș, O., Vermeșan, H., Vasile, O., Popa, F., & Pîntoi, R. (2022). New composite materials made from rigid/flexible polyurethane foams with fir sawdust: Acoustic and thermal behavior. *Polymers*, *14*(17), 3643. <https://doi.org/10.3390/polym14193643>

- Tiuc, A.-E., Nemeş, O., Vermeşan, H., & Toma, A.-C. (2019). New sound absorbent composite materials based on sawdust and polyurethane foam. *Composites Part B: Engineering*, *165*, 37–48. <https://doi.org/10.1016/j.compositesb.2018.11.103>
- Tudor, E. M., Barbu, M. C., Petutschnigg, A., Réh, R., & Krišťák, L. (2021). Acoustic properties of larch bark panels. *Forests*, *12*(7), 887. <https://doi.org/10.3390/f12070887>
- Trisnobudi, A. (2000). *Teori ultrasonik*. Bandung: Institut Teknologi Bandung.
- Priya, E., Vasanthi, P., et al. (2025). Sawdust as a sustainable additive: Comparative insights into its role in concrete and brick applications. *Cleaner Waste Systems*, *1*, Article 100286. <https://doi.org/10.1016/j.clwas.2025.100286>
- Rusjadi, D. (2015). *Konsep dasar akustik untuk pengendalian kebisingan lingkungan*. Yogyakarta: Graha Ilmu.
- Sarojo, A. G. (2011). *Gelombang dan optika*. Jakarta: Salemba Teknika.
- Wibowo, A. Pradana, Wicaksono Rahmawan, dan Yulianto Agus. 2013. Pembuatan dan Pengujian bahan Peredam Suara dari berbagai serbuk kayu. Semarang: Universitas Negeri Semarang
- Wicaksono, A. B., Djafar, Z., & Kusno, A. (2025). Density influence on acoustic performance of waste composite materials. *PENA TEKNIK Jurnal Ilmiah Ilmu-Ilmu Teknik*, *10*(1), Article 3037. [https://doi.org/10.51557/pt\\_jiit.v10i1.3037](https://doi.org/10.51557/pt_jiit.v10i1.3037)
- Yuliita, N., & Nurbaiti, U. (2022). The natural composite of sawdust teak as a sound absorption material using the resonator space method. *Physics Education Research Journal*, *4*(1), 29–34. <https://journal.walisongo.ac.id/index.php/perj/article/view/8601>
- Zou, S., et al. (2021). Research on improving comprehensive properties of a new eco-friendly sawdust composite insulation material. *Construction and Building Materials*, *287*, 123091. <https://doi.org/10.1016/j.conbuildmat.2021.123091>