# Sound Absorption Capacity of Oil Palm Frond Fiberboard with Different Finishing

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## Abstract

This research studied primarily the sound absorption of oil palm frond fiberboard with different finishing, i.e. rough, screen and perforated surfaces. All boards confirmed that the higher the frequencies, the better the sound absorption coefficients. Although the density of the samples with rough surface was the lowest, their sound absorption capacity was the highest at every measured octave band frequencies. Perforated samples showed the better sound absorption coefficients than the ones with screen surface. When comparing their sound absorption coefficients with those of the sound absorbing materials in commercial use, oil palm frond fiberboards generally showed a better sound absorption capacity.

*Key words:* sound absorption / porous / oil palm / frond

## 1. Introduction

In the past, asbestos was commonly used to produce sound absorbing material because of its good sound absorption and fire retardant properties. Later on, clear evidences indicated that asbestos can cause asbestosis, lung cancer and mesothelioma (Newhouse and Thomson, 1965; Ribak et. al., 1988; Wagner et. al., 1960). Although other materials such as glass wool, slag wool and rock wool have increasingly been used to substitute this material, their health effects are also of concern. (Drent et. al., 2000; Miller et. al., 1999; Roller et. al., 1996; Saracci et. al., 1984). Consequently, other natural fibers have been used and tested as alternative materials such as bamboo (Koizumi et al., 2002), tea leaf (Ersoy and KÜÇÜk, 2008), rice straw (Yang et. al., 2003), wool (Ballagh, 1996), coconut coir (Nor et. al., 2003), oil palm frond (Sihabut, 1999) and so on. Among these, oil palm frond is proving an interesting material because of its huge quantities, basic sound absorptive characteristics and environmentally friendly production and disposal. In 1999, Sihabut produced sound absorbing material from fronds by chemical method. Although the sound absorption capacity was high, low yield and large time consumption were observed. Consequently, another production method was used in this study. Additionally, the effects of decoration to sound absorption coefficients were explored. Moreover, environmental concerns in terms of biological oxygen demand ($BOD_5$) and suspended solid (SS) in released wastewater were recorded.

## 2. Methods

Thermomechanical method was chosen to convert oil palm chips to fibers because it required no chemicals and gave more yields (Sihabut, 2010). To explore the production method, soaking raw materials in water for 3-24 hours and cooking those starting from 150-160 ºC for 3-21 minutes were randomly tried. The best method which gave high quality fibers without any rejects was selected to produce the materials in this experiment. In sum, 350 grams of frond chips (dried weight) were soaked for 24 hours and then steamed at the temperature of 160 ±

3 °C for 21 minutes. At this stage, three fiber and wastewater samples obtained from steaming process were randomly selected to quantify the fiber yield and Biological Oxygen Demand (BOD) loading, respectively. To make the fibers softer and more defibrillate, they were ground by a defibrillator at the disk clearance distance of 0.5 millimeter. Before being poured in a 35x35 square former, the fibers were soaked in the alum solution at the pH 4.5 for 30 minutes to reduce water absorption and mixed with 6 grams of wax for 8 minutes to improve water resistance. At this point, the mats were treated by three different methods. The first one was letting fibers bond themselves without any force input to the surface area. The second one was cold pressed on a screen inserted at the base of a press machine. The last one was the latter dried cold pressed material which was then perforated by a chisel approximately five percents of the mat’s surface area. The density and thickness of the mats were measured after they were dried naturally and set aside at room temperature for a week.

To measure the sound absorption coefficients, each mat with different finishing was randomly cut into four circles (two with diameter of 99 millimeters and another two with diameter 29 millimeters). According to the calculated diameters of impedance tubes, two smaller specimens were used to determine the coefficients at high frequencies (2000 Hz), while the other two were used to determine this parameter at low frequencies (250-1000 Hz). Standing wave apparatus, which mainly assembles of audio generator, microphone, impedance tube, loudspeaker and oscilloscope, was used to measure the sound absorption coefficients as shown in figure 1. To do this, a specimen was inserted in a holder capped at end of an impedance tube. Microphone was moved along the tube to detect the signals released from audio generator at a certain frequency. Maximum and minimum sound pressure then were read by an oscilloscope and used to calculate the sound absorption coefficient. More detail is in ASTM C 384. For a specimen, three replications of sound absorption coefficient measurements at each frequency were conducted. The environmental conditions in a test room were 23±3 °C, 1013.25±.15 hPa and 50± 15 percent of relative humidity. To compare the sound absorption capacity of our material with others, the rockwool samples of two commercialized brands were also tested by the same equipment.

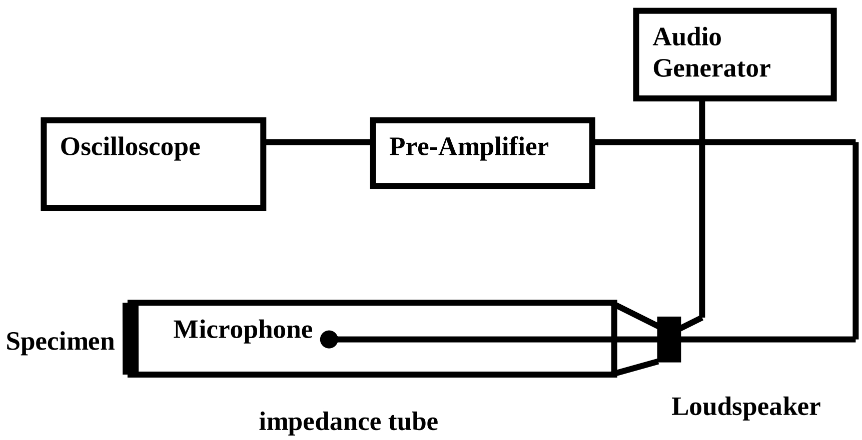


**Figure 1** Simplified diagram of standing wave apparatus

## 3. Results and Discussions

### *3.1 Yield, BOD, SS*

In our previous study, fronds were cooked by chemical process (Sihabut, 1999; 2008). The fiber yield was only 25 percent while the thermomechanical method used in this experiment gave percent yield up to 63±1.18 percent. In addition, the cooking duration by the previous process was consumed approximately 180 minute while this one took only 21 minutes. For forming process, wet forming process without any adhesive was applied in this study because fibers can attach themselves by hydrogen bonding (Suchsland and Woodson, 1986).

Regarding wastewater released from this process, $BOD_5$ and SS were 5150±87 mg/l and 722±26 mg/l, respectively. $BOD_5$ in this study were higher than BOD loading in wastewater from wet-process fiberboard manufacture observed by United States Environmental Protection Agency (USEPA, 1978). In this experiment, measured wastewater samples taken from cooking process was very concentrated because they were not diluted by wastewater from other processes like the one in the manufacturing process, thus resulting in high BOD loading. For suspended solids which were rather high, fine screen was recommended to sort the fine pulp in the wastewater before discharging. This will not only prevent the pulp loss but also reduce the amount of suspended solid in wastewater.

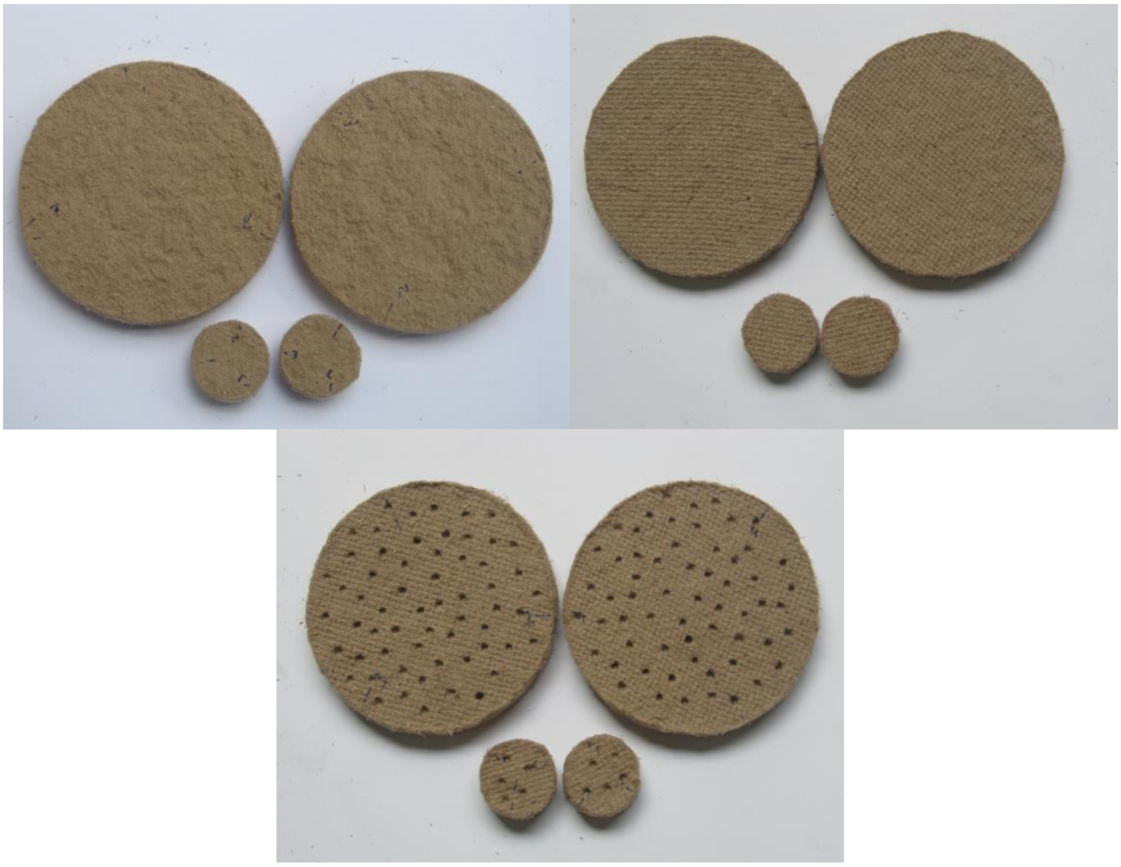

**Figure 2** A set of specimens with various finishing: rough surface (above), screen surface (middle), perforated surface (below)

***3.2 Visual Appearance***

All fiberboards were medium brown with different surfaces as shown in figure 2, depending on treatment input. The fiberboard without any press was the thickest and posed a somewhat rough surface. The mat with cold press was smooth on one side and posed a screen pattern on another side. The last mat was the cold pressed material and it was then perforated at the side with screen pattern surface.

***3.3 Density and Sound Absorption Coefficient***

The density and sound absorption coefficient of the mats is presented in table1. Sound absorption coefficient of fiberboard without pressing ranged from 14.17-84.83 %, while the one with pressing ranged from 11.50-56.83 %. Perforated board posed the sound absorption coefficients ranging from 11.92-70.50%. Overall, all mats showed that the higher the frequencies, the better the sound absorption coefficients. Also, we can notice that the mat without any press showed the lowest density but posed the highest sound absorption coefficients at every measured frequency as shown in table 1 and Figure 3. This might result from the different forming method. As mentioned before, the boards with rough surface were formed without any force input, resulting in the thickest material. In theory, the greater the thickness, the better the sound absorption coefficient at high frequencies. Additionally, pressing after forming the board might also be involved. If the material is too tight, it may not be a good absorber because friction and vicious loss converted from sound energy moving inside the tortuous path of the material is low. Therefore, sound absorption, which results from the conversion of incident sound to other forms of energy, of the materials with cold press is lower than the material without any press.

Comparing the sound absorption coefficients of the mats with cold press only and the mats with cold press and perforation, the results showed that the mats with perforated surfaces posed a significantly higher sound absorption at high frequencies. This could result from the mat finishing. Perforation possibly made the fiber attachment loosen. If the incident sound hit this mat, the sound energy might dissipate to other areas more easily than the mat with cold press only. In addition, movement of small fibers resulting from sound incidence upon the surface might be more flexible than the ones of material with pressing only. Consequently, incident sound converted to heat energy here was more than in the other, resulting in a higher sound absorption efficiency of the perforated materials.

Compared with commercialized materials made from rockwool, frond fiberboards were lighter and generally exhibited the higher sound absorption coefficients as shown in table 1. Fiberboards with rough surface showed the best sound absorption coefficients at most measured frequencies while the sound absorption coefficients of fiberboards with screen and perforated surfaces were generally close to those of compared rockwool fiberbords.

**Table 1** Density, thickness and sound absorption coefficient at various frequencies

| Material Surface | Thickness (mm) | Density (g/cm$^3$) | Sound Absorption Capacity (%) | | | |
|---|---|---|---|---|---|---|
| | | | 250 Hz | 500 Hz | 1000 Hz | 2000 Hz |
| Rough | 13 | 0.132±0.007 | 14.17±0.75 | 28.25±0.69 | 44.83±4.17 | 84.83±0.52 |
| Screen | 12 | 0.164±0.004 | 11.50±0.55 | 24.08±0.80 | 41.42±1.66 | 56.83±1.69 |
| Perforated | 12 | 0.164±0.004 | 11.92±0.74 | 20.42±0.49 | 40.25±0.82 | 70.50±1.05 |
| Compared material no.1 | 12 | 0.385 | 10.50±0.71 | 32.00±2.83 | 41.75±3.89 | 48.50±6.36 |
| Compared material no.2 | 12 | 0.324 | 10.50±0.71 | 24.25±0.35 | 47.75±1.06 | 65.00±4.24 |

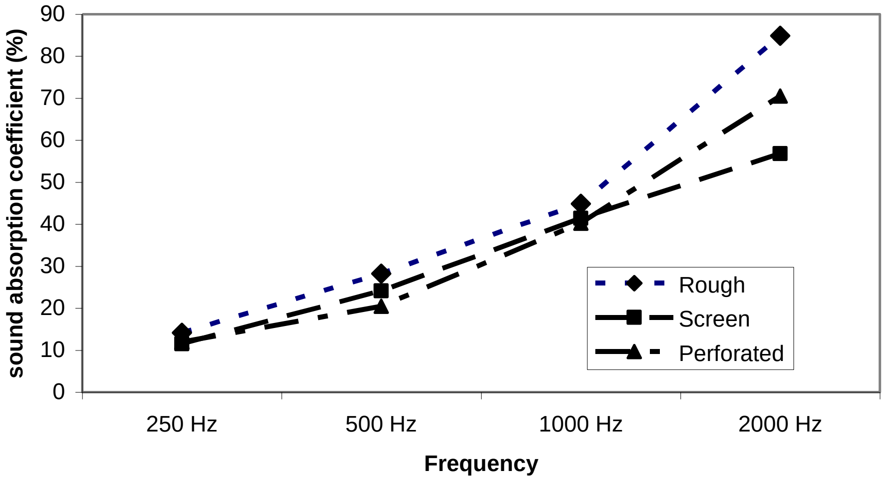


**Figure 3** Percentage of sound absorption of oil palm frond fiberboard with different finishing

## 4. Conclusion

In this study, oil palm frond fibers created from thermomechanical methods were proved to be a better alternative material for producing sound absorber due to its high sound absorption capacity. This process gave more yields and consumed less cooking duration than the chemical one. Considering its sound absorption capacity, the material without cold press showed the highest sound absorption capacity. When pressed, the material showed lower sound absorption capacity. However, sound absorption capacity of the same material improved at high frequency if perforated. These showed that the finishing can affect the sound absorption efficiency. Compared with commercialized rockwool fiberboards in term of sound absorption capacity, our sound absorbing materials was very interesting competitor.

## 5. Acknowledgements

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