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Acoustic Properties of Mixing Empty Fruit Bunch and Oil Palm Frond Natural Fibres

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Abstract: Natural fibre is being studied and used as sound absorber for its promising acoustic properties. For instance, Germany have commercial plants that are producing sound absorbers from natural fibre. Natural fibre is eco-friendly and has no effect on human health. Besides that, the production cost of natural fibre is cheaper than synthetic fibre. This research reported the thickness effects on acoustic properties in different ratios of natural fibres of empty fruit bunch (EFB) and oil palm frond (OPF). Four different thickness of low density fibre board (LDF) have been fabricated (12 mm, 14 mm, 16 mm and 18 mm) in density of 120 kg/m^3. The Sound Absorption Coefficient (SAC) was tested by using the Impedance Tube Method (ITM) according to ASTM E1050-98 standards at frequency from 0 Hz to 6400 Hz. The results show the values of SAC for all samples increase with increasing in thickness from frequency range of 0 Hz – 4500 Hz. It is noteworthy that the LDF with thickness of 16 mm and 18 mm can be classified as Class A sound absorbing material according to sound absorption classes and possess the SAC values of 0.8 and above at a wider frequency range, which is 2500 Hz to 6400 Hz. The combination of EFP and OPF natural fibres has a very promising and excellent performance in acoustic properties.

Keywords: Empty fruit bunch, Impedance tube method, natural fibre, oil palm frond

I. INTRODUCTION

Ignorance towards noise pollution has worsened. As days go by the noise pollution is increasing. Noise or unwanted sound disturbs people's daily routine and human health unknowingly. A limit of 85 dB for eight hour per day is the limit set by National Institute of Occupational Safety and Health (NIOSH) after doing their research and survey [1]. A person is exposed to ear pain and other health problems if subject to noise or unwanted sound more than 8 hour.

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Nowadays, Malaysia noise level has already exceeded the limit set by the Department of Environmental of Malaysia [2]. Few ways can be used to overcome this impending issue and one of the most prominent way is using sound absorbing material. Sound absorber is increasing in popularity due to the increase of noise pollution. Sound absorber is the material that can absorb the unwanted sounds. A research on fiberglass, which was conducted by the US government, proven that the shedding of fiberglass can cause lung infection and irritation to the skin [1] [2]. However, researchers are looking towards a more green and sustainable material that can replace the synthetic fibre. Many researches towards natural fibres have been done and explored on its acoustic properties in recent years [3 – 12]. Oil Palm Trunk (OPT) [3], Oil Palm Empty Fruit Bunch (EFB) [4], Arenga Pinnata [5], Coconut coir [6], Kapok [7], Paddy straw [8], Kenaf [9], Bamboo fibre [10], Mesocarp [11] and etc. These studies showed that the acoustic properties of natural fibre are good enough to replace the synthetic fibre. It is not only good in acoustic properties but also renewable, biodegradable and ecological. These are the main reason of why natural fibres are being chosen as they have such beneficial properties to the environment and can be exploited [3] [12].

A research was conducted on date palm fibre and the findings show a promising result of acoustic absorption coefficient (AAC). The acoustic absorption coefficient (AAC) was able to reach 0.90 at frequency of 1365 Hz for sample with thickness of 50 mm. But the highest AAC achieved by sample 50 mm was 0.99 at frequency range of 4200 Hz to 4353 Hz [13]. Other than these, oil palm trunk (OPT) also has a very promising future as sound absorber. According to R. Kalaivani et. al. OPT natural fibre almost reached unity (1.0) at frequencies of 3000 Hz, 6000 Hz and 6400 Hz with sample thickness of 12 mm and density of 100 kg/m^3 [14]. OPT has been conducted and showed a promising result when tested the low density fibreboards (LDF) with thickness of 10 mm, 12 mm, 14 mm and 16 mm at density of 170 kg/m^3. The highest SAC values (~0.99) obtained for thickness of 10 mm, 12 mm and 14 mm at frequency range of 3500 Hz to 6000 Hz. Whereas for LDF with thickness of 16 mm, the SAC value of 0.97 has been obtained at frequency range of 3500 Hz to 6000 Hz [15].

EFB and OPF are good sound absorbing material from previous research. The findings on acoustic properties of EFB show very promising results where the SAC values are able to achieve 0.9 at frequency of 1000 Hz [4] [16]. As for the acoustic performance of OPF.

The OPF has good SAC values of (> 0.80) at frequency range of 500 Hz to 1000 Hz [17]. In addition, both EFB and OPF have similar chemical compositions since they are from the same source. The chemical compositions including Lignin, Holocellulose, Alpha cellulose, Pentosans, water, ash and etc [18]. Based on the studied, it stated that the content of Lignin can enhance the acoustic performance of the material [19]. The mixing of natural fibres from different part of Oil Palm Tree
has not evaluated by previous research.
Thus, it is interesting to study the effects of different thickness on acoustic properties of different mixing ratio of EFB and OPF natural fibres.

II. EXPERIMENTAL DETAILS

In this research, natural fibres of Oil Palm Empty Fruit Bunch (EFB) (50%) and Oil Palm Frond (OPF) (50%) were used to fabricate low density fibreboard (LDF) in thickness of 12 mm, 14 mm, 16 mm and 18 mm with density of 120 kg/m^3. There are seven steps in fabricating the low density fibreboard and all boards were fabricated at Malaysian Oil Palm Board (MPOB) [20].

i. **Chipping:** The empty fruit bunch and frond were chipped to smaller size using the Maier Chipper in MPOB. To achieve moisture content of 10 %., the EFB and OPF were subjected to oven dry at temp of 100 °C.

ii. **Refining:** It's known as cottonizing processing, this process was done to enhance the property of the fibres. A cotton like fibre is produced by using the Sprout-Baur (ANDRITZ) from EFB and OPF.

iii. **Gluing:** This is where the refine fibre of EFB and OPF is blended according to their desired ratio in a Mechanical blender. Urea Formaldehyde (UF) glue was added on regular basis. To obtain the desired thickness and density, the mass of the fibre and glue were measured perfectly beforehand.

iv. **Mat Forming:** A square box of 30 cm x 30 cm acted mold to shape to fibre. The fibre was put into that wooden box.

v. **Pre-Press:** Since it's a Low Density Fibreboard (LDF), the pre-press process was done manually using a metal plate flattener.

vi. **Hot Press:** After the pre-press, the fibre was sent for solidification.

vii. **Cool down:** After the fibre was heated up in the hot press machine for 300 s, the fibreboard was taken out and cooled down to room temperature.

III. RESULTS AND DISCUSSION

Sound Absorption Coefficient, SAC (α) is a fraction of sound energy that being absorbed. The values are expressed as numbers between 0.0 to 1.0, as (0.0) stands for total reflection of unwanted sound and (1.0) stands for perfect absorption [3]. Figure 1 shows the SAC values of the LDF in thickness of 12 mm, 14 mm, 16 mm and 18 mm. The factors that influence the performance of acoustic properties are types of natural fibres, density, thickness of the fibreboard, porosity and etc [21] [22] [23]. Figure 1 shows the SAC values of all samples almost increase with increasing in frequency. LDF with thickness of 16 mm and 18 mm show a subtle decrease after 4000 Hz. Besides this, it has been found that the SAC values almost increase with increasing in thickness. Theoretically, better sound absorption results from the complexity pathway inside a porous material. The complexity of the path makes the time taken longer for the sound to travel through thus the wave takes a longer time to contact with the fibre [24] [25]. It has been found that, the SAC values for all LDF can reach 0.8 and above in frequency range of 4000 - 6400 Hz. Furthermore, LDF with thickness of 16 mm and 18 mm possess the SAC values of 0.8 and above at a wider frequency range, which is 2500 Hz to 6400 Hz. Research has been done for sugar cane fibre and tested for its acoustic properties. The SAC only reached 0.80 at frequency 4000 Hz whereas based from figure 1 all the thickness exceed SAC 0.80 at frequency 4000 Hz. As for coir and grass, they only manage to exceed SAC of 0.50 at frequency of 4000 Hz [10]. When compare to oil palm trunk SAC results, although it's good enough but it's still not on par with empty fruit bunch and oil palm frond mixture. At high frequency of 5000 Hz, all the thickness sample for empty fruit bunch and oil palm frond mixture exceed SAC of 0.92 and still increasing while the oil palm trunk started to decrease in SAC at 5500 Hz [13].

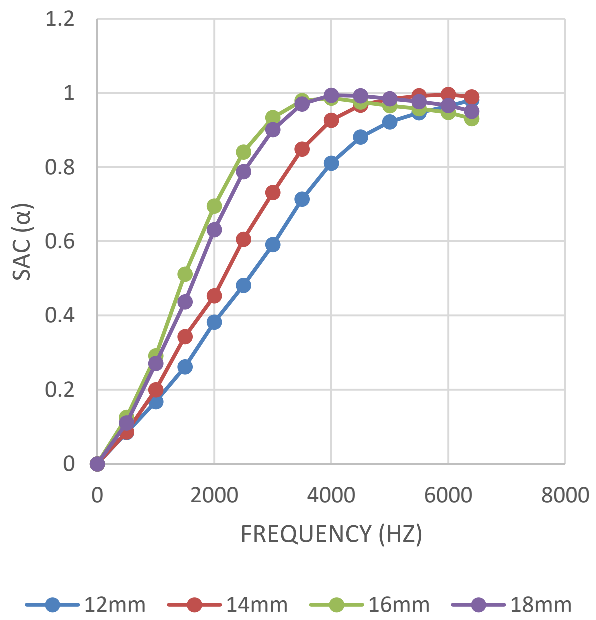

Fig. 1 Sound Absorption Coefficient versus Frequency of LDF for thickness of 12 mm, 14 mm, 16 mm and 18 mm with density of 120 kg/m3 at frequency range of 0 Hz - 6400 Hz

Figure 2 shows the SAC values of all LDF in frequency range of 4000 Hz till 6400 Hz. It is interesting to note that all LDF except the sample with thickness of 12 mm can reach the SAC values of 0.9 and above from 4000 Hz till 6400 Hz. LDF with thickness of 12 mm is found to increase exponentially from 4000 Hz till 6400 Hz and almost linearly from 5000 Hz till 6400 Hz. All the LDF can be classified as Class A sound absorbing material according to sound absorption classes table.

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In addition, LDF with thickness of 14 mm almost reach unity (~0.99) at frequency range of 5500 Hz to 6400 Hz as shown in Figure 2. LDF with thickness of 18 mm almost reach unity at frequency range of 4000 Hz to 4500 Hz. For thickness 12 mm and 16 mm, both
thicknesses almost reach unity once at respective frequency of 4000 Hz for 16 mm and 6400 Hz for 12 mm.

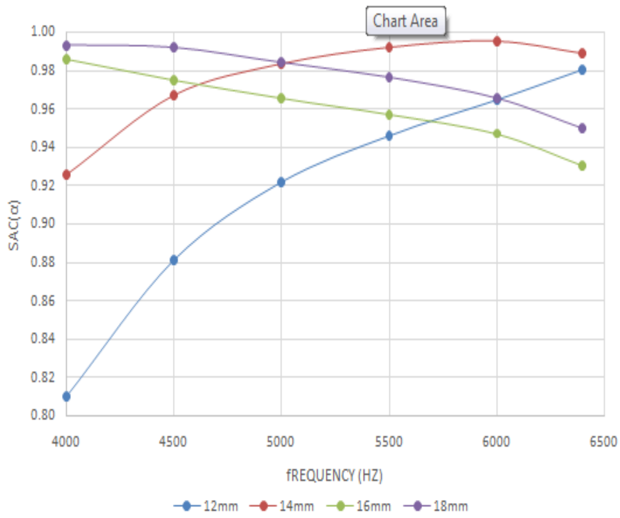

Fig. 2 Sound Absorption Coefficient versus Frequency of LDF for thickness of 12 mm, 14 m, 16 mm and 18 mm with density of 120 kg/m3 at frequency range of 4000 Hz - 6400 Hz

IV. CONCLUSIONS

The sound absorption coefficient (SAC) was carried out for EFB and OPF mixed fibreboard with ratio of 50 % - 50 % in different thickness (12 mm, 14 mm, 16 mm and 18 mm). LDF with thickness of 14 mm reached unity (1.0) where 100% of unwanted sound or noise can be absorbed at frequency of 6000 Hz. Beside this, LDF with thickness 16 mm and 18 mm almost reach unity at frequency range of 3000 Hz to 4500 Hz. LDF with thickness of 16 mm and 18 mm possess the SAC values of 0.8 and above at a wider frequency range, which is 2500 Hz to 6400 Hz. The values of SAC for all samples increase in thickness from frequency range of 0 Hz – 4500 Hz. The findings show the mixture of EFB and OPF fibreboard can perform very well for application that require high frequency range like recording studios. This research shows that the combination of EFP and OPF natural fibres has a very promising and excellent performance in acoustic properties and can be hold its ground against synthetic fibre in sound absorber industry.

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