THE EFFECTS OF DIFFERENT THICKNESS OF OIL PALM TRUNK (OPT) FIBERBOARD ON ACOUSTIC PROPERTIES

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ABSTRACT: *Nowadays, the demand for environmentally friendly sound absorber is growing globally due to increase in consciousness about the effects of synthetic materials on human health and environment. This paper has investigated the suitability of oil palm trunk (OPT) natural fiber as sound absorbing material in different thickness of 8 mm, 12 mm and 16 mm with an average density of 200 kg/m^3. Sound absorption coefficient, α (SAC) was measured and analyzed using Impedance Tube Method. From the results, the SAC of all OPT fiber with an average density of 200 kg/m^3 showed minimum value of around 0.60 at frequency range from 3000 – 6400 Hz. Furthermore, SAC of OPT fiber with an average density of 200 kg/m^3 has a moderate value over wide frequency range of 3000 – 5000 Hz if compared with other natural fibers. It is noteworthy that sample with thickness of 8 mm showed higher absorption rate over wide frequency range of 3000 – 6400 Hz and SAC value of this sample exceeded 0.8 after 6000 Hz. Hence, it can be concluded that oil palm trunk fiber is a very promising natural fiber to be used as a sound absorbing material.*

Keywords: Oil Palm Trunk (OPT); Sound Absorption Coefficient (α); Impedance Tube Method

1. INTRODUCTION

Noise is an unwanted sound that annoys or irritates perceivers. It can affect and cause disruption to human health. The National Institute for Occupational Safety and Health (NIOSH), Malaysia suggests the safe exposure limit is 85 decibels for eight hours per day. Human hearing is at jeopardy if continuously being exposed to a high volume of sound. This situation can be solved by installing sound absorbing material in places that are necessary to avoid unwanted noise. Generally, sound proof or sound insulated material are used in recording studios, industrial work site with heavy sound pollution, theatres, office spaces, home depot and automotive industry [1].

Synthetic materials used as sound absorber that are available in the market now are produced from fiberglass, mineral wool, and so on. The fiber shedding from fiberglass or mineral based materials are hazardous to human health especially in causing infection in lung and triggering irritation to skin, eyes, and throat which also lead to breathing difficulties. According to the research piloted by US government in "Fiberglass effects on human DNA" can cause cancer [2]. Furthermore, another research proved the effects of fiber shedding causing the growing of tumor in the lungs on animals and affected the DNA structure [3].

Thus, to replace synthetic materials by natural fibers as sound absorbing material is a must. Natural fibers have many advantageous properties as compared to conventional reinforcing fibers. Natural fiber is a fully biodegradable, non-toxic material and lightweight with high specific properties make it an attractive material considered for sound absorbers [4, 5]. The abrasive nature of natural fibers is much lower compared to that of glass fibers, which offers advantages with respect to processing techniques and recycling [6].

Moreover, many researches focused in natural fibers such as palm, coconut coir, kenaf and many others as acoustical panel [7]. High elasticity and hollow space paddy straw was found suitable to be used as acoustic panel [8]. In addition, jute fiber and coconut can be used as sound absorber [9]. At higher frequencies region, coconut coir fiber showed good sound absorption but not at lower frequencies region [10]. Then, the industrial tea-leaf-fiber waste material also has sound absorption properties at high frequencies [11]. All these researches showed that natural fibers have high potential to be used as sound absorbers.

Oil Palm Trunk (OPT) is richly available in Malaysia, and it is less expensive to be used as raw material to produce the potential value-added product such as particleboard, laminated board, plywood and fiberboard [12]. However, the research in acoustic studies of OPT fiber is less and therefore lack of information in acoustic properties from available literature. For that purpose, it is interesting to study the effects of different thickness of OPT fiber on acoustic properties. In this research, the acoustic properties of OPT fiber with average density of 200 kg/m^3 in three different thicknesses, 8 mm, 12 mm and 16 mm have been measured.

2. EXPERIMENTAL DETAILS

The OPT fiberboard was prepared from oil palm tree trunk. It began with chipping process, where the trunk was cut and chipped into small pieces using Laboratory Maier Chipper. After that it was dried up to 100 ^oC in an oven to reach 10 % of the moisture content. This is followed by the refining step by using Sprout-Bauer (ANDRITZ) refiner to convert OPT chipped to cottonized fiber. The cottonized fiber was then dried up until the MC reached 4 % – 5 %.

Mettler Toledo HB 43 Halogen moisture meter was used to measure the moisture content. The refined OPT fiber was charged into the Mechanical Blender. Then, urea formaldehyde glue was sprayed from a pressurize nozzle onto the OPT fiber to ensure homogeneous mixing during blending process. After resin blending, the samples were prepared according to required mass of the refined fiber and UF glue mixture that were designed to achieve an average density of 200 kg/m^3.

The samples were formed into three different thicknesses of 8 mm, 12 mm and 16 mm using a wooden former with the dimension of 300 mm × 300 mm. The mixture was manually shaken and formed to ensure sufficient compactness and evenness distribution of OPT fiber inside the wooden former. To measure the SAC (α), the fiberboard was cut into 30 mm in diameter to be fitted into the impedance tube ((Bruel & Kjaer (B&K) Impedance Tube Type 4206) and measured from frequency range of 0 – 6400 Hz.

3. RESULTS

The results obtained are illustrated from Figure 1 to Figure 3 and Table 1.

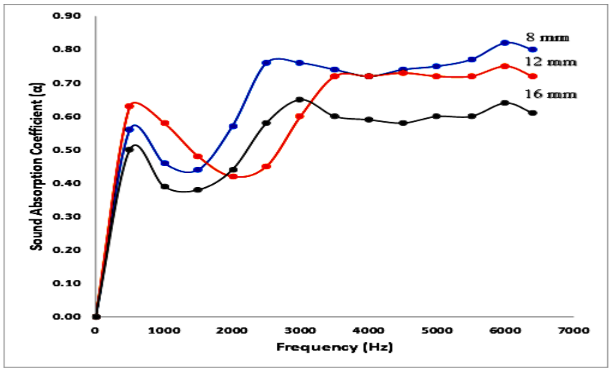

Figure 1 SAC (α) vs Applied Frequency (Hz) of OPT fiber with an average density of 200 kg/m^3 in three different thickness of (a) 8mm, (b) 12mm and (c) 16mm at frequency range of 0 – 6400

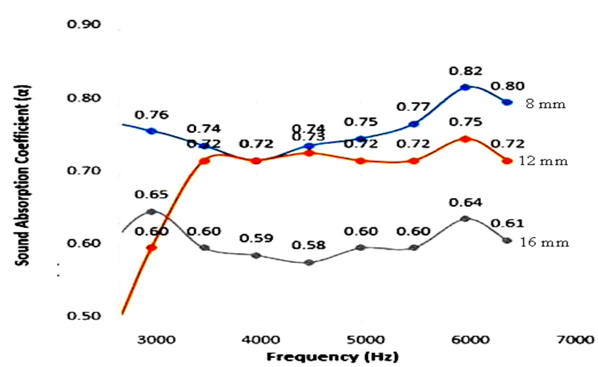

Figure 2 SAC (α) vs Applied Frequency (Hz) of OPT fiber with an average density of 200 kg/m^3 in three different thickness of (a) 8 mm, (b) 12 mm and (c) 16 mm at frequency range of 3000 – 6400 Hz

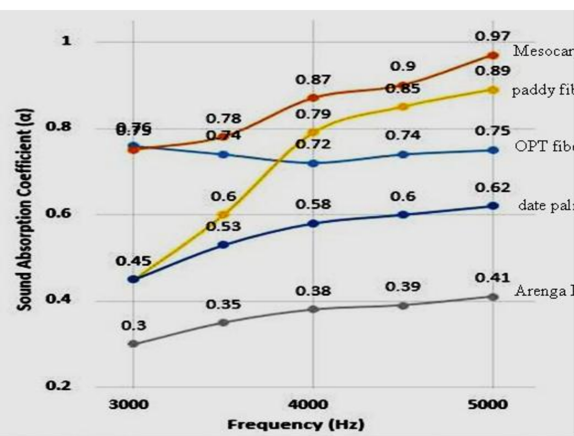

Figure 3 SAC (α) comparison between OPT fiber, Mesocarp fiber, Arenga Pinnata, paddy fiber and date palm fiber at frequency range of 3000 – 5000 Hz.

Table 1 Sound absorption coefficient (SAC, α) comparison between OPT natural fiber, Mesocarp fiber, Arenga Pinnata, paddy fiber and date palm fiber.

	OPT Fiber	Mesocarp Fiber	Arenga Pinnata	Paddy Fiber	Date Palm Fiber
Density	200 kg/m^3	~ 200 kg/m^3	-	~ 200 kg/m^3	~100 kg/m^3
Thickness	8 mm	50 mm	10 mm	10 mm	12 mm
References	-	(Hanif et al. 2016)	(Ismail et al. 2010)	(Putra et al. 2013)	(Elwaleed et al. 2014)
3000 Hz	0.76	0.75	0.30	0.45	0.45
3500 Hz	0.74	0.78	0.35	0.60	0.53
4000 Hz	0.72	0.87	0.38	0.79	0.58
4500 Hz	0.74	0.90	0.39	0.85	0.60
5000 Hz	0.75	0.97	0.41	0.89	0.62
5500 Hz	0.77	-	-	-	-
6000 Hz	0.82	-	-	-	-
6500 Hz	0.80	-	-	-	-

4. DISCUSSIONS

SAC (α) is a dimensionless number valued between zero and one, that represents a percentage of sound energy absorbed based on a unit area exposed to the sound. The value of zero and one indicate the incidence sound energy is reflected and absorbed, accordingly [13].

Figure 1 shows the SAC (α) of OPT natural fiber with average density of 200 kg/m^3 in three different fiberboard thickness of 8mm, 12mm and 16mm. The results showed an inversely proportional relationship between the SAC (α) values and the thickness of the fiberboard. The sound absorption performance is influenced by material thickness, density, airflow resistance, porosity, fiber type and size [14]. When the thickness of OPT fiberboard increases, it decreases the rate of absorption level.

It can also be seen clearly from Figure 2 that the sample with thickness of 8 mm is the nearest sample to achieve the optimum level of the SAC (α) ≈ 0.82 at 6000Hz compared to the samples with thickness of 12 mm (α = 0.75) and 16 mm (α = 0.64). It may be due to the higher airflow resistance in this particular thickness (8mm). Higher usage of the material will reduce the air movement in the sample. This results in a difficulty for the sound energy to be transmitted to the porous media and hence high sound reflection seems to be occurred. Naturally, the finely crushed fiber material helps to dissipate the sound energy due to an increase in airflow resistance [14, 15]. In this case, the OPT fiber molecules were unable to do so may due to the compactness and closely arranged fiber molecules that causing the difficulty movement of sound wave through the material. The peak absorption is found to be occurred at frequency of 500 Hz for all samples (Figure 1).

Figure 3 and Table 1 show the comparison of SAC (α) between OPT fiber and few different natural fibers (Mesocarp fiber, Arenga Pinnata, paddy fiber and date palm fiber) that have been tested as sound absorption materials [13, 16, 17, 18]. The comparison between these fibers was made from frequency range of 3000 Hz to 5000 Hz only. This is due to insufficient results obtained from other natural fiber materials. Among the natural fibers, the highest sound absorption rate was shown by Mesocarp fiber followed by OPT fiber, date palm fiber and Arenga Pinnata. Paddy fiber exhibited very drastic change in SAC (α) between the frequencies of 3000 Hz to 5000 Hz.

Mesocarp fiber, almost reached unity at frequency of 5000 Hz shows that it possesses very good acoustic properties compared to other natural fiber. Meanwhile, OPT fiber shows an average of SAC (α) = 0.75 throughout the frequency range of 3000 Hz to 5000 Hz. However, when the frequency is increased, the SAC (α) also increases accordingly. This shows that it may reach the unity at even higher range of frequency. Date palm fiber and Arenga Pinnata fiber showed a very low absorption rate at a frequency above 3000 Hz compared to OPT fiber. This may be due to the material properties that are less porous compared to OPT fiber. The SAC (α) of paddy fiber is in the range of 0.45 – 0.89 which is better than the OPT fiber at frequency above 3800 Hz but slightly lower than OPT fiber at frequency below 3800 Hz.

5. CONCLUSIONS

The results obtained from this research can be concluded as follow

(1) Sound absorption coefficient (SAC) of all OPT fiber with an average density of 200 kg/m^3 showed minimum value of around 0.60 at frequency range from 3000 – 6400 Hz.
(2) SAC (α) of OPT fiber with an average density of 200 kg/m^3 has a moderate value over wide frequency range of 3000 – 5000 Hz if compared to Mesocarp fiber, paddy fiber, date palm fiber and Arenga Pinnata.
(3) OPT fiber with thickness of 8 mm showed higher absorption rate over wide frequency range of 3000 – 6400 Hz and exceeded 0.8 after 6000 Hz.
(4) OPT natural fiber performs a better sound absorption behavior than date palm fiber and Arenga Pinnata at frequency range of 3000 – 5000 Hz.

6. ACKNOWLEDGEMENTS

The authors would like to thank Universiti Tenaga Nasional (UNITEN) and Malaysian Palm Oil Board (MPOB) for supporting the research work.

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