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THE INFLUENCE OF PHYSICAL PROPERTIES AND DIFFERENT PERCENTAGE OF THE OIL PALM MESOCARP NATURAL FIBER

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ABSTRACT

High performance acoustic material is an attractive solution to a sound pollution. Nowadays, the used of synthetic fiber as a common acoustical panel has been detected hazardous to human health. There are several types of natural fiber materials, which have lower environmental impact than the synthetic materials and show better sound absorbing and sound insulation performances. Therefore researchers have become interested to find sustainable materials to be an alternative sound absorber material. This paper investigated the potential of oil palm Mesocarp fiber as fibrous acoustic material. The binder is constructed at prescribed percentages of polyurethane (PU). The measurement of sound absorption coefficient (SAC) was done by using the impedance tube method. The samples were also tested for physical properties which is the density and porosity. The result indicated that oil palm Mesocarp fiber is capable to be good sound absorption panel.

Keywords: sound absorption, natural fiber, oil palm mesocarp, polyurethane, density, porosity.

INTRODUCTION

Most panels available in the market at present are variety of traditional synthetic fibers such as glass wool, rock wool and asbestos, because of their high performance at mid-high frequencies. Unfortunately, some of the synthetic fiber not only can be harmful to human health but also contributes higher to Global Warming Potential (GWp) kg CO_2 (Asdrubali, 2006). Since 40 years ago, the European Council Directive stated that the synthetic fiber has several disadvantages where the fiber can lay down in the lung alveoli and cause skin itchy (European Council Directive, 1967). Hence, researchers have now driven their concern to find the natural or renewable materials instead of producing and using non-renewable materials. There are several studies that have been published in recent years such as coconut fiber (Nor *et al.* 2004), Kapok fiber (Sambu *et al.* 2015), Arenga Pinnata (Ismail *et al.* 2010), Paddy straw (Abdullah *et al.* 2011), Kenaf (Saad and Kamal, 2013), Rice husk (Zaidi *et al.* 2009) and so on. The general reason for using natural fibers as alternative material according to (Zhu *et al.* 2013) was due to biodegradable, low density and price. However, the disadvantages of these fibers were their inhomogeneous quality and their dimensional instability. The synthetic fiber that still be the choice because of their moisture resistance and have good mechanical properties even though they were difficult to recycle and expansive.

This paper provides alternative material used as sound absorber panel from waste which is oil palm Mesocarp. There are about 57% of total production occurs in west Malaysia and 99% in Sabah and about 5 million hectare of area oil palm has been planted (Malaysia Palm Oil Board, 2011). Most of these natural plants in the country are left abandoned. Approximately 22% fiber produced from oil palm industry is a waste (Badri and Razali, 2005).

At present, Malaysia is famous in the producing of palm oil in the international market. The oil palm tree are not only produce oil but provide raw material such as oil palm (OPF), oil palm trunk (OPT), empty fruit bunch (EFB), palm kernel shell (PKS), palm kernel cake (PKC), palm kernel expeller (PKE), palm oil mill effluent (POME), dry decanter cake (DDC), ash and Mesocarp fiber (Cuah, 2009).

In addition, the Forest Research Institute of Malaysia (FRIM) and Malaysian Palm Oil Board (MPOB) has conducting fundamental research for many years the potential of using oil palm residues as raw materials for various products. In recent years, the raw material that obtained from oil palm trees have been used widely in biomass media, mattress, fiber board, cushion, rugs, carpets, and rope manufacturing.

Incorporation of PU in lignocellulosic materials not only used as the binder but also showed improvement of its mechanical properties. There are several researchers that have been using PU as a binder in their study (Badri *et al.* 2005; Mahzan *et al.* 2010; Asdrubali et, al., 2008; Stankevičius *et al.* 2007). A preliminary study on acoustical performance of oil palm Mesocarp, Kenaf, Ijuk, and Coir natural fibers was investigated previously in Acoustic and Vibration Research Group laboratories, Universiti Tun Hussein Onn Malaysia (Latif *et al.* 2015; Sambu *et al.* 2015). Those studies covered with the effect of air gap, thickness and binder; Polyurethane and Latex.This research is to study the effect of binder and determine the optimum acoustical performance of the oil palm Mesocarp natural fiber. The physical properties of samples were also been investigated in this study.

The parameters that involved in this study give information about the physical characteristics and the effect of the physical on NRC results. The finding key parameters are percentage of binder, porosity and density. In order to understand the acoustical characteristics of natural fiber material that mixed with binder, it is necessary to know about the optimum percentage ratio of mixing to produced the best of acoustical performance. In literature, several of researchers agreed that high porosity tend to be good absorber and the density has a significantly influence on the properties of sound absorption.

MATERIAL AND METHODS

Oil Palm Mesocarp Fiber

The oil palm Mesocarp fiber used in this research is obtained from oil palm mill after press station. Before being used, the materials have to undergo several pre-treatment processes. Initially, the fibers were soaked in the water, washed and dried to remove the unwanted dirt's. All shell and kernel were removed from the fiber. The fibers was crushed to obtain small grain and mixed with the PU as the binder. Table-1 shows the percentage of fibers and binder. Here, the percentage of PU varies in order to investigate the influence of binder on the sound absorption. Furthermore, the samples were prepared in cylindrical shape with two different diameters of 28mm and 100mm for high frequency measurement and low frequency measurement range, respectively. The sample used for this research was initially of thickness of 50 mm as shown in Figure-1.

Figure-1. Sample of oil palm Mesocarp.

The experiment was conducted using Impedance Tube Method (ITM) to obtain the SAC which is based on ASTM E1050-09 standard. This method places a loudspeaker at one end of an impedance tube and a small sample of the material under test at the other end. The loudspeaker generates broadband, stationary random sound waves. The sound wave propagate within the tube strike the sample and is reflected resulting in a standing wave interference pattern. The result indicated between zeros to one by the SAC which indicate the reflection and total absorption respectively.

Table-1. Percentage of oil palm Mesocarp and PU.

Sample	Oil Palm Mesocarp Fiber (%)	PU
1	100	0
2	90	10
3	80	20
4	70	30
5	60	40

Porosity and density was tested in this study. Porosity is one of the important factors that should be considered while studying sound absorption mechanism in porous material. It is represented by its ratio of pore volume to the total volume of the absorbent material. Density also considered as an important when dealing with the sound absorption behavior of the material. Materials with different densities tend to have different sound absorption properties.

RESULT AND DISCUSSIONS

Acoustical Properties

The variations of SAC against frequency for oil palm Mesocarp with different percentages of PU at normal incidence as measured by impedance tube is shown in Figure-2. In general, all samples demonstrated higher absorption coefficient at mid-high frequency range with the average sound absorptions above 0.5. The SAC of most samples at first increase from under 0.2 to about 0.9, but then decrease to about 0.7 in 2000 Hz and increase to reach approx 1 in 4000 Hz. It normally increases SAC by increasing frequency up to peak of absorption and decreases subsequently. Sample 2 with 10 percent PU shows the superior performance in most of low to mid frequency range. However, sample 3 with 20 percent PU reach the high value of sound absorption of 0.99 at 1000 Hz. It found that the amount of binder used effects the acoustics performance of material.

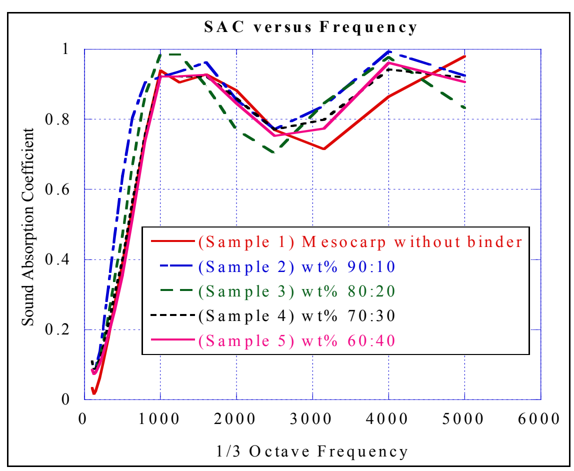

Figure-2. Sound absorption coefficient of various percentages of fiber and binder.

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As seen in Figure-3, glass wool fibers showed better results at low frequencies compared to samples 1 and 2, ranging from 100 Hz to 630 Hz. However, all samples reach the maximum peak before the glass wool. It can be seen that Mesocarp result still lacking at low frequencies, but it is still comparable in the performance compared to glass fibrous wool.

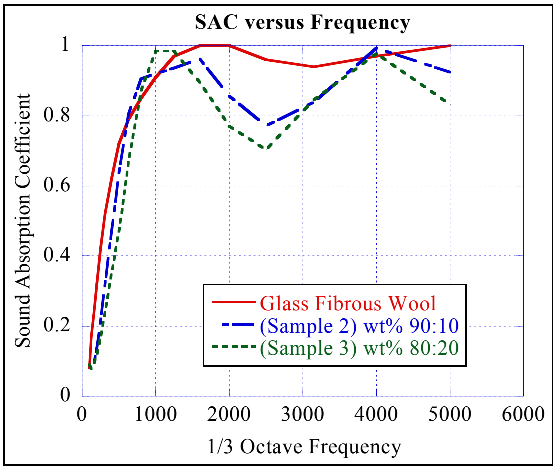

Figure-3. Comparison between two optimum result of Mesocarp and glass fibrous wool.

Further, analysis was determined by calculating the noise reduction coefficient (NRC) values. NRC is a single number rating system for indexing absorption of a material. It is an arithmetic average of SAC over human speech frequencies range at 250, 500, 1000, and 2000 Hz. Table-2 shows the results of NRC values for all samples and from other researcher. It was found that NRC for all samples was above 5.0 and this indicated that all samples are highly absorptive (Cowan, 1993). The optimum value for NRC is 0.66 that produced from sample 2. This value indicated that the sample can absorb 66% of incident sound tricking them and the rest 60% of incidence sound energy are reflected back into the space or transmitted through. Less binder contents give better absorption. On the other hand, NRC for all samples produced higher values compared to other natural fibers.

Physical Properties

As seen in Table-3, a comparison of different densities was recorded for different samples. The result indicated that the percentage content of binders is related to the density values; where less PU content is less dense. It was predicted that by increasing the percentage of binder will decrease the pores in the samples. The result also shows that the density influenced the NRC values. Generally, denser structure gave better NRC value from mid to high frequency range but tends to decreases at the low frequency. This can be seen clearly by comparing the density result with Figure-2 and Table-2.

Table-2. Noise reduction coefficient for all samples and from other researchers.

Material	Frequency (Hz)				NRC	References
	250	500	1000	2000		
Pure Mesocarp (sample 1)	0.11	0.39	0.94	0.88	0.58	-
Mesocarp with 10% binder (sample 2)	0.21	0.64	0.92	0.86	0.66	-
Mesocarp with 20% binder (sample 3)	0.17	0.47	0.98	0.77	0.60	-
Mesocarp with 30% binder (sample 4)	0.15	0.40	0.92	0.86	0.58	-
Mesocarp with 40% binder (sample 5)	0.13	0.35	0.92	0.85	0.56	-
Coir Fiber	0.06	0.12	0.46	0.97	0.40	(Fouladi et. al., 2013)
Corn Fiber	0.06	0.16	0.28	0.81	0.33	(Fouladi et. al., 2013)
Sugarcane Fiber	0.05	0.13	0.88	0.63	0.42	(Fouladi et. al., 2013)
Grass Fiber	0.08	0.14	0.45	0.98	0.41	(Fouladi et. al., 2013)
Polyurethane	0.22	0.55	0.70	0.85	0.58	(Bies and Hansen, 2009)
Glass Wool	0.42	0.72	0.91	1	0.76	(Bies and Hansen, 2009)

Table-4 shows the influence of porosity on NRC. The result demonstrates that the values of porosity were inversely to density; porosity values increase when the density values decrease. The result also shows that the porosity values significantly increased with sound absorption. The optimum NRC is attained from the sample with optimum porosity value. The higher the pores, the greater the viscous and thermal losses caused by frictional loss within the porous as the sound wave propagates through them; thus more absorption. This is in agreement to the fact that by adding more percentage of binder will increase the density and decrease the porosity.

Table-3. Influence of density on NRC.

Sample No.	Density (kg/m^3)	NRC
1	246.65	0.58
2	266.79	0.66
3	283.88	0.60
4	291.73	0.58
5	310.16	0.56

Table-4. Influence of porosity on NRC.

Sample No.	Porosity (%)	NRC
1	0.847	0.58
2	0.882	0.66
3	0.801	0.60
4	0.766	0.58
5	0.639	0.56

CONCLUSIONS

As a conclusion the influence of physical and different percentage of binder was investigated. The optimum SAC of Mesocarp fiber obtained when the percentage of binder is 10% of the total weight of the fibers. In order to validate this study, a comparison with glass fibrous wool and other researcher has been done. Denser material absorbs sound at high frequencies (>1600 Hz), less dense material perform better at low frequency range. Other than that, density increase will give lower value of porosity. Porosity also affects the sound absorption, whereas SAC increased with increasing porosity. Overall, density, porosity and percentage of binder influenced the sound absorption performance.

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