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Sound Absorption of *Arenga Pinnata* Natural Fiber

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Abstract**—**Arenga pinnata is an abundantly natural fiber that can be used for sound proof material. However, the scientific data of acoustics properties of Arenga pinnata was not available yet. In this study the sound absorption of pure arenga pinnata was measured. The thickness of Arenga pinnata was varied in 10 mm, 20 mm, 30mm, and 40mm. This work was carried out to investigate the potential of using Arenga pinnata fiber as raw material for sound absorbing material. Impedance Tube Method was used to measure sound absorption coefficient (α). The Measurements was done in accordance with ASTM E1050-98, that is the standard test method for impedance and absorption of acoustical materials using a tube, two microphones and a digital frequency analysis system . The results showed that sound absorption coefficients of Arenga pinnata were good from 2000 Hz to 5000 Hz within the range of 0.75 – 0.90. The optimum sound absorption coefficient was obtained from the thickness of 40 mm. These results indicated that Arenga pinnata fiber is promising to be used as raw material of sound absorbing material with low cost, light, and biodegradable.

Keywords**—**Sound absorption, *Arenga pinnata*, raw material.

I. Introduction

DUE to noise pollution in our surrounding, there are need and demand to find alternative materials that capable to reduce the noise level at various frequency ranges. Researches on composite materials and natural fibers were done on acoustical panels. The common acoustical panels are made from synthetic fibers that are hazardous to human health and environment and quite expensive for small need. Therefore, some researchers showed their great interest in trying to make alternative sound absorber from recycled materials, such as textile, foam, rubber or plastic. A study on acoustical characteristics and physical-mechanical properties of plaster with rubber waste additives was done [1]. The sound absorbent material made from scrap tyres with small grains yields showed better sound absorption [2]. Even product made from recycled are welcomed, issues like energy consumption during producing and environment impact of binders need to be considered. Thus, alternative raw materials those are of low cost, renewable, plentiful, and save for environment and human health is needed.

Moreover, many studies focused in developing natural fibers as raw material have been done and reported, such as palm, kenaf, coconut coir, and many others that have potential to be used as raw material of acoustical panel. Paddy straw was reported suitable for acoustic panel because of its high elasticity and hollow space [3-4]. A single layer acoustic panel made of paddy husk reinforced sodium silicate showed the optimum sound absorption coefficient at higher silicate content in high range frequencies [5]. Similarly, coconut and jute fiber have high potential to be used as a sound absorber material [6]. Coconut coir fiber has good sound absorption at higher frequencies but less for the lower frequencies, so did the oil palm fiber. Higher noise absorption of oil palm is due to its higher density [7-9]. Then, industrial tea-leaf-fiber waste material also has sound absorption properties at high frequencies [10]. Besides, kenaf can be properly seen as an alternative, especially for thermo-acoustic applications and sound barriers [11-13]. These show that natural fibers have high potential to be applied as raw material of sound absorbing materials. Though, sound absorption characteristic of some natural fibers has been investigated, the acoustical characteristics of *Arenga pinnata,* is rarely studied.

Arenga pinnata is one of natural fibers that abundantly available from palm sugar tree. Since the last decade, it is widely used for many applications like roof, rope, water filter, and sound proof in recording studio [14]. However, the scientific data of acoustics properties of *Arenga pinnata* was not published yet. Hence, this work is carried out to investigate the potential of using *Arenga pinnata* fiber as raw material for sound absorbing material.

II. Method

A. Raw Material Preparation

The material used in this study is *Arenga pinnata* fiber from palm sugar tree. The fibers were cleaned and spray with water, and dried in room temperature. The dry fiber was cut down in cylindrical shape according to impedance tube size. Two different diameter tubes were used to cover the full frequency range. Tube with 100 mm diameter is used to cover measurements over the frequency range from 150 Hz to 1600 Hz and a 28 mm diameter tube are used to cover measurements in the frequency range 1200 Hz to 6000 Hz.

B. Measurements

The acoustic property of *Arenga pinnata* studied in this work is sound absorption coefficient (α). Impedance Tube Method was used to measure the sound absorption coefficient in accordance with *ASTM E1050-98*. 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

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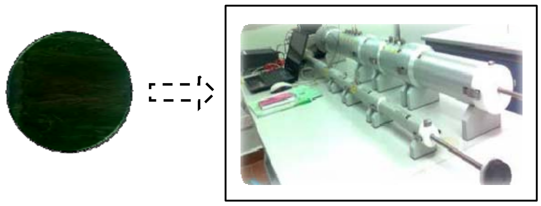
waves. The sound wave propagate within the tube strike the sample and is reflected resulting in a standing wave interference pattern. The sound absorption measurement was done by varied the thickness of *Arenga pinnata* fiber, 10 mm, 20 mm, 30 mm, and 40 mm. The measurement process was done from frequency 150 Hz - 6000 Hz. The material and equipment used are as shown in Figure 1.



a b

Fig. 1: Sound Absorption Coefficient Measurements Set Up (a: Arenga pinnata fiber, b: Impedance tube equipment)

III. Results and Discussions

A. Sound absorption coefficient of Arenga pinnata fiber

The sound absorption coefficient of pure *Arenga pinnata* fiber measured from the impedance tube test on four fibers thickness covers from low to high frequencies are as shown in Figure 2. In this study, the thickness was varied, that are 10 mm, 20 mm, 30 mm, and 40 mm.

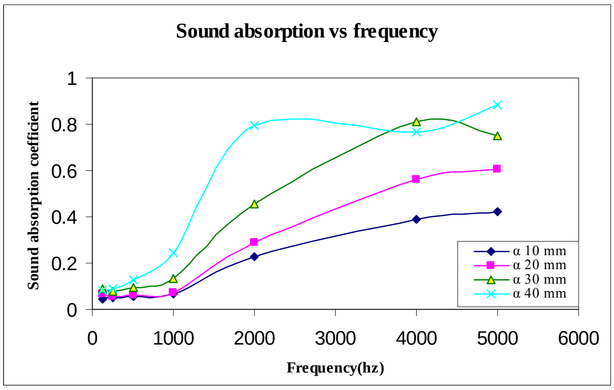


Fig. 2: Sound absorption of *Arenga pinnata* fiber

It shows that the pure *Arenga pinnata* fiber is a good absorber at frequencies especially from the 40 mm thickness fiber. It is a common property of porous (fibrous) material; they are good absorber at high frequencies and poor absorber at low frequencies. The optimum sound absorption coefficient, 0.88, was obtained at high frequency from *Arenga pinnata* from 40 mm thickness. The fiber thickness has influence to sound absorption coefficient of the material. Generally, the thicker material exhibits a maximum sound absorption coefficient at high frequencies.

B. Sound absorption coefficient of other material

Other sound absorption coefficients of natural fibers such as palm fiber and coir fiber have been determined by some other researchers. Their results are as shown in Figure 3.

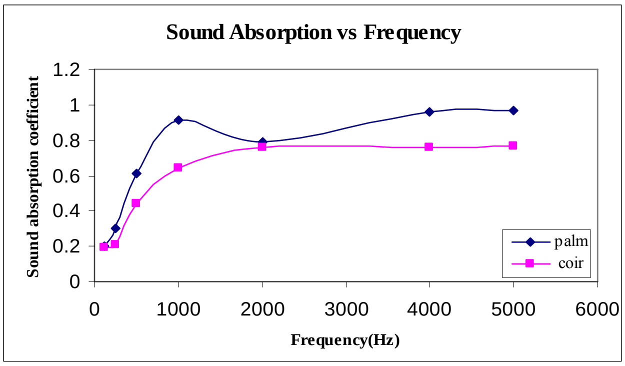


Fig. 3: Sound Absorption Coefficient versus Frequencies of Coir fiber and Oil Palm fiber [7]

Figure 3 shows the sound absorption coefficient of palm oil and coir fibers versus frequency, where the sound absorption of palm fiber is higher than coir fiber. Palm fiber has range sound absorption coefficient of 0.78 to 0.97 from 1000 Hz to 5000 Hz, while the Coir fiber has optimum sound absorption coefficient 0.77 at frequency 2000 Hz to 5000 Hz. Both the coconut coir fiber and palm oil fiber have good sound absorption from medium to higher frequencies but lower at the lower frequencies. Higher noise absorption of oil palm due to its higher density [7-9].

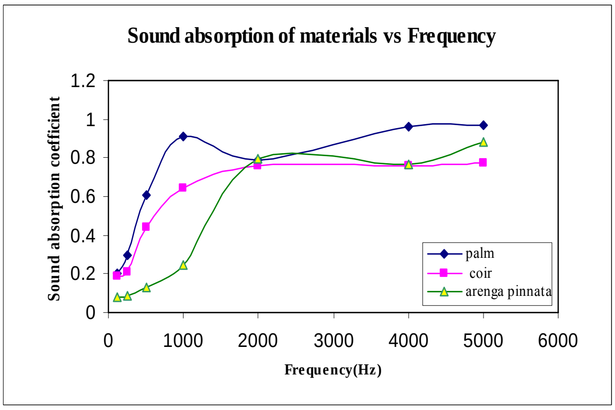


Fig. 4: Sound Absorption Coefficient versus Frequencies of palm, coir, and *Arenga pinnata* fiber

Figure 4 shows the comparison of sound absorption coefficient among palm oil fiber, coir fiber, and *Arenga pinnata* fiber. Sound absorption coefficient of palm and coir fiber are better than sound absorption coefficient of *Arenga Pinnata* in low to medium frequencies, that is from 0 – 2000 Hz. Above 2000 Hz, the sound absorption coefficient of *Arenga Pinnata* is in the range of 0.75 – 0.90 which is better than the coir fiber but slightly lower than the palm oil fiber. These natural fibers have good sound absorption coefficient at high frequencies band. Thus, *Arenga pinnata* fiber is promising raw material that can be used as sound absorbing material.

In addition, the flexural properties of composite panel made of *Arenga pinnata* reinforced epoxy of 10 wt. % woven roving fiber has the highest value compared to other fiber content in term of strong and rigidity [15]. It is showed that composite made of *Arenga pinnata* will have good mechanical and acoustical properties.

IV. Conclusions

The optimum sound absorption coefficient of Arenga pinnata was from the thickness of 40 mm. The sound absorption coefficients were good from the medium to high frequency that is from 2000 Hz to 5000 Hz within the range of 0.75 – 0.90 . These results indicated that Arenga pinnata fiber is promising to be used as raw material of sound absorbing material that low cost, less weight, and biodegradable.

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