Sound Insertion Loss of Kenaf and Arenga Pinnata

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Abstract. Heat Ventilation Air Conditioning System (HVAC) is designed to control the environment inside of residential, commercial or industrial buildings by controlling temperature of a room through heating and cooling. However, due to its mechanism, noise is produced in the system and reaches the people inside the building, thus causing distraction, discomfort and uneasiness. There are HVAC silencers in the market; however, the sound absorbing material used is of mineral wool types. In this study, the ducting silencer with the sound absorptive material that made of Arenga Pinnata, Kenaf and composition of these both materials were tested to identify its performance. The experiment was carried out in a testing apparatus that follows the ASTM E477-99 standard. Insertion loss was analysed at the end of the study. From the overall result and comparison, the insertion loss of Kenaf is averagely better than Arenga Pinnata, that is 97.5% higher than Arenga Pinnata. When composition of Arenga Pinnata and Kenaf is used, Kenaf plays important role in sound insertion loss, where when Kenaf composition increase, it increases the sound insertion loss capability.

Keywords: Kenaf, Arenga Pinnata, Ducting System, Insertion Loss

1. Introduction

The Heat Ventilation Air Conditioning (HVAC) system is used in most building to regulate temperature, humidity and supply fresh air from outdoor. HVAC have a bigger responsibility in maintaining comfort for occupants inside the building, but it is also created a negative effect to the person in the building, where noise created by HVAC system. HVAC system produce noise since the fan operates in the system and impact of air through the duct system create noise. The noise transmitted in the HVAC system through the HVAC duct and also directly from the noise source to the room or building. The noise that transmitted through the HVAC duct wall will create uncomfortable to people in the building. The noise that produced in HVAC system must be reduced, so the room remains comfortable. The material that mostly used as the dissipative silencer in HVAC system is Rockwool and Glass wool. The Rockwool and Glass wool that are usually used as dissipative silencer also have some disadvantaged. Rockwool and Glass wool are not bio gradable and its dust and fiber are bad for human health.
2. Literature review

Arenga Pinnata or Ijuk is a natural fiber that obtained from the palm sugar tree (Ismail et al., 2010). Arenga Pinnata is available in Southeast Asia like Indonesia and Malaysia. The products that mainly made are used in traditional application such as rope, broom, carpet and sofa cushion (Bachtiar, 2010) and is obtained directly from natural resources and it is also cheap.

Arenga Pinnata fiber is collected from the palm tree (Bachtiar, 2010) and cleaned with water then let it dry at room temperature. The dry fiber used in the applications such as dissipative silencer (Ismail et al., 2010). Arenga Pinnata has been tested sound absorption ability and it has shown ability as dissipative absorber. From the Figure 1, when thickness of Arenga Pinnata fiber is increase the sound absorbing coefficient also increases (Ismail et al., 2010).

Kenaf is a type of hibiscus plant and is a member of the Malvaceae family. It's can grow to a height of 2.5m to 5m in 4 to 5 months. Kenaf mainly cultivated for its fiber. The fiber from Kenaf has best resemble fiber and suitable for jute fiber. Fiber strands are 1.5m to 3m long. It is usually used to make rope, canvas, sacking, carpet backing and fishing net (Gowda, 2010).

Kenaf is a natural fiber which have advantages such as renewable, environmentally friendly, low cost, low density, flexibility of usage and biodegradable. Kenaf is one of the important sources of fiber in many applications. Kenaf have ability to be a reinforced fiber in thermosets and thermoplastic composites (Mohd Yuhazri, 2010).

Kenaf is chosen to be material for dissipative silencer for this study because Kenaf have the ability to absorb sound, where the sound absorbing coefficient of 0.74 for silencer thickness of 50mm according to Asdrubali (2006)’s.

A research carried out by D’Alessandro and Pispola (2005), Kenaf show an average absorption coefficient 0.85 in the 500Hz-5000Hz range and equal to 0.65 in the 100Hz-500Hz range as shown in Figure 2. Although Kenaf showed a slightly poor performance as sound absorber, it can be an alternate to the traditional mineral wool blanket for thermoacoustic application since its beneficial properties of low impact on human health and on the environment.

![Figure 1: The sound absorption of Arenga Pinnata fiber (where \( \alpha \) is the thickness of the Arenga Pinnata) (Ismail et al., 2010).](image-url)
Dissipative silencers consist of sound absorbing materials. Silencer can be active or passive type. Active type silencer is use noise cancelling techniques by using microphones, loudspeakers and signal processing to generate sound waves out of phase with the objectionable noise. Passive silencer is absorber type, where the noise is absorbed. Passive silencer usually used in HVAC system (Reid, 2006).

Another type of silencer usually used is baffle silencer. Baffle silencer installed parallel to gas flow. The silencer can be installed in many ways of configuration. Each type of configuration has its own advantages and disadvantages (Madlan, 2017). According to Rairat (2003), thickness of the absorptive material and spacing of absorptive material can affect the performance of silencer. The different thickness of noise absorptive material has different effect on silencer performance with varying range of frequency.

On the studies carried out by Ruggero, Davide and Corrado (2008), sound attenuation in the ducts line with granular material tested with varying thickness of absorbing lining. The experiment also conducted with linings of mineral wool, which traditionally used for sound absorption in lined duct. The result compared the insertion loss between granular material and mineral wool. From the Figure 3, it shows that the maximum insertion loss becomes smaller steadily as the thickness of the material increases.

From the result in Figure 4, it shows that the insertion loss seems independent of the thickness, in the frequency ranged tested for thickness higher than 50mm. Mineral wool has shown greater insertion loss than granular material. However, the granular material has shown good insertion loss at certain point.
of frequency. The insertion loss that get using granular material is quite good enough for it to be used in practical application.

The mineral wool traditionally used as sound absorption material but when it comes to health concern and resistance to environmental aggression, granular material can be an alternative to it (Ruggero et al., 2008).

![Figure 4: Spectral insertion loss for rectangular ducts lined with mineral wool of different thickness (Ruggero et al., 2008)](image)

National University of Singapore, School of Building and Real Estate conduct a test which is Acoustic Research Laboratory, Report No 990405 (Acoustic Research Laboratory). The test is about insertion loss when a silencer made by material glass wool is used. The length of silencer fixed to 3m and the diameter is varied to 50mm, 200mm and 250mm in the test. The test carried out within the frequency of 63HZ to 8000Hz.

![Figure 5: Graph of insertion loss versus frequency of noise of Acoustoflex’s silencer with three different diameters and two different diameters of normal flexible duct (Acoustic Research Laboratory).](image)

From the result in Figure 5, it shows that silencer with different diameter have different insertion loss at specific frequency. The silencer by Acoustoflex with 150mm has the highest insertion loss among all other silencer tested. From the result, it can observe that silencer with lower diameter have higher insertion loss for both Acoustoflex’s silencer and normal flexible duct, although Acoustoflex does not specify the material used for both silencer type (Acoustic Research Laboratory).
3. Methodology
ASTM standard E477-99 is followed and most procedure carried out based on that standard. The dimension of the testing apparatus is based on testing apparatus in ASTM E477-99 which is scaled down. Figure 6 shows the configuration of dissipative silencer. There are 7 types of samples tested, which are 60g Kenaf, 60g Arenga Pinnata, 30g Kenaf and 30g Arenga Pinnata, 30g Kenaf and 40g Arenga Pinnata, 30g Kenaf and 20g Arenga Pinnata, 30g Arenga Pinnata and 40g Kenaf, 30g Arenga Pinnata and 20g Kenaf. Sound absorptive material’s dimension are 250mm length, 150mm width, and 15mm thickness. Preparation of sound absorptive material is done by compress the fibers, which is Kenaf and Arenga Pinnata with selected mass in compression mold and using Latex as adhesive. A TES Sound Analyzer is used to measure noise at various 1/3 octave frequency at the data collection point. The complete setting of apparatus is shown in Figure 7. Figure 8 shows the real testing duct during conducting experiment.

Figure 6: Configuration of dissipative silencer

Figure 7: Setting of testing apparatus
4. Results and discussion

From the overall data, sound absorbing materials Kenaf, Arenga Pinnata and composition of both materials show ability to absorb sound. From the comparison of all 60g sound absorptive material, Kenaf have higher insertion loss than Arenga Pinnata. The trend of both graphs almost the same. The graph of insertion loss versus frequency for all 60g sound absorptive material shown in Figure 9. From the comparison of one material’s mass as constant and other material mass varying, the relationship between the material and which material majorly effect the sound absorbing performance can be identified. The graph of insertion loss versus frequency for Arenga Pinnata’s mass constant is shown in Figure 10 and Kenaf’s mass as constant on Figure 11.
5. Conclusion
As a result from this study, the trend of insertion loss at 1/3 octave frequency of dissipative silencer made of Arenga Pinnata and Kenaf shows the insertion loss is lower at the lower frequency and as the frequency increase, insertion loss also increases steadily until 10kHz. Insertion loss is higher when the sound absorptive material have mass percentage of Kenaf higher. 60g Kenaf has the highest insertion loss. Both Kenaf and Arenga Pinnata have the ability to absorb sound and this study shows that these natural fibers can make use as ducting silencer.

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