UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF GREEN NOISE BARRIER USING COCONUT FIBER

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering Technology
(Maintenance Technology)(Hons.)

by

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2015

DECLARATION

I hereby, declared this report entitled "Development of Green Noise Barrier Using Coconut Fiber" is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) (Hons.). The member of the supervisory is as follow:

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(Ahmad Yusuf Bin Ismail)

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TAJUK: **Development of Green Noise Barrier Using Coconut Fiber**

SESI PENGAJIAN: **2014/15 Semester 1**

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ABSTRAK

Penggunaan bahan-bahan sintetik sebagai penyerap akustik masih digunakan dalam industri. Bahan-bahan tidak boleh lupus ini bukan sahaja menyebabkan pencemaran alam sekitar, tetapi juga menyumbang dengan ketara dalam peningkatan karbon dioksida yang menyebabkan kesan pemanasan global. Projek ini membentangkan cara untuk mencari bahan-bahan yang mampan dan mesra alam untuk menjadi penyerap bunyi alternatif dengan menggunakan sabut kelapa sebagai bahan akustik berserabut. Satu panel penyerap bunyi daripada serat kelapa dan span difabrikasi dan keberkesanannya ditentukan melalui eksperimen dan indeks pengurangan bunyi. Data yang dikumpul dianalisa menggunakan perisian "Smart Office" untuk mencapai objektif dan membandingkan keberkesanan dalam menyerap tenaga bunyi. Serat kelapa dan span dengan komposisi bahan yang berbeza memberikan prestasi yang berbeza dalam mengurangkan bunyi bising mesin. Bahan ini menunjukkan prestasi yang baik sebagai penyerap bunyi di antara frekuensi rendah dan sederhana. Serat kelapa dapat mengurangkan tahap tekanan bunyi bising yang dihasilkan oleh kompressor walaupun pada komposisi peratusan lebih rendah.

ABSTRACT

The use of synthetic materials as acoustic absorbers is still applied in industry. These non-biodegradable materials do not only cause pollution to the environment, but also contribute significantly in increasing the carbon dioxide causing the effect of global warming. This project presents a way to find sustainable and eco-friendly materials to be an alternative sound absorber by using coconut fiber as a fibrous acoustic material. A green noise barrier from coconut fiber and sponge is fabricated and its effectiveness is determined through experiment and noise reduction index. Data collected is analyzed using Smart Office Analyzer Software to achieve the objectives on comparing its effectiveness in absorbing sound energy. Coconut fiber and sponge with different composition of material give different performance in reducing machinery noise. These fibers showed good performance as sound absorber at low and medium frequency region. Coconut fibers able to reduce sound pressure level of noise produced by compressor even at lower percentage composition.

DEDICATION

To my beloved family,

My supervisor,

and to all my friends,

Thanks for all support and ideas.

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First I would like to express my grateful to ALLAH S.W.T. as for the blessing given that I can complete my final year project. In preparing this paper, I have been involved with many people in helping me to complete this project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

BNC	-	Bayonet Neill-Concelman
NRI	-	Noise Reduction Index
P_o	-	Acoustic Pressure obtained from the Microphone
P_{ref}	-	Reference Pressure
PU	-	Polyurethane
SOA	-	Smart Office Analysis
SPL	-	Sound Pressure Level
SPL_b	-	Sound Pressure Level of Compressor without Noise Barrier
SPL_O	-	Sound Pressure Level of Compressor with Noise Barrier
STL	-	Sound Transmission Loss
USEPA	-	United States Environmental Protection Agency
UTeM	-	Universiti Teknikal Malaysia Melaka
dB	-	decibels
g	-	gram
Hz	-	Hertz
kHz	-	kilohertz
m	-	meter
mA	-	milliampere
Pa	-	pascal
℃	-	degree Celsius

CHAPTER 1
INTRODUCTION

1.1 Noise

Noise is an environmental problem which greatly affects human health nowadays. Noise is the unwanted sound that impact in both, psychologically and physiologically to the human and also can cause environmental pollution (Atmaca et al., 2005). It is possible to classify the effects of noise on ears in three groups: acoustic trauma, temporary hearing losses and permanent hearing loss (Melamed et al., 2001). Other than that, noise can cause heartbeat acceleration, increase of blood pressure and ringing or other noises in the ear or head known as tinnitus. The psychological effects of noise are more common compared to the psychological ones and they can be seen in the forms of annoyance, stress, anger and concentration disorders as well as difficulties in resting and perception (Cheung, 2004). Hearing loss might occur when there is an exposure to continuous and excessive noise at a level higher than 85 dB (Atmaca et al., 2005). Continuous hearing loss differs from person to person with the level, frequency and duration of the noise exposed (USEPA, 1974).

A noise problem generally consists of three inter-related elements which are the source of the sound, the receiver of the sound and the transmission path. This transmission path is usually the atmosphere through which the sound is propagated (Figure 1.1), but can include the structural materials of any building containing the receiver (Figure 1.2). The source of noise or undesirable sound may be a vibrating surface, a mechanical shock, a mechanical friction, a fluid flow, a flame burst or an explosion. The receiver in the noise control system is usually the human ear.

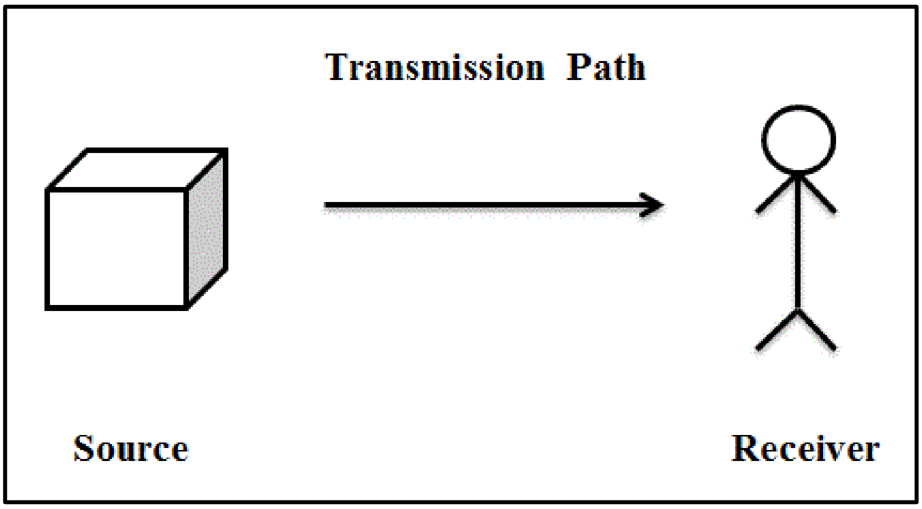

Figure 1.1: Inter-Relationship between The Elements of Noise (a) (Barron, 2003).

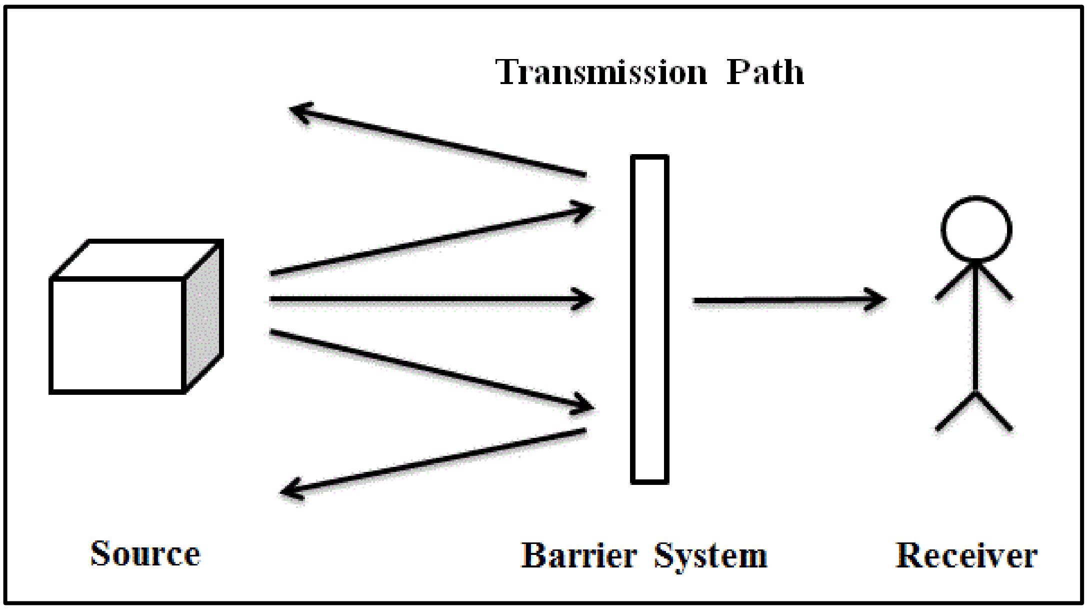

Figure 1.2: Inter-Relationship between The Elements of Noise (b).

1.2 Sound Absorption

Sound absorption material absorbs sound energy when sound collides with it and transforms the sound into heat and transmitted. Material that has low absorption ability has a tendency to reflect most of the sound waves and vice versa. There are two medium of sound absorber which is absorption by yielding walls and absorption by porous material. Yielding wall is a wall that is set into motion as a whole by the pressure variations of the sound field in front of it. It emits a secondary sound wave into outer space. For porous material, sound absorption is performed by pressure differences or gradients that enforce airflows within the pores. It is caused by internal friction (viscosity) and by heat conduction between the air and the pore walls.

1.3 Problem Statement

Industrial process and equipment are composed of various noise sources. Persistent expose to noise can give negative effect to the workers such as permanent damage to auditory nerve. Noise barrier control the noise disturbances by reducing direct contact of sound pressure to human. There are two types of sound absorption material that is commercially available which are glass and mineral-based fiber. But, they were found to be harmful to human being. These non-biodegradable materials do not only cause pollution to the environment, but also contribute significantly in increasing the carbon dioxide causing the effect of global warming. Current surges toward more sustainable living have changed the fiber industry. People around the world are becoming more conscious of their environmental impact. The demand for natural materials has arisen (Muensri et al., 2010). Instead of using synthetic material, natural fiber is selected because they are environmental friendly, recyclable and easily available source.

1.4 Objectives

The objectives of the project are:

1. To design and fabricate a prototype of a green noise barrier using coconut fiber with additional of sponge.

2. To study the effectiveness of green noise barrier in reducing the machinery noise.

1.5 Scope

The scopes of the project are:

1. Source of industrial machinery is compressor in the laboratory of Faculty of Engineering Technology, UTeM.
2. Conceptual design of noise barrier using SolidWorks software.
3. Preparation of green noise barrier using coconut fiber with addition of sponge.
4. Differentiation of sound transmission with different composition of material applied.
5. Experimental measurement of noise based on Noise Reduction Index (NRI).
6. The experiment will be conducted at the acoustic laboratory.

CHAPTER 2
LITERATURE REVIEW

2.1 Industrial Noise

A great majority of people working in industry are exposed to noise. Industrial noise is a noise associated with industrial processes that may cause hearing damage as a result of the high decibel level. Industrial machinery and equipment can be extremely loud and can be considered as noise pollution. The general effect of noise on the hearing of workers has been a topic of debate for many years (Jansen, 1992; Johnson, 1991; Alton & Ernest, 1990). People will feel uncomfortable and distress if there is uncontrolled noise pollution. The needs for controlling industrial noise are necessary to protect workers from harm. The basic mechanism of noise generation can be due to mechanical noise and fluid noise.

2.1.1 Fluid Noise

Fluid noise is a noise caused by pressure surges in a hydraulic system. Hydraulic systems are well known for their high levels of noise. By the 1950s, hydraulic powered machine noise had reached levels that caused frequent complaints (Skaistis, 1988). These problems caused by noise cannot only limit the application of fluid power, but also require the designers to replace it with other methods of power transmission systems, such as electrical systems (Anon., 2003).

For hydraulic machinery, more than 95% of the noise comes from the pumps and motors. Valves are another noise source, but they cause fewer problems in industry because of the masking noise from other predominating sources (Skaistis, 1988).

2.1.2 Mechanical Noise

Mechanical noise focused on noise that produced from a mechanical process. The main sources of causing noise are machines. It has been identified that the machine noises were in the frequency range from 1 kHz to 8 kHz (Chathurangani et al., 2012). The noise may came from excessive vibration of portions of the machine and transmission of machine vibration to the supporting structure.

2.2 Noise Control

2.2.1 Sound Insulation

Sound insulation act in reducing resonance in the room by reflection or diffusion. It can be classified into two as shown in Figure 2.1 which are airborne sound insulation and impact sound insulation (Kassim, 2012). Airborne sound is generated from a source and transmitted through the air. Then, the sound pressure will cause vibration of the material. New vibration will be set up in the next corresponding air to continue transmission of the sound. Impact sound also known as structure borne sound is caused by direct vibration of object. The example of impact sound is footsteps. The vibrations are transferred to the atmosphere including structure that connected with the material.

Figure 2.1: Airborne sound (a) an impact sound insulation (b) between two rooms (Kassim, 2012).

2.2.2 Sound Absorption

Materials that have low absorption ability have a tendency to reflect most of the acoustical energy. Sound absorption is a capability of a material to convert sound energy into other energy. This energy is usually converted to heat energy (Daigle, 1994). The property of a material absorbing ability is called sound absorption coefficient at a particular frequency range. Sound absorbing barriers allow sound waves to enter a sound panel, as the sound waves travel through the sound absorbing material within the panel, they are forced to change direction and follow a longer pathway. Every change in direction results in a decrease in the sound energy.

2.3 Sound Absorption Material

Sound absorption material absorbs sound energy when sound waves collide with it and transform into heat and then transmitted. Arenas and Crocker (2010) compared between old and new substances for their acoustic porosity. New substances are developed at higher quality and perfected to become safer and thinner, thus they are more effective in decreasing noise. There are three main types of porous absorbing material which are cellular, fibrous and granular as shown in Figure 2.2.

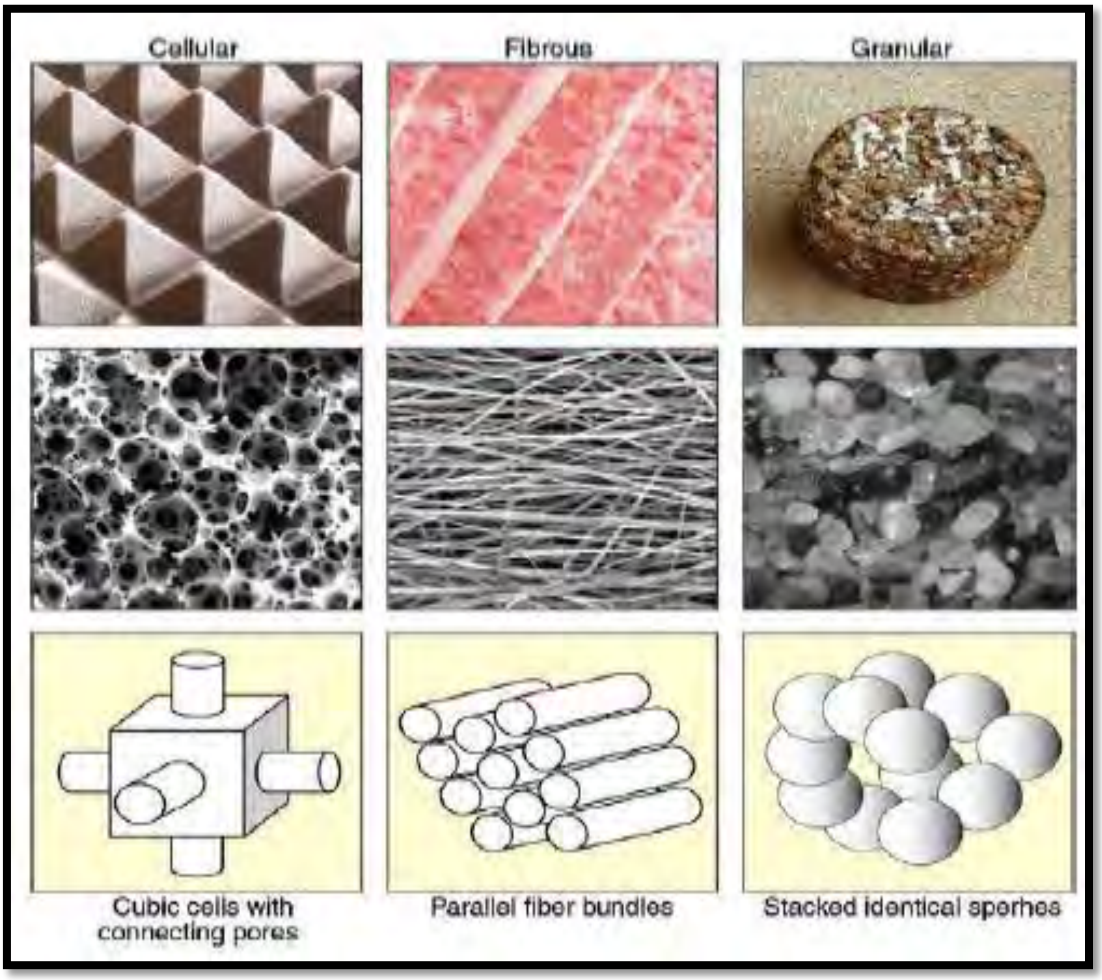

Figure 2.2: The three main types of porous absorbing material (Arenas and Crocker, 2010).

2.3.1 Natural Fiber as Sound Absorption Material

In practical applications, most sounds absorbing materials are synthetic materials because they are available in the markets, but they induce health risks to lungs and eyes. Therefore, researchers have looked into natural and agricultural waste to find alternative materials. This type of material has many benefits such as cheaper, nonabrasive, and renewable. Also, these organic substances impose less health and safety issues during processing. Moreover, (Van et al., 2004) reviewed on the environment impact of natural fibers and concluded that the impact of waste generation such as organic production was found more than the synthetic products.

(Khedari et al., 2003) investigated the lowest thermal conductivity in reducing heat transfer into space using new particle boards manufactured with durian peel and coconut coir fibers. In terms of heat reduction, these agriculture wastes are an economical and good option. After a year, (Khedari et al., 2004) discovered a particle board of low thermal conductivity manufactured using a mixture of durian peel and coconut coir, at an optimum ratio of 90:10 (coconut coir to durian) by weight.

In 2008, Zulkifli et al. have studied on the transmission loss index and acoustic absorption coefficient and made a comparison between them by using natural organic fiber perforated panels with or without filler. The result from experimental works and simulation of multi-layer coir fiber showed good absorption coefficient in reducing noise in all spaces.

Meanwhile, the sound absorption of an industrial tea leaves waste was investigated using three different layers with or without single backing layer of woven textile cloth to test experimental properties of sound absorption (Ersoy and Kucuk, 2009). The results determined that the sound absorption properties increased when the thickness of the layer with single backing cotton cloth layer also increase. It can be seen that the natural material and renewable material has good sound dissipation properties.

On the other hand, (Ayub et al., 2009) investigated the sound absorption capability of coir fiber and considered the effect of adding air gap to increase absorption at lower frequency range. Experimental measurements used impedance tube and calculated using Delany- Bazley equation at three different thicknesses. The" Johnson-Allard "model of perforated and multi-layer plate has been reported to give the best sound absorption capability at lower frequency.

In the same year, (Zulkifli et al., 2009) investigated on the effect of various sizes and air gap thicknesses on perforated plate in receiving a sound emitted. (Sakagami et al., 2009) considered analyzing model for the acoustic absorption of vibration on the microscopically perforated membranes plates" surface. They indicated that the plates can be converted through the control of ratio of perforator to understand the phenomenon of absorption through the plates.

(Boonen et al., 2009) developed the calibrating way to increase the precision analogy of sound impediment on the basis of measured impediment of the solid wall at different sites of the original section. The transmission of many identical waves will get rid of the acoustic speed.

(Yang et al., 2011) studied the absorption coefficient of four fiber assemblies, cashmere, goose down, and kapok. These are natural and acrylic fiber. The natural fibers had unique internal structures which would influence the sound absorption coefficient, which were measured according to their mass, sound frequency, and air gap to check the contribution of solid fiber against air. These fibers showed good performance at low to medium frequency, but the performance deteriorated at higher frequency. Therefore, at lower fiber density, and smaller diameter as well, the fibers are able to show good absorption coefficient performance.