UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND APPLICATION OF MACHINERY NOISE BARRIER USING PADDY STRAW FIBRE

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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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:

.....

(Mr. Ahmad Yusuf bin Ismail)

ABSTRAK

Pencemaran bunyi merupakan salah satu masalah biasa yang perlu manusia hadapi terutamanya mereka yang menetap atau bekerja di kawasan pembangunan. Di industri, sumber utama pencemaran bunyi ialah mesin. Penggunaan sistem penghalang bunyi merupakan salah satu kaedah pengurangan pencemaran bunyi mesin-mesin di industri di medium penghantaran bunyi di antara sumber dan penerima. Namun masalah timbul apabila bahan penyerapan bunyi yang lazim di gubakan untuk struktur penghalang bunyi ialah bahan sintetik. Para pengkaji berpendapat bahawa gentian semulajadi berpotensi untuk dijadikan sumber alternatif penyerap bunyi kerana ianya mesra alam, ringan dan murah daripada material sintetik. Tujuan kajian ini dijalankan adalah untuk mereka dan memfabrikasi satu sistem penghalang bunyi menggunakan gentian jerami padi. Iyanya bertujuan untuk mengkaji keberkesanan penghalang bunyi mesra alam ini dalam mengurangkan kadar kebisingan yang dihasilkan oleh mesin. Mikrofon akustic digunakan untuk mengesan tekanan udara yang dihasilkan daripada kompresor melalui sistem penghalang bunyi dan dihantar ke signal penganalisa. Hasil kajian menunjukkan gentian jerami padi lebih efisen berbanding span dalam mengurangkan kadar tahap kebisingan pada frekuensi kurang-sederhana dan frekuensi tinggi. Indeks pengurangan kebisingan kompresor bertambah apabila komposisi gentian jerami padi di dalam sistem penghalang bunyi bertambah. Ia telah digambarkan bahawa komposisi penghalang bunyi yang paling efisen ialah 60% gentian jerami padi, 40% span iaitu pengurangan sebanyak 3 desibel oleh kompresor pada kadar kebisingan yang paling tinggi.

ABSTRACT

Noise pollution is one of the common problems that need to be faced by the people, especially those who are living or working in the urban area. In the industry, the major source of the noise is machinery. Implementation of barrier system between the noise source and the receiver is one of the control methods at the transmission path of the machinery noise problem in the industry. However, the non-biodegradable and harmful synthetic materials are widely used as the absorbent materials for noise barrier structure. Many researchers believed that natural fibre is the alternative material to replace the synthetic materials because natural fibers are environmental-friendly, lightweight and cheaper compared to synthetic materials. This research is purposely to design and fabricate the noise barrier system by using paddy straw fibre. This study also purposely conducted to study the effectiveness of green noise barrier in reducing machinery noise. Acoustic microphone is used to detect the air pressure transmitted from the compressor through the barrier system and transferred to the signal analyser. The Noise Reduction Index (NRI) of the compressor after the implementation for each barrier system is calculated. Result shows that paddy straw fibre is more efficient compared to sponge in reducing the noise level in low-medium high frequency region as well as high frequency region. The Noise Reduction Index (NRI) of the compressor increases as the percentage composition of the paddy straw in the barrier increases. It is depicted that the most efficient composition of barrier system is 60% paddy straw fibre, 40% sponge which reduces 3 dB the sound pressure level (SPL) of the compressor at its highest peak.

DEDICATION

Specially dedicated to my parents

My siblings,

My friends

And to all those who stood beside me

For all your love and support

ACKNOWLEDGEMENT

I would like to convey my sincere appreciation to my supervisor, Mr. Ahmad Yusuf bin Ismail, for his constant guide along this research writing. It is impossible to for me to fulfill this research requirement without his supervision and encouragement. He also has helped me to have a better understanding regarding this research. I am truly grateful. I am also grateful to all of my lecturers for their continuous inspirations.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

SPL	-	Sound Pressure Level
OSHA	-	Occupational Safety and Health Administration
NRI	-	Noise Reduction Index
AAC	-	Acoustic Absorption Coefficients
PU	-	Polyurethane
dB	-	Sound intensity
dB (A)	-	A-weighted Decibels
g	-	gram
Hz	-	Hertz
SPLy	-	Sound Pressure Level Of Compressor Without The Barrier
SPLx	-	Sound Pressure Level Of The Compressor With The Barrier
P_{ref}	-	2×10^{-5} Pa
P_O	-	Acoustic Pressure obtained from the microphone
Pa	-	Pascal

CHAPTER 1
INTRODUCTION

1.1 Noise

Noise problem is one of the major concerns among the communities especially those who are living or working in the urban areas. The definition of noise differs for everyone but basically it is an unwanted and damaging sound that causes disturbances to the human and environment. Noise can be very harmful as excessive exposure to the noise will lead to the hearing impairment and health problems to the human such as stress, blood pressure, anxiety and others.

The three interconnected elements of noise are the source, transmission path and receiver

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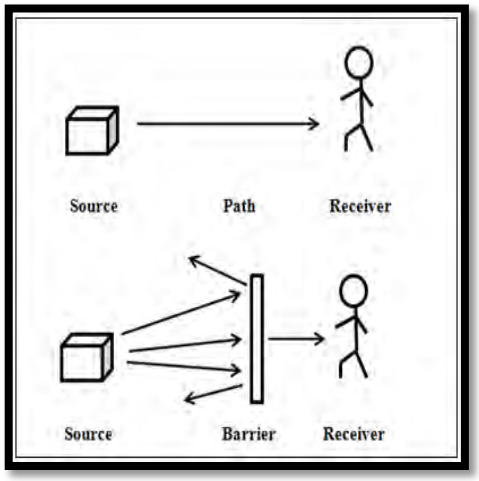

Figure 1.1: The Interrelated Components of Noise System.

1.2 Industrial Machinery Noise

Noise has always being one of the major hazards in the industry. In industry, the major source of the noise is machinery. Machines such as generator, motor, turbine and pump usually produce noise when operating. Continuous exposure to the noise level above 85 dB is considered hazardous because the standard limit of daily noise exposure at the workplace for most countries is 85 dB for an 8 – hour (Amedofu, 2007). Hence, it is compulsory to eliminate or at least reduce the source of noise from these machines to a safer level in order to protect the workers from continually exposed to it. Noise can be controlled by three means; noise control at the source, modification along the sound transmission path and noise control at the receiver (Monazzam & Fard, 2012).

1.3 Sound Absorption

Sound absorption is the amount of sound energy absorbed by a material Absorptive materials are the material decrease the acoustic energy as the wave passes through it by the phenomenon of absorption. Absorber material also help to reduces the strength of reflected noise by reducing the amplitude of the reflected waves and prevent a build-up of sound in enclosed spaces and. Absorptive materials are generally resistive in nature, either fibrous, porous or in rather special cases reactive.

1.4 Noise Barrier

Many noise controlling methods and applications have been introduced to overcome the machinery noise problem in the industry. One of them is modification along the noise propagation path through the implementation of barrier system. Barrier system defined as non-transparent obstacle to transmission path between noise source and receiver, where the noise propagates either above or around the wall barrier (Grubeša, et al., 2011).The performance of barrier system can be improved by additional sound absorption materials at the inner surface of barrier surfaces. Absorbent materials help to reduce noise by absorbing the machine's sound wave

that passes through it (Seddeq, 2009). Synthetic materials are widely applied to the barrier system as the absorbent materials. The use of synthetic materials for the noise controller that is not eco-friendly will be harmful to the human health

.

1.5 Synthetic Material

Synthetic materials are materials that are produced through chemical process. Synthetic materials have been widely used as the absorbent structure of barrier system since ages before. Synthetic materials are not only polluting the environment but also causing global warming because these materials produce carbon dioxide (Abdullah, et al., 2013). These materials have several weaknesses that make them no longer suitable to be used as the absorbent material for noise barrier system. Hence, it is an urge to find other absorbent materials that are safer and friendlier to be used for the barrier system.

1.6 Problem Statement

In the industry, there are several methods that are being practised to control the noise produced by the machinery. One of them is controlling noise along the transmission path through the implementation of barrier system. Barrier system consists of absorbent material on the inner barrier wall to reduce the sound intensity. The absorbent material helps to reduce the noise by absorbing the machine's sound wave that passes through it (Seddeq, 2009). But, problem arises as most barrier systems are made from synthetic materials.

Synthetic materials have several weaknesses that make them no longer relevant to be used. Synthetic materials are not only polluting the environment but also causing global warming because these materials produce carbon dioxide (Abdullah, et al., 2013). Hence, it is compulsory to find other materials that are safer and friendlier to the human and environment as the alternative way to replace the traditional absorbing materials.

Many researchers believed that natural fibre is the alternative material to replace the synthetic materials because natural fibres are eco-friendly, lightweight and cheaper compared to synthetic materials (Abdullah, et al., 2011). Moreover, natural fibre is a sustainable resource; hence they can be found abundantly and naturally produced without damaging the future needs (AL-Rahman, et al., 2012).

1.7 Objectives

There are two objectives of this research:

1. To design and fabricate a noise barrier system by using paddy straw fibre
2. To study the effectiveness of green noise barrier in reducing machinery noise

1.8 Scope

In order to reach the objectives, a few scopes have been stated:

1. Design of barrier system using SolidWorks 2013 x64 Edition software.
2. The natural fibre that will be used as fibrous absorbent material is paddy straw fibre and sponge as porous material.
3. The industrial machine that will act as the source of noise in this research is compressor in Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka (UTeM).
4. The experiment will be conducted in Faculty of Engineering Technology's acoustic room.
5. Experimental measurement of Noise Reduction Index (NRI) after implementation of the barrier system to the compressor.

CHAPTER 2
LITERATURE REVIEW

2.1 Noise

Noise pollution is one of the common problems that need to be faced by the people especially those who are living or working in the urban area. The definition of noise varies for scientists and engineers, but basically noise is an unwanted and damaging sound that causes disturbances to the human and environment. Noise differs for each person as it can be annoying for some people, but considered pleasant for other people (Fernández, et al., 2009).

Noise is produced when an object or surface vibrates and generate pressure wave, setting air molecules surrounding it into motion. The molecules travel in a sound wave and when it reaches a worker's eardrum, the eardrum will vibrate and brain translate it into what we perceive as sound. Sound intensity is measured in decibels and usually written as 'dB'. The decibel scale is established on a multiplication (logarithmic) scale because of the wide range of intensity of noises that occurs in the workplace. The higher the pressure, the louder the sound is because loudness of sound depends on the pressure of the sound wave.

The three interconnected elements of noise are the source, transmission path and receiver (Barron, 2003).

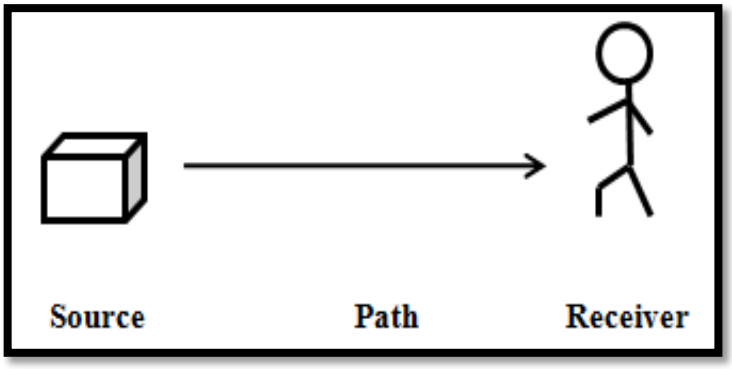

Figure 2.1: The Interrelated Components of Noise System (Barron, 2003).

2.2 Industrial Machinery Noise

Noise is one of the major hazards in the industry. Rapid development of technologies in the industrial sectors has contributed to the industrial noise problem. It has been identified that the frequency range of machine noise was from 1 kHz to 8 kHz. Continuous exposure to the noise level above 85 dB is considered hazardous because the standard limit of daily noise exposure at the workplace for most countries is 85 dB for an 8 – hour (Amedofu, 2007)

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Atmaca, et al., (2005) had conducted a research to determine the noise level at four different industries around Sivas which are concrete traverse, cement, iron and steel and textile industries. The findings show that noise levels of all four industries are much above the 80 dB. They also conducted a survey to 256 workers selected from all the industries regarding the noise issues. 73.83% of the workers admitted that they were disturbed by the noise at their workplace, 60.96% of them had faced nervous situation before due to the noise and 30.96% of them complained of having hearing problems although they did not had hearing examinations and using ear protectors.

2.3 Noise control

It is compulsory to eliminate or at least reduce the source of noise in order to protect the workers from continually exposed to the noise. Occupational Safety and Health Administration (OSHA) sets the admissible noise exposure limit in the workplace 85 dB for an eight hour period**.** In order to create an acoustically pleasing environment for the industrial workers, noise control and its principles play a very important role to bring down the intensity of sound to a safer level for human ears**.** In the industry, three common noise control methods are noise control at the source, noise control along the transmission path and noise control at the receiver (Barron, 2003)**.**

2.3.1 Noise Control at The Source

Noise control at the source of the noise is the best method to reduce the machinery noise level in the industry. Components of a machine may be modified to effect a significant change in noise emission and some noise emitted from the machine might indicates such as a need for maintenance

2.3.2 Transmission Path

Transmission path is the medium for the sound to propagate from the source to the receiver. When an object vibrates in the presence of air, the air molecules at the surface will begin to vibrate, which in turn vibrates the adjacent molecules next to them. This vibration will travel through the air as oscillating pressure at frequencies and amplitudes determined by the original sound source. An example of controlling noise at the sound transmission is placing barrier between the noise source and the receiver. When noise waves from outside hit the tile, the particles inside the tile excited and started to vibrate. Consequently, the air at other side of the tile started to vibrate creating a wave travelling through the tile. This is called the transmission.

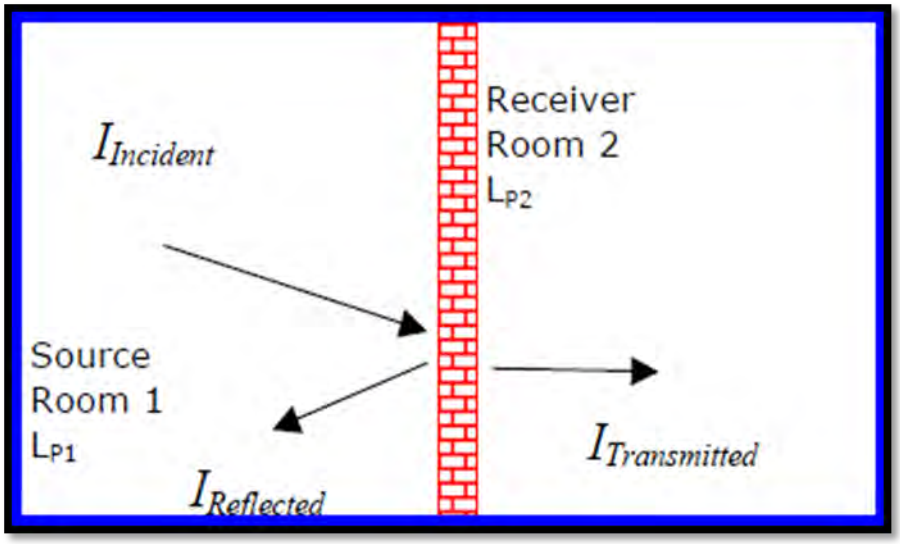

Figure 2.2 : Sound Path between Two Rooms (Lamancusa, 2000).

2.3.3 Noise Control at Receiver

Noise control at the receiver is the most common method at the industry. The term receiver is usually referring to the human ears and there is limited renovation can be done to the human ears. Two possible methods are limiting the exposure time of the workers or wearing the hearing protection. In order to protect the ears, many hearing protection are produced for the sake of the receiver convenience. Usually workers are provided with hearing protections such as earplugs and mufflers while working in the industry. These low-cost devices are commonly used in the industry as they are easily implemented to minimize the high-intensity noise exposure to the workers (Reinhold, 2012). This type of method is workable and suitable for low frequency of noise, but hearing protection devices deliver two major problems which are discomfort and inability to communicate (Qi & He, 2013). Workers always neglect the use of hearing protector, thus it is worrisome because many people do not aware of the consequences being exposed to the noise.

2.4 Barrier System

Many noise controlling methods and applications have been introduced to overcome the machinery noise problem in the industry. One of them is modification along the noise propagation path through the implementation of barrier system. Barrier system defined as an obstacle to transmission path between noise source and receiver, where the noise propagates either above or around the wall barrier (Grubeša, et al., 2011). Barrier system does not completely block the noise, but it helps to reduce the noise level. Barrier system reduces the noise either by reflecting, absorbing or transmitting the sound energy that fall on it (Hassan & Imam, 2013)

Table 2.1 : Previous Studies of Barrier System.

Researchers	Type Of Barrier	Measurement Parameter	Result
(Ishizuka & Fujiwara, 2004)	Barrier with different shapes and surface conditions	Measurement of sound insertion losses	The soft T-shaped barrier produces the highest performance
(Putra & Ismail, 2014)	Perforated plate	• Measurement on sound transmission loss of perforated panels • Investigates the effect of the hole diameter on the sound insulation	Transmission loss increases as the hole diameter is reduced