UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON THE EFFECT OF HOLES ARRANGEMENT OF ABSORPTIVE SILENCER ON THE SOUND TRANSMISSION LOSS PERFORMANCE

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

by

MOK JUAN CHIEN

B071310497

930428016291

FACULTY OF ENGINEERING TECHNOLOGY

2016

DECLARATION

I hereby, declared this report entitled "Study on the Effect of Holes Arrangement of Absorptive Silencer on the Sound Transmission Loss Performance" is the results of my own research except as cited in references.

Signature	:	…….
Author's Name	:	……
Date	:	……

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:

……

(MuhamadAzwar bin Azhari)

ABSTRAK

Penyenyap bunyi adalah peralatan yang digunakan untuk menghalang kebisingan dan melemahkan tahap bunyi kejadian yang dihasilkan oleh satu sumber. Penyenyap bunyi mempunyai reka bentuk lurus dengan gentian kaca dilindungi daripada arus ekzos oleh kepingan logam berlubang. Dalam kehidupan moden hari ini, kebisingan telah meningkat menjadi faktor persekitaran fizikal baru yang boleh mengancam keadaan kesihatan kita. Oleh itu, pembangunan dan penyelidikan penyenyap bunyi amat digalakkan untuk mengatasi masalah alam sekitar yang berkaitan dengan pencemaran bunyi. Kajian lanjut yang mengenai penyerap bunyi digalakkan atas akibat yang boleh menjejaskan kesihatan manusia dan alam sekitar.Pembangunan penyerap bunyimoden telah menjadi salah satu elemen penting pada masa hadapan. Kaedah susunan lubang pada permukaan tiub dalaman telah menjadi tumpuan dan parameter kajian dalam projek ini. Sebanyak lima sampel dengan susunan lubang yang berbeza telah berjaya dihasilkan dantelah diuji dan dianalisis dengan penggunaan tiub galangan mengikut kaedah ujian ASTM E2611. Hasil kajian menunjukkan bahawa lubang moden yang mempunyai susunan berbeza,berupayaan dalam mengecilkan tahap bunyi dalam pelbagai julat frekuensi. Dalam kategori penyenyap bunyi berdasarkan anjakan, 1 cm reka mempunyai prestasi yang ketara dalam kekerapan yang tinggi manakala 2 cm dan 3 cm mempunyai keupayaan pengecilan jelas dalam frekuensi tinggi sederhana dan sederhana rendah masing-masing. Sebaliknya, penyenyap bunyi berdasarkan sudut susunan 60 ° mempunyai prestasi penghantaran bunyi yang unggul. Sepanjang kajian ini, dapat disimpulkan bahawa pengecilan akustik penyenyap bunyilembap dalam frekuensi rendah dan persembahan parameter berkesan adalah dalam frekuensi tinggi.

ABSTRACT

Absorptive silencer is a device which used to impede noise and attenuate incident sound level produced by a source. Absorptive silencer had straight through design with fiberglass shielded from the exhaust stream by perforated sheet metal. In today modern life, noise has been rising to become new physical environmental factors that could threaten our health condition. Hence, development and research of absorptive silencer have been encouraged to overcome the environmental problems that related with noise pollution. Extensive researches on absorptive silencer have been encouraged due impact on human health and environmental concerns and the development of novel absorptive silencer has become one of the essential elements in the future.Holes arrangements have become the focus and the study parametric in this project.A total of five samples with different holes arrangement have been successfully developed and were all tested and analyzed by using impedance tube in accordance with proper testing methods of ASTM E2611. The findings show that different novel holes arrangement of absorptive silencer produced in this study have excellent sound attenuation properties in various frequency ranges. In the category of displacement based silencers, the 1 cm apart design has the significant performance in high frequency while 2 cm and 3 cm have the obvious attenuation capability in high-medium and low-medium frequency respectively. On the contrary, angle based arrangement silencer with 60° has the superior sound transmission performance. Throughout this study, it can be concluded that acoustic attenuation of absorptive silencers are poor in low frequency and most effects of parametricwas show in high frequency.

DEDICATIONS

This is devoted to my father who never stops believing and supporting me throughout my journey in building success and also to my mother who teaches me that nothing comes easy in life. This project also dedicated to my supervisor, Mr Ahmad Yusuf Bin Ismail who gives me a full support and suggestion to complete this project.

ACKNOWLEDGEMENT

First and foremost, I would like to express my sincere appreciation and gratitude to my supervisor, Mr. Ahmad Yusuf bin Ismail for being the best supervisor of the task. His perceptive advice, perceptive criticisms, and patient encouragement aided the writing of the report in inestimable ways. His support of the project was greatly needed and deeply appreciated

Besides that, I am also indebted to Mr. KhairilAmri Bin Kamaruzzaman, who has been a constant source of encouragement and enthusiasm during this thesis project. In addition, special thank to Dr. OlawaleIfayefunmi as making this thesis acquired an "English Shape".Other than that, thousands of gratitude dedicated to UTeM's staffs and technicians, friends and everyone that had given support throughout the process of completing the project.

Finally, my deepest gratitude goes to my family for their unflagging love and unconditional support throughout my life and my studies. They made me live the most unique, magic and carefree childhood that have made me who I am now. I also would like to thank and give appreciate to all the people I have met along the way and have contributed to the development of my research.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

%	-	Percent
°	-	Degree
Al	-	Aluminum
AMMCs	-	Aluminum-Based Metal Matrix Composites
ASTM	-	American Society for Testing and Materials
cm	-	Centimeter
dB	-	Decibels
GRC	-	Glass Reinforced Concrete
GRSC	-	Glass Reinforced Silicon- Calcium
HVAC	-	Heating, Ventilation and Air Conditioning
Hz	-	Hertz
IL	-	Insertion Loss
mm	-	millimeter
MPP	-	Micro perforated panel
MPPA	-	Micro perforated panel absorber
P_i	-	Pressure of the incident wave
p_t	-	Pressure of the transmitted wave
PV	-	Solar Photovoltaic
PVC	-	Polyvinyl chloride
SPL_1	-	System without muffler
SPL_2	-	System with muffler
STL	-	Sound Transmission Loss
VAV	-	Variable Air Volume unit

CHAPTER 1
INTRODUCTION

1.1 Noise

At its most basic, noise means erroneous sound in the improper place at the improper time. While noise pollution is the release of futile sound into the surrounding without regarding the detrimental effects it may have (Mishra et al., 2008). The establishing of the ambient sound waves is due to the surges of the corpuscle in medium and lead to later in the pressure of the transmitting medium. (Szalma and Hancock, 2011) From the perspective of physic, noise is a wave of sound that does random vibration. However in the view of environment protection, any sounds that interfere with human daily activities such as rest, study, work and even sound that impedance hearing is all categories as noise.

For most metropolitan's cities, noise pollution is always a challenge for the residents. The majority of denizens need to bear with the noise regardless day or night. 'Sound' is normally used to mean acoustic which can be perceived by the human ear. The perception of sound involves three basic terms which are intensity, frequency, and duration. Due to its remarkable sensitivity, the human ear is capable of receive and respond to an extremely wide range of intensity varied from 0 to 180 dB (Savale, 2014). However starting from 130 dB, human ear reaches the threshold of pain and permanent damage can do on the ear drum.

According to the United States Environmental Protection Agency (USEPA, 1974), continuously explore to an acute and harsh noise at a level greater than 85 dBA could actually cause impairs to the human ear. Depending on level, frequency, and duration of noise-exposed, the effect to human differs from each other. The

amplitude of the sound is appraised by measuring the sound pressure level (SPL). Bridger (2003) state that 1 decibel (dB) is the logarithm of the ratio of the measured sound pressure level to reference level in intensity between two sounds. Sound pressure level and sound level use in acoustics are also often express in decibel. The typical sound level of environments is shown in Figure 1.1.

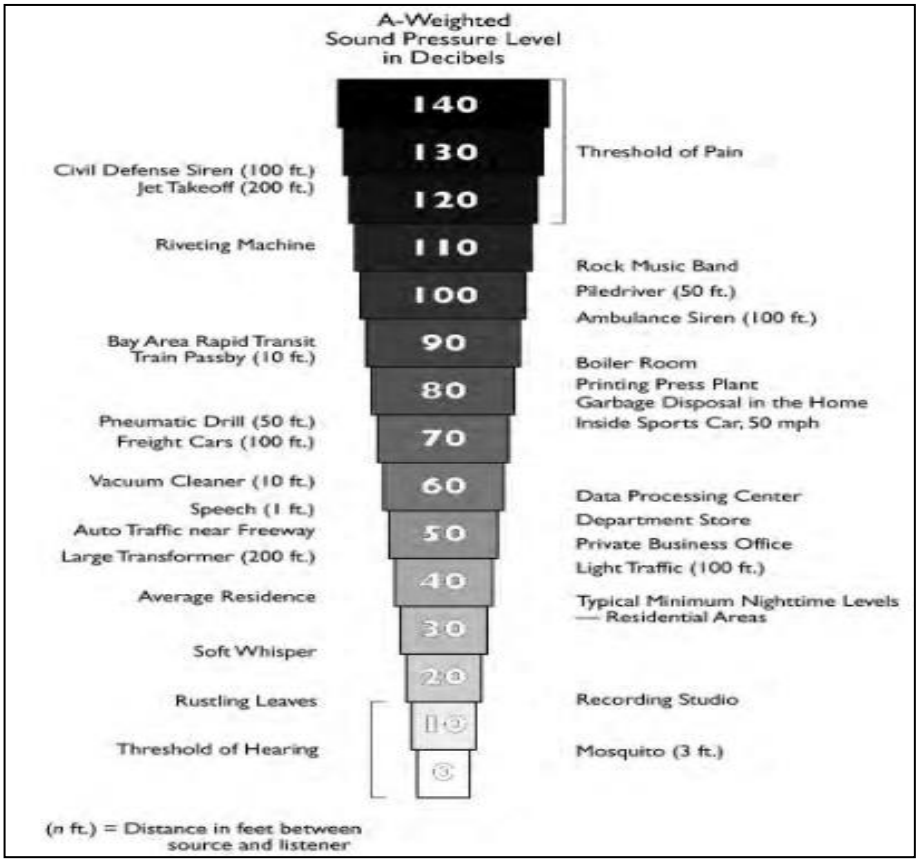

Figure 1.1: Typical sounds level (Peterson et al., 1972)

1.2 Effect of noise

In today modern life, noise has been rising to become new physical environmental factors that could threaten our health condition. Noise is a form of a wave with unpleasant sounds which will interfere human being in both physiologically and psychologically and bring environmental pollution by destroying

properties. It has been decade for people doing research on the effect of noise on the human health.

According to the research of health effects of noise (Camp Dresser and McKee Inc, 2001), they stated that potential physiological impact related with noise comprise of hearing loss, increased heart and blood pressure. These results might look ridiculous but it is also proven by Melamed and Froom (2001). The research done by Melamed and Froom (2001), is related to the effect of chronic exposure to noise and job complexity on changes in blood pressure and job satisfaction. From the finding, one could eventually increase in blood pressure when exposed to high noise even the task given is simple. Thus, it is not overstated to label noise as a stealth killer as these threats usually don't cause enough attention.

Beside increases of blood pressure, another common impact from noise is a loss of hearing. The most directly and affirmative health effect presented by the over expose of high sound levels is the loss of hearing (Comp Dresser and McKee Inc, 2011). From research result from Atmaca et al (2005), about 73.83% of workers in industries area are disturbed by the harsh noise in their working position or workplaces and causing 30.86% of them have ailments like ringing in ear or hearing losses. Hearing losses are the most general effects among the physiological ones. It is possible to classify the impact of noise on human ears into three different groups: acoustic trauma, temporary hearing losses, and permanent hearing loss.

The potential psychological effects pertain to noise can be shown in many forms. One of the impacts is sleep disturbances. Based on Dalton and Behm (2007), the community lives in the vicinity of highways, airport, and highly populated urban area tend to have insomnia or sleep disturbances due to the harsh noise from surrounding. The report from Comp Dresser& McKee Inc (2011), recommends the desired sound level about 25 and 45 dB is a suitable range for a sleep environment. Any sound level higher than 45 dB could actually hard for us to fall asleep. Sleep is essential for good physical and emotional health. Interference of sleep will result in a poor work performance effects.

Noise have the negatively affects over the public health, it can also influence human performance in such daily tasks as attention, comprehension, and vigilance. Due to the unveiling to high sound level during night time, an individual's performance will be affected on the next day (Dalton and Behm, 2007).

1.3 Acoustic Absorption

Numerous of surveys relate to the threatening of noise pollution in many regions around the world has been conducted (Olayinka, 2012; Ozdemir et al., 2014; Pramendra, 2011). Most researchers are all concerned with the consequences of the noise pollution and the findings are all beyond the comprehension.

With the changes of time, more and more new technologies have been invented. The most popular acoustic absorption technology in nowadays are noise barrier and silencer technology. An absorption technology will absorb sound energy to some degree thus reducing the noise emitted by another loud mechanism. Part of the acoustical energy in the wave will be absorbed and transmitted when the sound energy strikes the absorption material, and the remainder is reflected. The incident energy in the wave is always more than the reflected energy. The absorbed acoustical energy is transformed into another form of energy such as heat. The amount of energy absorbed is expressed in terms of the sound absorption coefficient (Owens, 2004).

A noise barrier is a solid structure that uses to intercepts the direct sound transmission path from a sound source to a receiver while a silencer is a device that wrapped the sound source to reduce the sound produced. Both acoustic absorptions technology have their own strengthens in a different application. For a noise barrier, it will reduce the sound pressure level to its shadow zone. The sound absorption of the coefficient of the noise barrier is majorly counting on the material of noise barrier, but for a silencer, the sound absorption coefficient relies on vast of aspect.

The design of the silencer is in a cylindrical pattern. In the cylindrical acoustic system, the longitudinal and the circumferences modes are the reasons for

the deterioration of noise among all the inherent modes. The reduction and the slight shift of the sound wave are due to the longitudinal modes in the annular cylindrical cavity being destructed (Yang et al., 2015). The best example for a silencer technology is the muffler.

Based on Potente and Daniel (2005), the general design of muffler can be categories into two group which are reactive and absorptive or dissipative muffler. A reactive muffler consists of series of expansion chambers that are designed to reduce and resonating the noise level at certain frequencies. On the other hand, absorptive or dissipative mufflers use the absorptive material in it to reduce the sound energy and convert into heat energy.

1.4 Problem Statement

Since the industrial revolution, the creation and use of all kinds of machinery and equipment have brought prosperity and progress to human beings, but this situation act as a double edge sword. At the same time, it brought us more and more noise. Noise can be defined as sound that has the characteristic of the irregular pitch, high intensity, and discordant sounds. Historically, there have been lots of publication describes the noise as a nuisance in public and the adverse effect of this unwanted, extraneous sound (Gibson, 1999).

The rapid urbanization and industrialization have lead to environment pollution. It is undeniable that noise pollution plays a role in dealing impact on human health condition, such as physical, physiological, psychological and performance (Ozdemir et al, 2014).

In general, noise comprises three interrelated elements which are the source, receiver and the transmission path of noise (Pramendra, 2011). In order to overcome the problem, people come out with different noise control method. The incident sound level can be reduced by two ways which are using sound absorption or sound transmission loss. One of the effective methods to reduce the noise level is the development of the absorptive silencer.

When a noise is transmitted into a silencer, the absorptive silencer will able to absorb and reduce the incident sound level. The absorption of sound in a silencer is determined by many aspects. Lots of researches have been done on an absorptive silencer with a different variance which includes the material of absorptive silencer, the internal structure of the silencer, holes size and holes pattern on the absorptive silencer. However, there is a neglected aspect of the whole research which is the holes arrangement on the absorptive silencer. A different holes arrangement will able to produce different level of sound, the best example to depict the important of holes arrangement is the development of music instrument flute. Different holes arrangement will get a different level of transmitted sound, thus a research on the effect of holes arrangement on an absorptive silencer had to be carrying on. It is believed that the holes arrangement on the absorptive silencer plays an important role in deteriorating the sound dissipation efficiency.

1.5 Objective of Research

1. To develop a novel holes arrangement design of an absorptive silencer.
2. To fabricate a novel holes arrangement absorptive silencer.
3. To test and analyze the new absorptive silencer using ASTM E2611 standard.

1.6 Scope of Research

1. Developing absorptive silencer with a novel holes arrangement.
2. Prepare the new absorptive silencer for sound transmission loss performance.
3. Testing and analyze prepared new absorptive silencer using STL method.

CHAPTER 2
LITERATURE REVIEW

2.1 Sound Barrier

A sound barrier is an exterior structure devised to guard the resident in an area that explore to sound pollution. The sound barrier is usually depicting as an efficient and uncomplicated method for deteriorating the noise level. Sound barriers are made from dense material and built as an obstacle between the sound sources and the receiving points. Sounds waves will be reflected, diffract and transmit after encounter the sound barriers (Zhou and Gou, 2009). The concept of sound insulation applied in the sound barrier is to ensure the diffracted sound is always higher than the transmission sound. Noise will be dissipative and alleviate through the dissemination process.

A sound barrier acts as an object that uses to block the propagations of the wave from a source to the sensor. The sound barrier can block the sound wave by absorption or reflection. The parameters that need to take into consideration when building up a barrier is the barrier dimension, layout, material density, position and shape (Indrianti et al., 2016). The characteristic of a sound barrier is usually depending on the selection of material. A porous material will be able to absorb sound better if compare to a less porous material. The sound energy will be dissipated into heat energy and released to the surrounding. Whilst nonporous materials are good in reflecting sound and mismatch the sound pattern. The sound level reduces to a lower value before passing through the barrier.

A good selection of materials is only the first step in designing a sound barrier. The further process is the arrangement of structure design of materials.

Acoustical performance of sound barriers is the best at the middle to high-frequency range but is poor at a lower frequency. In order to be more effective in low-frequency range, honeycomb sandwich panel, and damping tapes are add on the interior side of skin sub panels. This add-on treatment can be used on light weight noise barrier so it can be applied in an actual application such as electronic component enclosures, motor cars and fuselages of aircraft which are all in small enclosed space (Wen and Chung, 1998). In addition, the performance of this sandwich panel could be upgraded with a partition panel design in between the sandwich core. The material option for this sample will be either glass reinforced concrete (GRC) or glass reinforced silicon- calcium (GRSC). Any one of this material will result in a better sound transmission loss of sound barrier in low frequency.

Sound barriers can be applied to many field or situation. On a high-speed road or highway, sound barrier is built as long as there is a resident area nearby it. People may suffer from insomnia if there is no presence of the sound barrier. A noise barrier is an alternative method in abating noise sources from road, rail and industrial without using any source control (Indrianti et al., 2016). The barrier acts as a protective thick layer and prevents people getting damage by the sound effect. The only drawback for the sound barrier is the bulk size design. A sound barrier normally designed in thick and high pattern. This characteristic limited the available working area and also blocking the vision of observer towards the source of noise.

However, this bulk size defect has being used by Vallati et al. (2015) to develop a multitask sound barrier. This sound barrier is added on with a solar photovoltaic (PV) to become a photovoltaic sound barrier. This brilliant idea has to save a place for the need of extra space for installation of solar photovoltaic. The alternative installation of PV on sound barrier not only makes the sound barrier act as a noise attenuator and also an alternative energy supply system. There are still rooms for improvement on the sound barrier. Researchers can carry out further study on the material and structure of it, in order to have a better performance sound barrier.

2.2 Silencer

Silencer is the other pervasive sound control method that uses on sound reducing. The major different between sound barrier and silencer is the construction size. Silencer is much smaller and lighter compare to a bulky and thick layer of the sound barrier. A silencer could actually install the compressor, pump or another instrument while the sound barrier is to build around it. The development of silence eases the problem on the limited working area.

The working principle of a silencer is depending on the type of silencer. For a reactive muffler, the sound is reflected through the internal design of the silencer. The structure in it interference the sound wave pattern and when the sound wave reaches the atmosphere the sound level is reduced. For another type of muffler which is an absorptive silencer, it has better absorb sound energy compare to the reactive muffler. The differences in application between reactive and absorptive silencer are reactive silencer is used on a low-frequency acoustic and small exhausts outlets. Comparatively, the dissipative silencer is more effective in mitigating sound with high frequency or large exhausts outlets (David and Colin, 2003).

A silencer is usually installed on car exhaust system, noisy equipment such as duct of an air conditional. The light weight and ease of installation make silencer become one of the favorite on people choice. The best example for a silencer is the automotive muffler. The automotive muffler can divides into two main types which are reactive and absorptive. Both types of mufflers attenuate the sound level produced from the source by using the phenomenon of destructive interference (Potente and Daniel, 2005). A reactive muffler is designed to alleviate acoustic in a certain frequency. The distinguishing feature of reactive is the inlet and outlet tubes are in offset and are perforated. Acoustic will scatter out in multi directions and cause destructive interference in the expansion chamber (Potente and Daniel, 2005). Figure 2.1 shows the sample of reactive automotive muffler.