



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**SOUND ABSORPTION PERFORMANCE OF ACRYLIC BASED
PERFORATED PANEL**

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

by

MUHAMMAD AFIQ BIN ARSAT

B071210395

900625-04-5107

FACULTY OF ENGINEERING TECHNOLOGY
2015

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **Sound Absorption Performance of Acrylic Based Perforated Panel**

SESI PENGAJIAN: **2015/16 Semester 2**

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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 Engineering Technology (Type your department's name here) (Hons.). The member of the supervisory is as follow:

.....
(Ahmad Yusuf Bin Ismail)

ABSTRACT

The use of synthetic materials as acoustics absorbers is currently still widely applied in industry. These materials, in fact not only cause pollution to environment but also contribute to human health problem. This project presents a solution to find sustainable and eco-friendly materials to be an alternative sound absorber by using perforated acrylic plate as sound absorber materials. The perforated acrylic plate is fabricated and its effectiveness is determined through experiment based on ISO 10534-2 Standard. Data collected is analyzed to achieve the objectives on comparing the effectiveness in absorbing the sound energy. The result shows that the acrylic perforated panel with different size of holes gives different absorption performance in reducing sound energy. Generally, the plates are effective for reducing noise at 1500-3500Hz frequency range.

ABSTRAK

Penggunaan bahan-bahan sintetik penyerap akustik masih digunakan secara menyeluruh dalam industri. Bahan-bahan ini bukan sahaja menyebabkan pencemaran alam, tetapi meyumbang juga kepada masalah kesihatan manusia. Projek ini membentangkan cara untuk mencari bahan-bahan yang mampan dan mesra alam untuk menjadi penyerap bunyi dan menggunakan plat akrilik berlubang sebagai bahan penyerap akustik. Satu panel berlubang penyerap bunyi daripada plat akrilik difabrikasi dan diuji keberkesanannya melalui eksperimen berdasarkan ISO 10534-2. Data yang dikumpulkan dianalisis bagi mencapai objektif sebagai panel penyerap bunyi. Berdasarkan keputusan menunjukkan akrilik yang berbeza saiz memberi perbezaan keupayaan didalam mengurangkan tenaga bunyi. Secara keseluruhannya, panel ini amat efektif untuk mengurangkan bunyi di frekuensi antara 1500-3500Hz.

DEDICATIONS

To my beloved family,

My supervisor,

And to all my friends,

Thanks for all support and ideas.

ACKNOWLEDGMENTS

First I would like to express my gratitude to my supervisor, Mr. Ahmad Yusuf Bin Ismail whose expertise, understanding and patience to my graduate experience. I appreciate his valuable guidance and advice in many areas of knowledge and skill, and his assistance in writing reports, which increase my knowledge and confidence level.

I would also like to thank my family members for the sacrifices they provided me through my entire life. Lastly, I would like to thank and give my appreciation to all my friends and for those who are involved directly or not in completing this project.

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LIST OF SYMBOLS AND ABBREVIATIONS

MPP	=	Micro-Perforated Panel
DLMPP	=	Double Leaf Micro Perforated Panel
UTeM	=	Universiti Teknikal Malaysia Melaka
Mm	=	millimetre
Hz	=	Hertz
mA	=	milliampere
°C	=	Degree Celcius
PMMA	=	Poly (methyl methacrylate)

CHAPTER 1

INTRODUCTION

1.1 Noise

Sound that is undesired or too loud is called noise. Noise could result in damage of ear drum and hearing loss which can be from occupational or non-occupational sources. Noise not only could result in hearing problem but also disturb human health, sleeping disorder, cardiovascular problem and cause trouble to communicating due to the high level noise. The effect of noise on human health has been observed for many years ago. Industrial worker were the most exposed to high noise level in their workplace. An example of operations and equipment that produce noise in industry are crushing, riveting, quarries and mines, foundries, electric furnaces, drop forges, drilling, lathes, pneumatic equipment, tumbling barrels, plasma jets, cutting torches, sandblasting, punch presses, boiler making and milling machines.

There are two main sources of noise that is outdoor noise and indoor noise. Outdoor noise mainly caused by vehicle, transportation, trains and aircraft. Outdoor noise is also known as environmental noise. Lack of proper planning could result in noise pollution. Industrial building that is near the residential building could cause noise pollution to the resident nearby. Indoor noise mainly cause by machine and daily activities in the building. Exposure from noise for a long period of time will result in health problem.

1.2 Noise Control Strategies

Noise control strategies involve a combination of sound absorption and transmission loss of sound energy. There is a similarity between sound absorption and transmission loss such as the material use to control the sound energy.

1.2.1 Sound Absorption

Sound absorption is a process where sound wave strikes a material and the sound wave will be reflected by the material and some of the sound wave is absorb by the material. The sound wave energy that is absorbed by the material is transform into heat and transmits through the material. The energy which is absorb by the material is also known as energy loss. An example of sound absorption is soundproof. The objective of soundproof is to absorb sound energy which strike the wall as much as possible and transform the energy into heat. Sound absorption also works to reduce noise and to improve the surrounding sound. The amount of sound energy absorb by the material is based on the properties of the material itself. Soft material usually is the best sound absorber than hard material such as metal.

1.2.2 Sound Transmission

Sound transmission is also known as transmission loss. Transmission loss is a process which the objective is to increase the amount of sound energy as much as possible. Muffler is a good example of transmission loss. The function of the muffler is to increase the transmission loss in the system. The muffler is in good performance when the transmission loss of the muffler is higher.

1.3 Hybrid Material as Absorption Material

Hybrid material is a composite which is a combination between inorganic and organic compound at nanometer or molecular level. Combination between inorganic and organic will produce new material which is also called hybrid material. Hybrid material properties are far better than non composite material.

Nowadays, there are many commercial products that work as sound absorption material. Some of this product could come from hybrid material. Home interior usually use fabrics to work as noise absorption. Carpets can reduce echoing in the

house and carpets also can improve sound environment. Another product that works as sound absorption is acoustical tiling. Acoustical tiling is a commercial product that is design to function as noise absorption material. Acoustical tiling usually use for small area such as house, room and office. Larger areas which need some work on the sound absorption usually use acoustical panelling. The function for both products is still the same. Another product that is already being commercial and work as sound absorption material is noise absorption foam and noise absorption padding.

1.4 Problem Statement

During 1970s, the public is concern about health because during that time asbestos is used as sound absorbing material. The used of asbestos during that time affecting human health. Due to this problem, asbestos material is change to synthetic material which is much safer for human health (P.Arenas and J.Crocker, 2010).

Most of commercial panel absorber nowadays is made from synthetic material that is not really suitable for human body and environments anymore. Global warming caused by emission of greenhouse gases into the atmosphere by industrial manufacture could have change the acoustical material market. Research on acoustical material based on material which is safe, renewable could be use as alternative to the synthetic material.

In this project, the idea to use green alternative absorber which is perforated panel as acoustic absorber to reduce sound absorption problem.

1.5 Objectives

Objective of the project:

- i. To fabricate hybrid acrylic based perforated panel absorber.
- ii. To test sound absorption performance of acrylic based perforated panel.

1.6 Scopes

The scope of the project:

- i. Fabricating perforated panel using commercial acrylic.
- ii. Testing the sound absorption performance of acrylic based perforated panel with different hole diameter using impedance tube method ISO 10534-2.

CHAPTER 2

LITERATURE REVIEW

2.1 Sound Absorption

The conservation law of energy states that energy cannot be created and cannot be destroyed. Energy can only change from one form to another form. Excess of sound energy cannot destroy itself but the energy will be transformed into another form which could be harmful. Sound absorbing material will be used to absorb the excess sound energy. There are three types of sound absorbers which are porous absorbers, panel absorbers, and volume or resonance absorbers. Porous absorbers are mainly used for high frequency while panel absorbers and resonance absorbers are mainly used for low frequency. Figure 2.1 shows when sound energy travels in the air, small energy loss which is called heat loss E . When the sound energy hits the wall, some of the energy is reflected due to the acoustical material. Some of the sound energy manages to penetrate the acoustical material and due to the friction in the acoustical material, heat loss F also occurs in the acoustical material. When the energy hits another material some of the energy is reflected B and during the process heat loss also occurs H . The energy that manages to penetrate the material is getting weaker and more heat loss G occurs to the energy. When the energy manages to escape to the air D there is also energy that is reflected C and during this process more heat loss occurs to the energy I, J, K (F. Alton and C. Pohlmann, 2009).

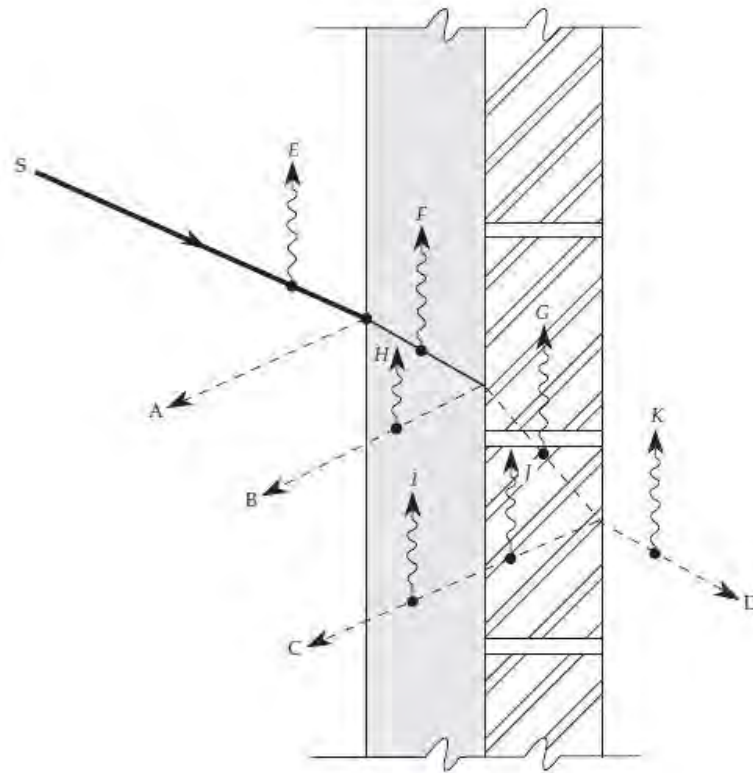


Figure 2.1: Sound energy strikes on the acoustical material then undergoes reflection from different surfaces and absorption from different material (F.Alton and C.Pohlmann, 2009).

Sound absorption material should always be used in a closed space such as room because it will improve the effectiveness of the sound absorption material. The used of sound absorbing material has increase for more than 50 years. This is due to the public concern about noise which interrupts their daily activities. Architects and acoustical engineer together has improve the sound absorbing material which is not only focus on the function of the absorbing material but also colours, shapes, sizes, light reflectivity, fire ratings and method on how to attach the sound absorbing material (P.Arenas and J.Crocker, 2010).

2.1.1 Porous Absorbers

Sound absorbing materials absorb sound energy that hits the material and reflect some of the energy to the air. Sound absorbing material is useful to control noise. There are many types of sound absorbing materials nowadays. Each and every of the sound absorbing materials provide different sound absorption properties depends on the frequency, composition, thickness, surface finish, and method to attach the material. It is found that materials that have high value of sound absorption coefficient are usually porous. Porous absorbing materials is one of the sound absorption materials which contain cavities, channels or gap that is function for the sound energy to enter through them. Figure 2.2 shows the schematic cross section of porous solid material. Closed pores are isolated from the outside but closed pores have effect on macroscopic properties of the material such as mechanical strength, thermal conductivity and bulk density. The only disadvantage of closed pores is less efficient in absorbing the sound energy than open pores. Open pores have a continuous channel through all the material which is good for absorption of sound. Open pores can also be blind or through (P.Arenas and J.Crocker, 2010).

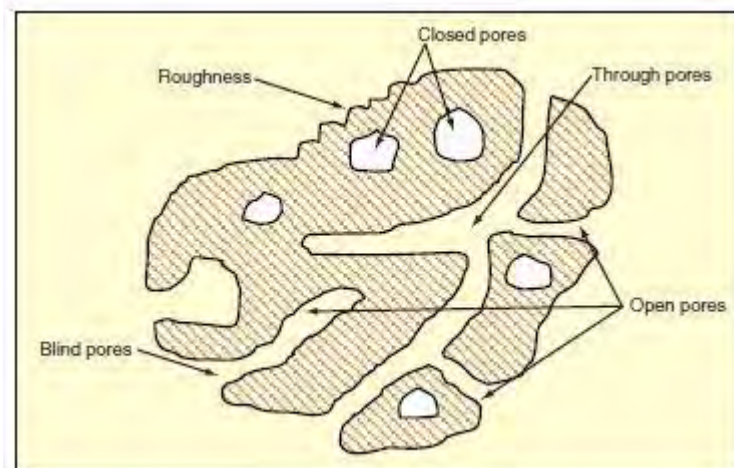


Figure 2.2: Schematic cross section of porous solid material (P.Arenas and J.Crocker, 2010)

Glass fiber is one of porous material which is good for sound absorption and heat insulator. Glass fiber can also be use for sound transmission. The transmission loss for porous material is directly proportional to the thickness travel of the sound energy (F.Alton and C.Pohlmann, 2009).

2.1.2 Volume / Resonance Absorbers

Based on a study by A.Sanada and N.Tanaka, (2012), extension of the frequency range of resonant sound absorbers using two degree of freedom Helmholtz based resonators with a flexible panel. The purpose of this study is to improve Helmholtz resonators for a wide range of frequency by using two degree of freedom Helmholtz based resonators. Result from this study shows that to increase the range of the frequency the panel should be lightweight and opening ratio and internal damping should be large.

2.1.3 Panel Absorbers

Panel absorbers generally used to absorb sound energy at low frequency. M.Toyoda et.al., (2011), study about effect of a honeycomb on the sound absorption characteristics of panel type absorbers. Sound absorption performance can improve when honeycomb structure are put at the back of porous layer. The thickness of the honeycomb on the panel absorbers also gives an effect on the sound absorption performance. Result shows that the thickness of the honeycomb should be carefully adjust so it can improve sound absorption performance and characteristics. Figure 2.3 shows the structure of honeycomb.