



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**SOUND ABSORPTION PERFORMANCE OF A ACRYLIC-BASED
MICRO PERFORATED PANEL**

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

by

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DECLARATION

I hereby, declared this report entitled “Sound Absorption Performance of a Acrylic-Based Micro perforated Panel” 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 Engineering Technology (Bachelor's Degree of Mechanical Engineering Technology (Maintenance Technology)) (Hons.). The member of the supervisory is as follow:

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ABSTRAK

Penggunaan bahan-bahan sintetik penyerap akustik masih digunakan dalam industri. Bahan-bahan ini bukan sahaja memberikan kesan kepada kesihatan manusia, tetapi juga menyumbang kepada pencemaran alam sekitar. Kajian ini membentangkan penyelesaian menggunakan papan akrilik sebagai alternatif untuk penyerap bunyi yang mampan dan mesra alam. Satu panel dari papan akrilik di fabrikasi dan keberkesanannya diuji melalui kaedah ISO 10534-2. Kaedah ISO 10534-2 adalah kaedah yang menggunakan tiub impedance, mikrofon dan perisian. Data yang dikumpulkan dianalisis bagi mencapai objektif berdasarkan keberkesanan dalam menyerap bunyi. Analisis menunjukkan papan akrilik dengan saiz lubang 0.5 mm adalah lebih efektif untuk mengurangkan bunyi pada kadar 2000-3000 Hz.

ABSTRACT

The use of synthetic materials as acoustic absorbers was currently still widely applied in industry. These materials, not only cause to human health but also contribute to the environment pollution. This study presents a solution by using acrylic plate as an alternative of sound absorbers for sustainable and eco-friendly materials. Micro perforated acrylic plate is fabricated and its effectiveness was determined through experiment based on ISO 10534-2 standard. ISO 10534-2 was the standard that used impedance tube, microphones and software. Collected data was analyzed to achieve the objectives on comparing the effectiveness in sound absorbing. The result shows the micro perforated acrylic plate with 0.5 mm perforations are effective for reducing sound at 2000-3000 Hz frequency range.

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DEDICATION

This project is lovingly dedicated to my beloved parents, family, my supervisor, Mr Ahmad Yusuf Bin Ismail, and to all my friends for the support during the completion this project. This project also dedicated to my beloved team mates in Final Year Project which give me a full support and suggestion to complete this project

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

ISO	-	International Standard for Organization
dB	-	Decibel
MPP	-	Micro perforated panel
DLMPP	-	Double leaf micro perforated panel
ASHRAE		American Society of Heating, Refrigerating, and Air Conditioning Engineers
α	-	Coefficient
%	-	Percentage

CHAPTER 1

INTRODUCTION

1.1 Noise

In general, noise can be explained in much type of definitions. Noise can be defined as unwanted sound that can affect to the environment and comfortable things. In terms of health noise can be explained that something that can be effect on harmful of health. Moreover, noise also can be effect on industrial equipment that can reduce the life span of equipment (Ropus et al., 2013).According to Etmaca et al., (2005) noise can be stated as an unpleasant sound that can be effect on the human in terms of physically and physiologically. Besides that, noise also can be destroyed the environmental properties and directly can make the environmental pollution. Noises that are happened are come from many types of sources. It also can be existed in many types of sources like road traffic noise, air craft noise, construction noise, industrial noise and many more. The activities that are existed in this type can produce a high volume of noise that was generated from machines, movement of traffic, and many more (Sutter, 1991). The exposure by noise through the years can make the human face with health problems like hearing impairment. It can be effect if the noises are occurs at 80dB or greater. In addition, it also can effect on the health such that cardiovascular disturbances. Exposure by noise can make the blood pressure and heart rate increase. Thus produce the permanent effect to the health (WHO, 1991). Other than that, another effect that are generating from noises are disturbances in mental health, sleep disturbances, interference with spoken communication and other.

Many types of noise absorption are produced by using the types of materials such as wood wool and rock wool in order prevent noise pollutant. In terms of noise absorption it can be said that it can reduce the volume and rate of the noise. In terms of health, the materials like wood wool and rock wool can effect on the health. Based on the U.S Department of Health and Human Services, (2002)said that the application of the materials like rock wool can be affected on the health such as acute irritation on skin, effect on eyes and upper respiratory tract. In this study, perforated panel are chosen as a materials that will use to absorb the noise. Maa (1974) in his study about theory and designing of micro perforated panel construction found that the micro perforated plate can change the levels of absorption into 20% from the ordinary process. Moreover, perforated plate is selected because it did not give an effect to the health.

1.2 Noise Propagation

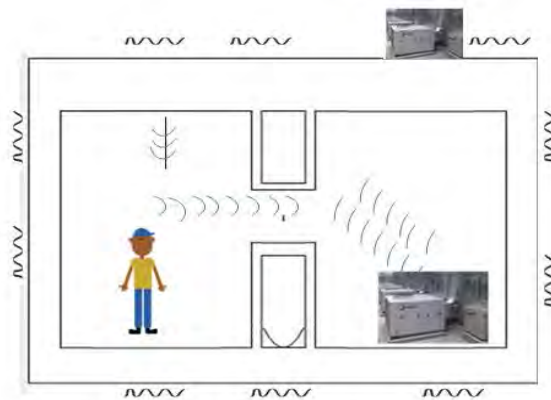


Figure 1.1: Illustration of airborne and structure borne noise

Figure 1.1 shows the typical environment noise pollutant in daily life. The noise exist from many types sources like human activities, machine operation and

vehicle or transportation. In this figure, it has two types of typical environment that generated noise that are airborne and structure noise. Airborne noise is the sources of noise that propagates through air. In this figure, the airborne noises are come from aircraft, the voice from playground and also exist from the operation of plant room. Other than that, the others are structure bone noise. Structure borne noise is the noise that propagates through structure of the buildings. In this figure, the source of noise that propagates through the structure borne is come from rain that hit the wall. The others sources are from plant room operation that the noise will flow through the ducting. The flowing noise will separated to structure of the building and produce the noise pollutant. In addition, the noise also generated from the plumbing system. It also similar with the plant room that flow the noise through the ducting before separated to the structure. The water flows inside the plumbing are in high pressure to move the water. From the operation, it will produce the noise before separated through the structure.

1.3 Noise Control Strategies

In order to prevent the effect from noise, there lots of ways are developed. The main objective is to ensure the environment always secure and protected from the effect of noise. Among the strategies that are developed to control the noise pollutant is by using absorption and transmission method. These strategies of absorption method are by applying the materials that have ability to absorb the noise frequency that are produced by the plant operation or other equipment. The ability of these absorption are depended on the materials that are selected such synthetic materials, hybrid materials and natural materials such as paddy straw and coconut fiber. Besides that, the efficiency of the absorbing also depends on the design of the materials that are chosen. It depends on the design whether as perforated or micro perforated because the volumes of noise absorption are very different for all the types of materials and design. According to Zulkifli et al., (2008) on their research about

the sound absorption, by applying the coir fiber stated that the materials also have a high coefficient in terms of noise absorption. It is proved that the ability of noise absorption also relies on the types of materials that are chosen. Besides that, the performance of the absorption also depends on materials design. Materials that are designed with micro perforated have a high coefficient to absorb the noise. This is proved by Xu et al., (2014) in their study that by using the micro perforated design will increase the coefficient of noise absorption. The materials with the micro perforation have the high ability to absorb the noise. In the other words decreasing of perforations rate will be affected on increasing of rate of absorption. The two aspects that are discussed will be the important aspect for the absorption.

The other method is called the transmission loss. Transmission loss can be defined as an ability of barriers to throughout the noise. The purpose of barriers or walls is to handle the noise from the sources and after that it can secure the interior side from outside noise. The ability of the barriers or wall to handle the noise is called the transmission loss. In more specific, transmission loss can be defined as a difference between the noise level from the source side and receiver side (Everest, 2009). As an example, the source of noise is higher and after the noise through the walls or barriers that has a good insulation, the noise level will be decrease to the some level that are lower from the actual.

1.4 Hybrid Materials as an Absorption Mechanism

The combination between organic and inorganic compound at the nanometer or molecular level will produce the new materials that are called as hybrid materials. Comparison between the hybrid materials with the non-composite materials stated that the hybrid materials are better than the composite materials. There a lot of materials that is used as noise absorption today and hybrid materials are one type of materials that are used. The examples of noise absorption that are develop from the

hybrid materials is carpets. It will be function to reduce the echoing of the noise and also can improve the sound environment.

The other products from the hybrid materials that are used absorption are acoustical tiling. The function of the acoustical tiling is to reduce the noise. The application of acoustical tiling is limited because it usually can be install for the small area such as house, room and office. For the larger area, the work of absorption will be done by acoustical paneling. The function for the both is still the same, the different is depends based on the area of the installation.

1.5 Problem Statement

Noise absorption has been developed in a long time ago. The purpose of the developing noise absorption is to control the noise pollutant that can be effect to the all living systems. It can be affected to the industrial equipment that is can be reduced the life span of machineries and others. Indirectly, it also can be affected to the production system in term of financial. The important reason why noise absorption has been developed is to protect the users or humans from effects that are generated from noise pollutant.

The important reason that needs to understand about the noise absorption development is the efficiency and the effect that are produce from materials that are selected. Lot of various materials has been used in the process to develop noise absorption. Type of materials that are used to develop noise absorption can be from synthetic materials, natural fiber materials, and hybrid materials. Example of natural fiber materials such as coconut fiber and paddy straw while for hybrid materials is acrylic plate.

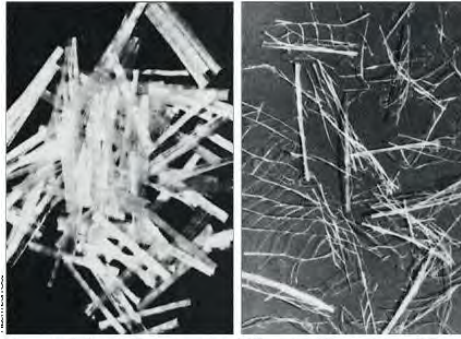


Figure 1.2: Synthetic fibers (Laning, 1992)

Figure 1.2 shows the type of materials that are used to develop the noise absorption. Synthetic materials are like fiber glass, glass door, and rock wool. Most of noise absorption that are used in industrial today are using synthetic materials like wood wool and rock wool that can be effect on human health, environments and not economically. Based on the U.S Department of Health and Human Services in Technical Briefing Paper about Health Effects from Exposure to Fibrous Glass, Rock Wool or Slag Wool in 14 June 2012 state that the synthetic materials can be effect to health human health like irritation of skin, eyes, and upper respiratory tract. For the long term effect, it also can develop the lung scaring and cancer. This is because synthetic materials can release the fiber before it carried out by air and at the same time inhalation process are existed by human. Inhalation process by human can cause the fiber from the materials and retain in respiratory tract that can effected to the human health.

In this study, the idea is to use the acrylic plate as a green alternative absorbers that will be used to absorb the noise with the micro perforated panel design. There a few things that will cover in this experiment, there are about the performance of acrylic plate as hybrid materials in term of noise absorption performance and at the same time as a materials that cannot give high effect to the human health. The first experiment about micro perforated panel state that the levels of noise absorption can be change into 20% from the ordinary process (Maa, 1975). The effective of the

micro perforated panels also discuss by Pfretzschner (2006). The experiment state that noise performance also depends on the submillimetric thickness. Moreover, it is seen as a material that can't give serious effect to the health. In terms of production, it can be reduce the cost production.

1.6 Objective

The objectives of the project:

- i. To design and fabricate micro perforated panel as a green acoustic absorber.
- ii. To test the micro perforated panel performance in term of absorption or transmission loss.

1.7 Scope

The scope of the project:

- i. Designing and fabricating the sample of micro perforated panel as a green noise absorber with the application of hybrid materials by using acrylic plate.
- ii. Testing the micro perforated panel using ISO 10534-2 method that are involve materials like pipe tube, noise sources and software in computer that are needed to record the data. The data will be analyzed to measure the performance of micro perforated panel in term of absorption loss.

CHAPTER 2

LITERATURE REVIEW

2.1 Noise Absorption

Noise absorption can be classified as are one type of noise control strategies. The strategies can be classified in two types. It is known as active and passive noise control. Active noise control can be defined as a modifying the sound field with electro acoustical approaches and for the passive noise control can be defined as a method that are modifying the environment that are close the noise sources in order to restrict the sound. The strategies to control the noise that are produced can be classified in several types. The types that are stated are absorption, reflection and transmission. Noise absorption can be said a method that are using to minimize the level of noise that are produced from the source.

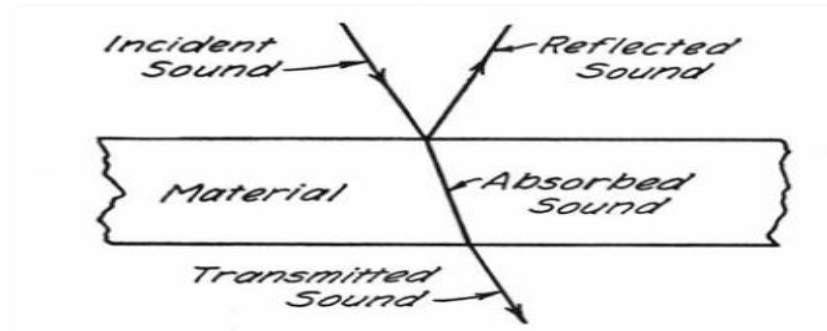


Figure 2.1: The process of absorbed, transmitted and reflected the noise by materials (Watson, 1927)

Figure 2.1 shows the process of noise control by the method of absorption, transmitted and reflected by some materials that are installed. For the absorption process, the noises that are through the materials will be absorbed and the level of frequency will reduce to the some level. After the action that is taken by the materials, the sound will be reflected to the others part into the lower frequency (Watson, 1927). For the transmission process, the noises that are generated from the source will be absorbed by materials. It will be eliminate as heat inside the wall and the others part of noise will be reflected to the sources or others part inside the room. The lastly the other noise will be transmit to receiver in term of low frequency. For all the process of noise control such as absorption and transmission are depends on the materials and the designs of the materials.

Commonly, most of materials will absorb the noise. The noise absorption method is by applying some materials such as synthetic materials, natural fiber materials and hybrid materials. The materials are installed must have ability to absorb or accept the noise level when it will install in the building, it will be function to do the process of absorption. The effectiveness of absorption is depends on several criteria. The criteria that are needs to emphasize are the type of materials that are selected and also about the design of materials. The designs of materials are discuss on how the materials are fabricate. The designs of materials that are provided are in term of perforation holes. The holes that are fabricate on the material such as perforated and micro perforated. The designs of the materials in holes fabricated will be effect on the quality of noise absorption.

2.1.1 Noise Absorption Coefficient

The effectiveness of noise absorption are measured based on the absorption coefficient, α . The coefficient of the absorption can be classified into several types. The types of coefficient that are means is noise absorption coefficient for a given angle of incident, statistical noise absorption coefficient, and also Sabine noise

absorption coefficient. For the noise absorption coefficient for a given angle of incident, it can be define as a ratio of noise energy absorption that are absorb by the surface and change to the noise energy incident at the given angle of the surface. For the statistical noise absorption coefficient, it can be define as a ratio of the noise energy absorption to the noise energy incident by the perfect area at the random angle. Lastly, for Sabine noise absorption coefficient, it can be define as a ratio of noise absorption energy to incident energy in echo room without or with absorption materials, (Rossing and Fletcher, 2004)

2.1.2 Measuring Noise Absorption Coefficient

The measuring of noise absorption coefficient that is discussed in this part is divided by two types that are measuring of noise in reverberation room and also in impedance tube. The purpose of measuring coefficient is to measure the ability of materials in terms of the level that materials can be absorbing the noise level. Generally, the measurement coefficient in the reverberation room is focus on the materials absorption inside the room that has noise pollutant and for the impedance tube measuring is more on the testing method to identify the level of noise absorption by the materials that are selected. For the impedance tube method, it has the special equipment or instrument that will be used to measure the level of noise absorption, (Rossing and Fletcher, 2004)

In specific, reverberation rooms have a reflector whether it is disorganized or irregular. The condition of the reflector will distribute back the noise energy with continually. Apart of that, the moving vanes from the machine inside the plant also act as contributor for the noise redistribute inside the reverberation room. The measurement of noise absorption in this room are depends on the area of absorption materials. If the areas of material that are apply is a large, then the absorption coefficient will be high and the noise pollutant can be control. Instead, if the areas of materials are too small, then the material is not effectiveness to absorb the noise