EFFECT OF FABRIC COVERS ON IMPROVING SOUND ABSORPTION

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This report is submitted in fulfillment of the requirement for the degree of Bachelor of Mechanical Engineering (Structure & Materials)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2017

DECLARATION

I declare that this project report entitled “Effect of fabric covers on improving sound absorption” is the result of my own work except as cited in the references

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Materials).

Signature :. ....

Name of Supervisor : ....

Date : ....

DEDICATION

This project is dedicated to my beloved mother and father, my supervisor, Associate Professor Dr. Azma Putra, and all my friends for the support during the completion this project.

ABSTRACT

Nowadays, the increasing request for quietness in building and auditoriums has inspired the use and development of the quality of sound absorption material. Textile material such as woven, nonwoven and knitted fabrics is one of the porous materials and has a great ability for sound absorption application. The researchers keep study about the absorptive materials using natural materials but not widely make the research about the acoustics textile. Fabrics usually used to cover the absorptive materials and sometimes using as a decoration but they do not know that each type of fabrics has their own acoustics characteristics. In order to expand the research about the characteristics of acoustics textile, three type of fabrics is used to become a fabric covers on the absorptive materials to find its effects on improving the sound absorption. The three types of fabrics are cotton fabric, plain fabric and satin fabric. This measurement of sound absorption coefficient is conducted by using the impedance tube according to ISO 10534-2. These three types of fabrics are put on the micro-perforated panel (MPP) and three types of natural fibers. The application of air gap enhances the sound absorption coefficient and shifted the peak to the lower frequency region. MPP with the satin fabric cover showed a good sound absorption performance compare with cotton and plain fabric. For the natural fiber, sound absorption performance of coir fiber increased drastically and showed a good absorption performance when put the fabric cover on it where the sound absorption coefficient achieved 0.5 and above in average frequency above 2500 Hz.

ABSTRAK

Pada masa kini,permintaan yang semakin meningkat untuk ketenangan di dalam bangunan dan auditorium telah memberi aspirasi kepada penggunaan dan pembangunan kualiti bahan yang menyerap bunyi. Bahan tekstil seperti tenunan, bukan tenunan dan kain rajutan adalah salah satu daripada bahan-bahan berliang dan mempunyai keupayaan yang besar untuk aplikasi penyerapan bunyi. Para penyelidik tetap meneruskan kajian tentang bahan-bahan penyerapan dengan menggunakan bahan-bahan semula jadi tetapi tidak banyak membuat penyelidikan mengenai tekstil akustik. Fabrik biasanya digunakan untuk menutup bahan-bahan penyerapan dan kadang-kadang ia juga digunakan sebagai hiasan tetapi mereka tidak tahu bahawa setiap jenis fabrik mempunyai ciri-ciri akustik yang tersendiri. Dalam usaha untuk mengembangkan penyelidikan tentang ciri-ciri akustik tekstil, tiga jenis kain digunakan untuk menjadi kain yang meliputi pada bahan-bahan penyerapan untuk mencari kesannya dalam meningkatkan penyerapan bunyi. Tiga jenis kain tersebut adalah kain kapas, kain plain dan kain satin. Pengukuran untuk mengukur pnyerapan bunyi dilakukan dengan menggunakan tiub galangan mengikut standard ISO 10534-2. Ketiga-tiga jenis fabrik ini diletakkan pada panel mikro berlubang (MPP) dan tiga jenis gentian asli. Penggunaan ruang udara di dalam tiub tersebut dapat meningkatkan pekali penyerapan bunyi dan mengalihkan puncak ke bahagian frekuensi yang lebih rendah. MPP dengan penutup kain satin mennjukkan prestasi penyerapan bunyi yang baik berbanding dengan kain kapas dan kain plain. Untuk serat semula jadi, prestasi penyerapan serat sabut meningkat secara mendadak dan menunjukkan prestasi yang baik apabila lapisan penutup kain di atasnya di mana pekali penyerapan bunyi mencapai 0.5 dan ke atas dalam kekerapan purata frekuensi di atas 2500 Hz.

ACKNOWLEDGEMENT

First and foremost, I would like to express my gratitude to my supervisor, Associate Professor Dr. Azma Putra whose expertise, understanding and patience in helping me to do the final year project with him. Thanks also to him because never give up on giving me guidance and advices during the process of completing my final year project. Without the guidance, this report may not complete on the time given.

I would like to thank to a few master student, Or Khai Hee, Lim Kah Hei, Nur Fazlin, and Lim Zhi Ying for spending some their time to helping me especially to conduct the experiment. They would like to share the knowledge about my project research about the acoustics. I also want to thank to laboratory assistant, En. Johardi for helping me use the acoustics laboratory.

Lastly, I want to thank my beloved parents for encourage me to complete the project. And my grateful to my friends for give me their support and also helping me during the experiment and completing the project.

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LIST OF ABBREVIATIONS

MPP	Micro Perforated Panel
GA	Geometrical Acoustic
RC	Reverberant Chamber
FFT	Fast Fourier Transform

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CHAPTER 1

INTRODUCTION

1.1 Background

Materials that reduce the energy of sound wave by the phenomenon of absorption are called sound absorptive materials. These materials are commonly used to reduce the amplitude of the reflected waves of sound. Nowadays, the increasing request for quietness in building and auditoriums has inspired the use and development of the quality of sound absorption material (Shahani et al., 2014). Among the acoustic absorptive materials, porous material is widely used and numerous achievements have been made in recent years (Xiang et al., 2013).

There are many types of porous materials which can usually classify as porous foam and fibrous medium (Ayub et al., 2011). These materials generally composed of porous synthetic materials such as glass wool, rock wool, polyester or polyurethane. Textile material such as nonwoven, woven and knitted fabrics also one of the porous materials and it has great ability for sound absorption application. Three categories can be can characterized in the acoustic properties of textiles which is absorption , propagation, and scattering and the properties can be expressed by flow resistance, transmission loss, absorption coefficient and scattering coefficient (Nayak, 2016).

The researchers keep study on progressing to reduce the usage of synthetics materials by replace it with natural material which more green and friendly to environment. Many research works have been done on finding the performance of sound absorption materials using the natural fibers. Some of the natural fibers that they use are coir fibers (Nor et al., 2010), oil palm fibers (Or et al., 2017), kenaf fibers (Ying et al., 2015, bamboo fibers (Koizumi et al., 2002), sugarcane fibers (Putra et al., 2013) and hemp fibers (Berardi and Iannace, 2015). These natural fibers have a great ability of sound absorption and can be applied for building or auditorium. Figure 1.1 shows the example of natural fibers.

Figure 1.1: The example of natural fibers (Berardi and Iannace, 2017).

This research discusses about the effect of the fabrics cover on the natural fibers in order to improve the sound absorption. Different type of fabrics is used to identify the best fabric material that can be used to apply on the fiber as well as can improve the sound absorption. The fabrics are placed at the front and the back of the natural fibers and then compared it with the fiber that not attached with fabrics. This experiment is conducted by using impedance tube with the proper standard ISO 10534-2:2001.

1.2 Problem Statement

Acoustic materials are widely known for its application for sound absorber especially for the sound quality in the building. Nowadays, natural fibers have been chosen to use as the sound absorptive materials in building or auditorium. For the auditorium, the fibers are applied on the wall of the building and at the same time the fibers needed to be covered. The fibers usually undergo some process to make it panel shape to make it easier to put on the wall. By doing this, the fiber panel needs to cover by using fabrics so that it may look nicer but had a greater ability of sound absorption.

The acoustic textiles are not often used in the industry because of the lack of the research about the acoustic textiles characteristics. Usually, the acoustic textile is used in the building such as hall or sound studio and can be used as a fabric wrapped panel. The fabrics also can be used as a cover for acoustical panels such as fiber panel because it has higher ability of sound absorption. The usage of the fabric also important to give a better quality of sounds absorption and also can be a decoration purposes. The type of the fabrics that can be used to cover the fiber panel is still lack in research. It is because each type of fabric has its own sound absorption characteristics that can affect the quality of sound in the building. For this research, three types of fabrics are choosing to expand the research about the acoustic textile to reduce noise in the building.

1.3 Objective

For this project, a few objectives can be determined as follows:

1. To measure the sound absorption coefficient by using different types of fabric covers on micro perforated panel (MPP).
2. To measure the sound absorption coefficient on three types of natural fibers by applying different types of fabric cover.

1.4 Scope of Project

This project focuses on the effects of fabric cover on improving the sound absorption. In this research, three type of fabric material is used which is Cotton (rough), Japanese Plain and Satin. The experiment is conducted on impedance tube by using micro perforated panel and three types of natural fiber, kenaf fiber, oil palm fiber and coir fiber. Other type of micro perforated panel material and fabric material are not covered in this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Sound Absorption Materials

Materials that reduce the energy of sound wave by the phenomenon of absorption are called sound absorptive materials (Kumar, 2011). Figure 2.1 shows the example of the phenomenon of sound absorption material. They are often used to moderate the acoustic environment of a closed volume by way of decreasing the amplitude of the reflected waves. Absorbing materials are usually resistive in nature, either porous, fibrous or reactive resonator (Bell et al., 1994). Mineral wools, fibrous glass and foams are the sample of resistive materials while the example of the resonator is such as sintered metal and hollow core blocks. A resonator is a passive standard for noise reduction by converting into a vibration. The resonator absorbs sound by making the vibration to produce heat loss due to the sound pressure differences (Liu and Hu, 2010). Most of the product material is provide some degree of absorption at the same frequencies and when the material thickness is increase, the performance at low frequencies also increase.

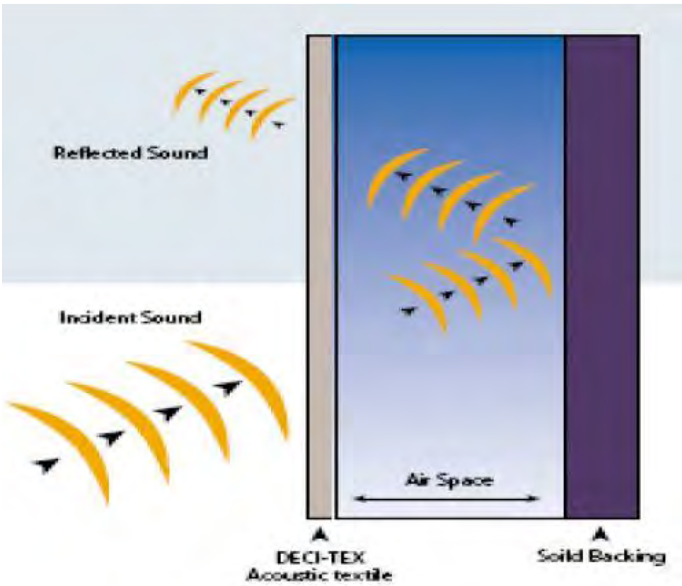


Figure 2.1: The example of the phenomenon of sound absorption material (Kumar, 2011)

Porous materials usually used as sound absorbers and it application are often assembled with a resistive layer. Chevillotte (2011) has stated that, the resistive layer can be used to increase acoustic properties of the porous material and usually it used for the protection or decoration. From this research, there are three type of numerical simulations that carried out which is influence of perforation diameter, influence of perforation rate and influence of downstream layer. Two multilayer textile + air and textile + glass wool are carried out in this experiment by using impedance tube. The results can be shows that the sound absorption selectivity is increasing when the perforation rate decreases. This is because the considered multilayer tends to act as a Helmholtz resonator. Figure 2.2 shows the example of multilayer made up of a downstream porous media and resistive layer.

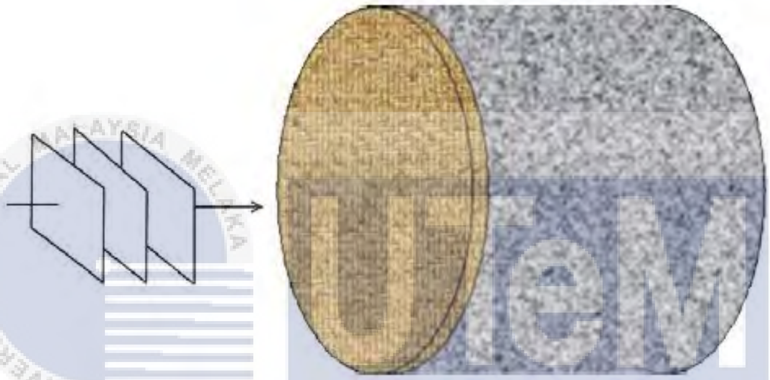


Figure 2.2: The example of multilayer made up of a downstream porous media and resistive layer (Chevillotte, 2011).

2.2 Sound Acoustics of Textile

Textiles are used in many application including the acoustics such as in automotive insulation, panels for workstations and halls. The used of textiles for noise reduction is based on two categorise which is low costs production and small specific gravity. Textiles materials have their own acoustics properties. Generally, acoustic materials are separated in two categories of porous sound absorbers which are (Kumar, 2011):

- Bulky, high loft textiles which basically act as rigid, porous sound absorber.
- Light weight, compact woven and nonwoven textiles that act as porous screen.

Textile materials is made up from fibres that can be either natural fibres or man-made. There are two types of fibres which are fibres of unlimited length that called filaments and fibres of much smaller length that called staple fibres (Sinclair, 2015). Normally, the filaments are combined and twisted to produce yarns while the staple fibres are rolled to create yarns. Yarns are usually woven or knitted into fabrics. A piece of fabric contains a huge number of fibres. Morton & Hearle (2008) stated that a small piece of fabric contain over 100 million fibres.

Fabric is the processed and assembled of the yarns. There are many ways by processing yarns to make a fabric such as woven, nonwoven and knitting. The fabrics processing in different way produces a variation in texture, appearance, drape as well as it performance characteristics such as strength and durability (Sinclair, 2015). In textile fibres, there are three types of fibre groups which are natural fibres, regenerated fibres and synthetic fibres. Regenerated and synthetic fibres are known as man-made (manufactured) fibres. Figure 2.3 shows that the variety type of textile fibres.

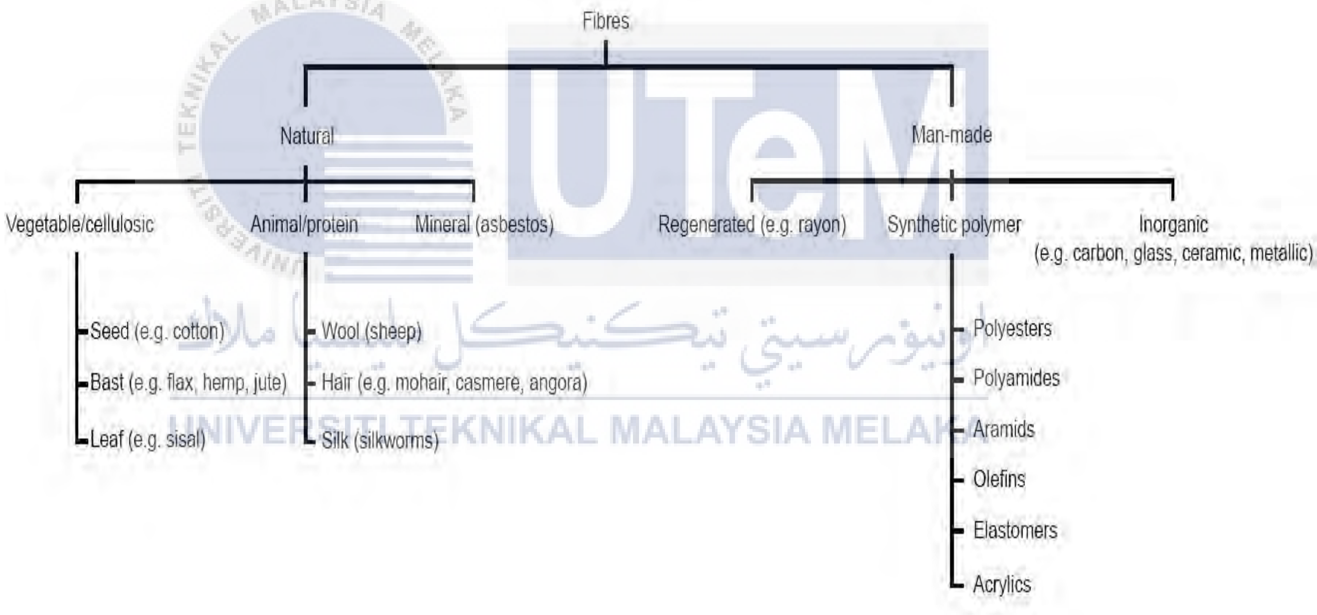


Figure 2.3: Types of textile fibres (Sinclair, 2015)

Natural fibres made of wool from sheep or cotton from the cotton plant while the regenerated fibres are made from natural polymers and it cannot use it in the form of original but can be regenerate to make fibres. For the synthetic fibres, it made of from polymerising that convert from smaller molecules into larger in an industrial process.

2.3 Sound Absorbing in Woven Fabrics

Woven fabrics can be used as a component of noise reduction assemblies made of textile materials and also as decorative cover of noise absorber that made of rock wool. Shoshani and Rosenhouse (1990) conduct the investigated about the relationship between the noise absorption coefficients of a cover made of woven fabric and its intrinsic parameters. The parameters considered were fibre content, yarn count, cover factor, air gap behind the fabric and the frequency of the impinging sound wave. There are 28 woven fabrics that conducted in the experiment varying with the parameters and the results shows that the intrinsic parameters of the woven fabric have a very little effect on absorption coefficient in the low frequency but has major impact at the highest frequency. Figure 2.4 shows the example of woven fabrics.

Figure 2.4: Example of woven fabrics (Raaz, 2014)

Nowadays, more and more building and hall are built that are both economical and environmentally friendly by using new materials and method. Lightweight constructions such as materials that made from textiles are needed in modern day constructions requirements (Baier, 2010). In the case study by Ricciardi and Lenti (2010), they conducted the analysis of acoustical performance of an auditorium in Italy, the historical S. Giorgio Palace in Genoa. The palace need to restoration but can only use woven materials for floor and curtains. Two different types of material which is carpet and felts were used in order to improve absorption at low frequencies in a multilayer system. Six sample of carpet were selected and has different for composition, thickness and mass per unit area.

Table 2.1 shows the description of the analysed sample of carpet. The results show that the absorption coefficient is increase with the frequency with 0.1 at 400 Hz up to 0.5 to 0.8 at 4200 Hz. The best sample among the six samples is the sample with made of 100% wool and having the highest thickness of 12 mm.

Table 2.1: The description of the analysed sample of carpet (Ricciardi and Lenti, 2010)

Test Sample	Composition	Total Thickness (mm)	Mass per unit area (g/m^2) of Fibre + Support	Colour
A	100% Wool	12	3934	Brown
B	100% Wool	8	2925	Dark Blue Plain
C	80% Wool 20% Polymide	14	2752	Brown & Green
D	80% Wool 20% Polymide	12	3809	Purple Veined
E	80% Wool 20% Polymide	10	3296	Ochre Plain
F	100% Polymide	12	2548	Electric Blue with Yellow Picture

Alonso and Martellotta (2015) investigated on how sound absorbing materials such as curtain which is hung freely in space can be analyse and modelled in geometrical acoustic (GA) software. This analysis is conducted in the scaled model measurement to replace with the real building room. The problem is to establishing the best way to model textile materials hung free in space. Four types of materials were use with different weight and thickness and were measured in reverberant chamber (RC). Figure 2.5 shows the detailed view of the different samples of textiles under investigation. Two samples were selected for the subsequent analysis after the measuring of all the materials in their acoustic properties including sound absorption, transmission coefficients and flow resistance. The GA software simulation was use to optimized the sound absorption coefficients in order to adjustment and matching of reverberation times. As the results show the measurement of absorption coefficient between the GA simulation and RC only showed small differences.

Figure 2.5: The detailed view of the different samples of textiles under investigation (Alonso and Martellotta, 2015).

2.4 Sound Absorbing in Nonwoven Fabrics

Porous materials such as nonwoven fibre are widely used as sound absorptive materials. By using nonwoven fabric as porous absorber, it is technically and economically one of the most extensive means among the variation techniques that used for the sound absorption (Moghaddam et al., 2015). According to Wang and Torng (2001), the sound absorption materials are widely used because of their fibrous structures due to the porosity, cost and low mass are capable of sound absorption. Compare to the woven and knitted fabric, nonwoven fabrics do not have an organized geometrical structure. Nonwoven fabrics are not easily recognized because they are commonly hidden even though it is used in various areas (Yilmaz and Deniz, 2009). There are some example of nonwoven application area such as in automotive, clothing, construction, home and healthcare.

The reduction of the sound insulation performance is generally due to the gaps, slits and openings for natural ventilation that usually occur around doors and windows. According to Shimizu and Koizumi (2015), by installing the nonwoven fabrics as a breathable material in the gaps, it can be improved the sound insulation performance and also improved the amount of ventilation as the total equivalent clearance area. In their study, they used the nonwoven fabrics as the sound absorbing materials so that it can maintain the air ventilation. Figure 2.6 shows the enlarged image of the nonwoven fabric. The measurement of the air permeability of the nonwoven fabrics through the gaps, the experiment was conducted by using the two chambers with the use of fan in order to varying the amount of ventilation. The sample is measured in differences of sound pressure level between the gaps and also in differences gap in height. The results can be seen that the sound insulation performance improves as the total equivalent area decreases. Even though the nonwoven fabrics have low flow resistivity and low sound absorbing performance, it can improved the sound leakage through gaps and be able to maintain the air ventilation by installing the nonwoven fabrics into the gap.

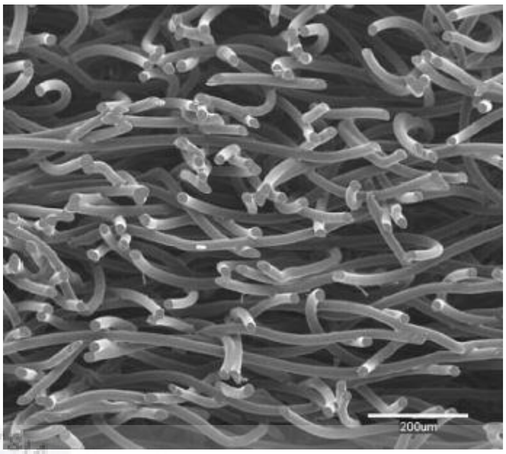


Figure 2.6: The enlarged image of the nonwoven fabric (Shimizu and Koizumi, 2015)

Shahani et al., 2014 studied about the acoustic characteristics of the structured needle punched nonwoven fabrics. This study focused in relation to fibre fineness, areal density, surface effect, punch density and chemical bonding process. The measurement of sound absorption was measured by using the impedance tube method and results shows the fabrics that produced from the finer fibres can absorb sound more effectively. While according to Moghaddam et al., (2015), Leafiran is one of the natural fibres that extracted from the Typha Australis plant that can be produced a nonwoven fabrics. Figure 2.7 shows the image of Typha fibres. This fibre was mixed with the polypropylene in order to produce nonwoven composite structure that can be used for determining the acoustics properties such as porosity, areal density and sound absorption coefficient. By the end of the test measurement, it shows that the Typha fibre have a good acoustics performance and can be used as sound reduction applications. So that, from both studied, the nonwoven fabrics are good materials for acoustics performance in sound absorption.

Figure 2.7: The image of Typha fibre (Moghaddam et al., 2015)

2.5 Factors of Fibre Size Affecting Sound Absorption

In the research by Young Joo et al., (2007), they used the micro fibre fabrics as a sound absorption material. In order to identify if the size can affected the sound absorption, they have tested the sound absorption coefficient of one regular fibre fabrics with the five micro fibre fabrics. The measurements were conducted by using reverberation room method. The results shows the micro fibre fabrics have higher sound absorption compare to the regular fibre fabrics that have same thickness or weight. This is because the structure of the micro fibre fabrics seems to be important for controlling sound absorption according to sound frequency.

A study from Koizumi et al., (2002), state that the sound absorption coefficient will increase with decreasing the size or diameter of the fibre. They used a natural resource which is bamboo fibre as the sound absorbing material. The diameters of the fibre are 90-125μm, 125-210v μm and 210-425 μm. Sound wave can move easily in thin fibre compare to the thick fibre (Puranik et al., 2014). Besides, to achieve more higher in air flow resistance, more fibres is needed to reach equal of the fibre that has same volume of density. This is due to the flow resistivity is inversely proportional to the squared fibre diameter (Qiu, 2016).

2.6 Application of Fabric Covers on Natural Fibers

Sound insulation is needed especially for the automobiles and equipment because they generating higher sound pressure drive the need to produce more efficient ways of producing sound absorption materials. Ersoy and Kucuk (2009) investigated the sound absorption of an industrial waste which processing a tea leaves. They use the tea leaves to make a fiber for the sound absorption. In their experiment, three different layers of tea leaf fiber waste materials with and without backing provided by a single layer of woven textile cloth were tested to find its sound absorption characteristics. From the experiment, it is shows that the sound absorption increase significantly when the lea leaf fiber is tested with the single layer of cotton cloth in backing position compares to the tea leaf fiber without backing. Figure 2.8 shows that the increasing of graph pattern on the tea leaf fiber with cotton cloth cover for with and without backing.

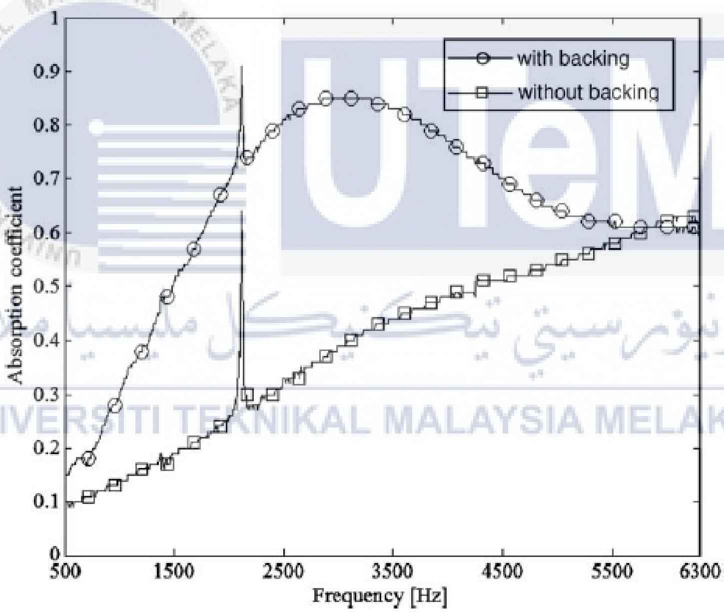


Figure 2.8: Sound absorption of tea leaf fiber with cotton cloth for with and without backing (Ersoy and Kucuk, 2009)

Another natural fiber that applied fabric cover is paddy fiber and luffa fiber. A study from Putra et al., (2013), state that the fibrous absorber needed to be cover by a layer for protection or decoration to avoid the fibrous absorber directly exposed to the sound. Polyester fabric was used and was attached on the surface of the sample on the front surface, back surface and both surface of the sample as shown in Figure 2.9. By covering the sample with the fabric improves the sound absorption at frequency range from 1.2 kHz to 3.2 kHz. If the sample only covered at the back surface, the sound absorption increase below frequency 3 kHz and this is same with the Ersoy and Kucuk (2009) research.

Figure 2.9: Paddy fiber attached with polyester fabric (Putra et al., 2013)

Koruk and Genc, (2015) investigated about the acoustic characterization of the luffa fiber and composite materials. From the Authors' knowledge, this research is the first paper for conducting the experiment of acoustics characteristics using bio luffa fiber because other researchers such as (Kocak et al., 2013) and (Demir et al., 2008) does not make a research about the acoustics characteristics of the bio luffa fiber. In their research, the luffa fiber sample without a matrix has shown a good result on sound absorption coefficient. When the luffa fiber is covered by a linen fabric, the sound absorption also increases. For their opinion, the linen also can be an acoustic design for hall that can also affect the quality of sound absorption. Figure 2.10 shows the luffa fiber with perforated linen.

Figure 2.10: Luffa fiber with a perforated linen (Koruk and Genc, 2015)

2.7 Parforated panel

Panel absorber is also known as Helmholtz absorber. This panel have important element such as stiffness, mass and frictional mechanism. Peters et al., (2011) stated that, the element in the panel absorber will be acting to convert the vibration energy into the heat. The vibration will be occurring at the resonance when the system is forced to vibrate that known as resonance frequency. There are two types of movement that can affected the absorption of the panel absorber which are first is the movement of air particles in Helmholtz resonator and second is the movement of materials inside the panel.

In the research by Zulkifli et al., (2010), they investigated the potential of using coir fiber as sound absorber. They also studied the effects of porous layer backing and perforated panel on sound absorption coefficient by using coir fiber. Figure 2.11 shows the sample used in this research. The results for the effects of perforated panel on the coir fiber shows that it can shift the absorption coefficient peak to lower frequency and the noise absorption coefficient decreased in high frequency. This shows that the perforated panel has the ability to reduce sound.

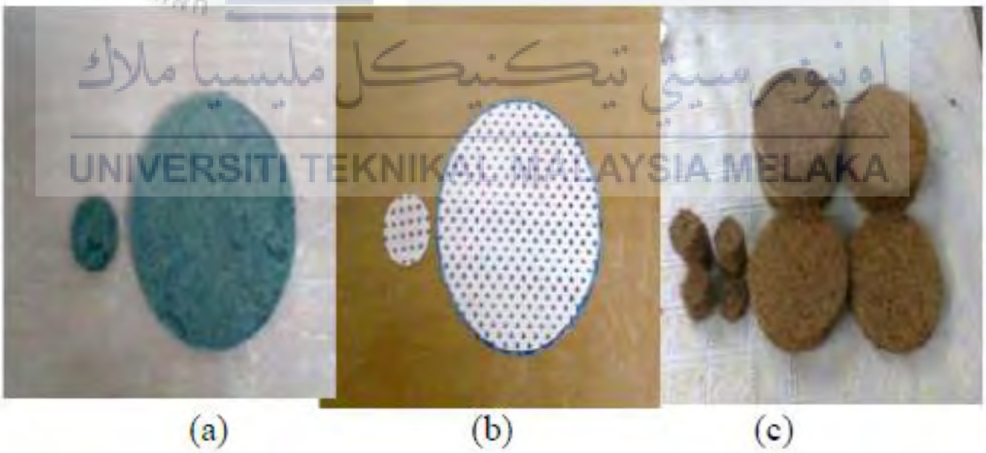


Figure 2.11: The test sample (a) porous layer, (b) perforated panel, (c) coir fiber (Zulkifli et al., 2010)

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the methodology used in this project to obtain results for sound absorption coefficient by applying fabric covers. The flow chart of the project is shown in Figure 3.1. The methodology is started by doing some research about the acoustic performance of selected materials as discussed it as a literature review. After the literature review, the next step is to select the absorptive materials that need to use in this project. Three types of fabrics are chosen which is cotton fabric, plain fabric and satin fabric. For the absorber materials, micro perforated panel and three other natural fiber which is coir fiber, kenaf fiber and oil palm fiber. The measurement of the sound absorption is done by using impedance tube and the result of the absorption coefficient is discussed whether it is good or not. If the result is not good, the measurement needed to do it again and after that proceed with the report writing if the result is accepted. This project starts by studying the software that is used to measure the sound coefficients which are Audacity and RT Pro Photon software. The study of the software is done to make sure the measurement data is accurate and valid.

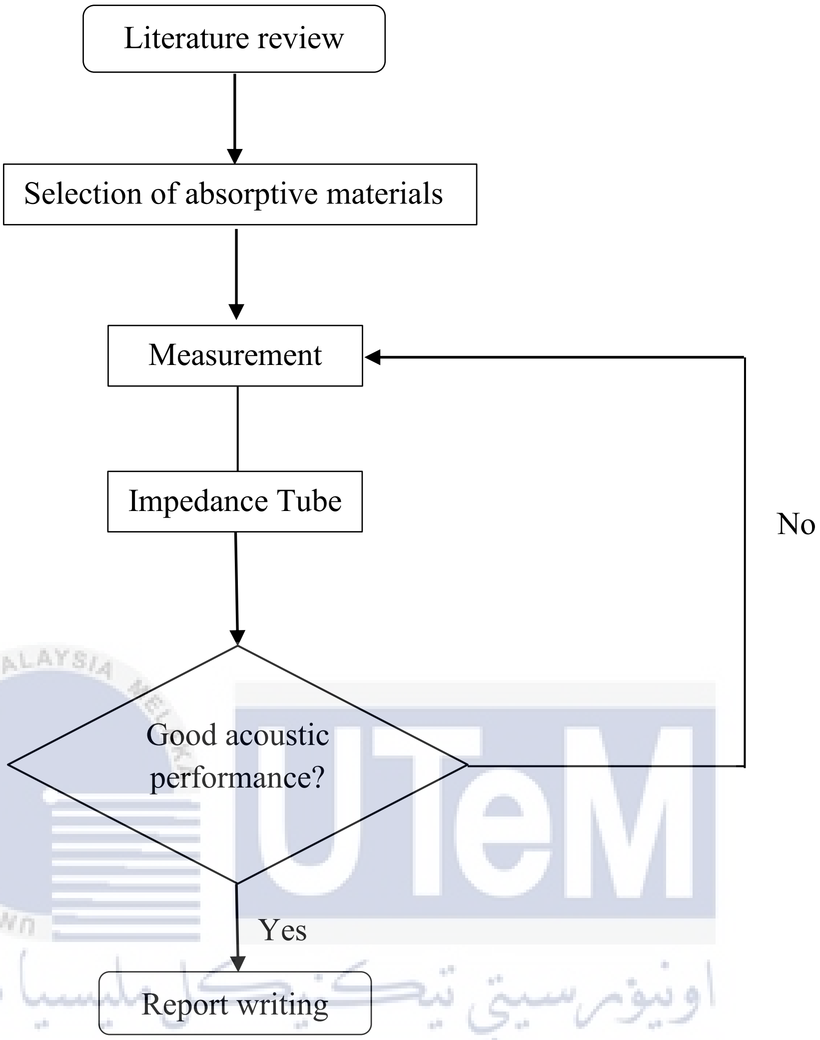


Figure 3.1: Flow chart of the methodology

3.2 Materials for panel absorber

For this research, a few types of materials for panel absorber are used to measure the sound absorption such as micro perforated panel (MPP) and natural fibers. The natural fiber that used in this measurement is coir fiber, kenaf fiber and oil palm fiber. In order to investigate the effectiveness of the fabric cover on improving the sound absorption, three types of fabrics is used which is Cotton fabric, Plain fabric, and Satin fabric.

3.2.1 Fabric covers

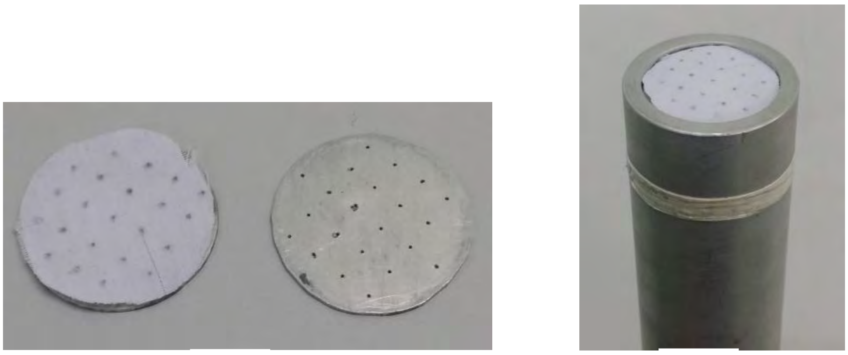
In this research, three types of fabric are used as a cover to the absorptive materials in order to find the sound absorption. Cotton fabric, plain fabric and satin fabric is used to become the cover for the sample use in the impedance tube. Figure 3.2 shows the type of fabric used. The fabric is cut into 33 mm diameter as the same diameter with the tube holder for each type to make it as a cover as shown in Figure 3.3.

Figure 3.2: Three type of fabrics from left cotton, plain and satin.

Figure 3.3: The fabrics are cut into circular shape with 33 mm diameter.

3.2.2 Micro perforated panel (MPP)

Micro perforated panel (MPP) is one of the sound absorptive materials that use in this research. The MPP use in this experiment has 0.5 of perforation ratio with 0.5 mm diameter hole. The measurement of the sound absorption is measured by combining the fabric cover with the MPP for two position of the fabric which is at front of the MPP and at the back of the MPP. The fabric cover needs to make hole with the same hole of the MPP before tested. Figure 3.4 shows the fabric covers on the MPP with the same holes.



(a) (b)

Figure 3.4: (a) Fabric cover with MPP, (b) The sample inside the tube holder

3.2.3 Natural fibers

Natural fibers that used in this research are kenaf fiber, oil palm fiber, and coir fiber. All the fibers has the same thickness which is 20 mm thickness except for the coir fiber, it has the other thicknesses which is 30 mm thickness. The fibers are covered with three types of fabrics at front and back of the fiber. Figure 3.5 shows the type of fiber used in this experiment.

Figure 3.5: (a) Coir fiber, (b) Kenaf fiber, (c) Oil Palm fiber

The fabric covers is put at front and back of the fiber and put it inside the tube holder as shown in Figure 3.6. The fabric needed to be closed together with the fiber so that the fabric does not fall when the air gap measurement is applied.

(a) (b)

Figure 3.6: (a) The position of the fabric covers, (b) The sample inside the tube holder

3.3 Measurement of Sound Absorption Coefficient

A few type of measurement method can be used to quantify the sound absorption behaviour of materials. The measurement method that used to measure the sound absorption properties of a materials are impedance tube, reverberation room and reflection methods (Takahashi et al., 2005). In this research, only one method is used to measure the sound absorption coefficient which is impedance tube method.

3.3.1 Impedance Tube

According to ISO 10534-2:2001, the measurement of sound absorption coefficient (α) was performed in an impedance tube by applying two microphone transfer function method. For this measurement of impedance tube, the type of acoustic microphone that is used is ½" Prepolarized free field microphone (40AE) and for pre-amplifier is used ½" CCP pre-amplifier (26CA). The microphone diameter must be less that 20% of the spacing between them. The microphone is used to measure the sound pressure level and temperature measurement inside the impedance tube. Test sample holder of the impedance tube is in separate unit which is tightly fixed to one end of the tube during the measurement. Amplifier and two-channel Fast Fourier Transform (FFT) analysing system is categories of signal processing system that required measuring the sound pressure at two microphones. The loudspeaker located at the opposite end of the tube from the test sample holder and must be contained in an insulating box to avoid airborne flanking transmission to the microphone. For this impedance tube, the reliable frequency range is between 500 Hz to 4.5 kHz with diameter of 33 mm (Putra et al., 2013). Figure 3.7 shows the impedance tube that used in this research.

Figure 3.7: Impedance tube

Two type of software is used to conduct the experiment which is Audacity and RT Pro Photon. Audacity program is an example of audio editor which can edit and record sound. For this research, audacity software is used to produce the white noise into the impedance tube. RT Pro Photon provides a comprehensive set of time and spectrum measurement tools for fast real time monitoring and analyse. Plane wave traveling in a duct is described as sound radiation in an impedance tube (Wolkesson, 2013). The impedance tube method is faster and reproducible that only required small circular sample. This method does not need to fabricate large sample with lateral dimensions several times the acoustical wavelength. The sound absorption coefficient can be determined by using two methods:

1. Two fixed microphone impedance tube which is broad band random signal is used as sound source. The sound absorption coefficient of the test materials can be measured faster and easier to compare.

2. Moveable microphone which is 1/3 octave frequencies method which based on standing wave ration. This method uses an audio frequency spectrometer to measure the sound absorption coefficient.

To obtain the sound absorption coefficient of the sample, MATLAB software is used by processes the recorded signals in the analyser in term of transfer function between the microphones. All the data are recorded in one-third octave band frequency.

3.4 Experimental Setup

This chapter describes the experimental setup for the measurement of sound absorption coefficient in impedance tube. All the method is explained according to the International Standard that suitable to conduct the experiment on impedance tube.

3.4.1 Experiment Setup for Impedance Tube

Figure 3.8 shows the initial experiment setup for sound absorption coefficient measurement by using impedance tube. The sample of the experiment is placed inside the sample holder tube which is connected with the speaker at the other end of the tube. The speaker is used to make white noise that generate from the Audacity software into the tube. Two acoustics microphone is assembled together with the preamplifier each and located in front of the sample to record the reflected sound from the materials and incident sound from the loudspeaker. Microphone 1 is connected to the channel 3 at the Photon+ while the microphone 2 is connected to the channel 1 at the Photon+. Calibrator is used to calibrate the acoustics microphone and determination of the acoustic centre of a microphone before the measurement is started and it usually performed with rigid termination of empty impedance tube. Software that used in this experiment is Audacity and RT Pro Photon analyser. This software was used as the data acquisition system.

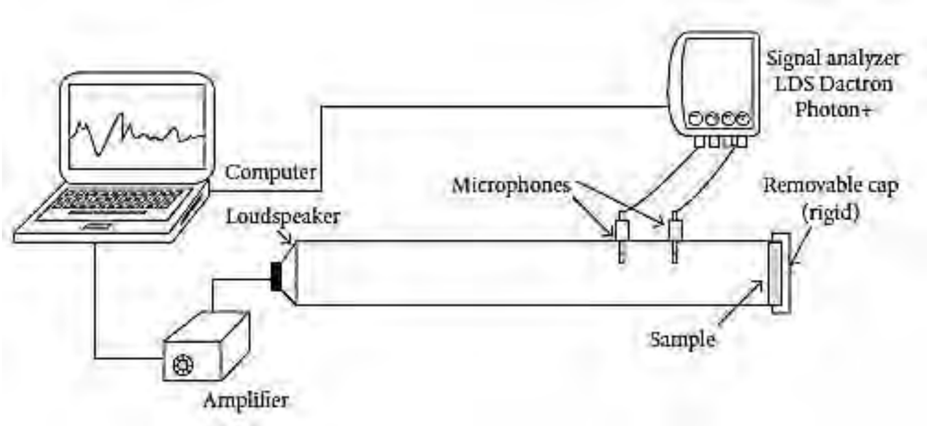


Figure 3.8: Diagram of the measurement setup in impedance tube (Putra et al., 2013)

The noise that generated from the loudspeaker using Audacity software is run for 10 minutes prior before start the measurement for the specimen to allow the temperature to stabilize inside the tube. After that, 1 minute is needed to measure the sound transfer by signal analyser using RT Pro Photon software. The frequency used by impedance tube range between 500 Hz to 4.5 kHz.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter describes the results of sound absorption coefficient of fabric cover on absorptive materials by using an impedance tube. The discussion of the results included the effects of different types of fabric covers on micro perforated panel and natural fibers. The type of fabric used is cotton fabric, plain fabric and satin fabric. The good acoustics performance is achieved when the sound absorption coefficient is more than 0.5. The results also discuss about the effect of air gap to the sound absorption coefficient for each experiment.

4.2 Measurement of sound absorption on fabrics and micro-perforated panel (MPP)

Figure 4.1 shows the position of the sample inside the tube holder before put it in impedance tube. The materials that use in the measurement are cotton fabric, aluminium micro-perforated panel (MPP), and combination of fabric and MPP. Two different positions that involved in the fabric-MPP combination is the position of the fabric which is at front of the MPP and at the back of the MPP. Figure 4.2 shows that the measurement of sound absorption coefficient, α using four type of different methods. For the measurement with 10 mm of air gap, the sound absorption coefficient for the fabric is lower which can be rise to 0.38 with increasing to the higher frequency compared to other sample. The pattern of the graph for the measurement of absorption coefficient using the MPP shows the same either using MPP only or combination of fabric-MPP. For the MPP sample, the peak absorption coefficient is 0.79 at the frequency 1400 Hz. When the fabric is placed at front of the MPP, the peak of absorption coefficient is 0.77 at the frequency 1500 Hz. The peak is shifted to the right and gain higher frequency compared to MPP. While for the

MPP with the fabric at the back shows the peak absorption coefficient of 0.78 at the frequency 1400 Hz and shifted to the lower frequency.

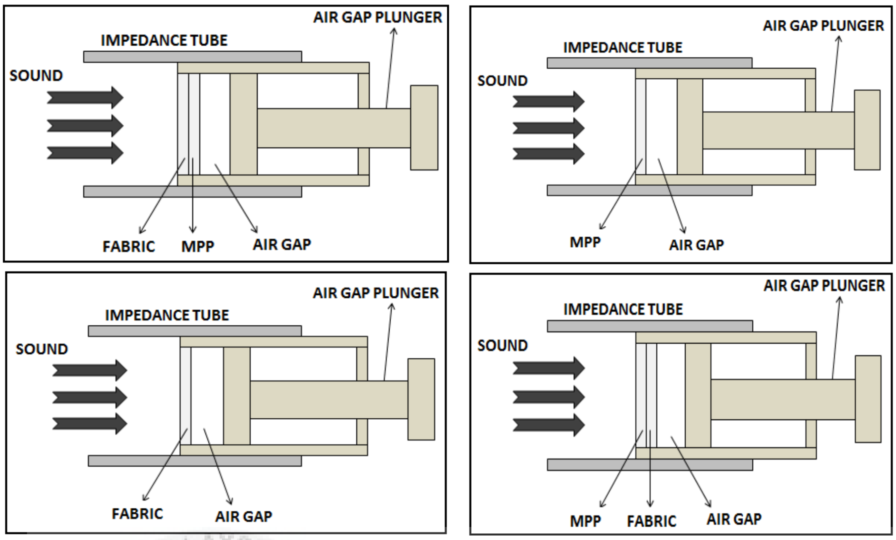


Figure 4.1: The position of the sample inside the impedance tube

Increasing the layer thickness by introducing the air gap can be seen in the Figure 4.2 (b) and (c) shifts the peak absorption coefficient to the lower frequency. Good performance of sound absorption coefficient more than a half which is $\alpha > 0.5$ can be seen in all materials. As a comparison, the fabric shows the frequency at 0.5 of absorption coefficient is 3200 Hz at 20 mm of air gap while 2700 Hz frequency at 30 mm of air gap. It is shows that the frequency is shifts to the lower frequency when the air gap increases. For the MPP and combination of fabric and MPP at 20 mm of air gap, the absorption coefficient is around 0.85 and frequency range between 900 Hz – 1000 Hz which can be seen they are almost the same which each other as shown in Figure 4.1 (b). For the 30 mm air gap, the frequency of the MPP and combination of fabric and MPP shifts at the range of 700 Hz – 900 Hz with the absorption coefficient 0.85 for MPP – fabric, 0.87 for MPP and 0.91 for fabric – MPP. The larger the distance between the air gap, the higher the sound absorption coefficient at lower frequencies and hence the reduction in the sound absorption coefficient at higher frequencies.

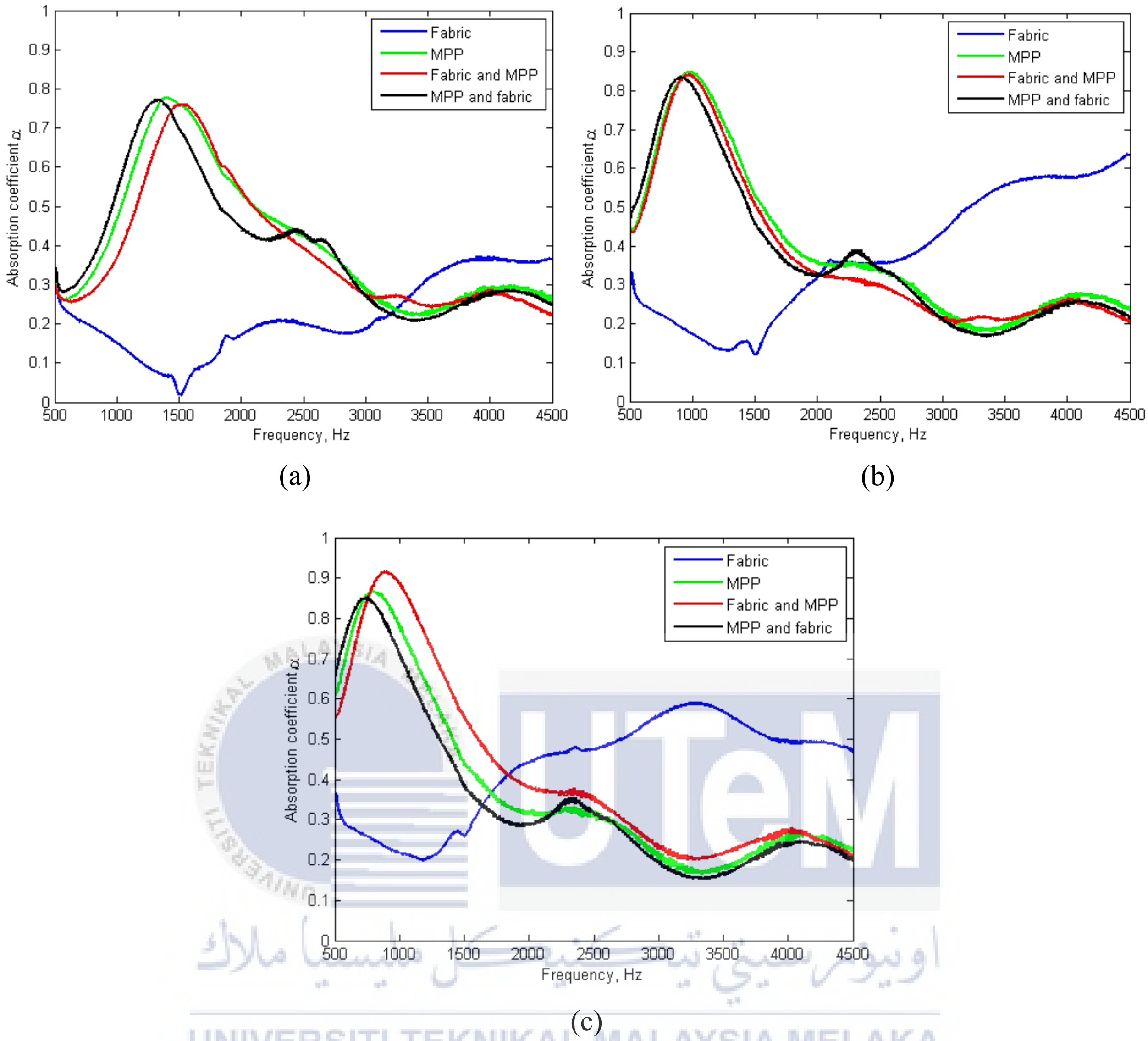


Figure 4.2: Sound absorption coefficient for (a) 10 mm air gap, (b) 20 mm air gap, (c) 30 mm air gap

4.3 The effect of distance between the samples

For this measurement, the sample is separated for 10 mm distance between each other as shown in Figure 4.3. For the MPP, the distance is counted even though there is no other sample with the MPP. All the measurement tested with applying an air gap which is 10 mm, 20 mm and 30 mm. In this measurement, cotton fabric is used to conduct the experiment.

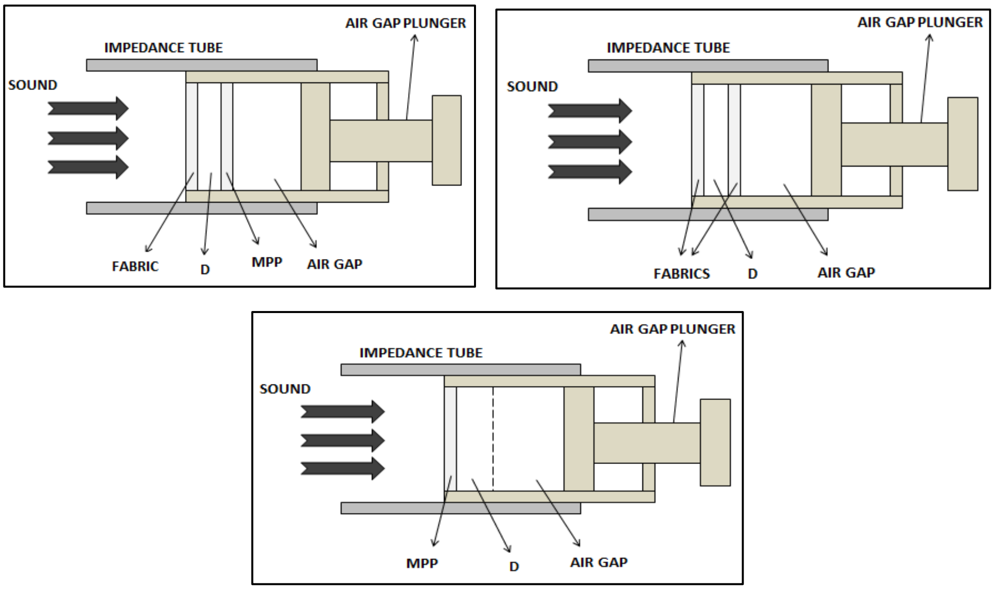
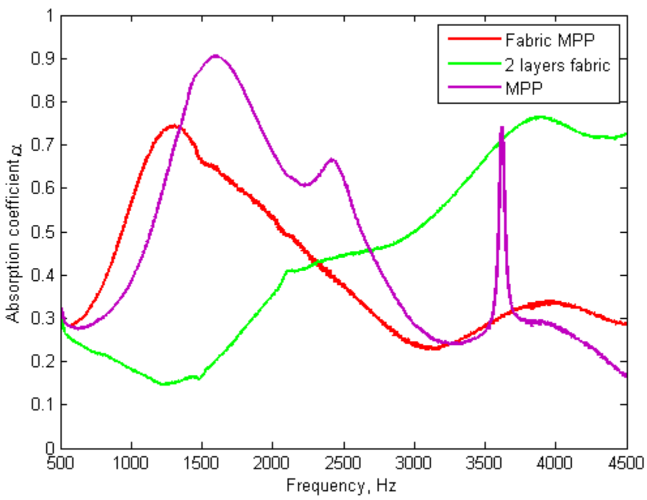


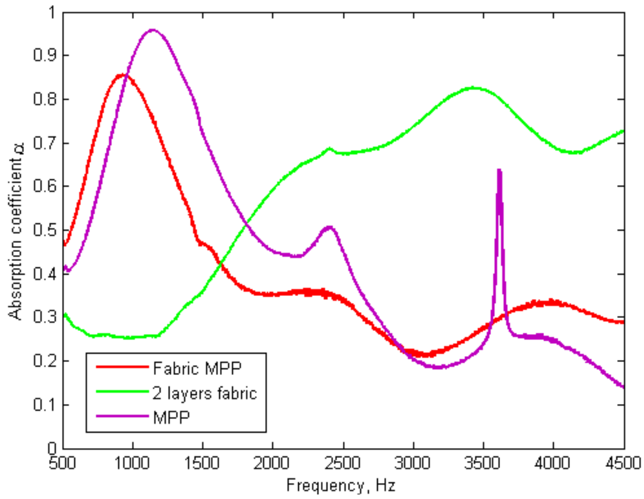
Figure 4.3: The position of sample for 10 mm distance

4.3.1 The distance between the samples is 10 mm

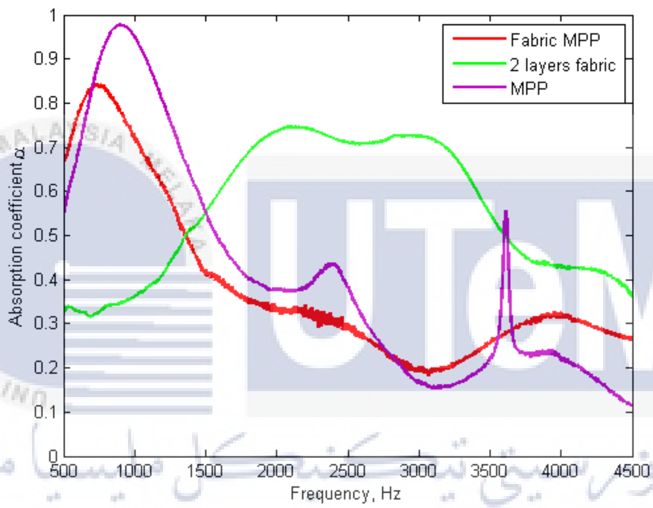
Figure 4.4 shows that the results of the sound absorption coefficient for a sample with the distance of 10 mm. The good acoustic performance is when sound absorption coefficient is more than 0.5. For the MPP, the good acoustics performance is achieved at frequency above 900 Hz and the peak of sound absorption coefficient is 0.75 at the frequency 1300 Hz. When put the fabric at the front of the MPP, the of sound absorption coefficient increase at the frequency above 1200 Hz. It is shows that the fabric can enhance the sound absorption when combined with MPP. Two layers of fabric shows increasing sound absorption coefficient at higher frequency more than 3000 Hz which can be seen the fabrics can be used for high frequency application. This measurement is done with 10 mm of air gap. When increased the air gap, the peak of sound absorption coefficient increased and shift to the lower frequency region as shown in Figure 4.4 (b) and (c). For the 20 mm of air gap, the peak of absorption coefficient for the combination of fabric and MPP is 0.98 at frequency 1200 Hz and increase to 0.99 at frequency 1000 Hz for 30 mm of air gap. For the MPP, absorption coefficient for 20 mm air gap is 0.83 at frequency of 900 Hz and for 30 mm air gap is 0.82 at frequency of 600 Hz. Although there is a slightly decreased for the MPP, the frequency still shifts to the left because of the increasing of air gap. Same with the 2 layers of fabric, the absorption coefficient for 20 mm air gap is 0.8 and for 30 mm of air gap is 0.72 with the frequency range of 2000 Hz to 3400 Hz.



(a)



(b)

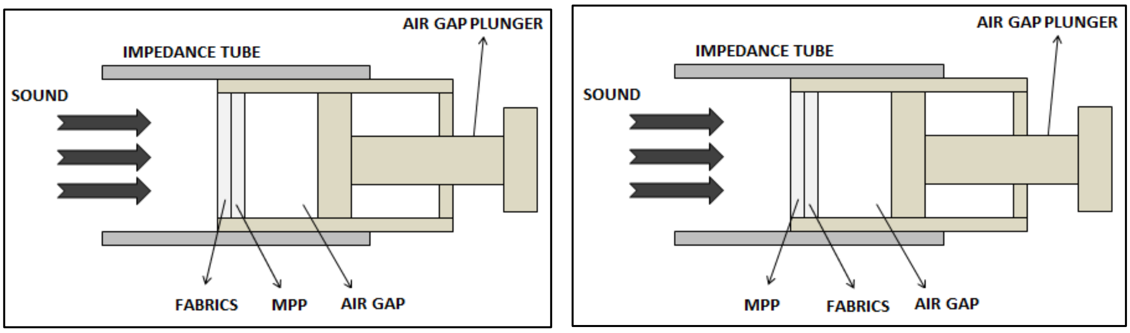


(c)

Figure 4.4: The sound absorption coefficient for D = 10 mm for (a) 10 mm air gap, (b) 20 mm air gap, (c) 30 mm air gap

4.4 Effect of fabric covers on micro perforated panel (MPP)

In this measurement, three type of fabric is used as a cover which is cotton fabric, plain fabric and satin fabric. Two methods used in this measurement, first is the fabric covers is placed at the front of the MPP and second is the fabric covers is placed at the back of the MPP. Figure 4.5 shows the illustration of the position of the sample inside the impedance tube.

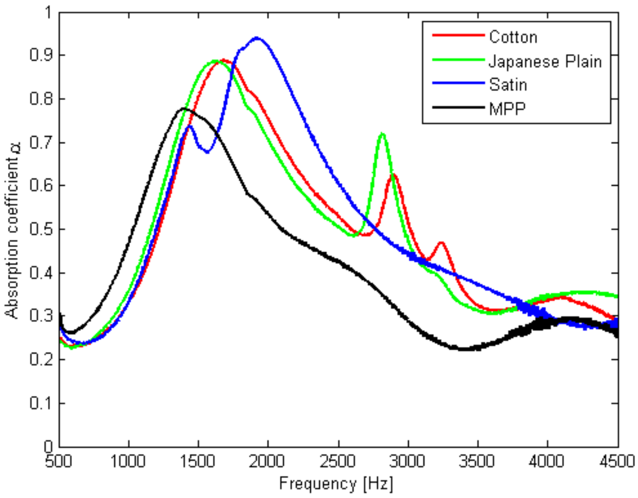


(a) (b)

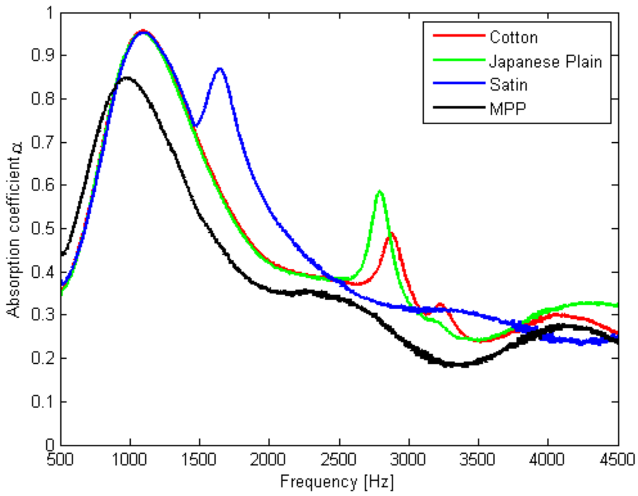
Figure 4.5: (a) The fabric cover at the front of MPP, (b) The fabric cover at the back of MPP

4.4.1 Fabric covers at front of MPP

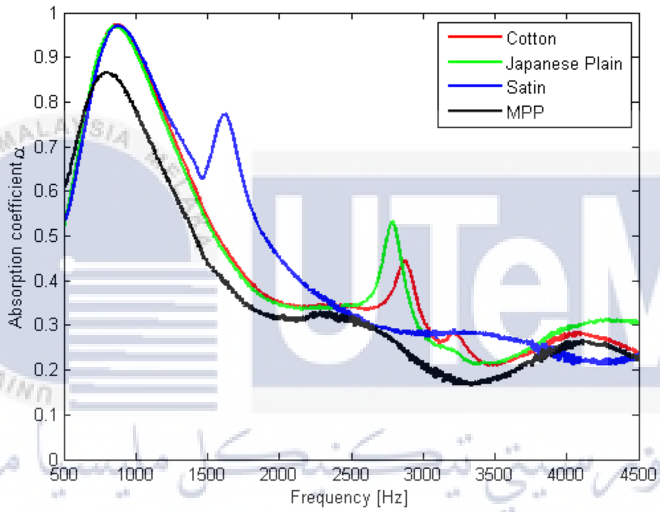
Figure 4.6 shows the result of sound absorption coefficient of MPP using three types of fabric covers and without fabric cover. The MPP achieved a good acoustics performance at the frequency more than 1000 Hz and the fabrics cover achieved at frequency more than 1200 Hz. The result for 10 mm of air gap shows that the MPP without fabric cover has a lower value of sound absorption coefficient which is 0.78 at the frequency 1300 Hz as shown in Figure 4.6 (a). After applying the fabric cover, the sound absorption improved depends on the type of fabric cover used. For the satin fabric cover, it shows the high improvement for peak of absorption coefficient at 0.92 at the frequency 2000 Hz compared with the other two. This is due to the satin fabric that can absorb more sound energy. For the cotton and plain fabrics cover, it shows that the both of the graph almost same with each other at absorption coefficient of 0.89 at frequency 1700 Hz. The pattern of the graph changed after increasing the air gap for 20 mm and 30 mm. For the 20 mm of air gap, the MPP without the fabric cover increase from 0.78 to 0.82 for sound absorption coefficient at the frequency 1000 Hz but after put the fabric covers, all the three type of fabrics enhance the sound absorption coefficient with the same value which is 0.97 at the frequency 1200 Hz as shown in Figure 4.6 (b). For the 30 mm of air gap, the absorption coefficient for the MPP without fabric covers is 0.88 at the frequency 800 Hz and for the MPP with fabric covers shows the same value for all type of fabric which is 0.98 at the frequency 900 Hz. With introducing the air gap, the peak of the sound absorption coefficient shift to the lower frequency region.



(a)



(b)



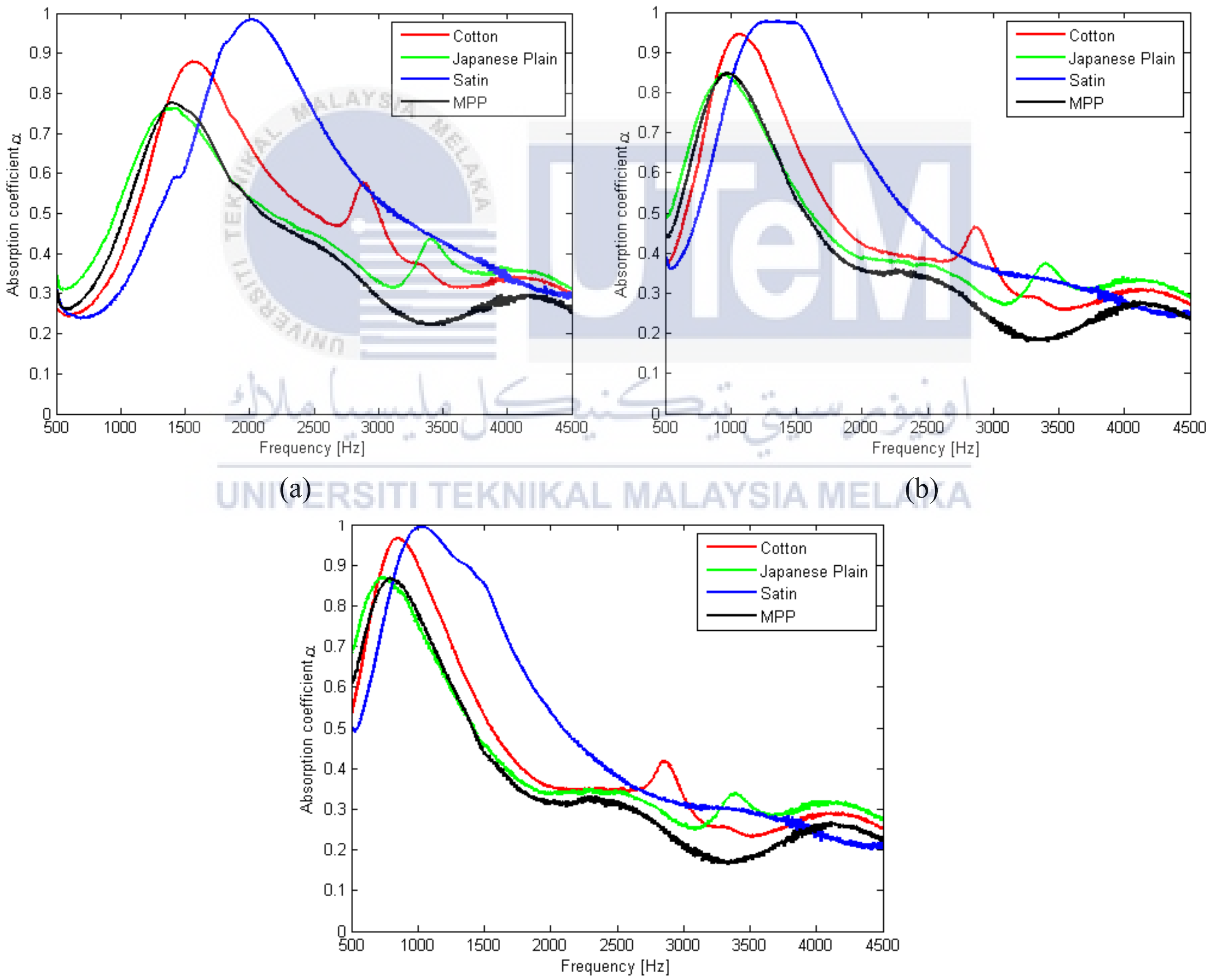
(c)

Figure 4.6: Sound absorption coefficient of fabric covers at the front of the MPP for (a) 10 mm air gap, (b) 20 mm air gap, (c) 30 mm air gap

4.4.2 Fabric covers at back of MPP

Figure 4.7 shows the results for the fabric covers at the back of the MPP. All the sample achieved good absorption coefficient at frequency more than 1000 Hz. For the 10 mm of air gap, the MPP without fabric cover has the peak absorption coefficient of 0.78 at the frequency 1300 Hz. After put the fabric cover at the back, the absorption coefficient increased especially for satin fabric cover that has the higher value of peak absorption coefficient which is 0.99 at the frequency 2000 Hz. For the second highest is cotton fabric cover which has value coefficient of 0.88 at frequency 1600 Hz and plain fabric cover has

0.76 of absorption coefficient at frequency 1300 Hz. When increased the air gap, the sound absorption coefficient for satin fabric cover almost become unity at the frequency 1100 Hz. For the cotton fabric cover, it has increased from 0.95 to 0.98 when the air gap increased up to 30 mm at the frequency 1100 Hz for 20 mm air gap and 900 Hz for 30 mm air gap. The plain fabric cover get the value almost same with the MPP without fabric cover for each air gap distance. The increasing of sound absorption coefficient is due to the application of the fabric cover at the back of the MPP because each type of the fabric has different acoustic performance. When the sound enters the air gap region, the sound energy flow through the MPP to the fabric cover is reflected back to the fabric again before the sound energy loses at the fabric.

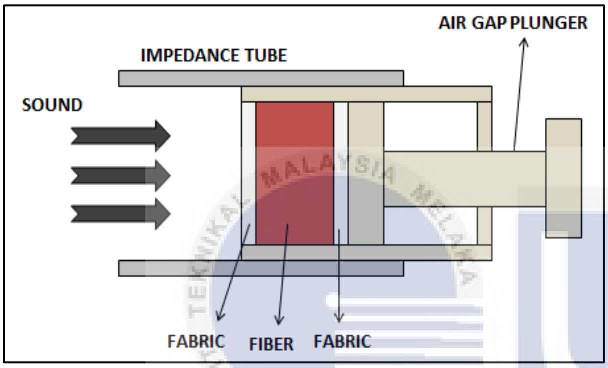


(c)

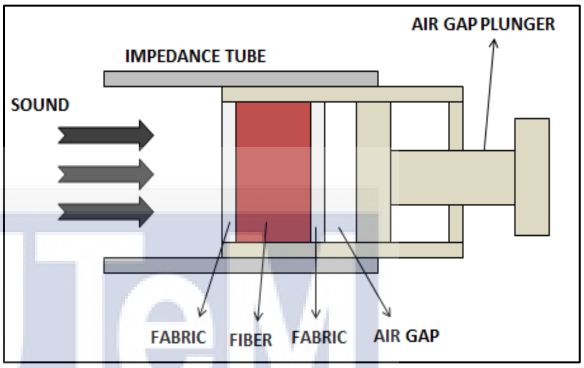
Figure 4.7: Sound absorption coefficient of fabric covers at the back of the MPP for (a) 10 mm air gap, (b) 20 mm air gap, (c) 30 mm air gap

4.5 Effect of fabric covers on natural fibers

In this measurement, the natural fibers are used to find the effect of fabric covers on improving sound absorption. Three type of natural fiber used in this measurement which is kenaf fiber, oil palm fiber and coir fiber. The thickness of the natural fibers is 20 mm and for coir fiber, another two thickness are used which is 30 mm and 40 mm. The fabric covers is put at the front and back of the natural fiber. Figure 4.8 shows the illustration for the position of the sample inside the impedance tube. Figure 4.8 (a) is for rigid backing measurement and (b) for air gap measurement.



(a)



(b)

Figure 4.8: The position of the sample inside the impedance tube for (a) rigid backing, (b) air gap

4.5.1 Kenaf Fiber

Figure 4.9 shows the results of sound absorption coefficient for kenaf fiber with and without fabric covers. The measurement is done with applying rigid backing and air gap to the sample. For the rigid backing measurement, the kenaf fiber without fabric covers achieved good acoustic performance when absorption coefficient is above 0.5 at frequency more than 1500 Hz and the value of peak absorption coefficient is 0.9 at the frequency 3200 Hz. When the fabric covers is applied on the kenaf fiber, the absorption coefficient is improved and almost unity at the frequency 1600 Hz for both cotton and plain fabric covers and 2100 Hz for the satin fabric covers. In this result, cotton fabric and plain fabric has good acoustic performance when become the fabric cover for the kenaf fiber. The effect of air gap can be seen in the Figure 4.9 (a), (b), and (c) that shows the peak of the absorption coefficient shifted to the left or lower frequency region. For kenaf fiber without fabric covers, the absorption coefficient is 0.89 and same for the following air gap but different in frequency region which are 2800 Hz for 10 mm of air gap, 1700 Hz for 20 mm of air gap and 1500 Hz for 30 mm of air gap. Same with the applying cotton and satin fabric covers, they have sound absorption coefficient that almost unity with the frequency 1600 Hz, 1400 Hz and 1100 Hz respectively for satin fabric covers and 1200 Hz, 1000 Hz and 800 Hz respectively for cotton fabric covers at 10 mm, 20 mm and 30 mm of air gap. But for the plain fabric covers, it has slightly decreased in absorption coefficient which in from almost unity to 0.97 at frequency 1200 Hz for 10 mm air gap, 1000 Hz for 20 mm air gap and 800 Hz for 30 mm air gap.

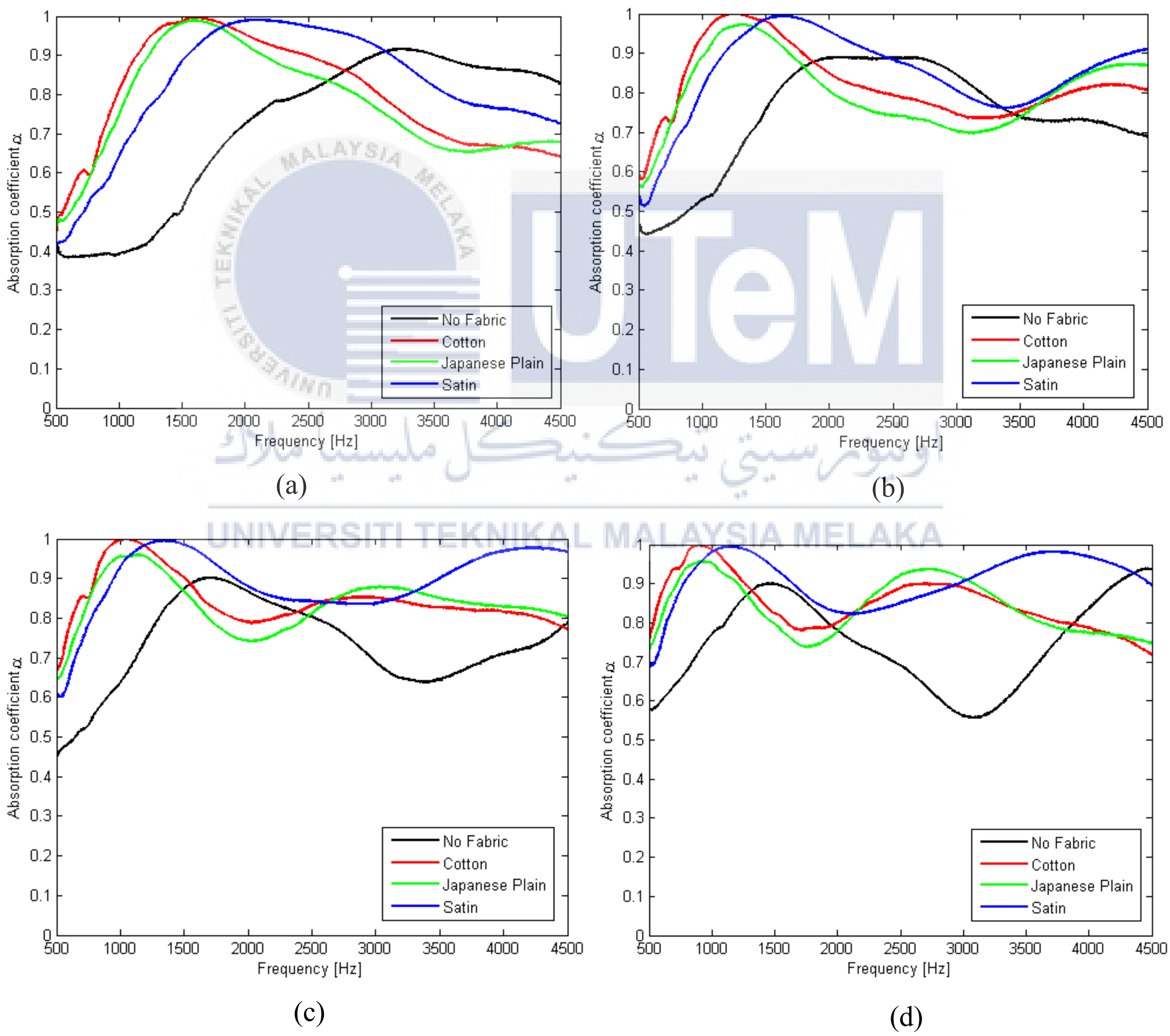


Figure 4.9: Sound absorption coefficient of kenaf fiber for (a) Rigid backing, (b) 10 mm air gap, (c) 20 mm air gap, (d) 30 mm air gap

4.5.2 Oil Palm Fiber

Figure 4.10 shows the results of the sound absorption coefficient for oil palm fiber with and without fabric covers for the rigid backing and air gap. Good acoustic performance for oil palm fiber without fabric covers can be seen to achieve at frequency more than 1000 Hz and when put the fabric covers it can achieved for frequency more than 700 Hz. For rigid backing measurement, the oil palm fiber without fabric covers has peak absorption coefficient value at 0.86 with frequency 2300 Hz. When the fabric covers is put on the fiber, the same value of absorption coefficient for cotton and plain fabric with the fiber without fabric cover but the peak is more to the lower frequency which at 1400 Hz. While for satin fabric cover, the peak absorption coefficient slightly lower with others which at 0.85 at frequency 1700 Hz. For the measurement with an air gap, the results shows that the absorption coefficient for oil palm fiber is almost same when increased the air gap which is 0.85 at frequency decreased from 1300 Hz to 800 Hz. For the fabric cover, the value of sound absorption coefficient for all the type of fabric covers seem like almost have the same value which is 0.85 at frequency 1000 Hz for 10 mm of air gap, 0.83 at frequency 800 Hz for 20 mm air gap and 0.82 at frequency 700 Hz. The introduction of air gap can be seen to shift the peak to the lower frequency region. The application of air gap performance can be equivalent with having full thicker absorber and thus can save the fiber materials.

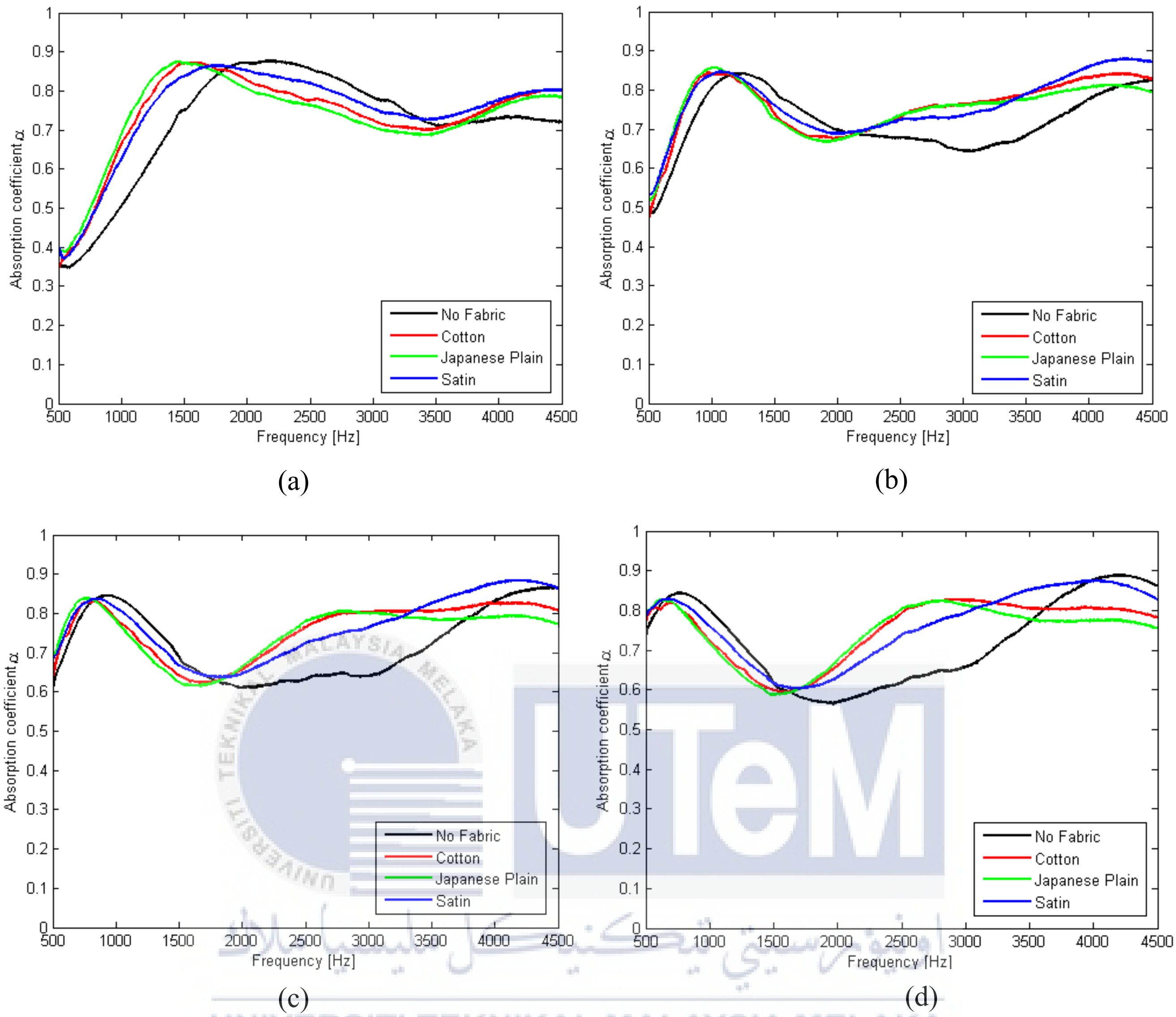


Figure 4.10: Sound absorption coefficient of oil palm fiber for (a) Rigid backing, (b) 10 mm air gap, (c) 20 mm air gap, (d) 30 mm air gap

4.5.3 Coir Fiber

For this measurement using coir fiber, two different thicknesses had been chosen to find the sound absorption coefficient which is 20 mm, and 30 mm thickness.

4.5.3.1 20 mm thickness

Figure 4.11 shows that the result of sound absorption coefficient for the coir fiber 20 mm thicknesses with and without fabric covers. Coir fiber is hard-type fiber which good sound absorption start at higher frequencies. It can be seen that the coir fiber achieved good sound absorption at the frequency more than 2800 Hz. At rigid backing condition, kenaf fiber without fabric covers tends to higher frequency which has peak absorption coefficient of 0.6. When the fabric covers is applied on the coir fiber, it shows that the absorption coefficient increase drastically. Plain fabric cover has the higher sound absorption compare to others which has peak absorption coefficient almost unity at the frequency 1600 Hz. It also has a large range of frequency from 700 Hz to 4400 Hz. Then the range become smaller when applied an air gap. For the cotton fabric cover, it has peak absorption coefficient at 0.98 for frequency 1700 Hz while satin fabric covers has peak absorption coefficient at 0.92 at frequency 2100 Hz. All this type of fabrics cover will shift its peak absorption coefficient to the lower region because of applying an air gap. Even though after apply the air gap, the graph pattern become increased at higher frequency.

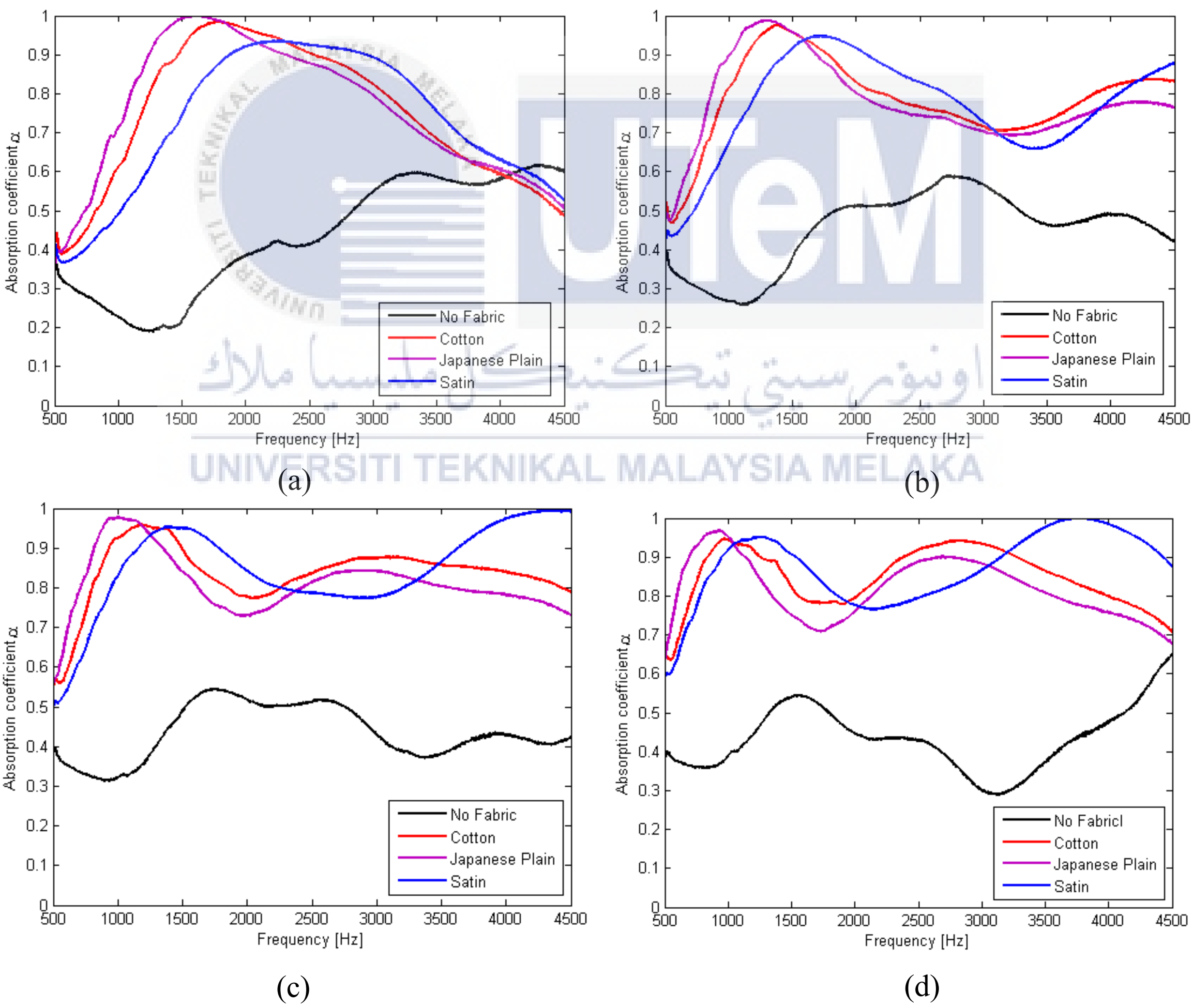


Figure 4.11: Sound absorption coefficient of coir fiber with 20 mm thickness for (a) Rigid backing, (b) 10 mm air gap, (c) 20 mm air gap, (d) 30 mm air gap

4.5.3.2 30 mm thickness

Figure 4.12 shows that the result of the sound absorption coefficient for coir fiber 30 mm thicknesses with and without fabric covers. Coir fiber without fabric cover has a peak absorption coefficient at 0.8 at frequency 3000 Hz for the rigid backing condition. For the same fiber, it is shown that the increase of the thickness enhances the absorption coefficient as shown in Figure 4.11 (a) and Figure 4.12 (a). After applying the fabric covers on the coir fiber, the sound absorption improved especially when using plain fabric covers. Plain fabric covers has a peak absorption coefficient at 0.98 for frequency 1500 Hz. For cotton and satin fabric covers, they have same peak absorption coefficient at 0.92 but in different frequency which cotton fabric at 1700 Hz while satin fabric at 1900 Hz. The peak of the sound absorption coefficient shifted to the lower frequency when increasing the air gap. By increasing the thickness of the fiber, it is equivalent when increasing the air gap because applying the air gap can save the use of fiber materials.

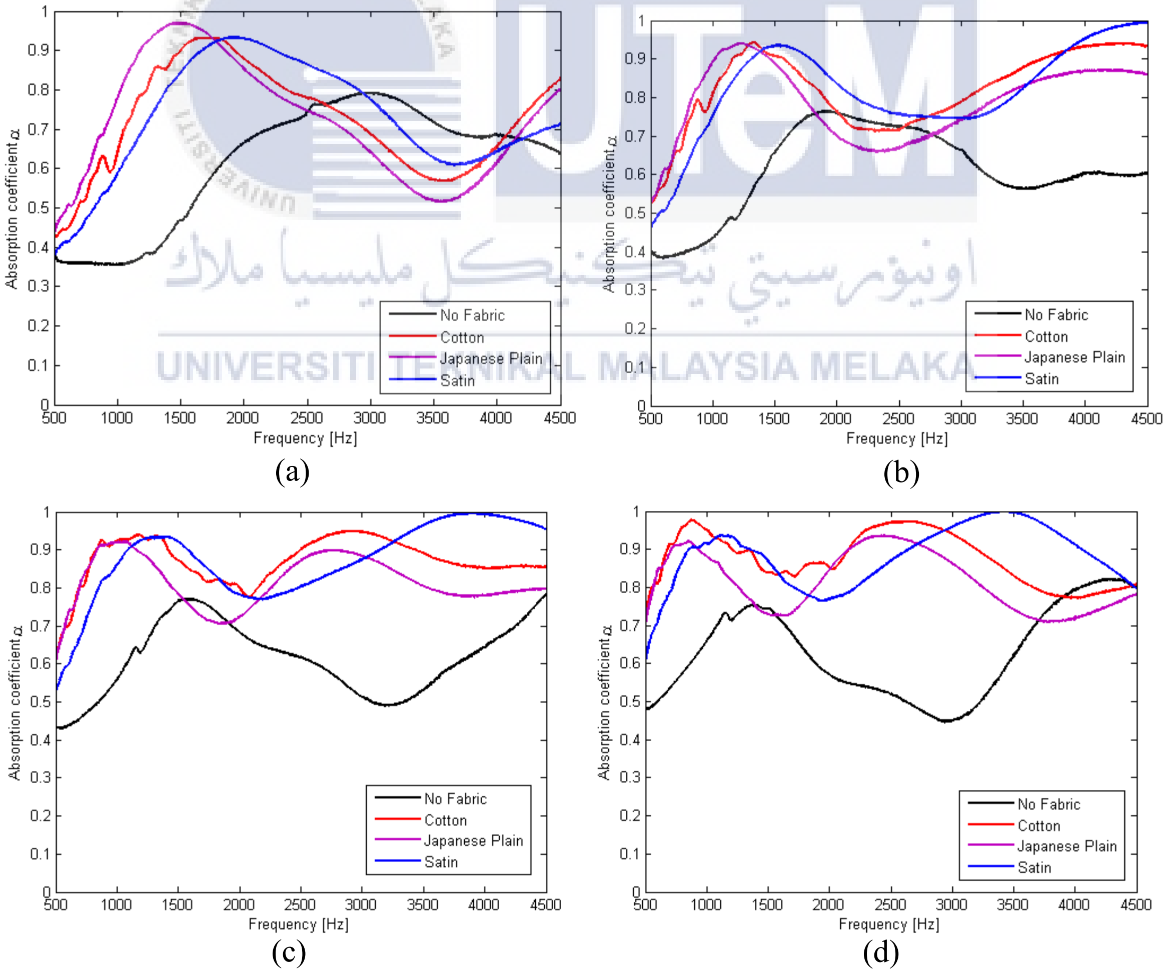


Figure 4.12: Sound absorption coefficient of coir fiber with 30 mm thickness for (a) Rigid backing, (b) 10 mm air gap, (c) 20 mm air gap, (d) 30 mm air gap

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The fabrics which can be used for decoration purposes are found to be a good absorber. Each type of the fabrics gives different performance to the sound absorption on the absorptive materials such as MPP and natural fibers. MPP and natural fibers has their own acoustics characteristics and by applying the fabric as the cover at the front and back, the sound absorption performance improved. This can be related to the focused of this research which is to investigate the effect of fabric covers on improving the sound absorption. When the sound absorption coefficient achieved more than 0.5, it is consider as a good absorption performance.

For the MPP sample without fabric covers, the sound absorption coefficient reached 0.78 at the frequency 1300 Hz and improved the absorption coefficient to 0.88 when introduced the air gap and shift the peak to the lower frequency range between 800 Hz to 1000 Hz. When applying the fabric covers on the MPP at the front, satin fabric has more absorption coefficient compare to cotton and plain fabrics at more than 0.9 at frequency 2000 Hz for 10 mm of air gap. When the air gap is increased, the sound absorption coefficient increased especially for all type of fabrics. For the fabric covers at the back of MPP, satin fabric also shows a good absorption coefficient which it can reached 0.99 at frequency 2000 Hz for 10 mm of air gap and the peak shift to the left as increasing the air gap which satin has almost unity at frequency 1100 Hz followed by cotton and plain fabrics.

For the 20 mm thickness of natural fibers, coir fiber shows significant improvement of sound absorption performance from no fabric cover which has 0.6 of absorption coefficient at frequency more than 4500 Hz. The sound absorption of coir fiber has improved when applying plain fabric cover at absorption coefficient almost unity at frequency 1500 Hz. Followed by kenaf fiber, without fabric cover, absorption coefficient reached 0.9 at frequency 3200 Hz. When the fabric covers is applied, the absorption coefficient of all the fabrics are almost unity at frequency range between 1600 Hz to 2100 Hz. For the oil palm fiber, the sound absorption coefficient without fabric covers has the same coefficient with the fiber with fabric covers. The sound absorption coefficient is 0.86 at frequency range 1400 Hz to 2300 Hz. Introduction to the air gap enhance the peak of sound absorption coefficient shift the curve to the lower frequency region.

5.2 Recommendation

In this research, it is only focused on improving the sound absorption by applying the fabric covers. Three type of fabric is used as fabric covers which are cotton, plain and satin fabric. For further extension of the research, other type of fabric like silk, wool, linen or leather fabrics can be used as covers to find the acoustic characteristics of the fabrics. Other than that, different type of natural fiber also can be variety with different thickness or density to measure the sound absorption with fabric cover on it.

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APPENDIX A

Figure 1: Experimental setup

Figure 2: Signal analyser

Figure 3: Microphones

Figure 4: Sound Calibrator

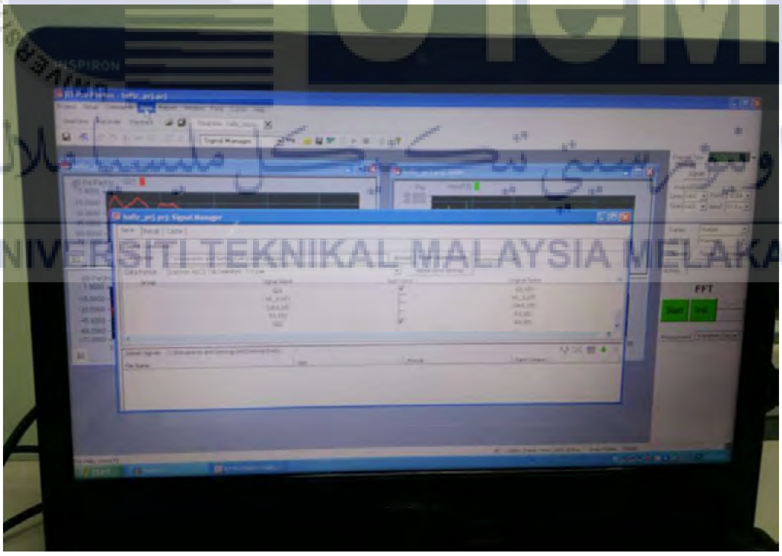

Figure 5: RT Pro Photon

APPENDIX B

Figure 1: Kenaf fiber

Figure 2: Coir fiber

Figure 3: Oil palm fiber

Figure 4: Fabrics cover

Figure 5: Micro Perforated Panel (MPP)

APPENDIX C

NO	TASK	WEEKS																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Preparation of Literature Study								MID-TERM BREAK											
2	Chapter 1: Introduction																			
3	Researching for Methodology																			
4	Chapter 2: Literature Review																			
5	Presentation Project Proposal																			
6	Submission Progress Report 1																			
7	Chapter 3: Methodology																			
8	Conduct Experiment																			
9	Chapter 4: Preliminary Results																			
10	Report Writing																			
11	Report Submission																			
12	PSM 1 Seminar																			

Figure 1: Gantt Chart for PSM 1

NO	TASK	WEEKS															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Chapter 3: Methodology (progress from PSM 1)								MID-TERM BREAK								
2	Materials selection																
3	Conduct experiment																
4	Submission Progress Report PSM 2																
5	Chapter 4: Results and discussion																
6	Chapter 5: Conclusion and recommendation																
7	Report Writing																
8	Report Submission																
9	PSM 2 Seminar																

Figure 2: Gantt Chart for PSM 2