DESIGN OF EXPERIMENT (DOE) IN THE SELECTION OF NATURAL FIBER PROPERTIES FOR THE SOUND ABSORPTION SYSTEM

ZAKIYYUDDIN BIN MOHAMAD

B091810406

BACHELOR OF ENGINEERING TECHNOLOGY AUTOMOTIVE WITH HONOURS

2021

Faculty of Mechanical and Manufacturing Engineering Technology

DESIGN OF EXPERIMENT (DOE) IN THE SELECTION OF NATURAL FIBER PROPERTIES FOR THE SOUND ABSORPTION SYSTEM

Zakiyyuddin Bin Mohamad

Bachelor of Engineering Technology Automotive with Honours

2021

DESIGN OF EXPERIMENT (DOE) IN THE SELECTION OF NATURAL FIBER PROPERTIES FOR THE SOUND ABSORPTION SYSTEM

ZAKIYYUDDIN BIN MOHAMAD

A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Engineering Technology Automotive with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this Choose an item. entitled " Design Of Experiment (DOE) In The Selection Of Natural Fibre Properties For The Sound Absorption System " is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Zakiyyuddin Bin Mohamad

Date : 18/01/2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Engineering Technology Automotive with Honours.

Signature : Najiyah

Supervisor Name : Dr. Najiyah Safwa Binti Kashi'ie

Date : 18/01/2022

DEDICATION

I praise to Allah S. W. T. For the successful completion my project as I plan. I dedicate this initiave to my lovely parents, Mohamd Bin Wahib and Robeah Binti Awang for always supporting me as well as to all my siblings. A special thank to my supervisor Dr. Najiyah Safwa Binti Khashi'ie, my co-supervisor and all instructor at Universiti Teknikal Malaysia Melaka (UteM) for their guidance and advice in this project.

ABSTRACT

Sound absorption contibutes a major requirements for human comfort in working, living and traveling environment nowdays. People always attempt to substitute the synthetic sound absorption material with the natural fibre material due to the potential risk on human health and environmental impact. By developing an eco-friendly material, it can help in improvement of human quality of life and also reduce the negative impact to the nature. Noise pollution can effect human mental health if their expose in long term. Then, sound absorbing material has been found as the most suitable things that can control unwanted noise. This study of sound absorption technology will help human reach their own level of comfort without getting a negative effect cause by material used. Analysis between thickness and type of natural fibre will intrepet all needed data and missing point when doing the experiment.

ABSTRAK

Penyerapan bunyi menjadikan keperluan utama untuk keselesaan manusia dalam persekitaran kerja, kehidupan dan perjalanan sekarang. Orang selalu berusaha untuk mengganti bahan penyerapan bunyi sintetik dengan bahan serat semula jadi kerana potensi risiko terhadap kesihatan manusia dan kesan persekitaran. Dengan mengembangkan bahan yang mesra alam, ia dapat membantu meningkatkan kualiti hidup manusia dan juga mengurangkan kesan negatif terhadap alam semula jadi. Pencemaran bunyi boleh mempengaruhi kesihatan mental manusia jika ia terdedah dalam jangka masa panjang. Kemudian, bahan penyerap bunyi telah dijumpai sebagai perkara yang paling sesuai yang dapat mengawal bunyi yang tidak diingini. Kajian teknologi penyerapan bunyi ini akan membantu manusia mencapai tahap keselesaan mereka sendiri tanpa mendapat kesan negatif oleh bahan yang digunakan. Analisis antara ketebalan dan jenis serat semula jadi akan merangkumi semua data yang diperlukan dan titik yang hilang semasa melakukan eksperimen.

ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

First of all, I want to express my thanks to Allah the Almighty, my Creator for everything that I have received from the beginning till I can complete my project. I would like to express my gratitude to Universiti Teknikal Malaysia Melaka (UTeM) for providing me the research environment. Thank you to the Malaysian Ministry of Higher Education (MOHE) for financial support.

For his guidance and motivation, I am grateful to my major supervisor, Dr. Najiyah Safwa Binti Khasie'ie. His unwavering patience in mentoring and offering invaluable insights will be remembered for the rest of his life. Also, thanks to my co-supervisors, Ts. Muhammad Nur Bin Othman and En. Sayed Kushairi Bin Sayed Nordin of Universiti Teknikal Malaysia Melaka (UTeM), for their unwavering support during my studies.My special thanks go to En. Azri Bin Azlan as my personal academic assistant for all the help and support I received from them.

Last but not least, I want to express my heartfelt thanks to my loving father, Mohamad Bin Wahib, for his support and encouragement throughout my life. My unending gratitude to Robeah Binti Awang, my mother, for her tolerance and understanding. I'd also like to express my gratitude to my loving family for their unwavering support, love, and prayers.

TABLE OF CONTENTS

.

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Hz	-	Hetz
RW	-	Rockwool
H	-	Porosity
Va	-	Volume of air in voids
Vm	-	Total volume of material
α	-	Sound absorption coefficient
E_I	-	Incident energy
E_R	-	Reflection energy
E_A	-	Absorbed energy
r	-	Incident reflection factor
I_{Abs}	-	Sound intensity absorbed
I_I	-	Incident sound intensity
CO_2	-	Carbon dioxide
mm	-	Milimeter
g	-	Gram
v	-	Volume
ρ	-	Density

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

In this chapter, a brief introduction and the objective study of the project are discussed. All information about project background, problem statement, and project scope will be set out on this chapter.

1.2 Project Background

The unpleasant sound is normally known as the noise that has become one of the four major pollution types in the world (Bai, 2019). Continuous exposes to noise can affect all kinds of health problems, human can get hearing loss or deaf and sleep disorder. People didn't take it as serious problems due to the lack of knowledge and awareness. In addition, many sounds insulation requirement in making safer environment and reach the human comfort. It could be in automotive field, manufacturing environments, and in living of daily life.

Generally, sound is produced when an object's vibrations move through a medium until they enter the human eardrum in a form of wave (Amares, 2017). As the particles vibrate, it moves nearby between particles and transmitting the sound through the medium. Human ear will detect the sound waves when it vibrates within the ear. Sound waves mostly is similar as the light waves, they both originate from the definite source and can be

disseminate by using numerous means. But sound waves only can travel through a medium which mean there's no sound in a space.

Nowadays, natural fibres are widely used to manufacture the environmentally friendly composite materials (Taban, 2019). The use of low cost and effective natural fibre such as coconut shells, kenaf, hemp and many more potential natural fibre can help in manufacturing the acoustic absorption materials. Since the 1970s, researchers have been studying the sound absorption properties of different porous materials. The absorption coefficient of cellular sound-absorbing materials was lower in low frequency and it kept increasing as the frequency went up, according to Sekar, (2018) research on glass fibre and mineral wool.

According to Amares (2017), there are three characteristics of the composite's sound absorption mechanisms were as follows. The air in the fibre pores vibrated and brushed against cell walls as acoustic waves propagated through the fibrous material. The acoustic energy was converted into thermal energy attenuation due to the induced viscous resistance. Next, when the air in the pores was compressed, it was heated. When it was expanded, it was cooled and acoustic energy was eventually transformed into thermal energy due to thermal conduction in the materials, which was irreversible. Lastly, the dissipation of acoustic energy may also be caused by the vibration of the fibre itself. These three aspects will be combined together then the acoustic energy transferred.

1.3 Problem Statement

In the study of long-term exposure to noise pollution, diversity of health problems such as annoyance, sleep disturbance, bad effects on the cardiovascular and metabolic system and cognitive impairment in children (Putra, 2018). According to the data taken in 2020, they estimate that environmental noise contributes to over 48000 new cases due to ischaemic heart disease per year and 12000 premature deaths. Furthermore, they evaluate that 22 million people having chronic high annoyance and 6.5 million more suffering from high sleep disturbance (Peris, 2020). However, noise pollutions seem give more negative effect related to mental health and quality of life. In fact, based on World Health Organization (WHO) data found that noise pollutions are the second largest environmental cause of health problems.

Natural fibre has a good thermal and sound absorption materials that can help manufacturing a better acoustic absorption system (Choe, 2017).

1.4 Objective

The objective of this study is related to the properties of natural fiber based on acoustic sound absorption. Testing will be carried out with the suitable experiment and specimen preparation. The aim is:

- To compare the sound absorption performance of coconut and cotton fiber with difference thickness and frequency.
- To analyse the relation between types of fiber and thickness of the fiber in sound absorption system by using data analyse software.

1.5 Scope

The main purpose of the project is to determine the selection of natural fiber properties for the sound absorption system between two chosen natural fiber that are coconut fiber and cotton fiber.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, all information had been collected from the journals, books and research studies from the internet to use as a guideline. Study of literature review will be discussed and compared to the project in order to complete the project successfully.

2.2 Sound Absorption

Sound absorption is when the sound waves had a contact with an absorbent surface materials and loss it's sound energy. The sound waves do not reflect back into the space. Sound absorbing material very important to reduce the unwanted sound or noise in the certain place such as recording studios, lecture theatres, cinemas, examination hall, meeting room and many more.

In this new era, there's a big possibility to use the natural fibre compared to synthetic fibre in sound absorption materials because of high in absorption capacity. Most natural fibre had a main feature to be a good acoustic absorber plus environmentally friendly (Taban et al. 2020). As an example, wood fibre was used to replace parts of the polyester fibre. Polyester fibre known as one of a good sound absorption property but contain chemical which bring negative effect to the environment and also high-priced.

Acoustic absorbing materials are labelled as the ability of the material to absorb as much as sound wave and give out as minimal as it can but at the same time it can transmit

more of the waves. In addition, there several important acoustic parameters that had to be focus during these researches, acoustic impedance and acoustic of sound reflection (Bai et al. 2019; Nasidi, 2021).

Acoustic impedance is the sound pressure ration the specimen's surface to the corresponding normal particle velocity, on the surface. Coefficient of sound reflection is the comparison of the total intensity of sound to the total intensity of the incident. A good performance of sound absorbing material will also influence by some factor which are thickness, density and porosity.

2.3 Sound Absorbing Influencing Factors

2.3.1 Material's Thickness

Increasing the thickness gives a better absorption of the waves and reflect less energy (Amares et al. 2015). Study by Azkorra (2015) shows that the thickness of the samples increases, the sound coefficient increases. At low frequency, waves have higher wavelength which means the thicker material help in better absorption. However, at higher frequency only give a small effect to the sound absorption.

2.3.2 Material's Density

Material density play an important role in acoustic absorption. Density controls the acoustic impedance and impedance determines the reflection of the materials. Research by Amares et al. (2017) stated that a high-density material (increase a mass) increases the sound absorption. Table 2.0 below justice that statement by Limited (2015). The density will be increasing the number of fibers (increases per unit area) and automatically decreases the energy loss due to the increased of surface friction. Then, the coefficient of sound absorption