RESPONSE SURFACE METHODOLOGY ON THE SELECTION OF NATURAL FIBER PROPERTIES IN THE SOUND ABSORPTION COEFFICIENT

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY WITH HONOURS

2023

Faculty of Mechanical and Manufacturing Engineering Technology

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

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this Choose an item. entitled " Response Surface Methdology on the Selection of Natural Fiber Properties in the Sound Absorption Coefficient " 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 : Nur Fatin Izzati Binti Md Saad

Date : 9/1/2023

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 Mechanical Engineering Technology with Honours.

Signature	:	
Supervisor Name	:	Dr. Najiyah Safwa Binti Khashiie
Date	:	25/1/2023

DEDICATION

This initiative is dedicated to my wonderful parents, Md Saad Bin Taib and Normah Binti Johari, as well as all of my siblings. I'd like to thank my supervisor, Dr. Najiyah Safwa Binti Khashi'ie, as well as all of my instructors at Teknikal Melaka Malaysia University (UTeM), for their advice and assistance with this project. Finally, thank Allah SWT for the successful completion of this project and its proper operation as planned.

ABSTRACT

This Bachelor Degree Project outlines the background of the project "response surface methodology on the selection of natural fiber properties in the sound absorption coefficient". Sound insulation in one's living space, when travelling, and at one's place of employment is currently regarded as one of the most essential components of contemporary human comfort. Noise pollution and numerous forms of both human and industrial waste are two examples of these problems. In recent years, a wide variety of natural compounds have undergone research and development to be used in acoustic applications. Materials that absorb sound take in the vast majority of the sound energy that is directed at them, while only reflecting a small portion of it. Because of that, the primary objective of this research is to prepare the acoustic material sample of rice husk with different thickness, density and airgap. Second, to study the sound absorption coefficient between different thickness, density and air gap using impendence tube. third, to analyze the significant of thickness, density and airgap using responde surface methodology with Minitab software. The Response Surface Methodology (RSM) is a statistical technique that be used to organise experiments, construct models, assess the effects of a number of parameters, and look for the conditions that provide the most acceptable results. In order to acquire relevant data for the goal of this inquiry, statistical techniques and the Box-Behnken design were applied, respectively. RSM, which is based on the Box-Behnken design, will explore the influence that specific parameter variables have on rice husk fibre through the utilisation of impendence tube testing. The data has been analyze by Analysis of variance (ANOVA) using Minitab software. These conditions include the presence of an air gap, as well as thickness and density. As a direct consequence of this finding, noise-controlling materials that absorb sound have been shown to be of tremendously beneficial utility. As a result, increasing the thickness of the sample leads to improvements in the performance of the sound absorption coefficient at low frequency. The application of the rice husk fiber to the sample led to a modest increase in the sample's absorption coefficient, as demonstrated by the results. When compared to scenarios in which there is no air gap behind the samples, the existence of an air gap behind the samples results in significantly improved sound absorption performance. This took place because individual particles in the air vibrated and caused the sound's energy to spread out. According to the findings, the samples of material rice husk fiber exhibit a better performance in absorbing the sound energy and are effective in reducing the amount of sound that is absorbed by materials.

ABSTRAK

Projek Ijazah Sarjana Muda ini menggariskan latar belakang projek "metodologi permukaan tindak balas pada pemilihan sifat gentian semula jadi dalam pekali penyerapan bunyi". Penebat bunyi di ruang kediaman, semasa melancong, dan di tempat pekerjaan pada masa ini dianggap sebagai salah satu komponen paling penting dalam keselesaan manusia kontemporari. Pencemaran bunyi dan pelbagai bentuk sisa manusia dan industri adalah dua contoh masalah ini. Dalam beberapa tahun kebelakangan ini, pelbagai jenis sebatian semula jadi telah menjalani penyelidikan dan pembangunan untuk digunakan dalam aplikasi akustik. Bahan yang menyerap bunyi mengambil sebahagian besar tenaga bunyi yang ditujukan kepada mereka, sementara hanya memantulkan sebahagian kecil daripadanya. Oleh itu, objektif utama penyelidikan ini adalah untuk menyediakan sampel bahan akustik sekam padi dengan ketebalan, ketumpatan dan jurang udara yang berbeza. Kedua, untuk mengkaji pekali penyerapan bunyi antara ketebalan, ketumpatan dan jurang udara yang berbeza menggunakan tiub impedans. ketiga, untuk menganalisis signifikan ketebalan, ketumpatan dan jurang udara menggunakan metodologi permukaan respon dengan perisian Minitab. Metodologi Permukaan Respons (RSM) ialah teknik statistik yang digunakan untuk mengatur eksperimen, membina model, menilai kesan beberapa parameter dan mencari keadaan yang memberikan hasil yang paling boleh diterima. Untuk memperoleh data yang relevan untuk matlamat siasatan ini, teknik statistik dan reka bentuk Box-Behnken telah digunakan, masing-masing. RSM, yang berasaskan reka bentuk Box-Behnken, akan meneroka pengaruh pembolehubah parameter tertentu terhadap gentian sekam padi melalui penggunaan ujian tiub impenden. Data telah dianalisis secara Analisis varians (ANOVA) menggunakan perisian Minitab. Keadaan ini termasuk kehadiran jurang udara, serta ketebalan dan ketumpatan. Sebagai akibat langsung daripada penemuan ini, bahan-bahan kawalan hingar yang menyerap bunyi telah ditunjukkan sebagai utiliti yang sangat berfaedah. Akibatnya, peningkatan ketebalan sampel membawa kepada peningkatan dalam prestasi pekali penyerapan bunyi pada frekuensi rendah. Penggunaan gentian sekam padi pada sampel membawa kepada peningkatan sederhana dalam pekali penyerapan sampel, seperti yang ditunjukkan oleh keputusan. Jika dibandingkan dengan senario di mana tiada jurang udara di belakang sampel, kewujudan jurang udara di belakang sampel menghasilkan prestasi penyerapan bunyi yang lebih baik dengan ketara. Ini berlaku kerana zarah individu di udara bergetar dan menyebabkan tenaga bunyi tersebar. Mengikut penemuan, sampel bahan gentian sekam padi menunjukkan prestasi yang lebih baik dalam menyerap tenaga bunyi dan berkesan dalam mengurangkan jumlah bunyi yang diserap oleh bahan.

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 her guidance and motivation, I am grateful to my main 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 of Universiti Teknikal Malaysia Melaka (UTeM), for their unwavering support during my studies. My special thanks go to En. Mohammad Rafi Bin Omar 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, Md Saad Bin Taib, for his support and encouragement throughout my life. My unending gratitude to Normah Binti Johari, 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.

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LIST OF SYMBOLS AND ABBREVIATIONS

α	-	sound absorption coefficient
EA	-	absorbed energy,
EI	-	incident energy,
ER	-	reflection energy
r	-	incident reflection factor
$IAbs$	-	Sound intensity absorbed
II	-	Incident sound intensity
	-	

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.0 Introduction

The purpose of this chapter is to explain the introduction and the project's goal. Before beginning the project fabrication, it is critical to understand the background project. The introduction, project background, problem statement, objective, and project scope will all be covered in this chapter.

1.1 Background

Unwanted sound is commonly referred to as noise. Nowadays, it is important to recognise that there are numerous ways in which an application can be used to reduce noise levels. Noise has a negative impact on both sleep and speech. Noise can also irritate non-auditory senses. Furthermore, exposure to high levels of voice will affect the hearing of the community, potentially leading to deafness (Amares, 2017). Due to a lack of knowledge and awareness, people did not consider it a serious problem. According to the most recent statistics, 53% of the population suffers from headaches, 36% from high blood pressure stress, 40% from anxiety, 36% from hearing loss, 15% from cardiovascular disease, 67% from irritability, and 61% from insomnia (Gupta, S, 2017). Besides, high levels of noise and vibration can cause structural failure and a reduction in the service life of many industrial tools and equipment. The process of heavy equipment and building activities are the major contributors to noise production and noise emissions.

Many researchers have been working on minimising this form of pollution in recent years, and many different methods have been proposed to manage or reduce excessive noise levels in both indoor and outdoor settings. In order to enhance the health and quality of life in industrial halls and buildings, sound absorbers are one method of noise management (U. Berardi et al, 2017). These acoustic materials are typically categorised as having fibrous, cellular, and granular features. The two main categories of fibrous absorbers are synthetic (organic and inorganic) and natural (derived from animals, minerals, and plants) fibres (S. Prabhakaran et al., 2019).

Natural materials are increasingly being used as viable sound absorption alternatives to traditional synthetic materials. Natural fibres, in particular, have recently been identified as viable raw materials for the production of low-cost sound-absorbing panels. Furthermore, these fibres are frequently thermally insulating, have no negative health effects, and are readily available in large quantities, often as a byproduct of other manufacturing processes.

Vegetable, stalk or wood, bast or skin, leaf, seed, and fruit fiber are the main categoriesfor fibers. Reeds, bagasse, cattail, corncob, cotton, date palm, durian, oil palm fibers, pineapple leaves, rice, sansevieria fiber, sunflower, and straw bale are some examples of natural fiber with a wide range of applications (Asdrubali F, et al., 2018). More complicated independent variables, including tortuosity and porosity, restrict the use of theoretical approaches, which are based on physical considerations of sound propagation in materials. There are numerous techniques for determining the amount of acoustic absorption, which are often done in impedance tubes with a loudspeaker and several microphones at low frequencies (Fouladi MH, et al., 2020).

1.2 Problem Statement

Sound analysis is critical in a room designed for a specific purpose, such as halls, lecture halls, recording studios, music centres, libraries, and others. To get the perfect feature sound, sound analysis must be performed. Noise pollution appears to have a more negative impact on mental health and quality of life. According to Eulalia Peris (2020) data, noise pollution is the second leading environmental cause of health problems. According to data collected in 2020, they estimate that environmental noise causes over 48000 new cases of ischaemic heart disease each year, as well as 12000 premature deaths. Furthermore, they estimate that 22 million people suffer from chronic high annoyance, with an additional 6.5 million suffering from severe sleep disturbance. Further to that, natural fibre has a good structure material, is low in cost, and can be obtained from waste disposal for plants because it is good for thermal and sound absorption.

1.3 Research Objective

The objective of this study is to investigate the properties of natural fiber based on sound absorption coefficient. The appropriate experiment and specimen preparation will be used for testing. The goal is to:

- To prepare the acoustic material sample of rice husk with different thickness, density and airgap.
- To study the sound absorption coefficient between different thickness, density and air gap using impendence tube.
- To analyze the significant of thickness, density and airgap using responde surface methodology with Minitab software.

1.4 Scope of Research

The scope of project is improtant in order to support the development process of this research. The description of scope for this research as listed below:

- Preparation the acoustic material sample with different thickness, density and airgap by using raw material rice husk fiber only.
- The research sound absorption coefficient between different thickness, density and air gap using impendence tube only for thickness (40 mm,50mm and 60mm), density (130 g/cm^3 , 150 g/cm^3 , 170 g/cm^3) and air gap (0mm, 10mm, 20 mm).
- The significant data of thickness, density and airgap follow from table factorial design combination of responde surface methodology by using Minitab software.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In The majority of the sound energy absorbed by sound absorbing materials is reflected very little. As a result, materials that absorb sound have been discovered to be extremely useful in noise regulation. They are commonly employed in a number of settings, such as near noise sources, in different directions, and frequently close to the receiver. There are numerous sound absorbing materials available, with absorption characteristics varying according to thickness, frequency, surface finish, composition, and assembly method. High-value products, on the other hand, are typically porous for sound amplification. The term "acoustical substance" has mostly been given to materials created with the intention of providing high absorption values (Arenas & Crocker, 2017). A porous absorbent is a substance that has canals, hollows, or interstices through which sound waves can flow. The impressing acoustic energy is converted into heating using absorption materials. 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 occurs when sound waves make contact with an absorbent surface material and lose energy. The sound waves do not return to the space. Sound absorbing materials are essential for reducing unwanted sound or noise in a variety of settings, including recording studios, lecture theatres, cinemas, examination halls, meeting rooms, and many others. Because of its high absorption capacity, natural fibre has a greater chance of being used in sound absorption materials in this new era than synthetic fibre. The main feature of most natural fibres was that they were good acoustic absorbers as well as environmentally friendly (Taban et al. 2020). Wood fibre, for example, was used to replace parts of polyester fibre. Polyester fibre is well-known for its good sound absorption properties, but it contains chemicals that have a negative impact on the environment and is also expensive.

The ability of a material to absorb as much of a sound wave as feasible while simultaneously producing as little as possible and transmitting a greater amount of the waves is the defining characteristic of acoustic absorption in materials. During the course of these investigations, it was necessary to place a strong emphasis on a number of significant acoustic factors, such as acoustic impedance and acoustic sound reflection (Nasidi, 2021). The acoustic impedance of a specimen can be defined as the ratio of the sound pressure that is exerted on the surface of the specimen to the normal particle velocity that is present on the surface. It is possible to determine the sound reflection coefficient by making a comparison between the overall intensity of the sound and the total intensity of the incident. The effectiveness of a sound-absorbing material can be affected by a variety of characteristics, including its thickness, density, and porosity.

2.3 Factors Influencing Sound Absorption

2.3.1 Fiber Size

Zumiju (2016) made the discovery that the sound absorption coefficient rose with decreasing fibre diameter. [Citation needed] This occurs as a result of the fact that thin fibres are able to move more easily on sound waves than thick fibers can. In addition, using small denier fibres necessitates using a greater number of fibres in order to achieve the same volume density, which results in a more winding path and a greater resistance to airflow (Lee Sun and Peng, 2010).

2.3.2 Thickness

Increasing the thickness improves wave absorption and reduces energy reflection (Amares et al., 2015). Azkorra (2015) determined that as sample thickness grows, so does the sound coefficient. Waves have a longer wavelength at low frequencies, therefore thicker materials help in absorption. However, at higher frequencies, the sound absorption is only marginally affected.

2.3.3 Density

Acoustic absorption is greatly influenced by material density. The acoustic impedance is controlled by density, and the impedance determines the materials' reflection. A high-density material (increased mass) rise sound absorption (Amares et al. 2017). The density increases the number of fibres (increases per unit area) and thus reduces energy loss due to increased surface friction. The coefficient of sound absorption will then be reduced. However, the thicker the structure, the better the function for frequencies above 2000 Hz, but the less dense and transparent the structure, the better the function for frequencies 500 Hz and below.

2.3.4 Position or Placement of Sound Absorption

It is a well-established fact that the position and positioning of a material can have an effect on the amount of sound that it absorbs (Alton Everest 2011). If different kinds of absorbers are employed, it is optimal to place some of each kind of absorber on the ceilings, sides, and ends of the room so that all three axial modes can be affected. This keeps the room from producing unwanted vibrations (longitudinal, transverse, and vertical). It has been shown that the most effective method of sound absorption in rectangular rooms is to position absorbing material around corners and around the edges of room surfaces. In vocal studios, it is important to apply high-performance materials that can absorb audio frequencies to the walls at head height. In point of fact, putting material to the lowest regions of high walls can be twice as effective as applying it to other parts of the wall.

2.3.5 The Effect of the Air Gap

Calculations of sound absorption were performed both with and without a 5 mm and 10 mm air gap between the backing of the adjustable plunger of the impedance tube and the back of the sample. In addition to this, the highest point for the various air gaps can differ (higher the air gap distance, maxima peak shift towards lower frequency). This would imply that there is a perfect value for an air gap beyond which the capabilities of sound absorption do not alter significantly.

2.4 Sound Absorption Coefficient (SAC)

The sound absorption coefficient, also known as SAC, is calculated by dividing the amount of sound that is absorbed by a material by the total amount of sound that is incident on the material. According to the research conducted by Kuczmarski (2011), an increase in the percentages indicates an improvement in the absorption, demonstrating that the vast majority of the sound is absorbed while just a little portion is reflected back . The following diagram, Figure 2.1, illustrates that there are three primary categories of waves that can be experienced by a substance: incident, reflected, and transmitted waves. Waves that are projected onto a certain substance are referred to as incident waves. After being projected onto the substance, incident waves can either be reflected or transmitted. The primary purpose of this test is to evaluate the capacity of a material to absorb sound waves. It is