UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ABSORPTIVE MUFFLER DESIGN BASED ON COCONUT FIBER TO ANALYSE SOUND TRANSMISSION LOSS USING IMPEDANCE TUBE

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2022

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Refrigeration and Air-Conditioning Systems) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

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2022

DECLARATION

I declare that this Choose an item. entitled “Absorptive Muffler Design Based On Coconut Fiber To Analyse Sound Transmission Loss Using Impedance Tube” 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	:	Muhunthaa
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Date	:	17/01/2022

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 Mechanical Engineering Technology (Refrigeration and Air-Conditioning Systems) with Honours.

Signature : .....

Supervisor Name : Ts. Mahammad Nur Bin Othman

Date : 22/01/2022

.....

DEDICATION

To my beloved family, friends and my supervisor Mr. Muhammad Nur Bin Othman

ABSTRACT

The sound transmission loss is an important parameter to anaylse absorptive muffler performance. Absorptive muffler have a poor performance at low frequencies compare to reactive muffler. The absorptive muffler which effective only in higher frequencies.This research is focus on an absorptive muffler design with different types of perforated tube to create a way to perform experimental to determine the sound transmission loss characteristics of absorptive mufflers. Furthermore, coconut fiber will be using for analyse sound transmission loss because it has low densities and are up to two times lighter than glass fiber, and also have a significantly higher specific stiffness than glass fibres with the same characteristic. The main goal of this study is to design the coconut fiber's absorptive muffler by using Solidworks software as well as to fabricate the design sketched by using 3D printer then to analyse the sound transmission loss of coconut fiber's absorptive muffler. Solidworks software will be used to designed an absorptive muffler, which will then be transferred to a 3D printer. Polylactic acid (PLA) is the material that will be utilised to make the absorptive muffler. The coconut fibre samples were inserted inside the muffler and arranged into the muffler after the fabrication was completed, and the impedance tube was used to analyze the sound transmission loss. In addition, this study used a muffler with a thickness of 1.2cm and four different length of coconut fiber arrangements. As a result, a circular absorptive muffler was successfully designed and fabricated using a 3D printer. For a 14cm length arrangement of coconut fiber, the highest sound transmission loss obtained was 18.71dB at 3150 Hz frequency. This project is expected that may help the world to be a better place to live by reduce the noise reduction by installing perforated tube in absorptive muffler and also reduce noise pollution.

ABSTRAK

Kehilangan transmisi bunyi adalah parameter penting untuk prestasi muffler penyerap anaylse. Penyerap muffler mempunyai prestasi yang buruk pada frekuensi rendah berbanding dengan muffler reaktif. Penyerap muffler yang hanya berkesan pada frekuensi yang lebih tinggi. Penyelidikan ini memfokuskan pada reka bentuk penyerap muffler dengan pelbagai jenis tiub berlubang untuk membuat cara untuk melakukan eksperimen untuk menentukan ciri kehilangan transmisi bunyi penyerap muffler. Selanjutnya, serat kelapa akan digunakan untuk menganalisis kehilangan transmisi bunyi kerana mempunyai ketumpatan rendah dan hingga dua kali lebih ringan daripada gentian kaca, dan juga mempunyai kekakuan spesifik yang jauh lebih tinggi daripada gentian kaca dengan ciri yang sama. Matlamat utama kajian ini adalah untuk merancang tiub impedans penyerap serat kelapa dengan menggunakan perisian Solidworks dan juga membuat reka bentuk yang dilukis dengan menggunakan pencetak 3D kemudian untuk menganalisis kehilangan transmisi suara tiub impedans penyerap serat kelapa. Perisian Solidworks akan digunakan untuk merancang penyerap muffler, yang kemudian akan dipindahkan ke pencetak 3D. Asid polylactic (PLA) adalah bahan yang akan digunakan untuk membuat penyerap. Sampel serat kelapa dimasukkan ke dalam penyerap muffler dan disusun ke dalam tiub impedance setelah fabrikasi selesai, dan tabung impedans digunakan untuk menganalisis kehilangan transmisi suara. Di samping itu, kajian ini menggunakan penyerap muffler dengan ketebalan 1.2cm dan empat panjang susunan serat kelapa yang berbeza. Hasilnya, penyerap muffler bulat berjaya dirancang dan dibuat menggunakan pencetak 3D. Untuk susunan serat kelapa sepanjang 14cm, kehilangan transmisi bunyi maksimum yang diperoleh adalah 18.71dB pada frekuensi 3150 Hz. Projek ini diharapkan dapat membantu dunia menjadi tempat tinggal yang lebih baik dengan mengurangkan pengurangan kebisingan dengan memasang tiub berlubang dalam penyerap muffler dan juga mengurangkan pencemaran bunyi.

ACKNOWLEDGEMENTS

First and foremost, I would like to praise my biggest source of guidance and strength, the one and only God the Almighty for giving me the patient, health, time, and knowledge to be able to conduct this Final Year Project report successfully and efficiently with less problems along the way.

Besides, I am also truly grateful to my amazing supervisor, Mr. Muhammad Nur bin Othman, who give me the proper guidance, encouragement, enthusiasm, and support at the start until the end of developing this report. I must also thank the support I got from my two beloved parents. The consistence love, support, words of encouragement and understanding given by them kept me going through and helped painted my pathway of success.

Last but not least, special thanks to all my high school friends and classmate for sticking with me through the thick and thin of the entire project. Finally, thank you to everyone that have directly or indirectly be involved in helping me out in completing this Bachelor Degree Project (BDP).

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LIST OF SYMBOLS AND ABBREVIATIONS

m	-	Metre
g/cm^3	-	Gram per cubic centimetre
MPa	-	Megapascal
%	-	Percentage
°C	-	Degree celcius
Wt.%	-	Weight percentage
mm	-	Millimetre
g	-	Gram
CO^2	-	Carbon dioxide
3D	-	3 dimensional
dBA	-	A-weighted decibels
dB	-	Decibels
PNC	-	Preferred Noise Criterion
SIL	-	Speech Interference Level
Hz	-	Hertz
cm	-	Centimetre
kV	-	Kilovolts
Kg/m^3	-	Kilogram per cubic metre
Ø	-	Diameter
NaOH	-	Sodium hydroxide

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Mufflers are used in pipelines to reduce noise and vibration transmission. Absorptive mufflers are constructed in such a way that sound entering the muffler interacts with the packing material and is converted to heat through friction. The performance of muffler is dependent on the packing material's absorption. Absorption is used by an absorptive muffler to minimise sound energy. The absorptive muffler design uses just sound wave absorption to reduce noise without affecting exhaust gas pressure. This is referred to as a glass pack muffler, and it reduces backpressure while increasing noise. When compared to other types of mufflers, the sound produced by this type of muffler is substantially louder. The energy of sound waves is transformed into heat in the absorptive material, which causes them to be diminished. A basic absorptive muffler is made up of a straight, round, perforated pipe enclosed in a bigger steel casing. A layer of sound absorptive material between the perforated pipe and the casing absorbs are the pressure pulses. Muffler have three simple objects for perfect operation. The first object is to absorb and also dissipate. And then, the second is to move exhaust gases. The last one is to maintain power and performance of engine while reached the first two objects. The transmission loss or insertion loss of a muffler is commonly used to describe its performance or attenuating capability. The difference between the sound occurring at the muffler's entry and the sound conveyed by the muffler is known as the transmission loss. (Zhuo Zhuang et al 2020)

Mufflers have been utilised in the suction and discharge ports of compressors for home appliances to reduce duct noise in the exhaust systems of internal combustion engines for automobile vehicles and big vessels. The noise attenuation performance of a muffler can be influenced by the entire system, but it's usually measured in sound transmission loss (STL), which is defined as the difference between the incident and transmitted acoustic power levels. For the same muffler, a high transmission loss value indicates a significant noise reduction, and the transmission loss varies with frequency and temperature. Several

partitions are usually installed inside the muffler to raise the transmission loss value in a specified frequency range. (Jong Kyeom Le et al 2021)

1.2 Problem Statement

A faulty muffler can be caused by a variety of factors. Mufflers naturally degrade over time as a result of exposure to moisture and heat. The interior of mufflers rusts due to moisture, lowering their quality. If the automotive collides with something that knocks against the component, the muffler may fail and it's time to inspect the exhaust system if the automotive suddenly becomes noisy, releases an unpleasant odour, or has a significant loss in fuel efficiency. Any noise problem may be characterised in terms of a source, transmission path, and receiver, and noise reduction can involve changing any or all of these components. The noise source is the point at which vibratory mechanical energy is generated as a result of a physical occurrence such mechanical shock, collisions, friction, or turbulent airflow. The noise levels at the locations where complaints are made must be determined. The next step is to apply acceptable noise level criteria to the levels that have been determined. Each location and, as a result, to determine the required sound transmission loss, which are typically calculated as a function of frequency bands of one octave or one-third octave.

Furthermore, absorptive muffler have a poor performance at low frequencies compare to reactive muffler. Muffler works well at the absorptive muffler which effective only in higher frequencies. Moreover, absorptive muffler material can degrade under certain circumstances for example high heat and etc. The thickness of the absorptive material and its spacing have a significant impact. Sound attenuation is a term used to describe the process of reducing sound levels. At high frequencies, the attenuation increases dramatically. As the thickness of the absorbing material is increased, better performance at lower frequencies is gained.

Natural fibre has a higher specific strength and a similar specific modulus to glass fibre. Another factor to consider is the source of natural fibres available in our country, which theoretically offer desirable particular strengths and modulus at a lower cost. Thus, Natural fibres can also help to alleviate the pain caused by engines, exhaust systems, gears, and wheels, which is manifested as noise, heat, and electrostatic charges. Natural fibres are a good choice in terms of safety because they are nonabrasive and do not create sharp edges when deformed like glass fibres. Natural fibres have many advantages over synthetic fibres,

including relatively renewable resources, biodegradability, low cost, less damage to processing equipment, low weight, improved surface finish of moulded parts composites, abundant flexibility during processing, and good relative mechanical properties like tensile and flexural modulus. Natural fibres, which have low densities and are up to two times lighter than glass, have a significantly higher specific stiffness than glass fibres with the same characteristic.

1.3 Research Objective

There are several objective to achieve.

i. To design the absorptive muffler using Solidworks software.
ii. Fabricate the absorptive muffler using 3D printer.
iii. To analyse the sound transmission loss of coconut fiber using impedance tube.

1.4 Scope of Research

The scope of this research are as following:

The scope in this study focus on reducing noise pollution using absorptive muffler. The main objective of the project is to analysis sound transmission loss based on coconut fiber using impedance tube. Furthermore, a suitable muffler is designed for noise reduction. There are some breakdown task need to perform during this project. The first breakdown task is muffler design. Design a muffler is a important part and needed a suitable muffler design for a better noise reduction and also for optimum backpressure. Thus, need a impedance tube to measure specific impedance, sound absorption coefficients, sound transmission losses and acoustic properties. Material selection criteria for natural fiber have to choose for better noise reduction. The parameter which need to observe and control is the muffler's quadrupole properties. The quadrupole parameters are subjected to a sensitivity analysis utilising and transfer matrix analysis. And then, the transmission loss also need to observe and control. The distinction in sound power occurring at the muffler entry as well as the sound power conveyed by the muffler is the parameter which needed to observe and control. The thickness of absorptive material also the parameter should be observe and control, as the gap is narrowed, the attenuation increases significantly at high frequencies. The limitations that will face to complete the project will be the characteristics of absorptive muffler design and also the methodology that impacted the interpretation of the project. The project is suggested

that full fluid-structure connection of the structure with the acoustics medium be considered in future work. However, it lengthens the calculation time and increases the problem's complexity. To reduce the influence of absorptive mufflers on air pollution, more environmentally friendly absorptive materials should be studied.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Mufflers are devices that reduce the amount of noise that is transmitted through muffler. They've devised a variety of strategies to lessen the noise created in their inlets, including passive and active measures. Active mufflers aren't quite ready for widespread manufacture yet. As a result, industrial emphasis is concentrated on passive mufflers, which limit the energy of transmitted noise by using either reflection or absorption methods. Absorptive mufflers should be used for intermediate to high frequency ranges, is. greater than 500 Hz, with little back pressure, while reactive mufflers should be utilised for low frequency ranges. The reactive type muffler is usually tight, preventing even nice engine noises from coming through, but it does an excellent job of noise reduction. Most absorptive type mufflers, on the other hand, are less restrictive but allow too much engine noise to pass through. Absorptive type mufflers, regardless of packing material, tend to become noisier with age. Experimental trial and error, as well as electro-acoustic parallels have been used to produce mufflers throughout the last century. Stewart developed the fundamentals of acoustic filter theory and design using electro-acoustic analogies many years ago. The implementation utilising four-pole parameters of two-port network theory is a significant step advance in the investigation of muffler acoustic performance. (Mostafa Ranjbar & Maryam Alinaghi, 2016)

On the other research, Noise pollution from automobiles is one of the major sources of noise pollution in the environment. A muffler is a device that reduces the noise produced by an internal combustion engine's exhaust. Inside the muffler, there is also a pressure drop. Muffler is the last component attached to the exhaust system and is located after the catalytic converter. A vehicle muffler's main purpose is to reduce engine noise emissions. A car without a muffler will appreciate how much of a difference a muffler can make in terms of noise level. There would be an intolerable amount of exhaust noise in our immediate environment if vehicles did not have mufflers. Sound is a pressure wave created by

alternating high and low air pressure pulses. Pressure waves are created in an automobile engine when the exhaust valve is opened and closed repeatedly, allowing gas injected at high pressure into the exhaust system. The sound is made up of these pressure pulses. As the engine rpm rises, the pressure fluctuations rise with it, resulting in a higher-frequency sound. Unwanted sound is referred to as noise. The vehicle muffler can allow exhaust gases to pass through while limiting sound transmission. Back-pressure is defined as the difference between the ambient and back-pressure pressures, which is caused by a drop in stagnation pressure via various perforated elements and abrupt area discontinuities. Absorption is used in an absorptive or dissipative muffler to attenuate sound energy. The energy of sound waves is transformed into heat in the absorptive material, which causes them to be diminished. A basic absorptive muffler is made up of a straight, round, perforated pipe enclosed in a bigger steel casing. A layer of sound-absorbing material sits between the perforated pipe and the casing, absorbing some of the noise. (Mostafa Ranjbar & Maryam Alinaghi, 2016)

2.2 Noise Reduction

The project's goal was to look at passive noise reduction strategies in mufflers. Another goal of this research is to look at and create mufflers with different geometry. This is where you'll study about the effect of geometry on muffler noise transmission loss maximazation performance. To do so, the four-poles approach is used. For the mufflers, two different cross-sectional geometries are considered: rectangular and circullar. These mufflers have been manufactured and tested. The noise transmission loss of these mufflers is measured using a noise transmission test bench. The analytical results of the simulation were compared to the experimental data. The influence of muffler geometry on the maximum transmission noise loss is examined and reported. Students can use the findings of this study to learn the fundamentals of muffler design for noise reduction applications. It also demonstrates how geometry affects the acoustic performance of muffler (Mostafa Ranjbar et al. 2017).

The ambient temperature is set to 20°C, the sound speed is set to 343 m/s, and the density of air is set to 1.204 kg/m3. These conditions have the potential to alter the factors that influence the four pole constants.