FABRICATION AND MECHANICAL ANALYSIS OF SPENT TEA LEAF MATERIALS FOR SOUND ABSORPTION

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B051110247 BACHELOR OF MANUFACTURING ENGINEERING (ENGINEERING MATERIAL) (HONS.) 2015 UTeM

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This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Hons.)

by

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2015

DECLARATION

I hereby, declared this report entitled "Fabrication and Mechanical Analysis of Spent Tea Leaf Materials for Sound Absorption" is the results of my own research except as cited in references.

Signature	:	……………….
Author's Name	:	FIONA SHIM MAY FA
Date	:	05^{th} JUNE 2015

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirements for the Degree of Manufacturing Engineering (Engineering Materials) (Hons.). The member of the supervisory committee is as follow:

……………………………………

(Supervisor)

(PROF. DR. QUMRUL AHSAN)

ABSTRAK

Kajian ini memberikan tumpuan kepada penyediaan dan analisis mekanikal untuk hampas daun teh (HDT) sebagai bahan dalam penyerapan bunyi. HDT yang juga dikenali sebagai bahan buangan di kilang-kilang teh telah dianggap sebagai sumber semula jadi yang baru untuk bahan penyerap bunyi bermatrikkan getah asli komposit. Objektif kajian ini adalah untuk menentukan pencirian fizikal dan mengkaji sifat penyerapan bunyi struktur penyerapan bunyi hijau diperbuat daripada komposit hampas daun teh bermatrikkan getah asli (HDT/GA) dan daun teh yang dimampatkan. Kajian ini menyimpulkan penyediaan dan pencirian bahan penyerapan bunyi. Terdapat dua gred serat HDT yang digunakan dalam kajian ini, iaitu BHE-BM dan BHE-SW daripada tangkai daun pokok teh. Bahan penyerapan bunyi yang dihasilkan kemudian dilakukan pemerhatian mikroskopik, ujian fizikal dan penyerapan bunyi. Daripada kajian ini, keputusan penyerapan bunyi telah menunjukkan bahawa daun teh gred BHE-SW yang telah dimampatkan memberikan koefisien penyerapan bunyi yang tertinggi. Tambahan pula, penambahan ketebalan jurang udara juga meningkatkan koefisien penyerapan bunyi dan mengalihkan puncak penyerapan ke kawasan frekuensi yang lebih rendah.

ABSTRACT

This research focuses on the fabrication and mechanical analysis of spent tea leaf materials for sound absorption. Spent tea leaves (STL) which are known as waste materials in tea producing factories have been considered as new natural resources for sound absorbing natural rubber foam composite materials. The objectives of this research are to determine the physical properties and to study the sound absorption properties of sound absorbing materials made of spent tea leaves filled natural rubber foam (STL/NR) composites and compressed spent tea leaves materials. This research deduces the fabrication and characterization of sound absorbing materials. Two grades of STL are used in this research, which are BHE-BM and BHE-SW from the stalk of the tea plant. The fabricated composites are subjected to microscopic observation, physical and sound absorption testing. From this research, the sound absorption results has shown that compressed spent tea leaves of finer grade BHE-SW provides the best sound absorption coefficient. Furthermore, increased air gap thickness also increases the sound absorption coefficient and shifts the peak of absorption to lower frequency region.

ACKNOWLEDGEMENT

First of all, I would like to express my highest gratitude to my beloved supervisor, Prof. Dr. Qumrul Ahsan for his advices, valuable information and guidance, which helped me in completing the Final Year Project on time and fulfil the requirements.

Besides, special thanks is also dedicated to my team mates Nurul Naili binti Mohamad Ishak and Wan Muhammad Faiz bin Wan Mohamed Arshad because always provide me cheers, comments, and cooperation.

Last but not least, I would like to show my deepest appreciation to my family members for their moral support, understanding and encouragement throughout this project.

DEDICATION

Dedicated to
my beloved father, Lawrence Shim Nyuk Min
my appreciated mother, Mary Voo Min Lan
and my adored siblings Nellie Shim Fui Ping and Yvonne Shim Eng Fa
for giving me moral support, cooperation, encouragement and also understanding.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
BHE-BM	-	coarse spent tea leaves grade
BHE-SW	-	fine spent tea leaves grade
BM100	-	compressed spent tea leaves of grade BHE-BM
FTIR	-	Fourier Transform Infrared Spectroscopy
GA	-	Getah Asli
KBr	-	Potassium Bromide
MBTS	-	Benzothiazyl Disulfide
NR	-	Natural Rubber
NR/BHE-BM	-	BHE-BM grade spent tea leaves filled natural rubber foam composite
NR/BHE-SW	-	BHE-SW grade spent tea leaves filled natural rubber foam composite
NR100	-	pure natural rubber foam
OM	-	Optical Microscope
phr	-	part per hundred rubber
SMR-L	-	Standard Malaysian Rubber Grade L
STL	-	Spent Tea Leaves
SW100	-	compressed spent tea leaves of grade BHE-SW

LIST OF SYMBOLS

°	-	degree
%	-	percent
cm	-	centimeter
Hz	-	Hertz
mg	-	milligram
mm	-	millimeter
kg/cm^2	-	kilogram per centimeter square

CHAPTER 1

INTRODUCTION

This chapter describes the background study, the problem statement, the objectives and the scope of the study.

1.1 Background Study

According to Oxford dictionary, noise is a sound, especially one that is loud or unpleasant or that causes disturbance. Potential hazardous noise is produced from automobiles, manufacturing environment and equipment. According to Al-Rahman *et al.* (2012), discomfort resulted from long term exposure to continuous noise may lead to several health problem such as hearing loss, heart problem and high blood pressure. To solve this problem, acoustic material is designed to absorb sound that might otherwise be reflected. There are three categories of sound absorbers, which are porous absorbers, panel absorbers and resonators (Jacobsen *et al.*, 2011). Porous absorbers generally provide more bass sound absorption or damping and the absorption coefficient increases with increasing thickness of the absorbers. For panel absorbers, they are most efficient at absorbing sound of low frequencies whereas for resonators, they usually absorb sound in narrow mid-frequency range. Over the years, sound absorbing materials slowly develop from synthetic material to natural material due to environmental issue and public health concern. Biodegradable natural fibers such as hemp, coconut coir and jute are used to replace the synthetic sound absorbing materials (Fatima and Mohanty, 2011).

1.2 Problem Statement

Noise pollution has become a significant issue which threatens comfort and health. Arenas and Crocker (2010) explained that the existing sound absorbing materials are mostly made of synthetic fibers manufactured from minerals and polymers through high temperature extrusion and industrial processes based on synthetic chemicals. These synthetic chemicals especially petrochemical sources have significant carbon footprints and pose big impact on the environment. Thus, the existing sound absorbing materials have disadvantages in terms of cost and sustainability. Synthetic fibers are higher in cost and often induce sustainability issues such as biodegradability and landfill problem.

Therefore, natural fibers are used as the green sound absorbing materials to replace synthetic fibers. Natural fibers are biodegradable, safer for human handling and possess high quality at competitive prices with modern technical developments which made natural fiber processing more economical and environmental friendly.

In this study, spent tea leaves with the characteristics of biodegradable, light weight and low cost are considered as a new resource for sound absorbing materials. Tea leaves have fresh scent which can eliminate unpleasant smell. Besides, tea leaves have anti-bacterial properties (Chaturvedula & Prakash, 2011) which contribute to its high resistance to fungal and termites properties. Tea leaves are also rich in tannis which makes it possess high durability (Yalinkilic *et al*., 1998) and high resistance to fire (Dittenber & GangaRao, 2012).

1.3 Objectives

The aims of this research include:

(a) To determine the physical properties of spent tea leaves filled natural rubber foam composite and compressed spent tea leaves materials.

(b) To study the sound absorption properties of spent tea leaves filled natural rubber foam composite and compressed spent tea leaves materials using rigid backing and various air gaps.

1.4 Scope

The scope of this study was focused on the sound absorption properties of spent tea leaves filled natural rubber foam composite and compressed spent tea leaves materials. Two grades of spent tea leaves such as BHE-BM and BHE-SW were used as the filler of the composite. The raw materials with different formulated weight ratio were mixed and compressed. The sound absorption coefficient of the fabricated composite was determined through impedance tube testing. Distribution of fillers in the composite was also examined to correlate it with the sound absorption behavior of the composite.

CHAPTER 2

LITERATURE REVIEW

A literature review on previous research work in various areas which is relevant to this research is presented in this chapter.

2.1 Acoustic Materials

Noise pollution has become a significant issue with increase urbanization (Fatima and Mohanty, 2011). According to Al-Rahman *et al.* (2012), some of the sources of unwanted noises are sound emitted from industries, construction machines and vehicles. Prolonged exposure to continuous noises can cause discomfort and health problems such as weakness in nerve, pain in internal tissues, heart problem, high blood pressure and to a certain extent even hearing loss in serious cases. Besides, noise induced stress creates tension which contributes to mental illness (Yuhazri *et al*., 2011).

Fatima and Mohanty (2011) stated that noise can be controlled by two methods, which are suppression of noise generating factors and application of noise proofing materials to reduce the acoustic wave's energy by blocking or absorption. In acoustical control, barriers and absorbers are the two classes of acoustical treatments used to address airborne noise whereas isolators and dampers are used to address structure–borne noise. Effective noise control usually incorporates both barriers and absorbers for airborne noise and both isolators and dampers for structure-borne noise (Parikh *et al.*, 2006). Sound insulation requirements in automobiles, industry environments and equipment which generate higher sound pressure encourage the development of more efficient and economical ways of producing sound absorbing materials (Ersoy & Küçük, 2009). Figure 2.1 shows an acoustical material with sound being incidenced on it.

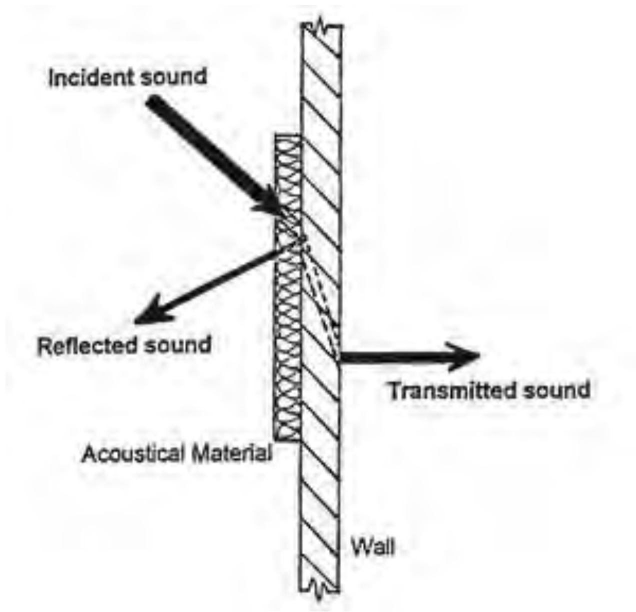

Figure 2.1: Acoustical material.
(Source: < http://www.acousticalsurfaces.com/acoustic_IOI/101_7.htm> 30/10/2014).

2.1.1 Sound absorbing materials

Zhou *et al.* (2007) claimed that viscous loss, thermal damping and Helmholtz resonance effects contribute the most in sound dissipation. Sound absorption occurs when sound energy is converted to heat energy, with a reduction in sound pressure. When an incident sound wave is subjected on the material, the sound pressure and velocity fluctuate within the material. This causes vibration of the material matrix, which is known as damping. The oscillating particles within the material rub against the matrix and the sound is converted to heat by friction. Seddeq (2009) supported that the conversion of sound energy into heat energy can prevent a buildup of sound in enclosed spaces and reduces the strength of reflected noise. Figure 2.2 shows the mechanism of sound absorption in sound absorbing material.

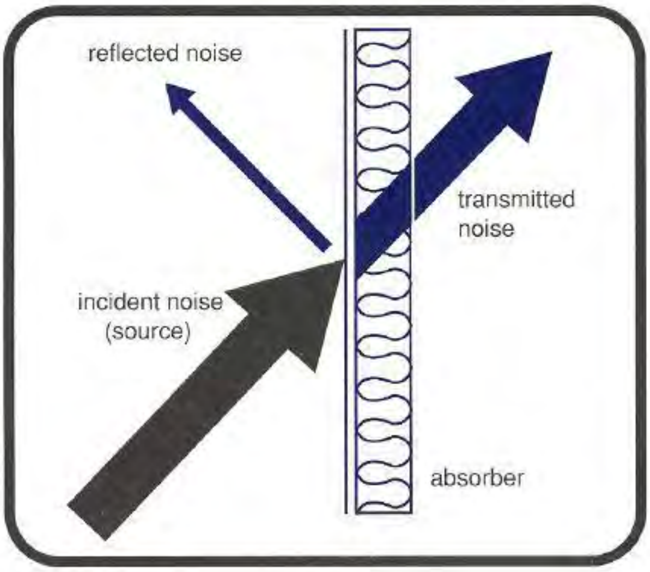

Figure 2.2: Mechanism of sound absorption in sound absorbing material.
(Source: <http://www.acoustic-material.com> 30/10/2014).

According to Jacobsen *et al.* (2011), the three most common types of sound absorbing materials are porous absorbers, membrane absorbers and resonator absorbers. The variation of sound absorbing coefficient for different absorbers is as shown in Figure 2.3. Porous absorbers are most efficient at absorbing high frequencies whereas panel absorbers are most efficient at absorbing low frequencies. Helmholtz resonators show highest absorption coefficient at narrow mid frequency range.

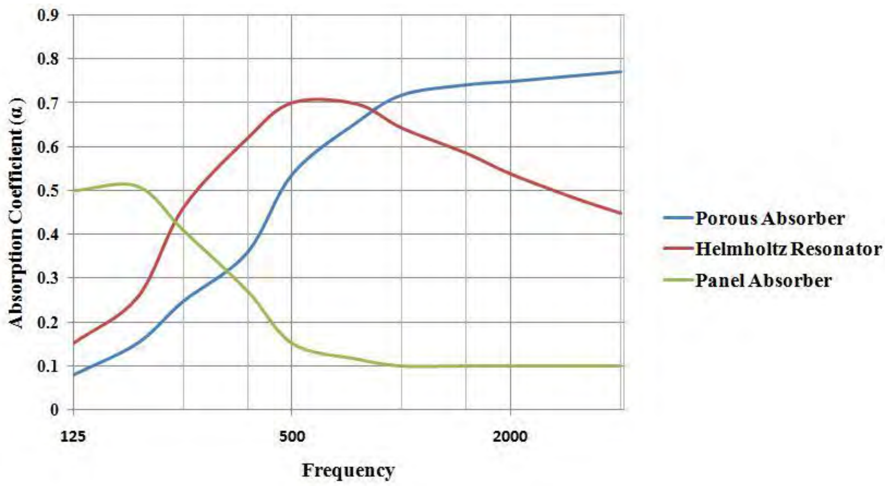

Figure 2.3: Variation of sound absorbing coefficient for different absorbers (Jacobsen *et al.*, 2011).

2.1.1.1 Porous sound absorbing materials

Jacobsen *et al.* (2011) described porous materials as an open structure which is accessible by air. Air can be pressed through the material depending on the flow resistance. The sound absorption properties are affected by viscous friction between the moving air molecules. Sound energy is converted into heat energy especially in the structure where large internal surface area is present. Arenas and Crocker (2010) improved the explanation with microscopic configurations of the porous sound absorbing materials. Porous materials have the characteristic of allowing sound waves to enter through surfaces with a multitude of small holes or openings. As illustrated in Figure 2.4, porous sound absorbing materials can be classified into cellular, fibrous and granular structures.

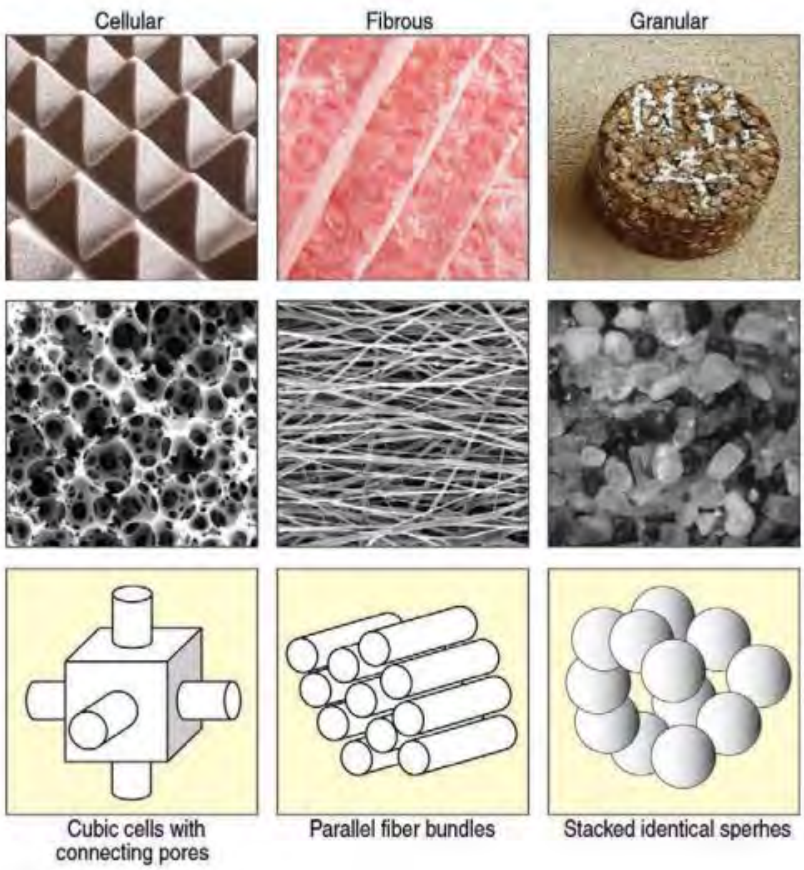

Figure 2.4: The three main types of porous sound absorbing materials (Arenas and Crocker, 2010).