DEVELOPMENT AND ACOUSTICAL ANALYSIS USING KENAF AND COCONUT FIBRES AT DIFFERENT FIBRE LOADING

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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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2016

DECLARATION

I hereby, declared this report entitled “Development and Acoustical Analysis of Hybrid Composite Using Kenaf and Coconut fibre” is the results of my own research except as cited in references.

Signature :

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Date : 1st JULY 2016

APPROVAL

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

……..…….

(DR. MOHD YUHAZRI BIN YAAKOB CEng MIMechE)

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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ABSTRAK

Kajian akustik dalam kajian ini adalah tentang penyerapan bunyi antara kenaf dan kelapa hibrid komposit semulajadi pada frekuensi yang rendah, sederhana dan tinggi. Salah satu sebab untuk mengaji kajian ini adalah pengurangan perladangan kelapa yang secara beransur-ansur serta gantian dengan tanaman komoditi lain seperti kenaf. Kajian ini juga membuka peluang bagi menentukan laluan alternatif untuk menghasilkan bahan penyerapan bunyi semula jadi. Dengan menggunakan kenaf dan campuran kelapa pada loading serat yang berbeza dengan lateks getah asli sebagai pengikat untuk mengukur pekali penyerapan bunyi. Teknik yang digunakan ialah tiub galangan kaedah eksperimen dengan pematuhan kepada ASTM E1050-98 (2006) serta merujuk kepada standard ISO 10534-1. Kesimplulan bagi kajian ini adalah penambahan serat optimum kenaf dan kelapa dengan pekali penyerapan bunyi yang tinggi pada jarak frekuensi sederhana (500 Hz ~ 2000 Hz) dan tinggi (2000 Hz ~ 4500 Hz) adalah berbeza-beza. Apabila kandungan kenaf meningkat, pekali penyerapan bunyi meningkat. Selain itu, ketebalan sample juga meningkatkan pekali penyerapan bunyi pada frekuensi yang lebih rendah.

Abstract

Acoustic study in this research is the sound absorption coefficient of kenaf and coconut hybrid natural composite at low, medium and high frequency range. As the noise has been another major concern of pollution in this globalization. In addition, the obstacles in using passive sound absorbing material is to achieve high sound absorption coefficient in low frequency range that is within 0 to 1500 Hz in general. Furthermore reduction of coconut plantation that gradually replace by other commodity plant such as kenaf also a factor that lead to this research as to determine alternative route to produce natural sound absorption material.to replace synthetic sound absorbing material. This research uses kenaf and coconut mixing at different fibre loading with natural rubber latex as binder to measure the sound absorption coefficient using impedance tube method experiment that compliance to ASTM E1050-98 (2006) with reference to ISO standard 10534-1. The expectation in the findings of this experiment is the optimum fibre loading of kenaf and coconut with high sound absorption coefficient at high and medium frequency range. The study found that as kenaf fibre loading increase, the sound absorption coefficient increase, meanwhile the thickness of the sample influence the sound absorption coefficient peak by shifting to lower frequency range.

DEDICATION

I hereby dedicate this to
my beloved father, Lim Kong Hoi
my dearest mother, Tan Siew En
and my two lovely sisters Lim Loo Hwei and Lim Wei Qing
last but not least my coolest brother Lim Hong Yew .
Thank you for giving me support and courage to finish years of education.

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SEM	-	Scanning electron microscopy
FTIR	-	Fourier transform infrared spectroscopy
ASTM	-	American Society for Testing and Materials
ISO	-	International Organization for Standardization
SAE	-	Society of Automotive Engineers
PLA	-	Polylactic acid
MAPP	-	Maleic anhydride polypropylene
EPDM	-	Ethylene propylene diene terpolymer
CNC	-	Celulose nano-crystal
TEM	-	Transmission electron microscopy
FESEM	-	Field emission scanning electron microscopy
H_2SO_4	-	sulphuric acid
CMC	-	Carboxymethyl cellulose
PLLA	-	Poly ($_L$- lactic acid)
VARTM	-	Assited Resin Transfer Moulding
CFC	-	Chlorofluorocarbon
PBAT	-	Poly(butylene adipate-co-terephthalate)
USD	-	US dollor
RM	-	Ringgit Malaysia

LIST OF SYMBOLS

dB	-	Decibels
kHz	-	kilo Hertz
m	-	metre
%	-	percentage
N	-	Newton
˚C	-	Degree Celcius
g/cm^3	-	gram per centimeter cube
cm	-	centimeter
mm	-	milimetre
MPa	-	Mega pascal
pH	-	Acidity
wt%	-	weight percentage
g/tex	-	Tenacity
µm	-	micrometer
GPa	-	Giga pascal
N/mm^2	-	Newton per milimetre square
α	-	sound absorption coefficent

CHAPTER 1
INTRODUCTION

1.1 Research Background

Acoustic is the study of sound by analysing the propagation of sound from source to receiver as stated by Dunn *et al.* (2015). The study of acoustic has been widely use in concept of physic, engineering, psychology, neuroscience and more. Example of sound processing is vibration, change in air flow, time-dependent heat sources and supersonic flow. The allowable sound intensity for human is more than 10^{12} dB, meanwhile the ration between peak and lowest frequency that can be heard by human is 10^3. Furthermore, the intensity ratio between sound that hurt human ears and the weakest audible sound is more than 10^{12}. In recent years, noise has been one of the main cause of pollution that is torturing human. Sound pollution affect human health and lifestyle especially hearing. Arnsten and Goldman (1998) research found that exposure to noise will cause stress impaired delayed-response performance. Moszynski (2011) stated that one of the environment factors that contribute to disease in Europe is environmental noise as noise pollution caused annoyance, sleep disturbance, heart attacks, difficulties in learning and tinnitus. Besides, high level noise causes hearing loss especially employee that exposed to high level noise working environment. The shear number of machines is crucial than noise emitted need to reduce in order to prevent noise propagation to external environment. Sound pollution has led to creation of soundproof materials to reduce the noise level or to enhance sound. Soundproof materials are used widely in musical field to enhance music and increase one's pleasure. The vital usage of soundproof board is during recording as the reflection of sound affect the original performance. In fact, some contemporary music instrument is attached with soundproof material such as layer of cotton or wood.

Moreover, understanding the physiological and psychological acoustics assure correct approach in research. Human hearing or auditory system is capable to respond to a stimuli, identify pitch, timbre and direction of sound. The lowest threshold frequency that can be heard by human is 3 to 4 kHz. The threshold frequency varies in different living things.

Understanding the way to manipulate the sound in a confined space has been studied of acoustician. In a confined space, sound reflects from surface and slowly fades off (Beranek and Martin, 1996). Background noise usually come from house appliance such as ventilator, air conditioner, plumbing system and other electronic devices. Meanwhile the external noise is caused by transportation, industrial sound emission and other source. Therefore, installing sound absorbing material or innovated architecture to reduce noise has been essential in this globalization.

In addition, there are difficulties in suppressing acoustic noise using passive sound absorber at low frequency range as the acoustic wavelength become large and exceed the thickness of sound absorber. For instance, the sound wave of frequency 100 Hz has a wavelength of approximately 3.4 m in the air under ambient condition (Elliott and Nelson, 1993).

In this modernization world, composite materials are beginning to emerge in acoustic, especially composite material that related to natural fibre and biodegradable. The applications are mostly on sound absorption and ultrasound application. Research are mostly done on coconut fibre, hemp fibre, jute fibre and kenaf fibre. Nevertheless, synergism of two different fibre has yet to be discovered in term of acoustic properties.

Kenaf fibre has been developing in Malaysia in recent years to be use in paper making industry, bio-composite for automotive door trimmings and interior shelving also building materials (Khalil *et al.,* 2010; Natsuno *et al.,* 2002; Nacos *et al.,* 2006; Thi Bach *et al.,* 2003). There are recent research using kenaf on acoustic analysis and results are positive (Berardi & Iannace, 2015; Sambu *et al.,* 2015). In contrast with kenaf, coconut has a declining trend of 11.5 % in Malaysia in 2006 as stated in statistic review done by Arancon (2009). The author has reviewed that coconut plantation

decrease due to deforestation, natural disaster such as hurricanes and floods, also destruction by pests for instance in incident in 2008 in Papua New Guinea, hybrid coconut plantation is destroyed by beetles of different species. Furthermore, urbanization and new crops plantation also led to decline of coconut plantation. In spite of decline in coconut plantation, coconut fibres are known to have good acoustic performance (Zulkifli *et al.*, 2008, Asdrubali *et al.*, 2012)

Therefore, the aim in this research is to fully utilize the redeeming properties of kenaf which is also a commodity plantation in Malaysia now. As stated in previous paragraph the coconut plantation is declining, thus, this research is in hope of determining optimum ratio between kenaf and coconut fibre to obtain good acoustic performance as to replace pure coconut fibre sound absorbing material.

1.2 Problem Statement

One of the factors to encourage this research is due to the searching of alternative resources because the drawbacks of acoustic absorbing materials that have been using currently such as, polymer foams, glass fibre, polyester and mineral wool are from fossil fuels which are non-renewable and led to pollution such as carbon dioxide emission and by-product that is discarded into the river. Besides, the high cost of synthetic sound absorption material that is produced based on petrochemical (Berardi and Ianance, 2015) has shifted the trend to a more sustainable resources. The shift of trend to explore renewable sources were also initiated by Kyoto Protocol in 1992 due to global warming and carbon dioxide emission (Rwawiire *et al.*, 2013).

Research on acoustic are done mostly on one type of natural fibre. Berardi and Ianance (2015) has characterized the acoustic properties of kenaf, wood, hemp, coconut, cork, cane, cardboard and sheep wool at different thickness and has drawn the relationship between porosity and acoustic behaviour. Sambu *et al.*, (2015) then compared the acoustic properties of ijuk fibre, kenaf fibre and coconut fibre. Moreover, a noise control studied has been done on jute fibre by Fatima and Mohanty (2015) due

to the increase in awareness on the noise emitted by home appliance such as dish washer, hair dryer and more.

Albeit, coconut fibre is a natural resource, the recent trend has shown decline in coconut plantation in most Asia countries as illustrated by Arancon (2009). The observations stated by the author showing in 2003, the Cyclone Ami in Fiji has reduced the coconut supply by 50 % approximately in reference to APCC's The Community Newsletter in March, 2003. Furthermore, survey APCC in 2008 has reported that the wiping out of hybrid coconut plantation in Papua New Guinea by scapanes bettle, rhinocerous beetle and black palm weevil.

Simultaneously, there are more crops plantation which are more valuable such as oil palm, banana, fruit trees causing decline in coconut plantation and Malaysia has been showing continues decline in coconut plantation at rate of 2.5 to 3.5 % every year. Same goes in Papua New Guinea, trend has moved to oil palm plantation causing roughly 15 % of coconut plantation to be reduced ever since middle of 1980s (APFC Survey, 2008). Thus, using hybridization natural fibre composite of kenaf and coconut fibres may reduce usage of coconut fibre in hope that the performance may retain. In addition, kenaf plant is commodity plantation in Malaysia as mentioned by Khalil *et al.* (2010), hence, increase utilization of kenaf may indirectly boost the economy.

This research determine the impact of acoustic properties on natural fibre hybrid composite as compared to one type natural fibre composite. This research focuses on coconut and kenaf fibre, also to analyse acoustic properties by combining of both kenaf and coconut fibre that has not been carried out by others. The purpose of using kenaf and coconut fibres are due to the abundance of the two plants in Malaysia. In the research of Yahaya *et al.* (2015) stated that the advantages of natural fibres include low cost, density and process energy. Furthermore, the abundance of natural fibre can replace non-renewable sources such as fossil fuels.

1.3 Objective

Objectives of study are as follows:

(a) To develop sound absorbing material at different thickness using two natural fibres which are kenaf and coconut fibres at research level

(b) To analyse acoustic performance based on fibre loading of kenaf and coconut fibre at different frequency range

(c) To identify fibre loading that yields optimum acoustic properties among the samples prepared.

1.4 Scope

The scopes of study of this research are as follows:

(a) Determine kenaf and coconut fibre loading use for the experiment as the experiment focus on acoustic analysis using hybrid natural composite.

(b) Determine the suitable binder and additive use on the specimen in order to maintain the shape yet not affecting the result of experiment.

(c) Measure the sound absorption coefficient of hybrid natural fibre composite at different fibre loading that are kenaf fibre and coconut fibre by using Impedance tube method.

(d) Relate the experimental result of sound absorption coefficient of hybridized natural fibre composite at different fibre loading.

(e) Interpret result of sound absorption coefficient by comparing with results that had done by other researchers to understand the cause and effect.

1.5 Rationale of Research

The rationale of this research is to provide alternative route for acoustic related application, especially related to sound absorbing materials as Ismail *et al.* (2010) states that coconut coir fibre has good sound absorbing characteristic at high frequency range but low at low frequency range. Therefore, by mixing or hybridizing two type of natural fibres perhaps provide better acoustic properties or the result may suit for certain acoustic application. In addition, research on hybridization natural fibre composite has not been discovered whereby research between hybridizing natural fibre and synthetic fibre has carried out by Prabhakaran *et al.* (2014) by using flax fibre and glass fibre. This indicating that research may provide deeper understanding on sound absorbing materials, simultaneously providing information to assist further research on sound reverberation for instance.

As awareness on environmental pollution issue raises people are in the effort of reducing usage on synthetic fibre due to the emission of air pollution during processing and infinite decomposition. This lead mankind to resort in using biodegradable material though the mechanical properties is not as good as to synthetic. However, research has been giving promising results on the properties of natural fibre with comparably high mechanical properties and good acoustic properties.

On top of that, varieties of research are done on natural fibre which include kenaf and coconut fibre as to fully utilize the usage of natural fibre. An abundance of kenaf fibre and coconut fibre are found in Malaysia due to the commodity of both plantation. Coconut can be used in acoustic application, household application, food and beverage whereas kenaf is used for paper making, cardboard and cordage, moreover, both plant can provide biomass energy.

Besides that, if usage of both kenaf and coconut are increase, indirectly boosting up Malaysia's economy due to local plantation and processing. Research and development, processing and exportation can provide more job opportunity.