EFFECT OF FIBRE SIZE AND SAMPLE THICKNESS ON KENAF CORE AS A POTENTIAL ACOUSTICAL MATERIAL

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EFFECT OF FIBRE SIZE AND SAMPLE THICKNESS ON KENAF CORE AS A POTENTIAL ACOUSTICAL MATERIAL

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

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DECLARATION

I hereby, declared this report entitled "Effect of Fibre Size and Sample Thickness on Kenaf Core as a Potential Acoustical Material" is the result of my own research except as cited in references.

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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:

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ABSTRAK

Akustik adalah berkaitan dengan pengukuran bunyi atau pendengaran. Pada masa kini, bahan akustik banyak menggunakan bahan dari sumber sintetik dan penggunaan bahan semulajadi juga ada tetapi lebih kepada pengunaan gentian berbanding teras. Oleh itu, kajian ini memberi tumpuan kepada teras kenaf sebagai bahan mentah untuk penyerapan bunyi kerana ringan dan keliangan yang tinggi. Kenaf mempunyai nama saintifiknya iaitu Hibiscus Cannabinus L. Objektif kajian ini adalah untuk mengkaji kesan prestasi akustik berdasarkan saiz serat yang berbeza dan ketebalan sampel pada frekuensi rendah, sederhana dan tinggi. Terdapat empat jenis saiz serat yang digunakan dalam kajian ini, iaitu 0,420 mm, 0.841 mm, 1 mm dan 2 mm. Lima gred ketebalan sampel yang digunakan dalam kajian ini, iaitu 10 mm, 20 mm, 30 mm, 40 mm dan 50 mm. Sampel direka adalah tertakluk kepada pemerhatian mikroskopik dan ujian penyerapan bunyi yang dinamakan ujian impedans. Ujian ini adalah berdasarkan piawaian ASTM E1050-98 standard. Melalui ujian ini, teras kenaf dengan saiz serat daripada 1 mm dan sampel ketebalan 50 mm mempunyai prestasi akustik yang optimum pada frekuensi rendah. Untuk frekuensi sederhana, saiz serat 2 mm dengan ketebalan sampel 20 mm mempunyai pekali penyerapan tertinggi. ketebalan sampel dengan 40 mm dengan saiz serat daripada 1 mm mempunyai prestasi akustik yang terbaik pada frekuensi tinggi di kalangan sampel disediakan. Tambahan pula, ketebalan sampel mempunyai kesan yang besar ke atas penyerapan bunyi pada frekuensi rendah.

ABSTRACT

Acoustic is relating to the sound or sense of hearing measurement. Nowadays, the acoustic material made from synthetic and also natural material. Most of the researchers used natural fibre as reinforcement in the acoustic material rather than natural core. Hence, this research focuses on the kenaf core as the raw material for sound absorption due to its light weight and high porosity. Kenaf has its scientific name, which is Hibiscus Cannabinus L. The objectives of this research are to study the effect of acoustic performance based on different fibre size and sample thickness at low, medium and high frequencies. There are four types of fibre size used in this research, which are 0.420 mm, 0.841 mm, 1 mm and 2 mm. Five grades of sample thickness are used in this research, which are 10 mm, 20 mm, 30 mm, 40 mm and 50 mm. The fabricated samples are subjected to microscopic observation and sound absorption testing which is impedance tube test. This test is compliance to ASTM E1050-98 standard. Through this testing, kenaf core with fibre size of 1 mm and sample thickness of 50 mm has the optimum acoustic performance at low frequency. For medium frequency, fibre size of 2 mm with sample thickness of 20 mm has the highest absorption coefficient. Sample thickness with 40 mm with fibre size of 1 mm has the best acoustic performance at high frequency among the sample prepared. Furthermore, sample thickness has significant effect on sound absorption at low frequency.

DEDICATION

Dedicated to

my beloved father,

Ngu Woo Hua

my appreciated mother,

Loi Leh Ming

my adored siblings,

Ngu Ung Kiong, Ngu Ung Kuong, Ngu Ung Hong, Ngu Ung Poh

my teammates,

Yeap Hong Kheng, Tew Huei Theng, Yap Sin Yin, Lim Reo Sei for

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LIST ABBREVIATIONS, SYMBOLS AND NOMENCLATURES

%	-	percentage
μm	-	micrometer
ASTM	-	American Society for Testing and Materials
cm	-	centimetre
CMC	-	Ceremic Matrix Composite
d	-	diameter
g/cm^3	-	gram per centimetre cube
GPa	-	Giga Pascal
Hz	-	Hertz
ISO	-	International Organization for Standardization
kg/ha	-	kilogram per hectare
kg/m^3	-	kilogram per metre cube
m	-	metre
mm	-	millimetre
MMC	-	Metal Matrix Composite
MPa	-	Mega Pascal
N	-	Newton
NRC	-	Noise Reduction Coefficients
PMC	-	Polymer Matrix Composite
RM	-	Ringgit Malaysia
SEM	-	Scanning Electron Microscope
t	-	thickness
wt %	-	weight percent

CHAPTER 1

INTRODUCTION

1.1 Background of Research

Sound absorption panels for room acoustic applications are generally composed of porous synthetic materials such as glass fibre which are expensive to produce and often based on petrochemicals. The growing awareness towards the environmental implications and human health issues of these materials has increased the attention towards natural materials (Berardi and Iannace, 2015).

Billions of tons of natural fibres are grown around the world. Natural fibres are fibre than can be obtained directly from and animal, vegetable and mineral sources. They are inexpensive, abundant and readily available. In recent years, natural materials are becoming an alternative for synthetic material as natural materials provide good health to a greener environment (Sambu *et al.,* 2015). Furthermore, natural fibres have very low toxicity thus causing them to be environmental friendly (D'Alessandro and Pispola, 2005). Fibres can be illustrated as hair like material that appears in continuous filaments or in discrete elongated pieces which is similar to pieces of thread. These fibres can be spun into filaments, thread, rope or use as a component for composites materials (Tudu, 2009).

Many studies have shown that some natural fibres exhibit high potential to be applied as alternative materials for sound absorbing materials. Paddy straw was reported suitable for acoustic panel because of its high elasticity and porosity (Christina, 2007). The same researcher has reported that a single layer acoustical panel from paddy husk reinforced with sodium silicate exhibits optimum sound absorption coefficient at higher silicate content at high range frequencies. Albeit, coconut coir shows good sound absorbing properties in high frequency range but inferior performance is observed in low frequency range. In addition, an oil palm fibre has shown the high noise absorption due to its higher density (Christina, 2007; Zulkifli *et al.,* 2009).

Kenaf plantation is new in Malaysia, however, great support has given to kenaf plantation among Malaysians since kenaf is a warm season annual fibre crop closely related to cotton and okra (Saad and Kamal, 2013). Kenaf is one of these resources which is economically viable and ecologically friendly. With this growing demand for cellulose resources (Karimi *et al.,* 2014), kenaf has received increasing attention as an alternative fibre for the acoustic material. Kenaf is in an advantageous position over other lignocellulosic crops since it has a short plantation cycle which can adapt to environmental conditions and requires relatively low use of pesticides and herbicides (Wang and Ramaswamy, 2003). Thus, kenaf is considered as economical and ecologically friendly crop (Nishino *et al.*, 2003).

The two advantages possess by kenaf crop are the ability to grow fast as well as the two types of fibres such as bast (outer part) and core (inner part) which can be utilized as raw materials for the production of paper products, building materials, absorbents, textiles and livestock feed. Kenaf is able to reach a height of 3 to 5 m within a period of 3 to 5 months under favourable environment condition. Kenaf is able to produce between 12 and 25 tons/acre of biomass annually, when it is planted under warm and wet conditions (Saad and Kamal, 2012)

The kenaf core is light and porous, having a bulk density of 0.10 g/cm^3 to 0.20 g/cm^3. It can be crushed into light-weight particles. Currently, kenaf core has received less attention compared to bastin paper and bio composite industries, even though numbers of researches have revealed that kenaf core is useful to produce insulation composites (Saad and Kamal, 2013), medium-density particleboards (Xu *et al.*, 2013; Grigoriou *et al.*, 2000), fire retardant-treated particleboards (Xu *et al.,* 2013; Grigoriou *et al.*, 2000; Kamal *et al.*, 2009), polymer composite, thermo-acoustic applications and sound barriers (Xu *et al.,* 2004). Through the study of Rowell and Han (1999), kenaf bast fibres grow much more active than kenaf core fibres. This is the possible reason why kenaf core receive less attention.

In this globalization era, studies have been going on to develop new materials and technologies to improve the sound absorption properties since the noise problem has become much more complex and serious (Jayamani and Hamdan, 2013). The thin, light weight and low cost of row materials that will absorb sound waves in wider frequency regions are strongly desired to fulfill the demand for a tranquil environment and more comfortable life styles.

In most studies, researchers used kenaf bast fibre instead of kenaf core in acoustic application. This is because kenaf bast fibres are longer and relative stronger than kenaf core fibres (Rowell and Han, 1999). Thus, this research are going to study more scientifically on optimizing the kenaf core as acoustic application due to core have high porosity and low density. This research will help us to more understand the effect of particle size and sample thickness of kenaf core on acoustic performance. At the end of this research, best fibre size and sample thickness of kenaf core that has highest sound absorption coefficient in low, medium and high frequencies among the samples prepared will be proposed.

1.2 Problem Statement

Nowadays, noise pollution has become the third pollution resource that has great adverse influences on the environment, human health and economy. Hence, the means of controlling noise is very important to reduce and absorb the noises of a wide frequency range by effectively dissipating sound energy on the process of propagation (Yang and Li, 2012).

In the last five decades, the usage of sound absorbing materials have increased in large amount. This is mainly due to both improvement of technology and public concern on study of noise. Hence, architects and acoustical engineers play important role to choose the materials that provide the desired acoustical properties (Crocker and Arenas, 2007).

A great attention has been focused on “green” materials. In order to have low impact on the human health and environment, an increasing attenton has been turned from synthetic materials to natural and renewable materials. Natural materials have non-toxicity and their production processes would not emit the green house gases into the atmosphere which will cause the global warming. In general, the production processes of synthetic materials is the main factor to the emission of carbon dioxide that cause ozone thinning. Thus, indicating greenhouse gas emissions has caused directly and indirectly by synthetic material production affects the carbon footprint, has becoming increasingly vital. In additional, public concerns on the consequence of pollution has led consumers to favor environmentally friendly materials that has less contamination during process or recycled products. Therefore, it is important to increase the research on acoustical materials by using natural and renewable resources that can lead to viable alternatives to conventional materials for current and future applications (Arenas and Crocker, 2010).

Most researchers are using kenaf fibre reinforced polyester or epoxy to study their acoustic performance, but only one journal (Sambu et al., 2015) is explained the acoustic performance of kenaf fibre reinforced latex. Therefore, this research is carried out to explore the effect of pure kenaf core fibre on acoustic performance. Besides, there are no researcher study the effect of sample thickness on kenaf core fibre until now. This is because most researchers pay more attention on the long fibres instead of short fibres. Thus, this research is implemented to study the effect of the sample thickness of kenaf core on acoustic performance. Recently, there are no scientifically study the effect of particle size of kenaf core on acoustic performance. Hence, this research is applied to study the effect of particle size of kenaf core fibres on acoustic performance.

1.3 Objective

The objectives of research as follows:

(a) To study the effect of acoustic performance based on different fibre size of kenaf core.

(b) To evaluate the effect of sample thickness on kenaf core as a potential acoustical material.

(c) To propose the fibre size and sample thickness that has optimum acoustic performance in low (500 Hz to 1500 Hz), medium (1501 Hz to 3000 Hz) and high frequencies (3001 Hz to 4500 Hz) among the samples prepared.

1.4 Scope

The scope of this research as follows:

(a) Research on the effect of fibre size of kenaf core as a potential acoustical material. This research is focus on finding the particle size of kenaf core which resulting in term of acoustic performance.

(b) Study the effect of sample thickness on kenaf core as a potential acoustical material. This is concern more about the different sample thickness of kenaf core with same value of density.

(c) Conduct the acoustic analysis on experiment data by understanding the interaction between particle size and sample thickness on kenaf core by using impedance tube test.

(d) Propose the fibre size and sample thickness of kenaf core that has optimum acoustic performance in low, medium and high frequencies among the samples prepared.

1.5 Rational of Research

The rational of research as follows:

(a) A new experience and knowledge such as impedance tube testing method, effect of particle size and sample thickness of kenaf core on acoustic performance, which can be gained through this research.

(b) Kenaf core might achieve different acoustic properties when the it does not reinforced with any binders. Therefore, this research is done to explore the effect of pure kenaf core on acoustic performance at low, medium and high frequencies among the samples prepared.

(c) Compare the different sample thickness of kenaf core with other composite design such as different particle size of kenaf core. Study the effect of particle size and samples thickness of kenaf core on acoustic performance.

(d) Generate scientific information and deep understanding on the role of particle size and sample thickness of kenaf core in the acoustic performance. Gather the useful information on technical data of acoustic performance after done the experiment.

(e) Reduce the usage of synthetic material that suitable to environment and enhance the acoustic performance on pure kenaf core.

(f) Kenaf core occupy around 60 % to 70 % of the plant by weight. Therefore, kenaf core is cheaper than kenaf bast. Through this research, this can utilize the waste of kenaf core in the acoustic application.

(g) Most of the researchers had done their research on kenaf fibre rather than kenaf core. Hence, it is an opportunity to do the research about the kenaf core on acoustic application.

1.6 Summary of Methodology

This research will have five steps. Firstly, kenaf core is chosen as raw material for acoustic testing sample. Kenaf core fibres are prepared in particle size of 0.420 mm, 0.841 mm, 1 mm and 2 mm. After that, the sample of kenaf core is put inside the mould with different thickness but same diameter and density. All samples are weight to obtain the same volume density. Then, the samples are tested by impedance test method to measure the sound absorption coefficient of each sample. Furthermore, the data obtained from the experiment and then interpretation will be carried out. Finally, the conclusion of this experiment will make based on the analysis and the data obtained.

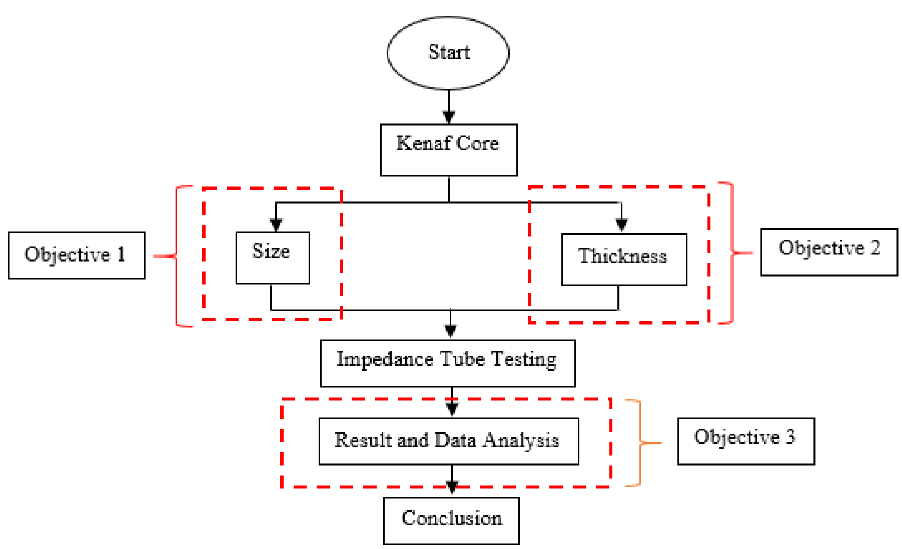

Figure 1.1: Flowchart of framework of methodology