Faculty of Engineering

THE STUDY OF LEMONGRASS FIBRE REINFORCED HDPE COMPOSITES

Azmeera Binti Shaibi

Bachelor of Engineering (Hons) in Mechanical

And Manufacturing Engineering

2016/2017

UNIVERSITI MALAYSIA SARAWAK

Grade: A

Please tick (√)

Final Year Project Report	/
Masters	
PhD	

DECLARATION OF ORIGINAL WORK

This declaration is made on the 25th day of July 2017.

Student's Declaration:

I Azmeera Binti Shaibi, 40686 and Mechanical and Manufacturing Engineering hereby declare that the work entitled The Study of Lemongrass Fibre Reinforced HDPE Composites is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

25 July 2017

Azmeera Binti Shaibi (40686)

Supervisor's Declaration:

I Dr. Nicholas Kuan Hoo Tien hereby certifies that the work entitled The Study of Lemongrass Fibre Reinforced HDPE Composites was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of Bachelor of Engineering (Mechanical and Manufacturing), and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: (Dr. Nicholas Kuan Hoo Tien) Date: 25 July 2017

I declare that Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*
☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done)*
☑ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirm with free consent and willingly declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature ______________ (25 July 2017)

Supervisor signature: ______________ (25 July 2017)

Current Address:
Lot 1779 Lorong B25 Kampung Muhibbah 95000 Sri Aman Sarawak

Notes: * If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

[The instrument is duly prepared by The Centre for Academic Information Services]

ACKNOWLEDGEMENTS

I would like to express my special thanks of gratitude to my supervisor, Dr. Nicholas Kuan Hoo Tien for giving me the golden opportunities to do this wonderful research of The Study of Lemongrass Fibre Reinforced HDPE Composites and also for his unlimited guidance and motivations throughout this project.

Special thanks to my senior, Mr. Lee Meng Chuen for helped me in doing this research that I came to know so many new things that I really feel thankful for.

Next, I thank my parents for the constant supports and encouragement without whom it was impossible for me to complete this project.

Last but not least, I would like to thank Mohd Shauqi bin Isa and my fellow friends for always giving me motivations, inspirations and endless supports towards completion of this project.

ABSTRACT

This research is about the fabrication of two types of lemongrass fibres which are cooked lemongrass fibres and juice waste lemongrass fibres reinforced HDPE composites using hot press compression moulding. Nine samples of composites were fabricated to investigate the mechanical properties and water absorption behaviours based on fibres volume fractions. The fibres volume fractions were calculated after the fabrication. Cooked lemongrass fibres with HDPE composites produced 10%, 13%, 17% and 20% of fibres volume fractions. Juice waste lemongrass fibres with HDPE composites produced 13%, 17%, 20% and 27% of fibres volume fractions. The results then compares regarding to mechanical properties and water absorption behaviours based fibres volume fractions and type of lemongrass fibres. Scanning electron microscope (SEM) was used to observe the tensile fracture of the composite samples.

ABSTRAK

Kajian ini mengenai fabrikasi dua jenis serat serai iaitu serat serai yang dimasak dan serat sisa jus serai menggunakan kaedah mampatan panas acuan. Sembilan sampel komposit telah difabrikasi untuk mengkaji ciri-ciri meknikal dan keupayaan menyerap air berdasarkan jumlah serat pecahan. Jumlah serat pecahan dikira selepas selesai fabrikasi. Serat serai yang dimasak digabungkan dengn HDPE komposit menghasilkan 10%, 13%, 17% dan 20% jumlah serat pecahan. Serat sisa jus serai pula menghasilkan 13%, 17%, 20% dan 27% jumlah serat pecahan. Keputusan ujikaji kemudian dibandingkan berdasarkan ciri-ciri mekanikal dan keupayaan menyerap air berdasarkan jumlah serat pecahan dan jenis serat serai. SEM digunakan untuk memerhati patah tensil oleh sampel komposit.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

MMC	-	Metal Matrix Composite
CMC	-	Ceramic Matric Composite
PMC	-	Polymer Matrix Composite
HDPE	-	High Density Polyethylene
PE	-	Polyethylene
PP	-	Polypropylene
LDPE	-	Low Density Polyethylene
MDPE	-	Medium Density Polyethylene
CLG	-	Cooked lemongrass
JLG	-	Juice waste lemongrass
UTM	-	Universal Testing Machine
ASTM	-	American Society for Testing Materials
v_f	-	Fibre volume fraction

CHAPTER 1

INTRODUCTION

1.1 Composite

In the recent years, scientists and researchers continuously searching for material that is low weight, relatively low cost, durable and well supplied, especially in times of global warming (Belarmino et al., 2012). The efforts are to invest on utilizing the usage of naturally occurring material that is not depleted and environmental friendly (Hsie, Tu & Song, 2008). The usage of composite nowadays has been an emphasis in the world of engineering. Numerous metallic components have been replaced by composite materials in several of field especially in aerospace, avionic, automobile, civil, structural, and sports equipment industries. According to Hashemi and Smith (2011), composite can be formed by combining two or more substances to create more advanced material . This combination consists of reinforcement and matrix material. The predominant types of composite can be fibrous in which it composed of fibers in the matrix or particulate where the particles composed in a matrix (Hashemi & Smith, 2011). Composites can be classified into two which are natural composite and synthetic composite. Compared to the conventional materials such as steel, composites are much more preferable since they usually provide major weight savings.

1.2 Types of composite material

Sakhtivel and Rajendran (2014) classified the composite material into three groups according to their matrix material which are:

i. Metal Matrix Composites (MMCs)
ii. Ceramic Matrix Composites (CMCs)
iii. Polymer Matrix Composites (PMCs)

1.2.1 Metal Matrix Composites (MMCs)

Mortensen and Llorca (2010) reviewed the metal matrix composite as a metal that is combining together with another material, usually with the material that is not in the same phase, to create a new material have interesting characteristics particularly in engineering. In other word, MMCs are composite materials that combine between two types of metals or between metal and other type of material. Hybrid components of MMCs can be made with three or more constituents are present.

MMCs have higher specific modulus and specific strength, desirable properties at high temperature and less coefficient of thermal expansion compared to monolithic metals (Sakhtivel & Rajendran, 2014). For instance, the aluminum matrix composites reinforced with ceramics are of interest such as silicon carbide in particulate, platelet, or whisker form because of the higher stiffness, wear resistance and high strength in temperature relative to aluminum. Other examples that be implanted to produce MMCs are continuous carbon, silicon carbide or ceramic carbide.

1.2.2 Ceramic Matrix Composites (CMCs)

The purpose on making CMCs is to improve the toughness. The materials in CMCs consist of two or more distinct ceramic phase combined on a microstructural scale (Warren, 1991). Ceramic materials normally performed well in both physical and mechanical properties such as elevated refractoriness. However, the usage of ceramic materials is restricted because of the brittleness. In order to enhance the strength and toughness, the brittle ceramics particle-strengthening and fibre-reinforcement have been employed, with little success (Donald & McMillan, 1975).

1.2.3 Polymer Matrix Composites (PMCs)

Polymer matrix composites (PMC) are the type of composite that will be used in this research. PMC constitute of longitudinal or short fibres that bound together by an organic polymer matrix that is mostly used matrix matrices. The design of PMCs are conducted to enable the mechanical load in the structure of the composite can be supported by the reinforcement where the matrix is to combined together with the fibres and spread the load among them. There are several types of composite reinforcement as shown in Figure 1.1.

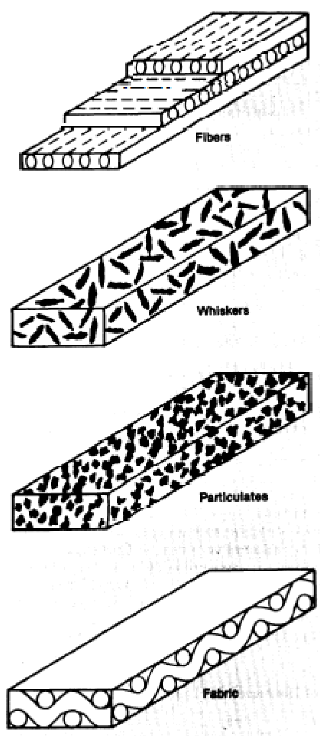

Figure 1.1: Types of composite reinforcement

There are two advantages of using polymers as matrix material. Firstly, polymers have insufficient mechanical properties for the structural purposes. Compared to metals and ceramics, the strength and stiffness of the polymers are low. However, these weaknesses can be overcome by reinforcing the polymers with other materials. Besides, it is not necessary to use high pressure and temperature to process the polymer matrix composite (Sakhtivel & Rajendran, 2014).

The constituents of polymer matrix composites consist of matrix, thermoses, thermoplastics, reinforcement and interphase. Matrix properties in the PMC can determine the resistance of the degradative process with respect to the resistance of the PMC that can determine the failure of the composite structure such as impact damage, delamination, ability to absorb water, chemical attack, and high temperature creep. The matrix can be classified into two groups which are thermoses and thermoplastics. Matrix is known as the weak line in the structure of PMC.

1.2.3.1 Thermoset

Thermosetting resins include polyesters, vinyl esters, epoxies, bismaleimides, and polyamides. Initially, thermosetting resins have low viscosity. When thermoses resins undergo curing process, the chemical reaction occurred during that process connecting the entire matrix together in a three-dimensional network by crosslink the polymer chains. Hence, the three-dimensional crosslinked structures increase the dimensional stability, dimensional stability and better protection to solvents of the thermoses resins.

1.2.3.2 Thermoplastics

Thermoplastic resins including some polyesters, polyetherimide, polyamide imide, polyphenylene sulfide, polyether-etherketone (PEEK) and liquid crystal polymers. These resins consist of long, discrete molecules that melt to a viscous liquid at the processing temperature normally between 260ºC to 3710ºC. The degree of crystallinity of thermosetting when cooled down to an amorphous, semicrystalline, or crystalline solid has a strong influence on the properties of final matrix. Thermosetting resins are differing from the thermosetting resins. Unlike the curing process in thermoses, the processing of thermoplastics is reversible in which the thermoplastics can be reheated to obtain a desired shape. Compared to thermoses, thermosetting resins are more resistant to cracking and impact damage. Table 1.1 below shows the comparison of general characteristics of thermoset and thermoplastic matrices.

Table 1.1 Differences of general characteristics between thermoset and thermoplastic matrices

Resin type	Process temperature	Process time	Use temperature	Solvent resistance	Toughness
Thermoset…………….	Low	High	High	High	Low
Toughened thermoset...	↑	↓	↑	↑	↓
Lightly crosslinked thermoplastic…………					
Thermoplastic………..	High	Low	Low	Low	High

1.3 Classification of Fibres

The Figure 1.2 below shows the classification of fibres. There are two types of fibres which are natural fibres and synthetic fibres.

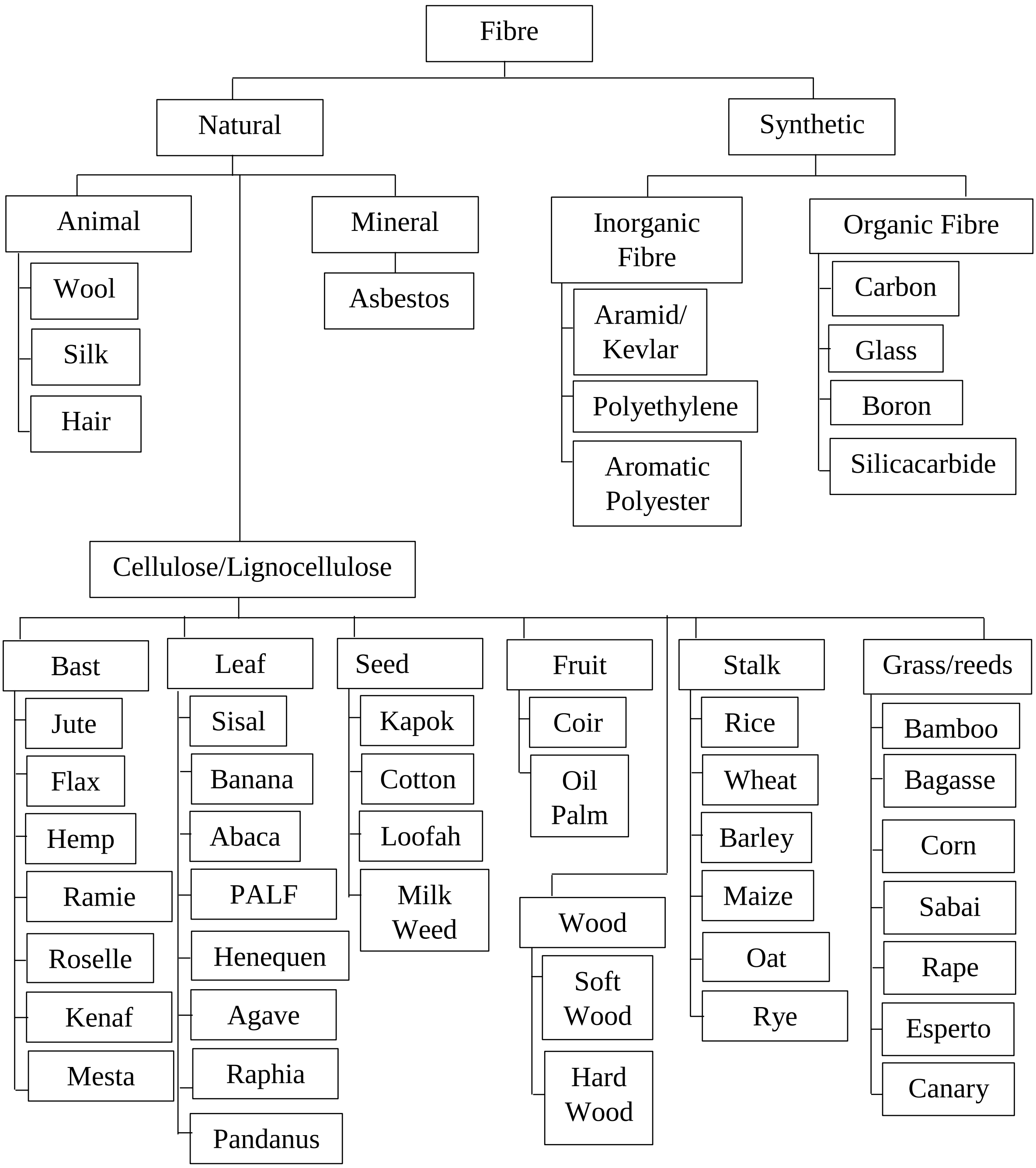

Figure 1.2: Classifications of natural and synthetic fibres (Jawaid & Abdul Khalil, 2011).

The fibres shown in Figure 1.2 are the fibres that can be used as the reinforcement in the composite. Generally, there are three types of natural fibre which are animal fibre, plant fibre and mineral fibre.

1.3.1 Animal Fibres

Animal fibres generally compromised with the protein of the animal. The animal fibre can be divided into three which are animal hair, silk and avian fibre as shown in Figure 1.2.

- Animal hair such as wool or hairs are the fibre obtained from the animals or hairy mammals. The examples of this kind of fibres are sheep's wool, goat hair such as cashmere and mohair, and alpaca hair.
- Silk fibres are fibre collected from dried saliva or of bugs or insects during preparation of cocoons such as silk from silk worms.
- Avian fibres such as feathers are the fibres from the bird.

1.3.2 Plant Fibres

Plant fibres are the type of fibres containing cellulose or lignocellulose. These types of fibres are commonly used to make paper or cloth in the manufacturing industry. Based on Figure 1.2, the plant fibres are classified into six subgroups which are bast, leaf, seed, fruit, stalk, wood and grass or reeds.

- Seed fibres can be obtained from the seed or seed case such as cotton and kapok.
- Leaf fibres are the fibres collected from leaves such as sisal and agave.
- Skin fibres are collected from the skin or bast surrounding the stem of the respective plant. Compared to the other type of plant fibre, skin fibre has a higher tensile strength. Examples of plant for the skin fibres are flax, jute, banana, hemp and soybean.
- Fruit fibres are fibres that collected from the fruit of the plant such as coconut (coir) fibre.
- Stalk fibres are fibres that are actually the stalk of the plant such as straws of wheat, rice and barley.

1.3.3 Mineral Fibres

Mineral fibres are fibres that naturally occurring fibres or slightly improved fibres procured from the mineral. Asbestos is the only mineral fibre that naturally occurring which is in the form of antophyllite.

1.4 Advantages of Natural Fibres Composite

The natural fibres have formed an interesting alternative especially as a material that can substitute glass reinforcement. The grown interests of using natural fibres are due to the reason that natural fibres are low cost, low weight and have better stiffness per weight compared to glass resulting in producing a lighter component. Furthermore, natural fibres are ‘thermal recycling’ or have the ecological advantages of using renewable resources. Other than that, natural fibres can be thermally recycled which has smaller environmental impact. Below are the benefits of utilizing natural fibres composites:

- Low specific weight which is good for the parts designed for bending stiffness.
- Sustainable resources where the production needs only a small amount of energy.
- Low investment with low cost production.
- Friendly processing.

1.5 Problem Statement

The extensive used of short conventional fibres such as glass, aramid and carbon as reinforcements of thermoplastic polymeric matrices cause concerns on disposal and recycling. Unlike natural fibre, the synthetic fibres composite cannot return to their virgin state since it is difficult to remove the fibres from the matrix. Furthermore, synthetic fibres are more readily burn compared to natural fibres, requires high energy consumption and cause health risk when inhaled. On the other hand, natural fibres offers on the making of biodegradable composites that is lightweight, low cost, ease of processing, safer handling and working condition compared to synthetic fibre.

Lemongrass (*Cymbopogon citratus*) is commonly used in Asian cuisine and also largely cultivated its essential oils for medicinal purposes. Instead of throwing away, the waste from lemongrass can be used as reinforcement in the composite by extracting lemongrass fibres. Moreover, there is no research yet using lemongrass fibres as reinforcement in the composite. Hence, in this research, natural fibre reinforced composite is fabricated by using lemongrass fibres as reinforcement and thermoplastics which is HDPE as matrix. Therefore, an experimental procedure will be conducted to the study of lemongrass fibre reinforced HDPE composites.

1.6 Research Objectives

The aim of this research is to get a better understanding on the various parameters that contribute to the lemongrass fibre reinforced HDPE composites. The objectives of this research are:

i. To fabricate and compare composites cooked lemongrass fibre and juice waste lemongrass fibre reinforced HDPE composites.
ii. To study the mechanical properties of lemongrass fibre reinforced HDPE composites.
iii. To investigate the water absorption behaviour of lemongrass fibres composites based on fibres volume fractions.

1.7 Thesis outline

Thesis outline used to explain the summary of each chapter from Chapter 1 to Chapter 5 in this research.

Chapter 1 is all about the introduction of the research. This chapter will give an outline of what this research is going to cover including the background details of the research, problem statements, and project objectives of the project research.

Chapter 2 discuss about literature review that describes the components in this research. This chapter is about discussion on the theoretical literature based on journals, articles, or textbooks. From the theoretical theories, we can obtain:

i. Overview of each theory and explanation
ii. The relevance and explanation of each theory regarding to the problem
iii. Application of the theoretical findings to the problem.

Chapter 3 which is the methodology will show the method or tools that being used together with the procedures on how to conduct the research study accordingly with clear manner of explanations. Other than that, this chapter will include the testing that being applied to the composites.

Chapter 4 is where all of the results are discussed by relating to the theories and literature reviews.

Chapter 5 is conclusion for the research based on literature reviews, results from the test conducted and also the analyses completed. This chapter also includes recommendations to improve the strengths and properties of the composites for further studies.