INVESTIGATION ON FLEXURAL AND MORPHOLOGICAL CHARACTERISTICS OF NOVEL HYBRID OIL PALM EMPTY FRUIT BUNCH/ KENAF REINFORCED HIGH DENSITY POLYETHYLENE COMPOSITE FOR AUTOMOTIVE APPLICATION

MOEY CHUNG MIN

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATION ON FLEXURAL AND MORPHOLOGICAL CHARACTERISTICS OF NOVEL HYBRID OIL PALM EMPTY FRUIT BUNCH/ KENAF REINFORCED HIGH DENSITY POLYETHYLENE COMPOSITE FOR AUTOMOTIVE APPLICATION

MOEY CHUNG MIN

This report is submitted
in fulfillment of the requirement for the degree of
Bachelor of Mechanical Engineering (Automotive)

Faculty of Mechanical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2017

DECLARATION

I declare that this project report entitled "Investigation On Flexural And Morphological Characteristics Of Novel Hybrid Oil Palm Empty Fruit Bunch/ Kenaf Reinforced High Density Polyethylene Composite For Automotive Application" is the result of my own work except as cited in the references

Signature	:	....
Name	:	....
Date	:	....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Automotive).

Signature :. ....

Name of Supervisor : ....

Date : ....

DEDICATION

To my beloved mother and father

ABSTRACT

Natural fiber composites (NFC) are aggressively being adapted into production of components and products, especially in the automotive industry, to achieve better vehicle end-of-life performance as well as to reduce the dependency of non-renewable materials. In addition, extensive research have been conducted to improve the mechanical properties of both natural fibers and polymer matrix for better bonding and load carrying characteristic of the final composites. One of the efforts is through hybridization method, whereby two different types of fiber are combined within a single matrix. The hybridization offer desirable advantage of gaining a balance between cost and performance between the combined fibers. In this research, a novel hybrid oil palm empty fruit bunch (OPEFB) and kenaf fibers was formulated, using thermoplastic high density polyethylene (HDPE) as the matrix. The aim was to investigate the flexural performance of hybrid OPEFB/ kenaf reinforced HDPE composites at varying OPEFB to kenaf fiber ratio. All samples were prepared at fix fiber to matrix ratio of 40:60 wt%. Meanwhile, the OPEFB to kenaf fiber loadings ratio were varied 0:100, 25:75, 50:50, 75:25 and 100:0 wt%. The fibers were first crushed and sieved to size between 1 to 5 mm. Hybrid fibers were later mixed with HDPE using compounding and formed into thin plates using hot compression moulding process. Finally, the sample is cut to size and characterize in accordance to the ASTM D790 for the flexural test. Findings of the research revealed that the highest flexural modulus was achieved at hybrid OPEFB:kenaf formulation of 25:75 wt% (from the total 40 wt% total fiber loadings), an increase of 6.5% compared to flexural modulus using 100% OPEFB composites. Furthermore, all hybrid formulation showed lower tensile strength compared to 100% OPEFB/HDPE composites and 100% kenaf/HDPE composites. The lowest flexural strength property was found at hybrid OPEFB:kenaf formulation of 50:50 wt%, which represent a reduction up to 16.1% from the tensile strength recorded for 100% OPEFB composites. The reason is maybe due to poor interfacial bonding between the fiber and the matrix, as observed in the fiber pull-out failure images on the fractured samples. The overall findings suggested that the hybrid OPEFB/ kenaf reinforced HDPE composites was able to slightly improve the flexural modulus of the 100% OPEFB reinforced HDPE composites, despite showing lower performance in term of flexural strength as compared to 100% OPEFB reinforced HDPE composites.

ABSTRAK

Serat semula jadi sedang disesuaikan ke dalam pengeluaran komponen dan produk, terutamanya dalam industri automotif, untuk mencapai kenderaan akhir-kehidupan serta untuk mengurangkan pergantungan bahan yang tidak boleh diperbaharui. Di samping itu, banyak penyelidikan telah dijalankan untuk meningkatkan sifat-sifat mekanikal serat semula jadi dan matriks polimer untuk ikatan yang lebih baik. Salah satu usaha ialah melalui kaedah penghibridan, di mana dua jenis serat semula jadi digabungkan bersama-sama di dalam matriks tunggal. Penghibridan ini menawarkan keseimbangan antara kos dan prestasi antara gentian. Dalam kajian ini, 'Oil Palm Empty Fruit Bunch(OPEFB) dan gentian kenaf telah dirangka, menggunakan 'High Density Polyethelyne' (HDPE). Tujuannya adalah untuk mengkaji prestasi lenturan OPEFB/kenaf diperkukuh komposit HDPE dengan perbezaan nisbah OPEFB kepada nisbah gentian kenaf. Semua sampel telah disediakan pada serat:matriks dalam nisbah 40:60wt%. Sementara itu, OPEFB kepada nisbah beban gentian kenaf telah diubah 0:100, 25:75, 50:50, 75:25 dan 100:0wt%. Gentian dihancurkan dan disaring saiz antara 1-5mm kemudiannya dicampur dengan HDPE menggunakan pengkompaunan dan dibentuk plat nipis menggunakan proses pengacuan mampatan panas. Akhir sekali, sampel dipotong kepada saiz mengikut ASTM D790. Ujian lenturan mendedahkan bahawa modulus lenturan tertinggi dicapai pada OPEFB:kenaf pada 25:75 wt% (daripada jumlah 40% berat jumlah beban serat), peningkatan sebanyak 6.5% berbanding dengan modulus lenturan menggunakan 100% komposit OPEFB. Tambahan pula, semua rumusan hibrid menunjukkan kekuatan tegangan yang lebih rendah berbanding dengan 100% komposit OPEFB / HDPE dan 100% kenaf / HDPE komposit Kekuatan lenturan terendah ditemui di OPEFB:kenaf 50:50 wt%, di mana pengurangan sehingga 16.1% daripada kekuatan tegangan yang dicatatkan bagi 100% komposit OPEFB. Sebabny mungkin kerana ikatan antara muka yang lemah antara gentian dan matriks, seperti yang berlaku di tarik-keluar gentian imej kegagalan pada sampel patah. Hasil dapatan menunjukkan bahawa hibrid OPEFB / kenaf diperkukuh komposit HDPE dapat meningkatkan modulus lenturan daripada 100% OPEFB diperkukuh komposit HDPE, walaupun menunjukkan prestasi yang lebih rendah dari segi kekuatan lenturan berbanding 100% OPEFB diperkukuh komposit HDPE.

ACKNOWLEDGEMENTS

I would like to express my appreciation to my supervisor Dr. Ridzuan Mansor for allowing me to complete my final year project with him. He offered me advice and guidance whenever problems arise during the research. I am thankful for his patience and advice throughout the research.

Secondly, I would like to thank a master student named Taufiq for spending his time to guide me whenever I needed help. He shared his experience and knowledge on biocomposite materials with me and guided me to carry out the experiment correctly.

In addition, I would like to thank my friends for giving me their encouragement throughout the research period. Lastly, I would like to thank my family for their love and support.

TABLE OF CONTENTS

LIST OF TABLES

TABLE **TITLE** **PAGE**

LIST OF FIGURES

FIGURE **TITLE** **PAGE**

LIST OF ABBREVIATIONS

CMCs	-	Ceramic Matrix Composites
MMCs	-	Metal Matrix Composites
PMCs	-	Polymer Matrix Composites
NFC	-	Natural Fiber Composites
CO_2	-	Carbon Dioxide
HDPE	-	High Density Polyethylene
OPEFB	-	Oil Palm Empty Fruit Bunch
L_C	-	Critical Length
NaOH	-	Sodium Hydroxide
SEM	-	Scanning Electron Microscopy
SiC	-	Silicon Carbide
Al_2O_3	-	Aluminum Oxide
SiN	-	Silicon Nitride
RPM	-	Rotation per Minute
PP	-	Polypropylene
MAPE	-	Maleic Anhydride–G–Polyethylene
OPPF	-	Oil Palm Press Fiber
NMT	-	Natural Fiber Mat Thermoplastic

LIST OF SYMBOLS

E	-	Flexural Modulus/ Young's Modulus
Ơ	-	Stress
ε	-	Strain

CHAPTER 1

INTRODUCTION

1.1 Background

In the material world, the current trend is using of bio-fibers as fillers and/or reinforcers in the plastics composites. The flexibility of natural fibers during processing, high specific stiffness, and low cost makes them an attractive alternative for the manufacturers. There is an increasing demand on plastics as an important raw material which is up to 80% made up of thermoplastics. Bio-composites are gaining popularity for structural applications (Faruk et al., 2012).

Bio-composite materials are advanced and flexible engineering materials. Combination of a plastic polymeric matrix with reinforcing natural fibers produces composites with corresponding properties of each material. Natural fiber reinforced composite refers to the natural fibers in any polymeric matrix which can either be thermoset or thermoplastic; natural or synthetic. Furthermore, bio-composites are environmentally friendly. With different combination of natural fibers and plastic polymer, different strength and toughness are achievable (Saba et al., 2014).

Oil palm empty fruit bunch (OPEFB) fibers are classified as natural fibers which are environmental friendly. These fibers are renewable, abundance, non-toxic, and low cost making them popular. However, the disadvantages of OPEFB fibers are the moisture absorption properties, and incompatibility with some polymer matrix. Polyethylene (PE) is the most frequently used thermoplastic in the production of natural fiber plastic composites due to its general availability, low melting point and low cost (Ewulonu & Igwe, 2012).

Kenaf is an industrial crop in Malaysia. It is one of the popular plants which is harvested for its fibers globally, after cotton. Kenaf has potential in the automotive market as well as the construction industries due its long fibers nature at the outer bark, bast. Kenaf is gaining popularity from researchers and industries for utilization in different polymer composites. In many research, kenaf fibers are reinforced with polymer matrix to form fiber reinforced polymeric composites which further improve the properties of the polymers. The kenaf fibers is comparable to existing materials in terms of mechanical properties, thus them a suitable replacements to glass fibers in polymer composites as reinforcing materials (Saba et al., 2015).

Issues arisen in composites are the thermal instability of natural fibers, the moisture adsorption of natural fibers, fiber matrix adhesion surface, bio degradation and photodegradation of fibers, processing for thermoplastic/thermoset composite and the modification of natural fibers (Saheb & Jog, 1999).

1.2 Problem Statement

As the automotive industries strive for improve in environment sustainability, remarkable achievements in green technology via the development of natural fiber composites (NFC) or bio-composites are achieved. Development of NFC are increasing, therefore making it a suitable replacement for synthetic composites which are non-biodegradable and required the use of non-renewable and non-recyclable resources. Furthermore, the final mechanical properties of the composites are influenced by many factors such as the fiber type, fiber size, fiber orientation, matrix type, fiber and matrix modification process and the composites processing methods. This allows a wide combination of composites architecture, which result in different mechanical properties for different needs. In this research, a novel hybrid NFC using the combination of oil palm empty fruit bunch (OPEFB) fiber and kenaf fiber are developed. Recyclable thermoplastic high density polyethylene (HDPE) is also used as the matrix for the hybrid composites. OPEFB/kenaf reinforced HDPE is a new and unknown composite. Up to date, there is very limited research on the characterization of hybrid OPEFB with other type of natural fibers, especially kenaf fiber. More limited source of information is also presence with regards to the performance of OPEFB composites produced using high density polyethylene (HDPE) thermoplastic matrix. This research was focused to investigate the flexural and morphological characteristics of hybrid OPEFB/kenaf reinforced HDPE composites for automotive application. Varying OPEFB to kenaf fiber loadings were used to prepare the hybrid samples. Hybrid fibers in short fiber form were selected for the composites construction while sample preparation involved compounding and compression moulding processes. The samples were later cut to size and subjected to flexural test based on ASTM D790 to obtain its flexural mechanical properties. In addition, morphology examination on the fracture samples using optical microscopy technique was also employed to determine the failure mechanism for the hybrid OPEFB/kenaf reinforced HDPE composites.

1.3 Objectives

The objectives of this project are as follow:

i. To identify the flexural properties of the hybrid OPEFB/kenaf reinforced HDPE with varying weight percentage of OPEFB and kenaf.
ii. To study the morphological characteristic of the hybrid OPEFB/kenaf reinforced HDPE with varying weight percentage of OPEFB and kenaf.

1.4 Scope of Project

The scopes of this project are:

i. Formulation of the bio-composite samples are fix at 40wt.% natural fibers and 60 wt.% HDPE.

ii. To conduct flexural tests for hybrid OPEFB/kenaf reinforced HDPE samples at varying weight percentage of OPEFB and kenaf fibers.

iii. To perform morphological examination on the fractured samples using optical microscope

iv. Report Writing.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Composites are defined as a combination of two different types of materials, which are the reinforcing phase and the matrix phase. Reinforcing and matrix phases can be ceramic, metal or polymers in nature. The matrix acts as a protection layer for the fibers before, during and after the processing. Furthermore, the matrix acts as a load distributor during loading between the fibers. With the flexibility of the combination of reinforcing phase and matrix phase, it is possible to create new composites with different properties. Composites can be design to suit different needs such as for thermal, electrical, structural and environmental applications (Kumar et al., 2014).

2.2 Types Of Composites

Composites are classified to into 3 different groups as shown below:

i. Ceramic Matrix Composites (CMC) : CMCs are composed of a ceramic matrix (i.e., SiC, Al_2O_3, SiN) and embedded fibers of other ceramic materials.
ii. Metal–matrix composites (MMC) : MMCs are used widely in the industry.
iii. Polymer Matrix Composites (PMC) : PMCs are thermoset or thermoplastic matrix bonded with reinforcement phases such as glass, carbon, Kevlar fibers and metal (Haghshenas, 2015).

2.2.1 Ceramic Matrix Composites (CMCs)

Ceramics are materials which demonstrates good mechanical properties in terms of its hardness/stiffness, melting point, resistivity to corrosion and low density). However, ceramics are brittle and perform poorly under loading. With reinforcement of ceramics with other material, its properties can be enhanced. This leads to a new composite material known as ceramic matrix composites(CMCs). CMCs are ceramic materials consisting of ceramic fibers either oriented unidirectional or arranged in nD architectures (n = 2, 3, 4…) and are combined in a ceramic matrix of different or same chemical composition (Zamawiany, 2005).

2.2.2 Metal–matrix composites (MMCs)

Generally, metallic materials are ductile, metallic bond, crystalline structure, good conductivity and chemically unstable. With the reinforcement of lighter metals, it is possible to create composites which are light weight making it suitable for weight reduction applications. Metal matrix composites are classified by its reinforcement and type of components in particle/layer/fiber and penetration composite materials. Furthermore, fiber materials can be classified into continuous fiber which are, multifilament or monofilament composite materials and short fibers or whisker composite. Currently, MMCs are used in aluminum crankcase with strengthened cylinder surface, fiber-reinforced engine piston, and particle strengthened disc brake (Kainer, 2006).

2.2.3 Polymer Matrix Composites (PMCs)

PMCs consist of a variety of short or continuous fibers bind using an organic polymer matrix, whereby the reinforcing phase provide stiffness and strength. The reinforcing phase functions to support the load whereas the matrix is to bond the fibers together and to transfer the loads evenly to the fibers. PMCs are favorable due to their low costing and simple manufacturing. The use of non-reinforced polymers is limited by its low mechanical properties. Besides that, polymers material possesses relatively low strength and low impact resistance. The desired mechanical properties is generally optimized through trial and error testing (Awalellu, 2016).

The most important manufacturing methods for polymer-based composites are gravity casting, under pressure casting, contact molding, simultaneous spray forming, bag molding, vacuum injection, cold pressing and hot pressing (Florea & Carcea, 2012).

2.3 Matrix

Matrix of composites mainly polymers can be classified into 2 types of materials which are thermosets and thermoplastics (Mohammed et al., 2015). Both are long chain-like molecules but differs in their bonding. In thermoplastics, long chain molecules are held by weak Van Der Waal forces as for thermosets, the long chain molecules held by strong bonds (Haider et al., 2012).

Matrix properties determines the overall resistance of the PMCs. The resistance includes the water absorption ability, chemical reaction, impact, delamination and high temperature creep. Therefore, matrix in the PMCs are the are more prone compare to the reinforcing phase as matrix provides a barrier against adverse environments, protects the surface of the fibers from mechanical abrasion and it transfers load to fibers (Pickering et al., 2016).

2.3.1 Thermosets

Thermosets consist of several types mainly, polyesters, epoxies, vinyl esters, bismaleimides, and polyamides. It is widely used in the formation of fiber-reinforced plastics. However, epoxies are more favorable in the advanced composites resin category. Thermoset resins undergo chemical treatment which crosslink the polymer chains, which results in connecting all the matrix together to form a 3D network. This chemical treatment process is known as curing and is irreversible. Thermosets, due of their 3D crosslinked structure, thermosets possess high dimensional stability, high temperature resistance, and good resistance to solvents (U.S. Congress, 1988).

2.3.2 Thermoplastics

Thermoplastic consist of materials such as polyesters, polyphenylene sulfide, liquid crystal polymers and many more. Thermoplastic have long and discrete molecule which melts to forms a viscous liquid. After forming, thermoplastics are then cooled to a semi crystalline, amorphous, or crystalline solid. The crystallinity of the thermoplastics affects it matrix properties. The processing of thermoplastics is reversible through a reheating process and thermoplastics, in general are inferior to thermosets at chemical stability and high temperature strength. Thermoplastic however are more resistant compared to thermosets in terms of cracking and impact. Thermoplastics are more favorable from a manufacturing point of view due to its ability to heat and cool quicker compare to curing a material for manufacturing (U.S. Congress, 1988).

2.4 Reinforcing Fibers

2.4.1 Natural Fibers

Natural fibers are defined as fibers that are not manmade or synthetic. Natural Fibers are sources from animals or plants. The use of natural fiber from renewable and non-renewable is becoming more favorable (Mohammed et al., 2015).

Natural fibers which are from plants or animals are used as reinforcement in polymer composites. Usage of natural fibers in products will lead to an eco-friendly environment, as these fibers are biodegradable as well as renewable. This demonstrates that natural fibers are easily produced and won't pollute the environment by releasing greenhouse gases