A STUDY ON THE EFFECT OF VARYING FIBER CONTENTS TO THE PHYSICAL AND MOISTURE ABSORPTION CHARACTERISTICS OF HYBRID OIL PALM EMPTY FRUIT BUNCH/KENAF REINFORCED HIGH DENSITY POLYETHYLENE COMPOSITES FOR AUTOMOTIVE APPLICATION

ADEB AHMED SAEED ALDARJI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Report

Projek Sarjana Muda II

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Faculty of Mechanical Engineering

Universiti Teknikal Malaysia Melaka

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ADEB AHMED SAEED ALDARJI

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

MAY 2017

DECLARATION

I declare that this project report entitled "A Study On The Effect Of Varying Fiber Contents To The Physical And Moisture Absorption Characteristics Of Hybrid Oil Palm Empty Fruit Bunch/Kenaf Reinforced High Density Polyethylene Composites For Automotive Application" is the result of my own work except as cited in the references.

Signature	:	------------------------------
Name	:	ADEB AHMED SAEED ALDARJI
Date	:	-------------------------------

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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 : DR. MUHD RIDZUAN MANSOR

Date : ....

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DEDICATION

Every time when I need them the most,

They are always by my side.

This humble work of mine I would like to dedicate to

My lovely father,

AHMED SAEED ALDARJI

My lovely and caring mother,

HANAN SALEH BAJNED

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My siblings and family,

My supervisor,

DR. MUHD RIDZUAN MANSOR

And

All my friend,

For their assistance & support.

ABSTRACT

Nowadays composites materials have become able to generate high quality, strong and cost-effective products. Therefore, composite materials can be found in several products which are being used in daily life applications. In addition, composites are used in several serious industrials such as aerospace, and military uses. The consumptions of economical agro-based renewable natural lignocellulosic fiber such as empty fruit palm, sisal, coir, and jute etc. in preparing composites with different thermoplastics and thermosetting resins have added much impetus in the latest years. Since Malaysia is the principal producers of palm oil, the profusion of oil palm cellulosic material that can be easily found from the products delivers a new part of attention for research improvement. The potential of utilizing oil palm empty fruit bunch (OPEFB) fibers into natural fiber composites is considering the abundance of the waste in current oil palm industry, especially in Malaysia. By hybridizing OPEFB fibers with stronger and locally available natural fiber resource, in particular kenaf fiber, the performance of the final composites can be enhanced to create higher value of the product with competitive cost. Nevertheless, information on the physical characteristics of the OPEFB/kenaf reinforced high density polyethylene (HDPE) composites is still lacking, especially on the effect of varying fiber contents to the hybrid composites density and water absorption performance. Therefore, the aim of this project is to achieve good combination of properties of hybrid OPEFB and kenaf as filler reinforced in polyethylene composites and to determine the effect of varying fiber contents to density and water absorption property. Physical test according to ASTM D792 were conducted by calculating the mass and the specific density of the samples. In addition, the standard deviation of the samples were calculated related to the mass and specific density. The expected value of the mass standard deviation is 0.07985g which obtains from sample (A). While the expected value of the specific density standard deviation is 0.004176 which obtains from sample (B). Water absorption test according to ASTM D570 were conducted by immersing the five samples in a distilled water bath at room temperature for different time duration. The samples were weighted within 30 seconds and they were immersed again. Same process were repeated to the samples after immersing them for 24, 48, 72, 144, 168, 192, 216 and 240 hours. The percentage of the water in the composites were calculated by weight difference between the samples immersed in water and the dry samples. The result obtained from the water absorption test shows that with increasing the time of immersing the samples in distilled water, the moisture absorption increases.

ACKNOWLEDGEMENT

I would like to express my deepest appreciation to my supervisor Dr. MUHD RIDZUAN MANSOR for giving me this opportunity to do final year project with him. He never hesitated to give me advice and guidance whenever I confronted problems. I am thankful for his patience and advice while leading me in this project.

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LIST OF ABBREVIATIONS

EFB	Empty Fruit Bunches
PMCs	Polymer Matrix Composites
MMCs	Metal Matrix Composites
CMCs	Ceramic Matrix Composites
CCMCs	Carbon-Carbon Composites
HDPE	High Density Polyethylene
LDPE	Low Density Polyethylene
CPE	Chlorinated Polyethylene
PP	Polypropylene
PS	Normal Polystyrene
PVC	Poly Vinyl Chloride
NFC	Natural Fiber Composites
OPEFB	Oil Palm Empty Fruit Bunch

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LIST OF SYMBOLS

ΔM	=	Moisture uptake
m_o	=	Mass before immersion
m_t	=	Mass after immersion
T	=	Temperature
P	=	Pressure

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CHAPTER 1

INTRODUCTION

1.1 Overview

In this chapter, a brief introduction of the research background is presented which consists of background information about composites, problem statement, objectives and the scopes of the research.

1.2 Background

Manufacturers, designers, and engineers understand the capability of composites materials to generate high quality, strong and cost-effective products. Composite materials can be found in several of the products which are used today, from the car we drive, to the boats, and RVs which we use on the holidays. In addition, composites are used in several serious industrial such as aerospace and military uses. However, in a marketplace where demands for product enactment are growing, composite materials have confirmed to be effective in dropping costs and improving performance. Campsites explain difficulties, increase performance stages and facilitate the improvement of various innovative products.

The consumptions of economical agro-based renewable natural lignocellulosic fiber such as empty fruit palm, sisal, coir, and jute etc. in preparing composites with different thermoplastics and thermosetting resins have added much impetus in the latest years (Khalid et al. 2006). Wide research has been executed on the agro fiber plastic composites which have been described by a quantity of works (Rowell et al. 1997). This is due to their low density, easy accessibility, nonabrasive natural, and low cost, in addition, their high detailed properties, and biodegradability features. An extensive range of agro-based of fiber is actuality used as the chief fundamental components or as filler agents in these composite materials. Malaysia is the

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principal producers of palm oil. The profusion of oil palm cellulosic material that can be easily found from the products delivers a new part of attention for research improvement.

Elaeis Guineensis is the source of oil palm which produces fruits that have big value in a countries like Malaysia and Indonesia. The fruits have been produced from the Elaeis Guineensis have a red color and they can be found in bunches of oil palm tree as shown in figure 1.1. However, 22 kg of palm oil and 1.6 kg of palm kernel oil can be produced from every 100 kg of fruits bunches (Gunawan et al. 2009). Therefore, a large amount of empty fruits bunches will be produced after the fruits have been taken out from bunches as shown in Figure 1.2. Malaysia hold a record of world's supply of palm oil with 47% production while Indonesia with 36% of palm oil volume therefore the empty fruits bunches will be risky to the environment, so those big countries producers need to find environmental solution to make the use of the waste.

Figure 1.1: Fruit Bunch of Oil Palm Tree.

Figure 1.2: Large Amount of the Empty Fiber Bunch.

1.3 Problem Statement

The potential of utilizing oil palm empty fruit bunch (OPEFB) fibers into natural fiber composites is vast considering the abundance of the waste in current oil palm industry, especially in Malaysia. By hybridizing OPEFB fibers with stronger and locally available natural fiber resource, in particular kenaf fiber, the performance of the final composites can be enhanced to create higher value of the product with competitive cost. Nevertheless, information on the physical characteristics of the OPEFB/kenaf reinforced high density polyethylene (HDPE) composites is still lacking, especially on the effect of varying fiber contents to the hybrid composites density and water absorption performance. Therefore, this project is conducted to find out the effect of varying fiber contents to the density and moisture absorption of the final OPEFB/kenaf reinforced HDPE composites. Based on the literature review, water absorption affect the physical properties of hybrid OPEFB/kenaf reinforced HDPE composites.

1.4 Objective

The objectives of this project are as follows:

I. To determine the effect of varying fiber contents to the density property of hybrid oil palm empty fruit bunch/kenaf reinforced high density polyethylene composites.
II. To determine the effect of varying fiber contents to the water absorption property of hybrid oil palm empty fruit bunch/kenaf reinforced high density polyethylene (HDPE) composites.

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1.5 Scope of Project

The scopes of this project are:

I. To formulate hybrid OPEFB/kenaf bio-composite are 40 wt. % natural fibres and 60 wt. % high density polyethylene (HDPE).

II. To formulate hybrid OPEFB/kenaf bio-composite at varying OPEFB to kenaf (OPEFB: Kenaf) fiber wt% ratio, which are 100:0, 75:25, 50:50, 25:75, and 0.100.

III. To perform density evaluation based on ASTM D792.

IV. To perform water absorption test based on ASTM D570 by immersing the sample in distilled water bath room temperature for different time durations.

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CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter will discuss the literature review related to the introduction of the composites, Also, the types of composites and constituents of the composites will be discussed in details. However, there are several types of manufacturing process that use to prepare the samples while some of these types will be discussed. Classification and performance in term of mechanical properties of natural fibers will be discussed in this chapter as well.

2.2 Introduction

Composites are materials that include tough weight conveying object (A.K.A reinforcement) inserted in very weak material (A.K.A matrix). Reinforcement supplies force and stiffness which help to carry and support constructional weight. The matrix, saves the location of the reinforcement. Expressively, composite's elements hold their individual, chemical and physical properties; yet together they manufacture a group of quality which singular elements would not be able of manufacturing along (Hull and Clyne 1996).

2.3 Types of Composites

For effortlessness, composites can be assembled into classes in view of the regular of the grid every sort has (Drzal, 2000). The ways of manufacture also shows difference according to chemical and physical proprieties of the matrices and reinforcing fibers.

2.3.1 Polymer Matrix Composites (PMCs)

Polymeric is the most regularly utilized matrix materials. The explanation behind this are two crease. All in all the mechanical belongings of polymers are lacking for some basic goal. To be exact their best quality and inflexibility are low contrasted with to material which are metals and ceramics (Jin, Xia, & Gerhardt, 2016). These challenges are solve and get rid of these challenges by reinforcing to dissimilar materials with polymers. Furthermore the handlings of polymer network composites require exclude every high pressure and do not necessitate other high temperature. Likewise types of gear needed for assembling polymer grid complexes are always less complex. Consequently polymer grid composites grew faster and quicker as soon got to be famous for auxiliary applications. Composites are utilized in light of the fact that common properties of the composites are way preferable than those of the individual and entity segments for instance polymer/ceramic. Composites have a more noteworthy modulus than the polymer part yet are not as fragile as pottery.

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2.3.2 Metal Matrix Composites (MMCs)

MMCs have various purposes and reasons of interest above strong metals like larger and higher specific modulus, higher specific quality, the enhanced properties at raised temperatures, and very low coefficient of warm enhancement (Simar & Aude, 2016). By virtue of these perfect qualities metal system composites are less and below thought for broad assortment of applications viz. consuming chamber gush (in rocket, space carry), lodgings, through tube, links, warm exchangers, auxiliary individuals and so on.

2.3.3 Ceramic Matrix Composites (CMCs)

Ceramic materials have great quality and modulus at lifted temperatures. In any case, their utilization as structural components is extremely constrained due to their fragility. The ceaseless fiber-fortified ceramic-matrix composites (CMCs), by fusing fibers in ceramic matrices to enhance the sturdiness, in any case, abuse their alluring high-temperature quality as well as decrease the inclination for disastrous disappointment. These materials have as of now been actualized on some air motors' parts (Li Longbiao,2016).

2.3.4 Carbon-Carbon Composites (CCMCs)

Carbon-carbon composites have been connected in aeronautics and aviation fields for their unrivaled warm and high temperature mechanical properties, for example, high warm conductivity, low thickness, high particular quality, fantastic substance and removal resistance (Kou et al. 2017).

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2.4 Constituents of Composites

2.4.1 Matrices

The concerned when the exchange could happen between the fibers to give an obstruction against an unfriendly atmosphere and to shield and protect the outside area of the fibers from any other mechanical scraped area is the part of grid in fiber-reinforced composites. The matrix accepts and enables an important and key part in the tensile load passing on limit and within boundary of a composite construction. The coupling specialist or matrix in the combined and composite is of its essential significance. There are exactly four noteworthy sorts of matrices, which actually have been accounted for: Metallic, Ceramic, Carbon and Polymeric. A large portion of the composites used as an important piece of the industry now days depend on polymer matrices. Polymer pitches have been accordingly separated broadly and divided into two types:

a) Thermosetting

Thermoset is a hard and hardened material and fabric that never mellow or easily can be flexible when it is heated (Hussien, Abass, & Abass, 2010). Thermosets are hardened and never extend like elastomers and thermoplastics do.

b) Thermoplastics

Thermoplastics are polymers, which it always needs hotness to allow them to be processable (Hassan et al. 2010). Then, following the last step is to cooling, materials hold their form and the shape have been resulted. Furthermore, these polymers possibly might be also warmed and transformed as well, frequently without noticeable and huge changes in their form and properties. The thermoplastics that have been operated as matrix for usual fiber reinforced composites are meant to be with high density polyethylene (HDPE), low density polyethylene (LDPE), chlorinated polyethylene (CPE), polypropylene (PP), normal polystyrene (PS), poly vinyl chloride (PVC), mixtures of polymers and recycled thermoplastics.

2.4.2 Reinforcing Fibers

2.4.2.1 Synthetic Fibers

The best major categories of synthetic fibers contain fiberglass, carbon, Aramid/ Kevlar fibers and boron fibers.

I. Carbon Fibers

Carbon fibers are mostly used for reinforcing a very specific lattice materials to make a form composites (Rezaei, Yunus, & Ibrahim, 2009). Carbon fibers are often unidirectional reinforcements and it can be arranged and in order for such a method in the composite, which is further to be grounded in the heading that it absolutely has to be bear loads. The physical properties of carbon fiber reinforced composite materials considered based on drastically on matrix's technique, putting the fiber in order , the amount and number part of the fiber and matrix, and based on the circumstances of the embellishment . Minimum types and kinds of matrix materials e.g., glass and ceramics, metal and plastics are always have to be well arranged as matrices for reinforcement by carbon fiber. Carbon fiber composites, to be exact those with polymer matrices, have transferred into the predominant forced and to push the composite materials for aviation, car, wearing merchandise and different applications, thus their high and perfect quality, well designed and high modulus, low density, and reasonable price for such and application needed to resist high temperature as on description of spacecraft's.

II. Glass Fibers

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Glass filaments are generally known as very familiar of all reinforcing fibers for polymeric (plastic) matrix composites (PMCs). The most important and informatics points of interest as the key of success of glass fiber are priced low, high tensile strength, ability to resist high chemical and astounding protecting properties. The two common types of glass fibers commonly arranged as an element of the fiber reinforced plastics businesses are E-glass and S-glass. The other type is market known as of C-glass arranged as well as a part of chemical applications, which also needs consume extra prominent imperviousness to acids than the amount it gives by E-glass.

III. Kevlar Fibers

Kevlar has a place with a gathering of exceedingly crystalline aramid (fragrant amide) fibers which also have the large amount reduced a certain gravity and as well large amount astounding malleable quality to weight proportion surrounded by the existing reinforcing fibers. All of the mentioned are being arranged and classified reinforcement as a part of numerous marine and aviation applications.

IV. Boron Fibers

A huge amount of prominent attributes of boron fiber that their enormously high tensile modulus. Boron fibers give and offer a perfect resistance to any unexpected collapse, which somehow puts an extra high compressive value and good class for boron fiber reinforced composites.

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2.4.2.2 Natural Fibers of Composites

Time and distance will eventually show late decades, thus, there has been some enhancing and improving in enthusiasm for each of the utilization of natural fibers in each of composite applications. The types of composites create many key points and important once contrasted with synthetic fibers, as an example, low instrument wear, which also has low density, less costly cost, accessibility, and biodegradability (Nishino et al. 2003). Famous and well known and recognized natural plant utilized and arranged as one part of uses are the most excellent fibers, for example, hemp, jute, flax, kenaf, and sisal. One purpose behind this creating purpose and attention is that natural fibers always better and more certain and specific quality and value than glass fiber and a similar modulus (Bledzki & Gassan, 1999). With these properties and qualities and not that much costly basis, these normal fibers hypothetically it shows and gives an attractive particular quality and modulus, at a very cheaper rate. In fact, many of the incident fibers are able to be utilized as composites, yet for the big piece in applications that has little stress in it. A little big piece of the fibers are obtained by handling horticultural, modern, or customer eventually fritter away (Bullions et al.2006). These materials have as of now been grasped by European car creators and this pattern has good accomplish North America and the Natural Fibers Composites Industry has 40–50% improvement has been registered and amid the year 2000 (Rouison, Sain, & Couturier, 2004).

Natural fibers are subdivided in view of their starting points, in both ways either they are extracted from plants, minerals or creatures as shown in Figure 2.1. As it has been proved in study grouping plant fibers are well known and famous because of the natural fibers, and the way it is arranged and utilized as reinforcement in fiber reinforced composites. Plant fibers slips and fit in bast fibers, leaf or hard fibers, seed, fruit, wood, cereal straw, and other types of grass fibers.

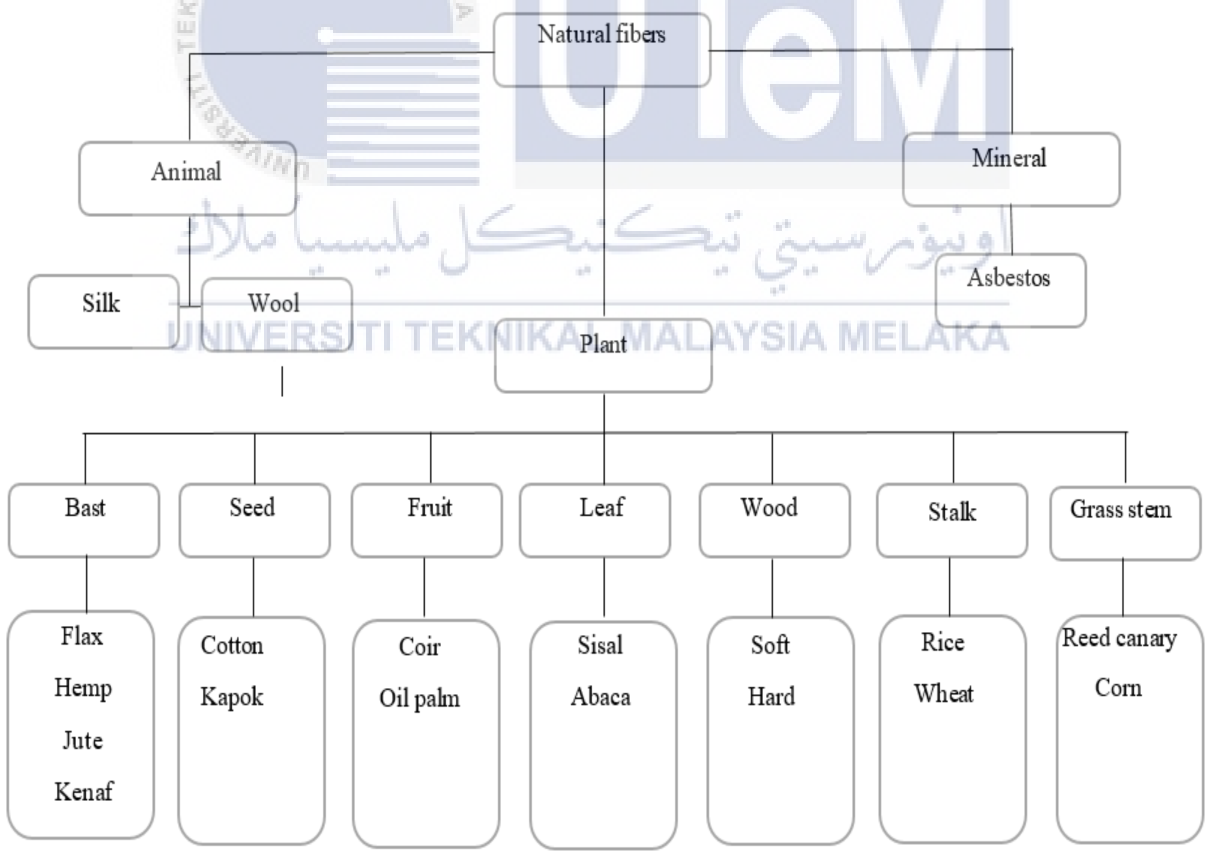

Figure 2.1: Classification of Natural Fibers (Al-Oqla et al. 2015).

a) Animal Fiber

Animal fiber usually known as comprises proteins for example, wool and silk. The wool is fiber that has been collected from animals or hairy mammals like many of sheep's wool and goat hair. While silk fiber is gathered and assembled from dried saliva of bugs or insects during the preparation of cocoons.

b) Mineral Fiber

Mineral fibers are obviously happening fiber or maybe somehow modified fiber obtained from minerals such as asbestos.

c) Plant Fiber

Plant fibers are usually includes and has the most important of cellulose such as cotton. Jute, flax, etc. Cellulose fiber as known offer the produced paper and clothe. On the other hand, the fiber can be classified into seed, fruit, stalk, grass of stem and bast.

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2.5 Type of Manufacturing Process Composites

Table 2.1: Type of Manufacturing Process for Composites (Ramesh 2016).

Methods	Advantages	Disadvantages
Hand lay-up	Cheap equipment. Versatile: well known in the market.	It takes a lot of time. It simply gives the shape air bubbles and disorientation of fibers. Contradiction.
Compressing molding	The shape has large distance. Parts are mixed. Steadiness. Form stability. Relatively uncomplicated.	Expensive machine. It takes time to be heated, cool down and treated. High cost molds. No complicated parts. Big amount of products.
Vacuum bagging	Very simple shape. Ability to merge fiber/matrix. Easy going with cheap cast fabric. Better and enhanced value for its price.	Cannot be heated up too much. Breeder clothe has always to be changed from time to time. Very slow pace. Inconsistency.
Pultrusion	It goes through the process automatically. It has high pace. Versati's form is cross sectional. Continuous reinforcement.	Die can be simply changed and spoiled. Expensive die. Has its main thermoset matrix.
Sheet molding	High productivity thus inexpensive and consistency.	Low volume fraction. Only board can be made.

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2.6 Hybrid Natural Fibers

Hybrid composites able to set up by unite of two or more fibers with only one matrix. Hybrid composites usually bring on any type of material which did not appear in nature and measured total of the individual components. Though, hybrid composites able to help us to accomplish a better mixing of properties than other type of fiber reinforced composites the fiber length, introduction, fiber/matrix interfacial bonding, fiber content, degree of blending of fibers, and the path of achievement of both of the fibers can all be proved by the properties of hybrid composites. A few methods can be formed hybrid composite by mixing natural fibers with polymeric matrices (Saba, Paridah, & Jawaid, 2015).

2.7 Advantages and Disadvantages of Naturel Fibers

Table 2.2: Advantages and Disadvantages of Natural Fibers (Isma'ila Mukhtar et al.2016).

Advantages	Disadvantages
Lightweight	Low thermal stability
Ease of machinability	Lack of interfacial adhesion
Availability and low cost	Quality variation
Low pollutant emission	Poor resistance to environment
Energy recovery	Poor compatibility with polymer matrix.

2.8 Performance in Term of Mechanical Properties of NFC

Table 2.3: Performance in Term of Water Absorption on Mechanical Properties of NFC.

Numbers	Materials used	Who did the study	Manufacturing process	Result with water absorption
1	Glass fiber reinforced unsaturated polyester composites.	(Huang & Sun, 2007)	Vacuum bagging.	Breaking strength and tensile stress of the composites decreased gradually with increased water immersion time.
2	Hemp fiber reinforced unsaturated polyester composites.	(Dhakal, Zhang, & Richardson, 2006)	Hand lay-up and compression molding.	Tensile and flexural properties of HFRUPE specimens were found to decrease with increase in percentage moisture uptake.
3	Recycled cellulose fiber reinforced epoxy composites.	(Alamri & Low, 2012)	Solution blending	Flexural strength, modulus and fracture toughness decreased as result of moisture absorption while impact strength was found to increase.
4	Sisal fiber reinforced unsaturated polyester composites.	(Sreekumar et al. 2009)	Resin transfer molding.	The water absorption studies showed that treatment decreases the water uptake of the composites.

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5	Napier grass fiber/polyester composites.	(Haameem et al. 2016)	Compression molding.	Tensile and flexural strength decreased with increased water absorption.
6	Jute fiber reinforced unsaturated polyester composites.	(Akil et al. 2009)	Pultrusion	The flexural and compression properties were found to decrease with the increase in percentage water uptake.
7	Flax fiber and epoxy matrix.	(Assarar et al. 2011)	Hand Lay-up	The tensile tests showed that stress decreased due to increasing of immersion time.
8	Jute and glass fiber-reinforced unsaturated polyester hybrid composites.	(Zamri et al. 2012)	Pultrusion	The flexural was found to decrease with an increasing percentage of water uptakes.
9	Short flax fibre bundle/polypropylene (PP) composites.	(Arbelaiz et al. 2005)	Melt-mixing method	After long period of water immersion mechanical properties drastically decreased
10	Cotton fabric-reinforced geopolymer composites.	(Alomayri et al. 2014)	Hand Lay-up	Flexural strength, modulus, impact strength, hardness and fracture toughness are decreased as result of water absorption.

2.9 Review on Natural Fiber Composites in Automotive Application

Natural fibres, which generally were consigned to the universe of thermosets, are presently quickly getting to be plainly one of the quickest developing added substances for thermoplastics also. As of late, the market has moved towards thermoplastics and request has taken off for such items as window, decking and door profiles, furniture, railings, siding, fencing, marine segments, flooring and car inside parts. Presently plant-inferred natural fibres of hemp, sisal, flax, kenaf and jute are advancing into parts of autos. In the most recent decade, natural fiber composites of thermoplastics and thermosets are always have been grasped by European carmakers for any gate or door sheets, headliners, package trays, seat backs, trunk liners and dashboards. Innovation for utilizing natural fiber composites in inside trim is being developed by Tier I and II automotive suppliers, normally in organization with makers of natural fiber-based tangle materials.

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CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter describes the methodology used in this project to explore the effect of varying fiber contents to the physical and moisture absorption characteristics of hybrid OPEFB/kenaf fibre reinforced HDPE composites. The flow chart in Figure 3.1 shows the sequence of processes carried out during this project.

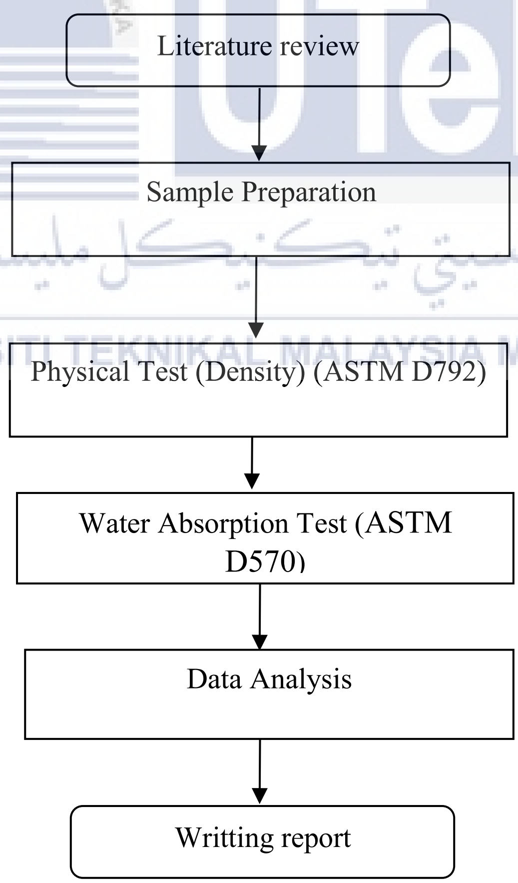

Figure 3.1: Flow Chart of the Methodology.

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3.2 Sample Preparation

To be able to conduct the water absorption test, samples must be in a good condition. As the results obtained from the last experiments in which the samples were prepared using compressing molding method have not met the desired result due to the separation of the layers and delamination failure. Therefore, mixer hot press method was used to obtain a good samples.

Samples were made of 40 wt. % natural fibers which are OPEFB/kenaf and 60 wt. % HDPE as shown in Table 3.1. OPEFB and short kenaf fibres was crushed to achieve the size between 1mm to 5mm by using Crusher machine as shown in Figure 3.2. After crushing the OPEFB and kenaf, they were weighted and washed. Then, OPEFB and Kenaf left to dray for 24 hours under the sun in order to remove the storage moisture as shown in Figure 3.3. Then, the natural fibers were weighted again to make sure the storage moisture has been removed from the fibers. Melt-mixing was performed at 160℃ for 10 minutes at rotor speed of 50 rpm. A steel mold plate of dimension of (200 x 100 x 3.2) mm was used to prepare the sample. However samples were made by using Hydraulic Hot Molding Machine as shown in Figure 3.4. The hot compression molding machine operated at 160℃ to touch the surface of the sample that placed into the steel mold plate for 15 minutes. Then, compressing forced was applied for 15 minutes and pressure adjusted to 9.8 MPa. The samples were removed and transferred to apply the cooling for 15 minutes. In Figure 3.5 shows the process of using hot compression molding machine.

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Table 3.1: The Weight Percentages Value.

	Fiber (wt. %)			Matrix (wt. %)
Samples	OPEFB	Kenaf	Total	HDPE
A	0%	40%	40%	60%
B	10%	30%	40%	60%
C	20%	20%	40%	60%
D	30%	10%	40%	60%
E	40%	0%	40%	60%

Figure 3.2: Crusher Machine.

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Figure 3.3: Draying Process.

Figure 3.4: Hydraulic Hot Molding Machine.

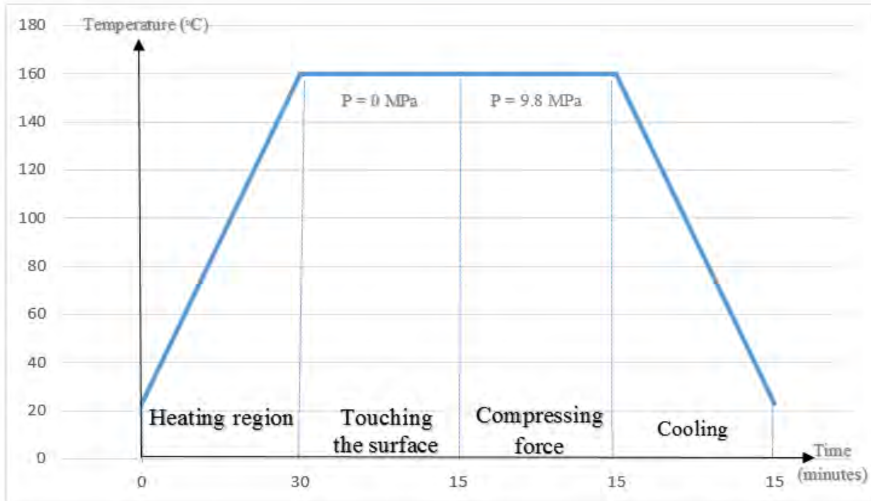

Figure 3.5: Process of Using Hot Compression Molding Machine.

3.3 Hybrid Composites Density Evaluation

Physical test according to ASTM D792 were conducted by calculating the mass and the specific density. In addition, each plates were cut to five samples to diminution of (20×40×3.2) mm and named A, B, C, D, and E as shown in Figure 3.6. Electronic Densimeter was used to calculate the mass and the specific density of the samples as shown in Figure 3.7.

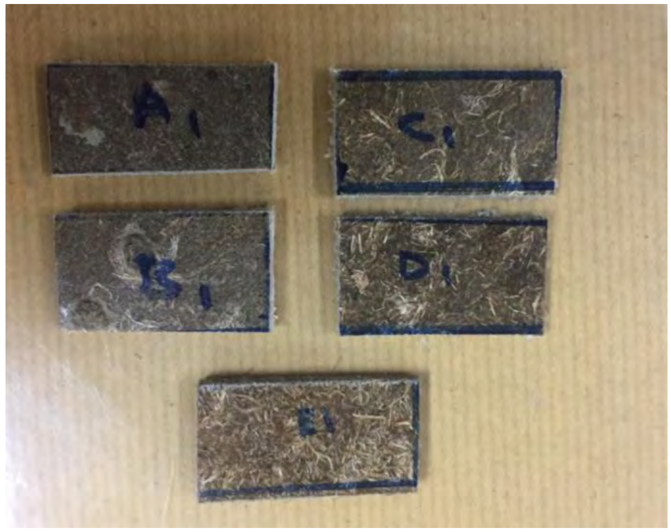

Figure 3.6: Samples.

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Figure 3.7: Electronic Densimeter.

3.4 Water Absorption Test

Water absorption test according to ASTM D570 were conducted by immersing the five samples in a distilled water bath at room temperature for different time durations. Sample were dried in an oven at 60^{o}C for 2 hours. Then, samples were immersed in distilled water and were left inside a box in order to make sure the temperate remains at 25^{o}c for 24 hours as shown in Figure 3.8. After completed 24 hours of immersing the samples, they were taken out from the distilled water and all surface water were removed with a clean dry cloth. The samples were weighted within 30 seconds and they were immersed again. Same process were repeated to the samples after immersing them for 48, 72, 144, 168, 192, 216 and 240 hours.

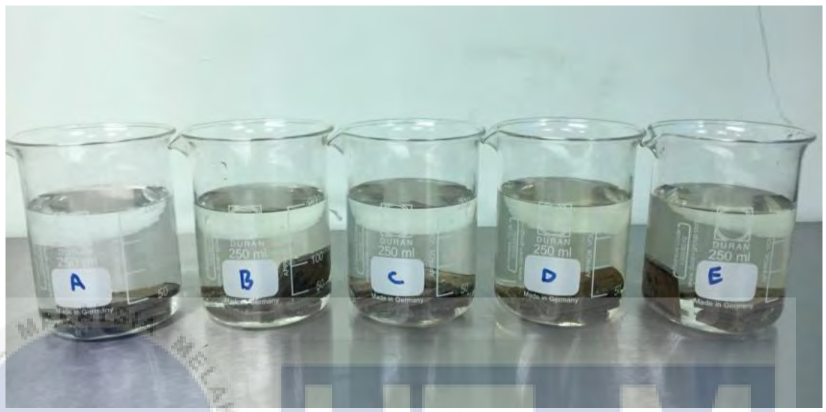

Figure 3.8: Immersing the Samples in Distilled Water.

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CHAPTER 4

RESULT AND DISSECTION

4.1 Overview

This chapter showed and discussed the result obtained for this project. However, in this project two tests have been conducted which are physical and moisture absorption. The initial mass and specific density with their standards devotion were calculated. Also the moisture absorption tests were calculated for different time durations.

4.2 Data and Result for Hybrid Composites Density Evaluation

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4.2.1 Data and Results of the Initial Mass

The initial mass and the standard deviation of the samples were calculated as shown in Table 4.1. However, in Figure 4.1 shows the graph of the initial average mass of the five samples, while Figure 4.2 shows the graph of the standard deviation related to the mass of the five samples.

Table 4.1: Value of the Initial Mass and Standard deviation.

	OPEFB %	Kenaf %	HDPE %	Sample1 G	Sample2 g	Sample3 g	Sample4 g	Sample5 G	Average G	Standard deviation g
A	0	40	60	2.66	2.68	2.88	2.69	2.75	2.732	0.07985
B	10	30	60	2.86	3.20	3.02	3.20	3.15	3.086	0.13078
C	20	20	60	3.37	3.14	3.04	3.14	2.94	3.126	0.14277
D	30	10	60	2.95	3.17	3.28	3.16	3.05	3.122	0.11269
E	40	0	60	3.22	3.42	2.99	2.82	2.70	3.030	0.26184

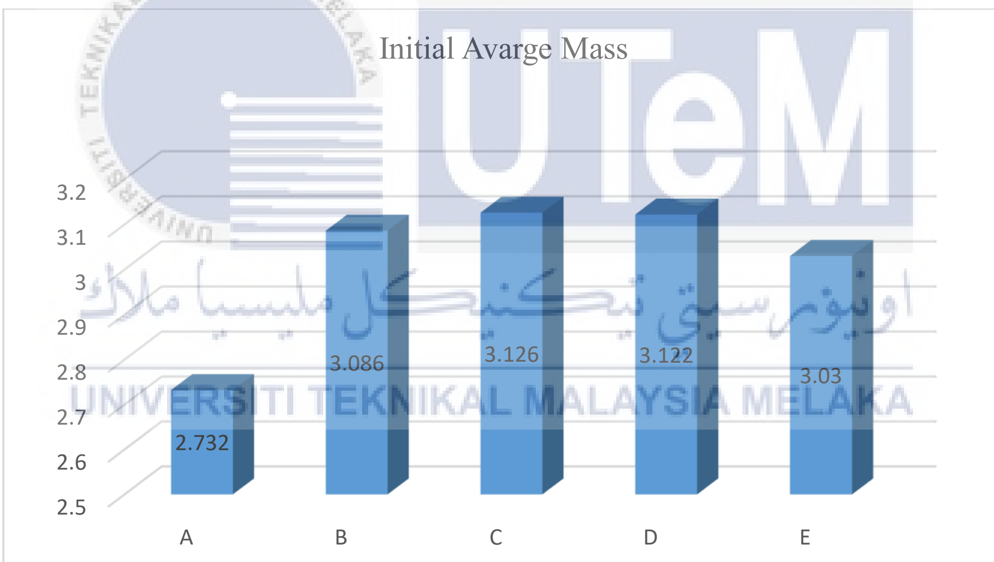

Figure 4.1: Initial Average Mass of the Five Samples.

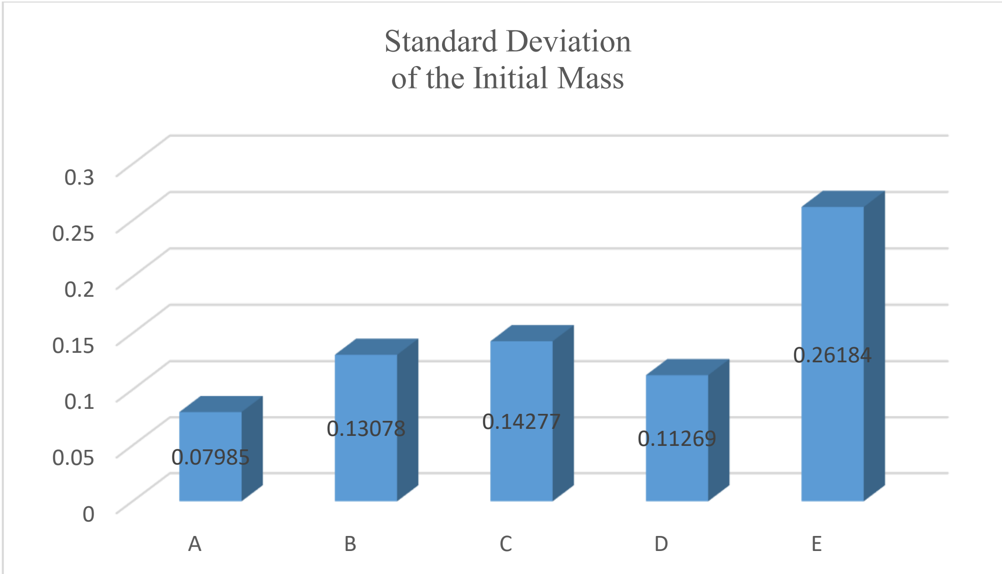

Figure 4.2: Standard Deviation of the Initial Mass for the Five Samples.

4.2.2 Sample Calculation of the Standard Deviation

The low standard deviation indicates that the date points tend to be close to the mean and also called the expected value. Therefore 0.07985g is the expected standard deviation which obtains from sample A. While the high standard deviation indicates that the date points are spread out over a wider range of values. The calculation of the standard deviation of the five samples are as follows:

- Samples (A)

Mean= $\frac{(2.66 + 2.68 + 2.88 + 2.69 + 2.75)}{5} = 2.732\text{g}.$

Variance= $\frac{(2.66-2.732)^2+(2.68-2.732)^2+(2.88-2.732)^2+(2.69-2.732)^2+(2.75-2.732)^2}{5} = 0.00638\text{g}.$

Standard deviation= $\sqrt{0.00638} = 0.07985\text{g}.$

- Samples (B)

Mean= $\frac{(2.86 + 3.20 + 3.02 + 3.20 + 3.15)}{5} = 3.086$g.

Variance= $\frac{(2.86-3.086)^2 + (3.20-3.086)^2 + (3.02-3.086)^2 + (3.20-3.086)^2 + (3.15-3.086)^2}{5} = 0.01710$g.

Standard deviation= $\sqrt{0.01710} = 0.13078$g.

- Samples (C)

Mean= $\frac{(3.37+3.14+3.04+3.14+2.94)}{5} = 3.126$g.

Variance= $\frac{(3.37-3.126)^2 + (3.14-3.126)^2 + (3.04-3.126)^2 + (3.14-3.126)^2 + (2.94-3.126)^2}{5}$ =0.02038g.

Standard deviation= $\sqrt{0.02038} = 0.14277$g.

- Samples (D)

Mean= $\frac{(2.95+3.17+3.28+3.16+3.05)}{5} = 3.122$g.

Variance= $\frac{(2.95-3.122)^2 + (3.17-3.122)^2 + (3.28-3.122)^2 + (3.16-3.122)^2 + (3.05-3.122)^2}{5}$ =0.01270g.

Standard deviation= $\sqrt{0.01270} = 0.11269$g.

- Samples (E)

Mean= $\frac{(3.22+3.42+2.99+2.82+2.70)}{5} = 3.030$g.

Variance= $\frac{(3.22-3.030)^2 + (3.42-3.030)^2 + (2.99-3.030)^2 + (2.82-3.030)^2 + (2.70-3.030)^2}{5}$ =0.06856g.

Standard deviation= $\sqrt{0.06856} = 0.26184$g.

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4.2.3 Data and Results of Specific Density

The specific density and the standard deviation of the samples were calculated as shown in Table 4.2. However, Figure 4.3 shows the graph of the specific density of the five samples, while Figure 4.4 shows the graph of the standard deviation related to the specific density of the five samples.

Table 4.2: Value of the Specific Density and Standard Deviation.

	OPEF %	Kenaf %	HDPE %	Sample1	Sample2	Sample3	Sample4	Sample5	Average	Standard deviation $\times 10^{-3}$
A	0	40	60	1.085	1.079	1.074	1.077	1.088	1.0806	5.1614
B	10	30	60	1.052	1.056	1.060	1.064	1.055	1.0574	4.1761
C	20	20	60	1.066	1.066	1.065	1.059	1.045	1.0602	8.0349
D	30	10	60	1.053	1.060	1.062	1.075	1.049	1.0598	8.9308
E	40	0	60	1.050	1.071	1.062	1.034	1.051	1.0536	12.4676

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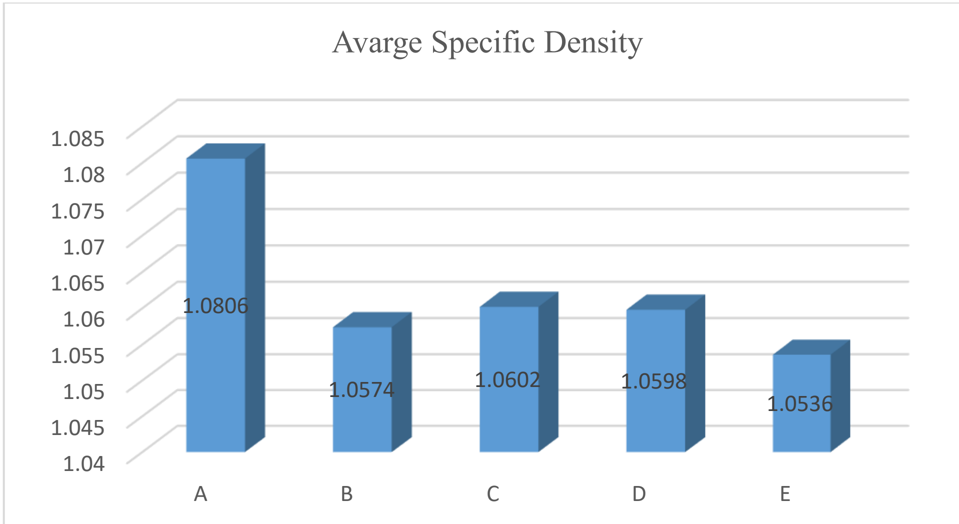

Figure 4.3: Avarge Specific Density of the Five Samples.

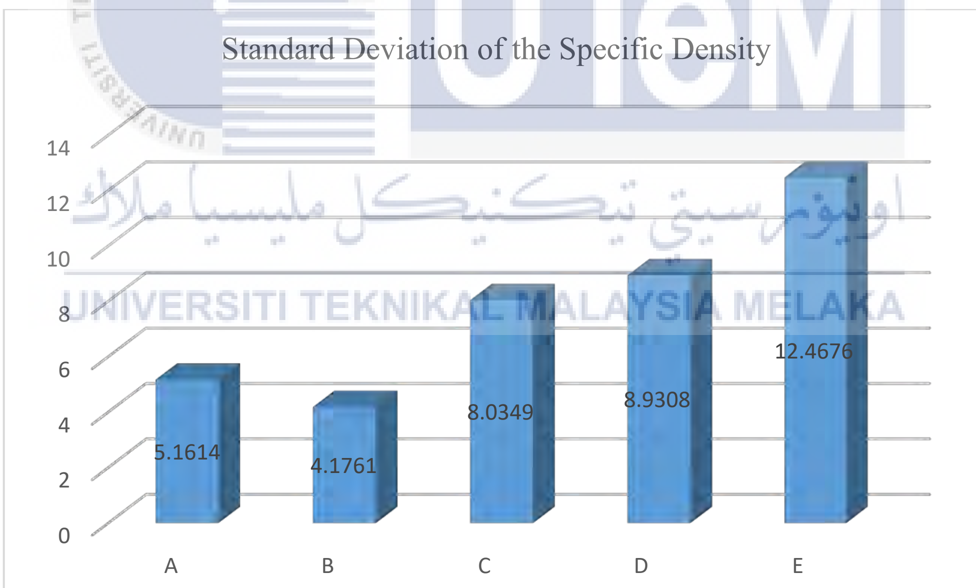

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Figure 4.4: Standard Deviation of the Specific Density for the Five Samples.

4.2.4 Sample Calculation of the Standard Deviation

The low standard deviation indicates that the data points tend to be close to the mean which is $4.1761\ \times 10^{-3}$ from sample B, while the high standard deviation indicates that the date points are spread out over a wider range of values which is 12.4676 $\times 10^{-3}$ from sample E.

- Samples (A)

  Mean= $\frac{(1.085+1.079+1.074+1.077+1.088)}{5}$ =1.0806

Variance= $\frac{(1.085-1.0806)^2+(1.079-1.0806)^2+(1.074-1.0806)^2+(1.077-1.0806)^2+(1.088-1.0806)^2}{5}$

$= 2.664 \times 10^{-5}$.

Standard deviation= $\sqrt{2.664 \times 10^{-5}} = 5.1614 \times 10^{-3}$.

- Samples (B)

  Mean= $\frac{(1.052+1.056+1.060+1.064+1.055)}{5}$ =1.0574

Variance= $\frac{(1.052-1.0574)^2+(1.056-1.0574)^2+(1.060-1.0574)^2+(1.064-1.0574)^2+(1.055-1.0574)^2}{5}$

$= 1.744 \times 10^{-5}$.

Standard deviation= $\sqrt{2.68 \times 10^{-5}} = 4.1761 \times 10^{-3}$.

- Samples (C)

  Mean= $\frac{(1.066+1.066+1.065+1.059+1.045)}{5}$ =1.0602

Variance= $\frac{(1.066-1.0602)^2+(1.066-1.0602)^2+(1.065-1.0602)^2+(1.059-1.0602)^2+(1.045-1.0602)^2}{5}$

$= 6.456 \times 10^{-5}$.

Standard deviation= $\sqrt{6.456 \times 10^{-5}} = 8.0349 \times 10^{-3}$.

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- Samples (D)

  Mean= $\frac{(1.053+1.060+1.062+1.075+1.049)}{5}$ =1.0598

Variance= $\frac{(1.053-1.0598)^2+(1.060-1.0598)^2+(1.062-1.0598)^2+(1.075-1.0598)^2+(1.049-1.0598)^2}{5}$

$= 7.976 \times 10^{-5}$.

Standard deviation= $\sqrt{7.976 \times 10^{-5}} = 8.9308 \times 10^{-3}$.

- Samples (E)

  Mean= $\frac{(1.050+1.071+1.062+1.034+1.051)}{5}$ =1.0536

Variance= $\frac{(1.050-1.0536)^2+(1.071-1.0536)^2+(1.062-1.0536)^2+(1.034-1.0536)^2+(1.051-1.0536)^2}{5}$

$= 15.544 \times 10^{-5}$.

Standard deviation= $\sqrt{15.544 \times 10^{-5}} = 12.4676 \times 10^{-3}$.

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4.3 Data and Result for Water Absorption Tests

Samples were immersed in distilled water and were left inside a box in order to make sure the temperate remains at 25°c for 24 hours. After completed 24 hours of immersing the samples, they were taken out from the distilled water and all surface water were removed with a clean dry cloth. The samples were weighted within 30 seconds and they were immersed again. Same process were repeated to the samples after immersing them for 48, 72, 144, 168, 192, 216 and 240 hours. The percentage of the water in the composites will be calculated by weight difference between the samples immersed in water and the dry samples using following equation:

$$\Delta M(t) = \left(\frac{m_t - m_o}{m_o}\right) \times 100 \qquad (1)$$

Where $\Delta M(t)$ is the moisture uptake, m_o and m_t are the mass of the sample before and during aging, respectively. Tables 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9 and 4.10 below shows the reading of moisture absorption.

Table 4.3: Mass of the Samples Immersing in Distilled Water for 24 hours.

	OPEFB %	Kenaf %	HDPE %	m(1) g	m(2) g	m(3) g	m(4) g	m(5) g	Average g	Moisture absorption %
A	0	40	60	2.6817	2.7118	2.9221	2.7304	2.7907	2.7673	1.2920
B	10	30	60	2.9731	3.3523	3.1122	3.2838	3.2996	3.2042	3.8302
C	20	20	60	3.4374	3.1980	3.1220	3.2160	3.0293	3.2005	2.3832
D	30	10	60	3.0349	3.2526	3.3974	3.2626	3.1279	3.2151	2.9821
E	40	0	60	3.3438	3.5600	3.1153	2.9010	2.7866	3.1413	3.6733

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Table 4.4: Mass of the Samples Immersing in Distilled Water for 48 hours.

	OPEFB %	Kenaf %	HDPE %	m(1) g	m(2) g	m(3) g	m(4) g	m(5) g	Average g	Moisture absorption %
A	0	40	60	2.7	2.8	2.9	2.8	2.7	2.78	1.7570
B	10	30	60	3.0	3.4	3.1	3.3	3.4	3.24	4.9903
C	20	20	60	3.5	3.2	3.1	3.3	3.1	3.24	3.6468
D	30	10	60	3.0	3.3	3.4	3.3	3.2	3.24	3.7796
E	40	0	60	3.4	3.6	3.1	2.9	2.8	3.16	4.2904

Table 4.5: Mass of the Samples Immersing in Distilled Water for 72 hours.

	OPEFB %	Kenaf %	HDPE %	m(1) g	m(2) g	m(3) g	m(4) g	m(5) g	Average g	Moisture absorption %
A	0	40	60	2.7	2.8	2.9	2.8	2.8	2.8	2.4890
B	10	30	60	3.0	3.4	3.1	3.3	3.4	3.24	4.9903
C	20	20	60	3.5	3.2	3.1	3.3	3.1	3.24	3.6468
D	30	10	60	3.1	3.3	3.4	3.3	3.2	3.26	4.4202
E	40	0	60	3.4	3.6	3.1	2.9	2.8	3.16	4.2904

Table 4.6: Mass of the Samples Immersing in Distilled Water for 144 hours.

	OPEFB %	Kenaf %	HDPE %	m(1) g	m(2) g	m(3) g	m(4) g	m(5) g	Average g	Moisture absorption %
A	0	40	60	2.7114	2.7454	2.9537	2.7637	2.8338	2.8016	2.5476
B	10	30	60	3.0142	3.4151	3.1681	3.3249	3.3919	3.2628	5.7304
C	20	20	60	3.4969	3.2526	3.1864	3.2845	3.1005	3.2642	4.4203
D	30	10	60	3.0965	3.3492	3.5090	3.3574	3.2018	3.3028	5.7905
E	40	0	60	3.4735	3.6757	3.2124	2.9951	2.8779	3.2469	7.1591

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Table 4.7: Mass of the Samples Immersing in Distilled Water for 168 hours.

	OPEFB %	Kenaf %	HDPE %	m(1) g	m(2) g	m(3) g	m(4) g	m(5) g	Average g	Moisture absorption %
A	0	40	60	2.7199	2.7535	2.9675	2.7746	2.8490	2.8129	2.9612
B	10	30	60	3.0252	3.4355	3.1933	3.3446	3.4059	3.2809	6.3156
C	20	20	60	3.5142	3.2684	3.2044	3.3048	3.1135	3.2811	4.9603
D	30	10	60	3.1073	3.3598	3.5352	3.3848	3.2196	3.3213	6.3850
E	40	0	60	3.4926	3.6950	3.2293	3.0023	2.8799	3.2598	7.5848

Table 4.8: Mass of the Samples Immersing in Distilled Water for 192 hours.

	OPEFB %	Kenaf %	HDPE %	m(1) g	m(2) g	m(3) g	m(4) g	m(5) g	Average g	Moisture absorption %
A	0	40	60	2.7271	2.7632	2.9753	2.7846	2.8577	2.8216	3.2789
B	10	30	60	3.0447	3.4502	3.1989	3.3532	3.4177	3.2929	6.7058
C	20	20	60	3.5267	3.2782	3.2100	3.3108	3.1280	3.2907	5.2700
D	30	10	60	3.1073	3.3720	3.5367	3.3900	3.2226	3.3257	6.5253
E	40	0	60	3.5026	3.6966	3.2331	3.0035	2.8829	3.2637	7.7142

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Table 4.9: Mass of the Samples Immersing in Distilled Water for 216 hours.

	OPEFB %	Kenaf %	HDPE %	m(1) g	m(2) g	m(3) g	m(4) g	m(5) g	Average g	Moisture absorption %
A	0	40	60	2.7315	2.7670	2.9776	2.7851	2.8591	2.8241	3.3697
B	10	30	60	3.0493	3.4535	3.2045	3.3553	3.4255	3.2976	6.8574
C	20	20	60	3.5309	3.2822	3.2215	3.3231	3.1329	3.2981	5.5061
D	30	10	60	3.1204	3.3876	3.5505	3.4062	3.2322	3.3394	6.9628
E	40	0	60	3.5092	3.7109	3.2467	3.0195	2.8937	3.2760	8.1188

Table 4.10: Mass of the Samples Immersing in Distilled Water for 240 hours.

	OPEFB %	Kenaf %	HDPE %	m(1) g	m(2) g	m(3) g	m(4) g	m(5) g	Average g	Moisture absorption %
A	0	40	60	2.7347	2.7761	2.9783	2.7861	2.8631	2.82766	3.5015
B	10	30	60	3.0523	3.4551	3.2050	3.3732	3.4461	3.30634	7.1400
C	20	20	60	3.5379	3.2956	3.2281	3.3343	3.1397	3.30712	5.7940
D	30	10	60	3.1325	3.3938	3.5678	3.4152	3.2415	3.35016	7.3081
E	40	0	60	3.5164	3.7192	3.2795	3.0419	2.9172	3.29484	8.7406

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Figure 4.5 shows clearly the behavior of water absorption against times in (hours), while Figure 4.6 shows the water uptake for composites as function of square root of immersion time. Samples consist of 60 percent of HDPE and 40 percent of natural fibers which are OPEFB and kenaf. It apparent from the graph that with increasing the time of immersing the samples in distilled water, the moisture absorption increases. In the first 24 hours, sample (B) has the highest value of increment of moisture absorption which is 3.8302%, while sample (A) has the lowest value of increment which is 1.2920%. After 240 hours have past the graph shows that sample (E) has the highest value of increment of moisture water which is 8.7406% and sample (A) has the lowest value of increment which is 3.5015%.

The result obtained from the water absorption test for the sample with 60 percent of HDPE and 40 percent of OBEFB will absorb the most water than the other samples while the sample with 60 percent of HDPE and 40 percent of kenaf will absorb the least water. However, there is a fluctuation for the moisture absorption on second and third reading which can be regarded due to using balancer with one digit while the other reading were obtained by using balancer with four digits.

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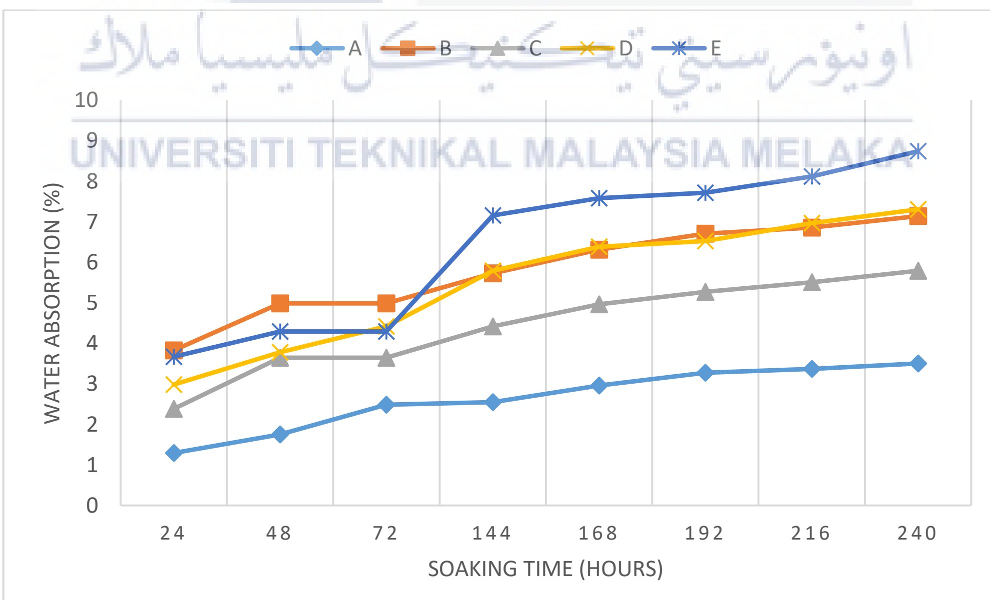

Figure 4.5: Water Absorption with Soaking Time.

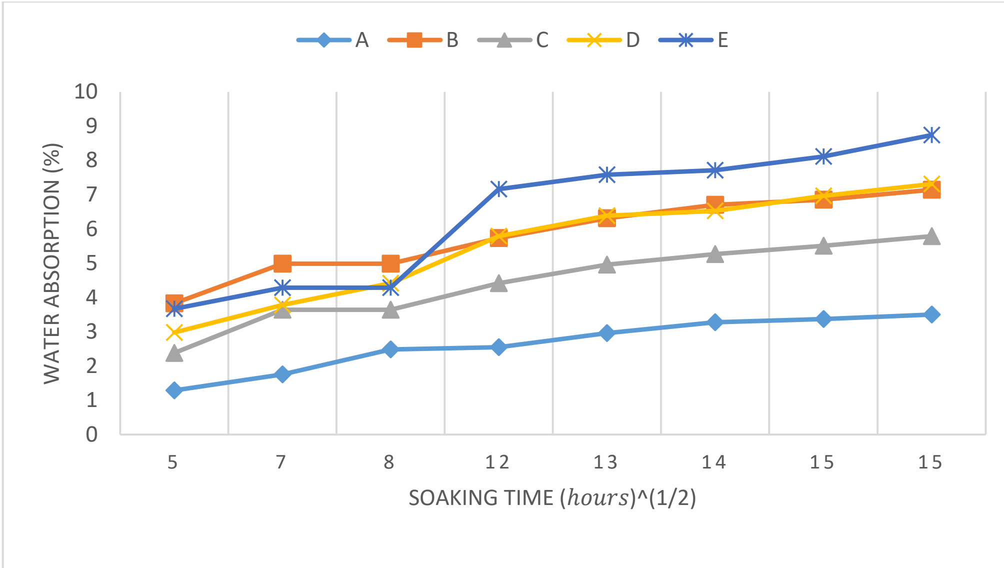

Figure 4.6: Water Uptake for Composites as Function of Square Root of Immersion Time.

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CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The effect of varying fiber contents to the density property and to the water absorption property of hybrid oil palm empty fruits bunches/kenaf reinforced high density polyethylene composites has been investigated. Mixer hot press method was used to obtain the samples. However, sample were made of 40% wt natural fibers which are OPEFB/kenaf and 60% wt HDPE. Physical test according to ASTM D792 were conducted by calculating the mass and the specific density of the samples. In addition, the standard deviation of the samples were calculated related to the mass and specific density. The small value of the standard deviation related to the mass shows that, the point is near to the mean and also called the expected value. Therefore, 0.07985g is the expected standard deviation which obtains from sample (A). While the small value of the standard deviation related to specific density shows that, the expected value is 0.004176 which obtains from sample (B).

Water absorption test according to ASTM D570 were conducted by immersing the five samples in a distilled water bath at room temperature for different time duration. The samples were weighted within 30 seconds and they were immersed again. Same process were repeated to the samples after immersing them for 24, 48, 72, 144, 168, 192, 216 and 240 hours. The percentage of the water in the composites were calculated by weight difference between the samples immersed in water and the dry samples. The result obtained from the water absorption test shows that with increasing the time of immersing the samples in distilled water, the moisture absorption increases. In the first 24 hours, sample (B) has the highest value of increment of moisture absorption which is 3.8302%, while sample (A) has the lowest value of increment which is 1.2920%. After 240 hours have past sample (E) has the highest value of increment of moisture water which is 8.7406% and sample (A) has the lowest value of increment which is 3.5015%.

5.2 Recommendations for Future Works

Several recommendation for future works related to this project as described as below

i. Using date palm which can be easily found in Middle East such as Saudi Arabia instead of oil palm.
ii. Using other methods to save the time of combining the samples as the compressing molding method takes time to be heated, cool down and treated.
iii. Using chemical treatment on natural fibers which are oil palm and kenaf.

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