A STUDY ON IMPACT PROPERTIES OF HYBRID OIL PALM EMPTY FRUIT BUNCH/ KENAF REINFORCED HIGH DENSITY POLYETHYLENE COMPOSITES FOR AUTOMOTIVE APPLICATION

MUHAMAD FAHMI BIN MD NOOR

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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MUHAMAD FAHMI BIN MD NOOR

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DECLARATION

I Muhamad Fahmi bin Md Noor declares that this project report entitled "A Study on Impact Properties of Hybrid Oil Palm Empty Fruit Bunch/ Kenaf Reinforced High Density Polyethylene Composites for Automotive Application", under the guidance of Dr. Muhd Ridzuan bin Mansor, is my original work except references material.

Signature : ______________________________

Name : Muhamad Fahmi bin Md Noor

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 : ____

Supervisors Name : Dr. Muhd Ridzuan bin Mansor

Date : ____

DEDICATION

I dedicated my study to my beloved mother and father who always give motivation and encouragement to finish my study until the ends. I also want to thanks to my brother and sister the person never left my side cheer and raise my spirit to work harder to complete the study. Not forgotten to my friends who always supported me throughout the process. Last but not least, I will always appreciated all they have done especially to Dr. Ridzuan the person always guide me to finish the work, Mr. Taufiq who assisted me in the laboratory and sharing knowledge. I want to give special thanks again to all person who helps in this works and supported me to the ends.

ABSTRACT

Nowadays, the natural fibre reinforced thermoplastic composites have attracted attention many researcher and industrial player as potential renewable and biodegradable source of raw material especially for automotive application. Among the potential candidate material for natural fiber composites (NFC) application is oil palm empty fruit bunch (OPEFB) fibres, which is a waste product in the oil palm industry. Hence, OPEFB offer very low cost with high availability, thus making it very suitable for NFC production. In this study, a novel hybrid NFC utilizing OPEFB and kenaf fibre reinforced thermoplastic high density polyethylene (HDPE) composites (OPEFB/Kenaf/HDPE) is developed. The purpose was to characterize the impact properties of hybrid OPEFB/Kenaf/HDPE composites at varying OPEFB fiber loadings. In addition, the effect of moisture to the impact properties of the hybrid OPEFB/Kenaf/HDPE composites was also investigated. The OPEFB fibre loadings were varied from 0, 10, 20, 30, and 40 wt%, with fixed HDPE contents of 60 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 molding process. Finally the sample is cut to size and characterize in accordance to the ASTM D256 for the impact test using Izod impact testing apparatus. For the moisture absorption study, all samples were soaked for 29 days in distilled water prior to the impact testing. Overall results from the tests showed that hybrid composites at 30 wt% of OPEFB have the highest impact strength compared to other hybrid formulation. The hybrid formulation was able to increase up to twice the impact strength of the 100% OPEFB/HDPE composites. Furthermore, the effects of water absorption were also found to increase the impact strength for all formulation as 12.8% in average. The findings showed the potential of utilizing hybrid technique to improve the impact performance of OPEFB/HDPE composites especially to cater higher impact load bearing automotive applications.

ABSTRAK

Pada masa kini, serat semulajadi komposit bertetulang termoplastik telah menarik perhatian ramai penyelidik dan juga industri sebagai sumber tenaga mentah yang boleh diperbaharui dan biodegradable terutamanya untuk aplikasi automotif. Antara bahan yang potensial untuk komposit serat semulajadi (NFC) ialah serat buah kelapa sawit (OPEFB), yang merupakan produk sisa dalam industri kelapa sawit. Oleh itu, OPEFB menawarkan kos yang rendah, mudah didapati, dan menjadikannya sesuai untuk pengeluaran NFC. Dalam kajian ini, NFC hibrid baru yang menggunakan OPEFB dan serat kenaf diperkuat komposit polietilena berketumpatan tinggi termoplastik (OPEFB/Kenaf/HDPE) dibuat. Tujuannya adalah untuk mencirikan sifat-sifat hentaman komposit OPEFB/Kenaf/HDPE hibrid pada pelbagai beban serat OPEFB. Di samping itu, kesan kelembapan kepada sifat hentaman komposit OPEFB/Kenaf/HDPE hibrid juga disiasat. Beban serat OPEFB berbeza berat dari 0, 10, 20, 30, dan 40%, dengan kandungan HDPE tetap sebanyak 60%. Serat dihancurkan dan disaring pada saiz antara 1 hingga 5 mm. Serat hibrid kemudian dicampur dengan HDPE menggunakan pengkompaunan dan dibentuk menjadi plat nipis menggunakan proses pengacuan mampatan panas. Akhirnya sampel dipotong kepada saiz mengikut ASTM D256 untuk ujian hentaman menggunakan alat ujian hentaman Izod. Untuk kajian penyerapan kelembapan, semua sampel direndam selama 29 hari dalam air suling sebelum ujian hentaman. Keputusan keseluruhan dari ujian menunjukkan bahawa komposit hibrid pada berat 30% OPEFB mempunyai kekuatan hentaman tertinggi berbanding dengan formula hibrid yang lain. Rumusan hibrid mampu meningkatkan hingga dua kali ganda kekuatan hentaman komposit OPEFB/HDPE sebanyak 100%. Selain itu, kesan penyerapan air juga didapati meningkatkan kekuatan hentaman untuk semua perumusan sebanyak purata 12.8%. Penemuan menunjukkan potensi menggunakan teknik hibrid untuk meningkatkan prestasi kekuatan hentaman komposit OPEFB/HDPE terutamanya untuk menampung kekuatan hentaman yang lebih tinggi pada aplikasi automotif.

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LIST OF ABBREVIATION

OPEFB	Oil Palm Empty Fruit Bunch
HDPE	High Density Polyethylene
PS	Polystyrene
PVC	Polyvinyl Chloride
PP	Polypropylene
PE	Polyethylene
CO_2	Carbon Oxide
HPT	High Process Temperature
LPT	Low Process Temperature
NaOH	Sodium Hydroxide
SEM	Scanning Electron Microscopy
Tp	Thermoplastic
Ts	Thermoset
(wt%)	Weight percentage
ρ	Density
V	Volume
m	Mass

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Malaysia is one the bigger producer of oil palm in the world. The huge production of oil palm is is worrying due to waste oil palm disposal problems. Therefore, there is need to reduce the waste and optimize the utilization of the oil palm product, by using the recycle method which can support the “waste to wealth” initiative, (Matovic, 2013).

Neutral fiber has three main different of classification which plant, animal and material and oil palm is one of natural fiber come from plant category. Each of categories has different properties and also widely used nowadays. Using of natural fiber is highly recommended because low cost, recyclability, and biodegradable advantages material but there must be the disadvantage and limit of use in natural fiber. Natural fiber is poor due to wettability and tendency of water absorption is high and also low thermal effective, (Yahaya et al., 2015).

The advantage of recyclability and biodegradability of neutral fiber, oil palm can be recycle and use to create new green biocomposite material by mixing neutral fiber with matrix to increase the properties of material. Base on the main issues of disposal problem of oil palm, it can turn it from waste to profit by using this method. This research only focusing on the mechanical and morphological properties of plant-based biocomposite, OPEFB/Kenaf reinforced high density polyethylene HDPE.

Kenaf is natural fiber and also widely used in producing composite material. Kenaf is one of world production material and cheaper material from other neutral fiber classification in Malaysia. From previous research, kenaf is used for reinforced matrix composite which shown good result properties from tensile and flexural testing (Saba et al., 2016).

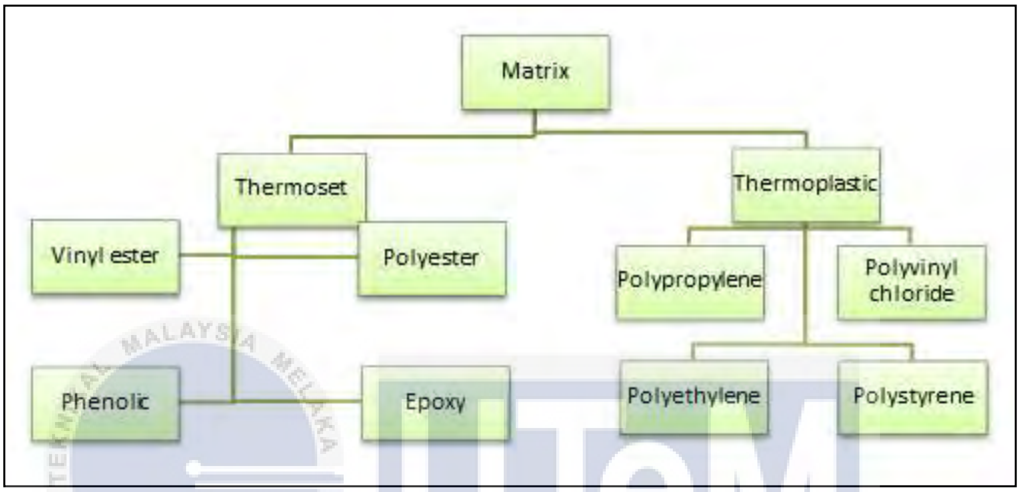

Figure 1.1 Classification of matrix

In this study will focus on thermoplastic instead of thermoset because of recyclability advantage of thermoplastic is more accurate type to create new green biocomposite material. Refer from previous studied report about polystyrene (PS) and polyvinyl chloride (PVC), there is not much data can get. Furthermore, between polypropylene (PP) and polyethylene (PE), PP contains carbon oxide, (CO_2) which in term of environmental of performance are lacking then PE. Therefore, PE is the best to use for creating new green biocomposite material. In mechanical properties PE, it has good deformation, fracture, thermal diffusivity and conductivity, and specific heat. In case to improve the toughness it can vary the volume of fiber. HDPE can be decrease in thermal conductivity and diffusivity by increase the volume of fiber material but the properties of HDPE remain same if heating the HDPE in range temperature of 170°C to 200°C. In other hands, specific heat will increase gradually with the temperature, (Faruk et al., 2012).

1.2 Problem Statement

OPEFB composite is good in term of density but lack in mechanical properties. This problem can be solves by using hybrid composites material method to improve the OPEFB mechanical properties. In Malaysia have certain fiber readily available such as banana, pineapple, and kenaf. Between all the fibers producing in Malaysia, kenaf is the best composites material in term of strength. The problem is the performance of hybrid OPEFB/kenaf reinforced HDPE composite in impact mechanical properties still undefined.

1.3 Objective

The objectives of the project are as follows:

i. To determine the effect of varying fiber contents on the impact properties of hybrid oil palm empty fruit bunch/ kenaf reinforced high density polyethylene composites.

ii. To evaluate the effect of water absorption on the impact properties of hybrid oil palm empty fruit bunch/ kenaf reinforced high density polyethylene composites.

1.4 Scope of Study

The scope of work is:

i. To conduct the literature review.

ii. To conduct sample preparation of hybrid OPEFB/kenaf at varying OPEFB weight content ($wt\%$) using compression molding process.

iii. To test sample using Izod impact testing machine.

iv. To conduct surface morphology examination using scanning electron microscopy.

v. To perform data analysis.

vi. Report writing.

CHAPTER 2

LITERATURE REVIEW

2.1 Natural fiber and classification

Commonly there are categorized natural fibers based on plant, animal and mineral. Based on plant fiber is containing cellulose as major structural. For mineral natural fibers basically exist within mineral group of asbestos. Nowadays, mineral natural fibers are avoided from used because of effect from health issues through breathing. Many countries around the world alert this issue and band it from used. Lastly the animal fiber original contain protein. (Pickering et al., 2016)

Cellulose can be divided into three categories. Each category depends on the plant extraction which from bast or stem fiber, leaf fiber or seed fiber. There are lots of type cellulose fibers reinforced with matrix to form new composite material. For example, kenaf, jute, and oil palm empty fruit bunch is commonly used in research study to form new composite material. (Jawaid & Abdul Khalil, 2011). Faruk et al., (2012) also stated that there are six types natural fibers basically. The classification as follows:

i. Bast fibers which is jute, hemp, flax, kenaf and ramie.
ii. Leaf fiber is sisal, abaca and pineapple.
iii. Seed fibers which are coir, kapok and cotton.
iv. A core fiber is hemp, kenaf and jute.
v. Grass fiber and reed fiber which is wheat, corn and rice.
vi. Other type’s fiber is from wood and roots.

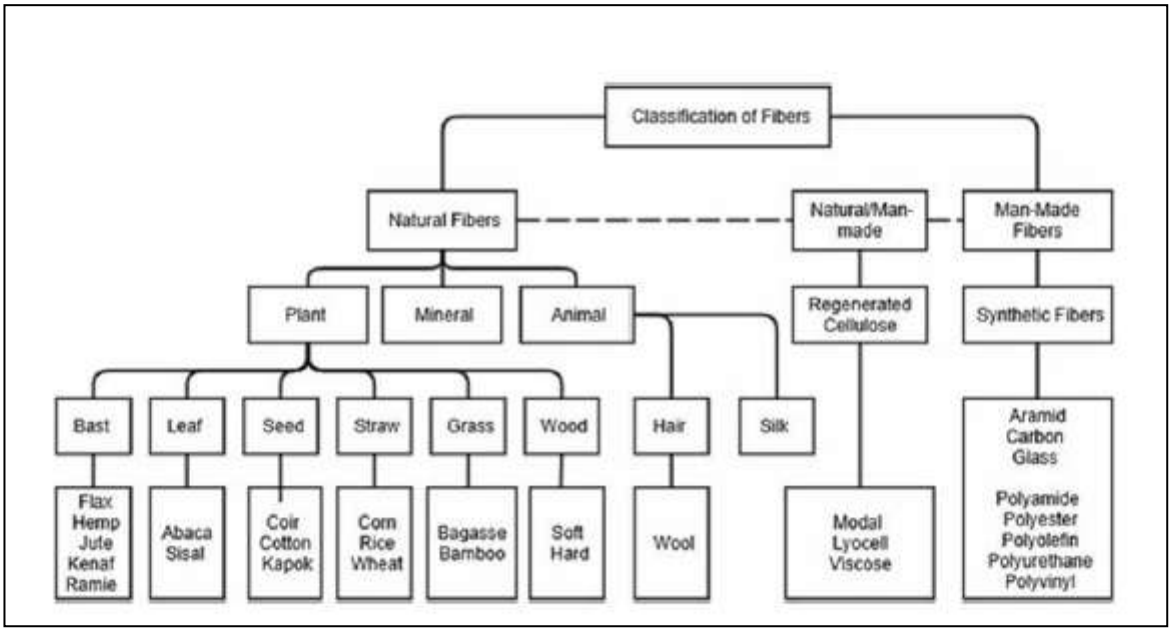

Figure 2.1 Schematic representation of fiber classification (Ramamoorthy et al., 2015)

There are a lot of advantages using natural fibers. It because natural fibers are low cost, and the material is availability. It also can be renewable, recyclable and biodegradable with low density and have good specific strength modulus. But improvement of natural fiber still limited in water absorption and low thermal stability (Yahaya et al., 2015). Based on Sanjay et al (2015) study, the natural fiber is different advantage between synthetic fibers. Natural fiber is having low density and also low cost then synthetic fibers. Furthermore, natural fiber can be recycle and renewable which synthetic cannot do both characteristics. Natural fibers also are biodegradable with no health risk when breathing. However, there are disadvantage of natural fibers due low water absorption, poor bonding with polymer, and low durability which bring to undesirable characteristic of composite in certain industrial usage. (Al-Oqla et al., 2015)

2.2 Kenaf fiber

Kenaf fiber is one of the natural fiber families. This fiber also widely used available and cheapest fiber. Kenaf can originally from plants genus Hisbiscus. The plant can be found in Africa and Asia in tropical and sub-tropical (Salleh et al., 2012). Within in three months, the growing of kenaf plant longer than 3 m with stem diameter range in 0.025m to 0.051m. Therefore, the kenaf plants is available as long fiber character (Mahjoub et al., 2014). Kenaf is is different in bast and core characteristic. For kenaf bast is contain 30% of total dry weight of stalk and kenaf core is contain 70% fibers. For core part consist low density which about 0.1g/cm^3. Additionally, kenaf stem can used for composite fiber and create products (Paridah et al, 2011).

Figure 2.2 Kenaf core and kenaf bast (Saba et al., 2015)

Among the natural fibers, kenaf is one of the the fiber in characteristic which have long fiber with small diameter. It also has good interfacial adhesion to polymer character (Yousif et al, 2012). Therefore, based on study Fauzani et al (2014), HDPE polymer are used to reinforced with kenaf fiber. The composites kenaf fiber/HDPE presented good tensile modulus outcome result at high process temperature HPT is better than at low process temperature LPT.

2.3 Oil Palm Empty Fruit Bunch (OPEFB)

OPEFB is obtained from the process of oil extraction from fruit bunch. The growth of oil palm plantation is creating the problem in vegetable waste and replanting operations. Malaysia have produced about 30 million tons of oil palm in recent past year study. Researcher stated this fiber will be give benefit to economic if utilization of the waste of OPEFB (Jawaid et al., 2010). Utilization of renewable resources is strategic to minimize the impacts of environment and give sustainable energy resources. In addition, it can solve the disposal problem and reduce the use of plastic in commercial applications (Razak & Kalam, 2012).

2.4 Matrices for biocomposites

Summerscales et al (2013) state that the mechanical performances depend on the load transfer and affect the bonding of chemical and physical properties between matrix and fiber. Therefore, to improve the performance of mechanical properties can be achieve by using polymers. Matrices can be classified into two classifications which are thermoset and thermoplastic. Each classification has different in mechanical properties. Based on Faruk et al (2014), to improve the performance of natural fiber need to do more research on varying fiber-matrix adhesion, process, manufacturing and treatment to natural fiber. Mostly, investigation focus on mechanical properties in tensile, flexural and impact test properties to analyze the weak spot of natural fiber reinforced matric composites.

2.4.1 Thermoplastic

Thermoplastic (Tp) is the one of the polymer classification that has biodegradability properties. To minimum the cost of expensive cost engineering, two or three polymers is blended together to improved performances. But the properties of polymer blend is depends method execution (Nurfatimah et al., 2015). Based on previous study HDPE is used as reinforced matrix with natural fiber which flax fiber. The experiment tests the properties of thermal conductivity, and thermal diffusivity of flax fiber reinforced HDPE biocomposites material. The result shown that in range of temperature of 170°C to 200°C the varying of fiber contents does not influence the thermal conductivity but it does influence to thermal diffusivity and specific heat (Li et al., 2008). Besides that, polypropylene (PP) has a lot of research by reinforced with kenaf, oil palm, jute, and other natural fiber (Faruk et al., 2012).

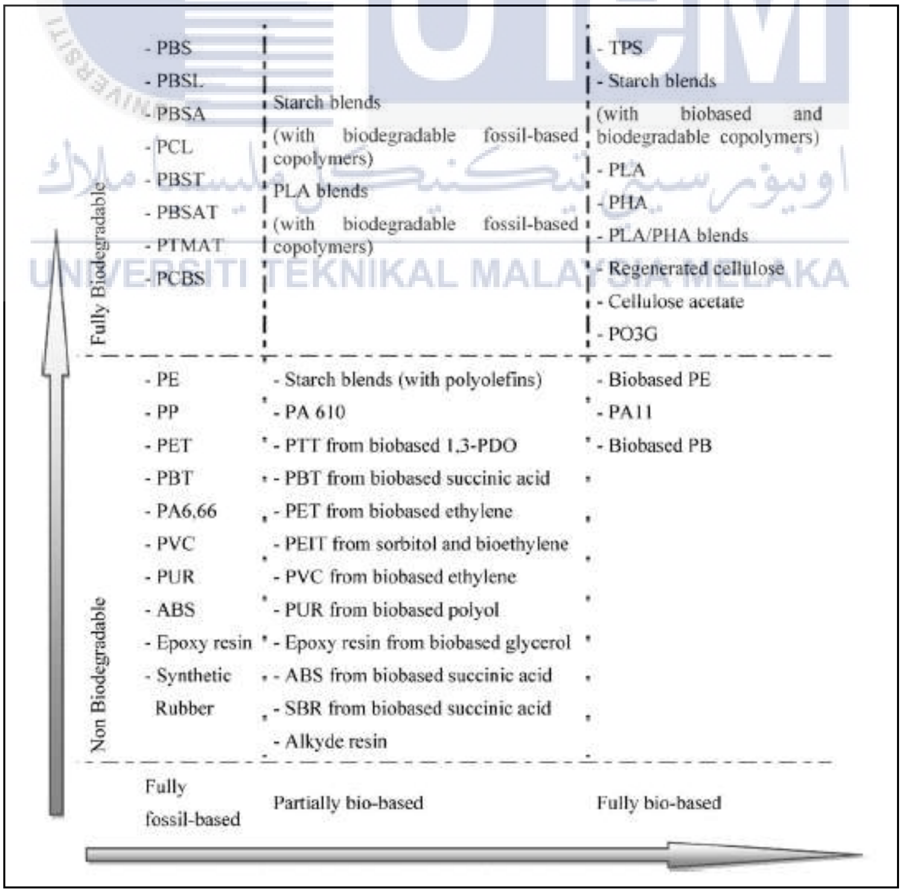

Figure 2.3 Current and emerging polymer and their biodegradability (Faruk et al., 2012)

2.4.2 Thermoset

Thermoset (Ts) is the materials that increase in strength during heating. Disadvantage of thermosetting is cannot be reheat or recycle after initial heating execution. The properties are contrast to thermoplastics which increase in strength during cooling. Based on Faruk et al., (2012) stated that, there are recently do investigation using polyester and epoxy composites as reinforcement. The results for using polyester as reinforced natural fiber have increase in flexural and tensile properties the volume of natural fiber (banana) is increasing but for impact properties is a opposite outcome.

2.5 Application of Hybrid Natural Fiber Composites

In recent years, world are aware the environment and start to focus on maximizing use the natural fiber reinforced with polymer matrix. From the research study show that the natural fiber reinforced matrix give high performance and can compete with glass fiber. This material has attracting the attention in engineering market which give good performance with low cost (Sanjay et al., 2015).

2.6 Previous Research on Natural Fiber of Impact Properties

In the previous research, there are a lot of researcher studies on natural fiber. There want to reduce the waste of natural fiber and also to maximized the use of this fiber. From previous journal paper study, there are lot of study based on composite natural fiber and hybrid composite natural fiber in impact properties analysis. There have shown various process methods to developed new material and be test by impact test to investigate the impact performance of materials.

In 2010, kenaf fiber and short glass reinforced polypropylene have been investigated by using melt blending method. To identify the impact properties, Ray Ran Pendulum impact test is run. The result show that by increasing the content of kenaf fiber will degrade the impact performance (Busu et al., 2010). Hybrid composite OPEFB with jute reinforced epoxy have been research by using hand lay-up method. Izod impact test is used to analyse the impact properties. From the result, OPEFB/Jute/ OPEFB has higher impact strength compared to Jute/OPEFB/ Jute composites. However, both hybrid composite showed lower impact strength compared to pure OPEFB composites (Jawaid et al., 2010). Kevlar with wood flour reinforced HDPE also has been research by using mixing process method. Impact test is conduct to investigate the mechanical impact properties by using Izod impact test. The result obtain show by adding kevlar content can improved the impact properties (Ou et al, 2010).

OPEFB and oil palm cellulose reinforced polypropylene by using mold composite process is investigated by (Razak & Kalam, 2012). In this paper show that Izod impact test is run to identify the impact properties of materials. The results obtain in the test show that polypropylene with cellulose give good adhesion and better performance in impact performance. Furthermore, OPEFB reinforced polypropylene and polypropylene nanoclay hybrid has also been studied. There is using compression pressure method for material process. Izod impact test is run to identify the impact properties. Result obtain that by adding the OPEFB will decrease the performance in impact properties (Razak & Kalam, 2012). Mishra & Biswas, (2013), is study on jute reinforced epoxy by using hand lay-up technique. From the impact test, the result showed that impact strength increase with increasing the filler loading. Furthermore, research on hybrid composite sisal, jute, and glass reinforced polyester by hand lay-up process has been done in 2013. The result obtain from Charpy impact testing show the higher impact performance obtain by hybrid composite glass with sisal (Ramesh et al., 2013).

In previous study on 2014, kenaf bast reinforced polylactic acid has been already study by using internal mixing process and compression molding method. Izod impact test is run to measure the impact performance of materials. From result show that polylactic/ impact modifier/ kenaf has obtain higher impact performance (Taib et al., 2014). Panneerdhass et al., (2014) have study on hybrid composite luffa with ground nut reinforced epoxy by using hand lay-up method. In impact test result proved that the treatment on fiber will give improvement in impact strength. Jute reinforced epoxy and jute reinforced polyester is investigate in paper 2014. The process is run by mixture molding process and using Charpy impact test to identify the impact performance. The jute reinforced polyester give best impact performance as the result (Gopinath et al., 2014).

Babaei et al., (2014), is study on foamed HDPE and wheat straw flour reinforced nanoclay is prepared by mixing process. Test is run to investigate the impact properties by using Izod impact test. In testing show that greater impact strength is natural fiber nanoclay composite. Hybrid composite of kenaf fiber with glass reinforced unsaturated polyester by using sheet molding process shown treatment will increase the performance of impact properties materials (Atiqah et al., 2014).

Alavudeen et al. , (2015), is study on hybrid composite of banana and kenaf reinforced polyester by hand lay-up technique. The study us Izod impact test to investigate the impact properties of material. The result proved that weaving pattern has greater impact than pure kenaf and banana reinforced polyester. Moreover, the study on hybrid composite of jute and ramie reinforced by vinyl ester is investigated on 2015. Resin transfer molding process is used to developed hybrid composites. Impact properties of material are analysis through Charpy impact test. In this investigation found that the hybrid composite show decreasing impact performance. This is because Jute is weak due to impact performance. Short jute reinforced epoxy have been study in paper 2015 by using composite sheet same as mold. Izod impact test is using to studies the behavior of impact properties. The results show that the longer the length of jute will increase the impact performance of materials (Bisaria et al., 2015).

In 2015, hybrid composite kenaf fiber with kevlar reinforced epoxy have study focus on layering sequence by (Yahaya et al, 2015a). The process method is using compression static load. Charpy impact test is used to study the mechanical impact properties. In result prove that the three layer sequence give better performance than 4 layering sequence. To improve the performance also can used 6% of NaOH treatment. The other paper is study on same hybrid composite but focus on orientation of fiber. The process methods are using compression pressure method. Charpy impact is run to test the impact properties of material. In result, the woven hybrid composite give better performance (Yahaya et al., 2015b).

Based on (Nisini et al., 2016), the study of hybrid composite of carbon, basalt and flax fiber reinforced epoxy by using hand lay-up method. The test has run by using falling weight impact. The result from testing show the different sequence of layering fiber does not give significant effect to impact properties. In paper (Khan et al., 2016), have study on Jute reinforced polylactic acid by using using hot press molding machine method. Charpy impact test has been run to investigate the impact properties of materials. Result show that the woven jute reinforced polylactic acid give good performance than non-woven jute. Therefore, woven fabricate play an important role in impact performance. In study 2016, hybrid composites kenaf fiber with coconut reinforced polyester by hand lay-up technique. The study on impact properties by using Izod impact test show higher impact performance can be obtain by adding 3% filler loading (Rosamah et al., 2016).

Table 2.1 Previous research

No	Title	Author	Process Method	Test type	Result obtain
1	Carbon, basalt with flax fiber reinforced epoxy(Ts)	(Nisini et al., 2016)	Hand lay-up	Falling weight impct	*overall impact is laminated N2 increase little than N1 but not significant

2	Jute reinforced polylactic acid (Tp)	(Khan et al., 2016)	Hot press molding machine	Charpy impact (notch)	*woven jute/polylactic acid is better than non-woven *warp direction give better performance than weft direction *woven fabricate important role in impact resistance
3	Kenaf with coconut reinforced polyester (Ts)	(Rosamah et al., 2016)	Hand lay-up	Izod impact (notch)	The higher impact strength is by adding 3% filler loading
4	Composite kenaf with kevlar reinforced Epoxy (Ts)	(Yahaya et al, 2015a)	Compression static load	Charpy impact (unnotch)	*3 layer better than 4 layer *treatment better give better performance
5	Composite kenaf with kevlar reinforced epoxy resin (Ts)	(Yahaya et al., 2015b)	Compression pressure method	Charpy impact (unnotch)	*non-woven kenaf + kevlar low density and void content * UD and woven same density *woven hybrid composite give better performance

6	Banana with kenaf reinforced polyester (Ts)	(Alavudeen et al. , 2015)	Hand lay-up with two different weaving patern	Izod impact (notch)	Weaving pattern has greater impact than pure kenaf and banana reinforce polyester
7	Jute with ramie reinforced vinyl ester	(Y. Li et al., 2015)	Vacuum assisted resin transfer molding process	Charpy impact	Because Jute is weak, the hybrid composite jute/ramie is decrease in impact properties
8	Short jute reinforced epoxy (Ts)	(Bisaria et al., 2015)	Composite sheet molding	Izod impact (notch)	Increase the length of jute fiber, increase the impact energy and strength
9	Foamed HDPE with wheat straw flour reinforced nanoclay (Tp)	(Babaei et al., 2014)	Mixing process	Izod impact (notch)	*great impact strength is natural fiber (NC) plastic composite *lowest strength contain NC 5phr chemical foam agent
10	Kenaf with glass reinforced unsaturated polyester (Ts)	(Atiqah et al., 2014)	Sheet molding component process	Izod impact	*treament give better performance *HDPE + kenaf15%+ GF15% is the best performence

11	Kenaf bast reinforced Polylactic acid (Tp)	(Taib et al., 2014)	Internal mixer process and compression molding	Izod impact (notch)	Polylactic acid/impact modifier (IM)/kenaf is the higher impact strength. The higher IM, the higher impact strength
12	Luffa with ground nut reinforced epoxy (Ts)	(Panneerdhass et al., 2014)	Hand lay-up	Charpy impact	*treatment to fiber gives improvement impact strength. *volume fraction fiber above 30% shown decrease on impact strentgh
13	Jute reinforced epoxy & Jute reinforced polyester (Ts)	(Gopinath et al., 2014)	Molding process (mixtured)	Charpy impact	*the fiber treatment 5% give high impact value *jute/polyester is the best performance
14	Jute + epoxy (Ts)	(Mishra & Biswas, 2013)	Hand lay-up	Low velocity impact test	Jute/epoxy impact strength increase with increase fiber loading
15	Sisal, jute with glass reinforced polyester (Ts)	(Ramesh et al., 2013)	Hand lay-up process and hydraulic press	Charpy impact	*glass + sisal impact stength higher than glass + sisal + jute

16	OPEFB reinforced PP and PPnanoclay hybrid	(Razak & Kalam, 2012)	Compression pressure method	Izod impact (notch/ unnotch)	*add OPEFB decrease on impact strength *unnotch impact energy greater than notch *powder size OPEFB increase, impact strength increase but not significant
17	Kenaf with short glass reinforced PP (Tp)	(Busu et al., 2010)	Internal mixer	Ray Ran Pendulum impact system (notch)	Increase kenaf content will decrease the impact performance
18	OPEFB with Jute reinforced epoxy (Ts)	(Jawaid et al., 2010)	Hand lay-up method	Izod impact (notch)	*OPEFB/Jute/ OPEFB is high impact than Jute/OPEFB/ Jute *hybrid less impact strength compare to pure OPEFB *content jute increase, impact strength decrease
19	Kevlar with wood flour reinforced HDPE (Tp)	(Ou et al, 2010)	Compounding process	Izod impact	*adding kevlar give improvement *for further improvement can by grafted of kevlar

20	OPEFB & OPcellulose reinforced PP (Tp)	(Khalid et al., 2008)	Compounder process and molded composite sheet	Izod impact (notch)	*PP/cellulose better adhesion comptibility with PP *PP/cellulose better than EFB/PP

2.7 Water Absorption

Based on study (Razak & Kalam, 2012) , the sample is prepared to be immerse in distilled water in order to measured characteristic of water absorption on the sample that done in regular interval of time. The water absorption is referring the standard ASTM D570-98. (Yahaya et al., 2015) said that the sample reach maximum water absorption after 360 hours sample immerse in water. the study show that the woven fiber absorb less water compared to unidirectional sample 8.07% and 26.84% respectively. Study also state that the water absorption also influenced the void content of materials which the weight of composites is increase because of water trapping in the void that create in samples

CHAPTER 3

METHODOLOGY

3.1 Introduction of methodology

In this chapter is describing methodology used in this project to obtain the best result of hybrid composite material impact properties kenaf fiber with OPEFB reinforced HDPE. The flow chart shows the process stage. This project starts by studying the best way to obtain the best sample preparation. By obtains the best sample, it can receive a good result in experiment testing.

3.2 General process

The process of overall project can be visualize by refer to figure. The first stage of process is focus on information study and gathering the related data from the journal, book, newspaper, websites and relevant sources. From the information data, the process method that can be used to developed new hybrid composite can be determined and also the type of impact test can be used for testing. References based on journals, articles, books and any related material regarding this project will be reviewed.

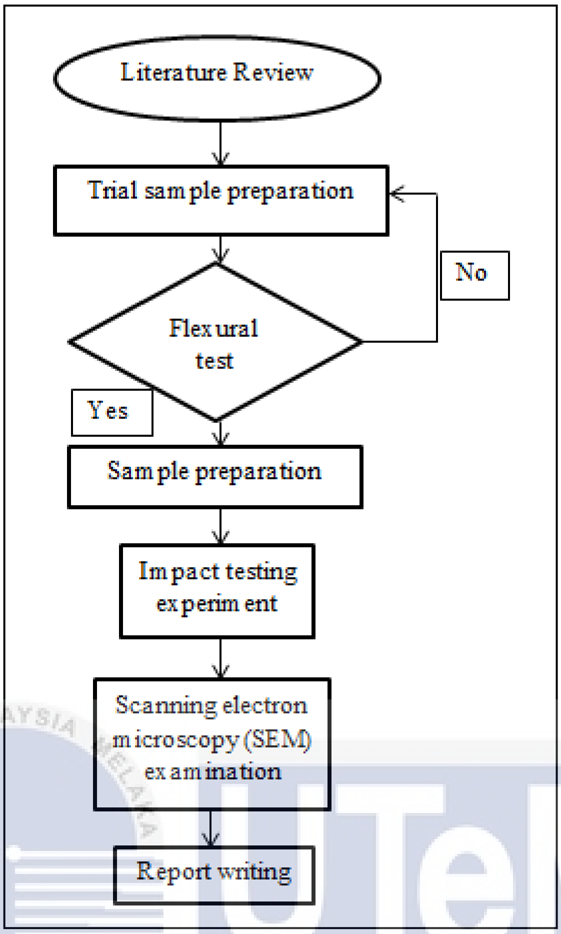

Figure 3.1 Flow charts

The second stage is the importance stage and required a lot of times to be completed. Sample preparation process required sub stage to be done. The first sub stage is to identify the suitable process for the hybrid composite natural fiber of kenaf with OPEFB reinforced HDPE. To obtain the best sample preparation, the suitable process is important things. The experimentation of sample preparation has been done to find suitable process. The flexural test is taken to prove the sample is good developed. OPEFB, kenaf, and HDPE material need to be prepared before mold the sample of hybrid OPEFB/kenaf reinforced HDPE composites. The sample is prepared with different of weight content of OPEFB for testing experiment by using compression molding process. Sample preparation will be conduct in polymer laboratory at Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka, UTeM.

The Impact test will be conduct in Fasa B at Faculty of Mechanical Engineering, UTeM. Izod impact test is select in this testing experiment. The toughness of sample composites is analyse by use impact energy to break the sample. The result data is record during testing experiment. After that, SEM is use to examine the morphological properties of failure surface of testing samples composite. Finally, all the study will be write on the reported.

Activity	**Semester 1 Session 2016-2017**														
	Week														
PSM 1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Project planning															
Chapter 1: Introduction															
Chapter 2: Literature Review															
Chapter 3: Methodology															
Chapter 4: Preliminary results															
Progress report submission															
Report submission															

Figure 3.2 Gantt chart PSM 1

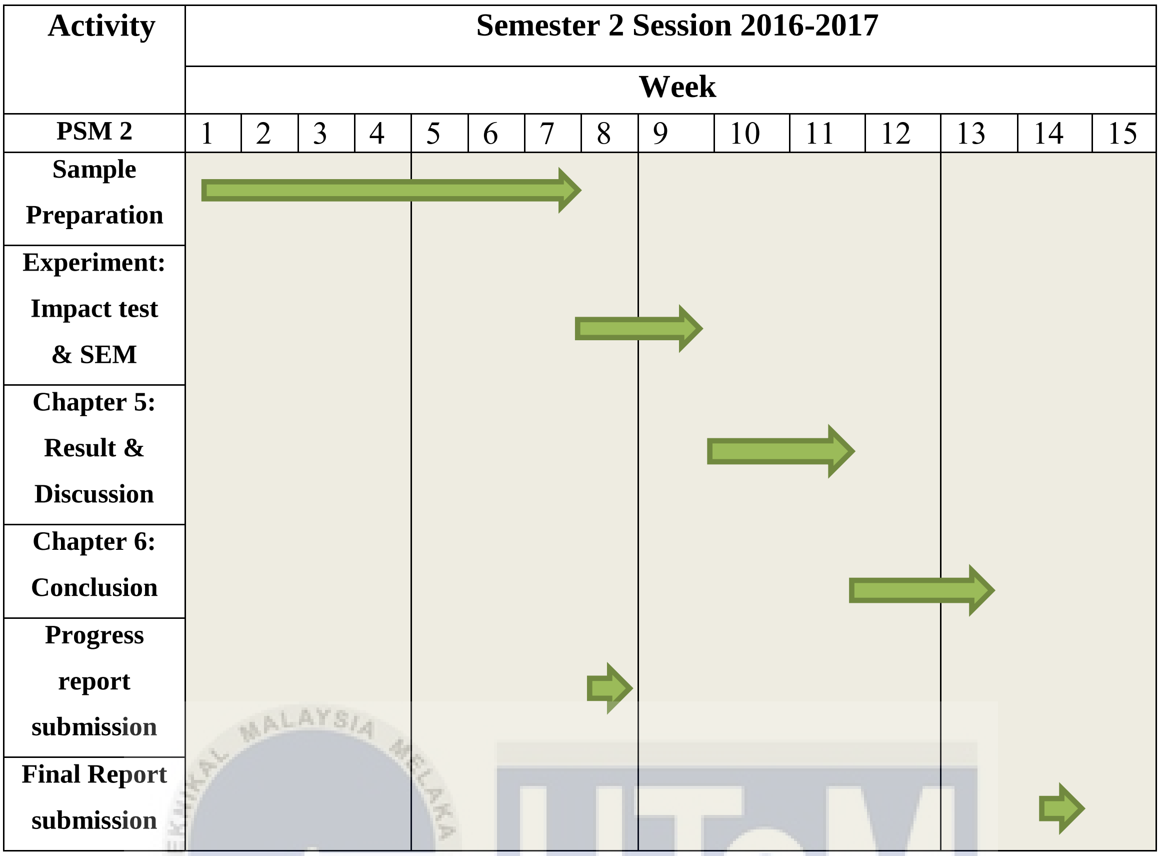

Figure 3.3 Gantt chart PSM 2

For PSM 1, the project will cover from background of study until preliminary results. The progress will expect taking 14 weeks to finished as planning. In other hands, PSM 2 will cover the sample preparation, experimentation and focus on final report writing. The expected time taken will need 14 weeks to finish. Overall project progress will refer to gantt chart in figure 3.2 and figure 3.3 to help progress run smoothly and manage.

3.3 Hydraulic hot molding

Compression molding process is used to make the layering of the fiber also HDPE. The machine can be operating until 100°C and above. Therefore, safety glove should be used to avoid any contact to human skin that can harm user.

Figure 3.4 Hydraulic hot molding machine

Standard of procedure:

i. For safety reason, safety glove is worn

ii. The machine and the water for cooling is switched on.

iii. The temperature is set required for compression

iv. The material is inserted into the molding. To avoid material stick to mold and difficult to removed, silicone removal use to sprayed the molding.

v. For compression molding process the molding is inserted into upper level. Then timer is set up.

vi. The molding will be put into lower level for cooling after compression is released, and timer is set up.

3.4 Crusher machine

Crusher machine is used to crush the OPEFB fiber and kenaf fiber to short fiber length. The short fiber length is needed in this project experimention.

Figure 3.5 Crusher machine

Standard of procedure:

i. For safety reason glove, mask, ear protection and glasses need to be worn.
ii. Make sure the machine is cleaned before used and switch on the machine.
iii. The material is inserted to be crush. Crushing slowly to avoided stuck during operation.

3.5 Sieving machine

Sieving machine is used for the proposed to identify the length of fiber. The length of fiber will give significant effect to the material. Therfore, to determined the length of fiber is important part of this samle preparation.

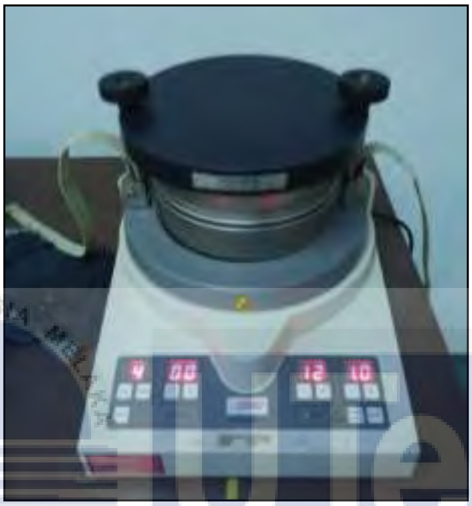

Figure 3.6 Sieving machine

Standard of procedure:

i. The machine is cleaned and then switched on.

ii. The size of sieving is selected for measured.

iii. The sieving is installed in the machine and the material is sieved.

iv. The timer and amplitude of vibration is setup. Then “START” button is pressed.

3.6 Speed rotor mill machine

Speed rotor mill machine is used for the proposed to crush the fiber for the very small size of fibers. Therefore, this machine is needed to crush the fibers for the sieving small size required.

Figure 3.7 Speed rotor mill machine

Standard of procedure:

i. Glove is worn

ii. The machine is clean, then switched on machine.

iii. The timer is setup

iv. The material is inserted to be crush. The material is inserted slowly to avoid machine jammed.

3.7 Material

In material preparation, OPEFB, kenaf fiber, and HDPE need to be prepared as the main ingredient in hybrid composites natural fiber. OPEFB is obtaining from Sime Darby Plantation Merlimau, Melaka. For kenaf fiber is obtain from Lembaga Kenaf dan Tembakau Melaka. The HDPE is get from Etilinas.

Figure 3.8 Kenaf fiber

Figure 3.9 OPEFB

In this project, kenaf fiber and OPEFB is selected and to investigated the impact properties. For the sample preparation, the content is been varying as table below:

Table 3.1 Fiber content in hybrid composite material

Natural fiber (%)		Matrix (%)
Kenaf	OPEFB	HDPE
40	0	60
30	10	60
20	20	60
10	30	60
0	40	60

The previous study as proved that the content of fiber is playing important role to developed the best properties of hybrid composites material. Therefore, the aim of this project to investigated the impact properties of varying the content of fibers.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Sample preparation

Samples are must be in good condition in order to be able to conduct impact test. However, some trial experiment is run in order to obtain the best sample. Three different methods will be done to find out which method will provide a best sample. The layering sequence is arranged as figure below.

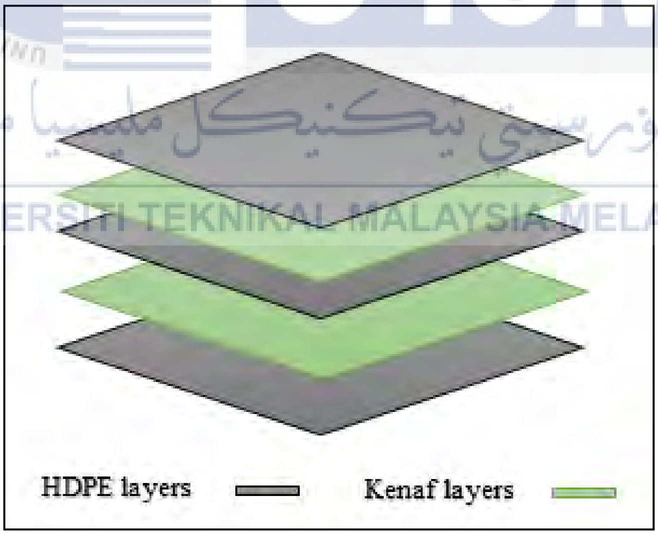

Figure 4.1 Layering sequence

Three layers of HDPE and two layers of kenaf fiber were prepared after crushing the kenaf by using the crusher machine. However, all layers were prepared by using hydraulic hot molding machine. In addition, steel mold of dimensions 200mm×200mm and with 3mm thickness was used. Layers have different value of weight as shown in the table

Table 4.1 Content of fiber

	HDPE	Kenaf	Total
Weight (%)	60%	40%	100
Weight (g)	180g	120g	300

For all three experiment trial are used the same content of fiber to determine the best sample preparation with suitable process. The different method of sample preparation will give different outcome of samples. Then the sample will be undergoes the flexural test to investigate the performance of each sample trial.

4.1.1 First trail of sample preparation

A 60g of HDPE was prepared and placed into the steel mold after polished and applied a mold-releasing agent which is silicone removal on the both surface upper and lower. After that, compressing force was applied for 5 minutes after the lower and upper with temperature heated is 140°C and the pressure adjusted to 20 ton. Then, steel mold was removed from the compressing force place to the cooling place and cooling was applied for two minutes.

After, cooling and taking the layer out from the steel mold, the HDPE is not melt fully. Therefore, time of the compressing force is increase to 8 minutes in order to make the HDPE melt more and fully fill the empty space in the steel mold. The same steps were done with increasing the time of compressing force to 8 minutes to make the others two layers of HDPE.

Two layers of 60g of kenaf fiber for each layer was prepared and placed into the steel mold after polished and applied a mold-releasing agent on the both surface upper and lower. Then, compressing force was applied for two minutes only to make sure that the kenaf fiber is not burn, while the lower and upper temperature heated to 140°C and the pressure adjusted to 20 ton as well. After that, steel mold was removed and transferred to apply the cooling for two minutes.

After making three layers of HDPE and two layers of kenaf fiber, the layering is arranged as shown in the figure 4.1. After arranging the layers sequence, materials were placed into the hydraulic hot molding machine to touch the surface of the layers for 15 minutes with zero pressure while the lower and upper temperature remains at 140°C. Then, 20 ton compression force was applied for another 15 minutes to the materials. The sample was removed and transferred to apply the cooling for 5 minutes. After cooling the sample is found the difficulty to remove from mold due to melting the HDPE. Therefore, the mold will be not used to for the second and third trial to avoid same situation happened.

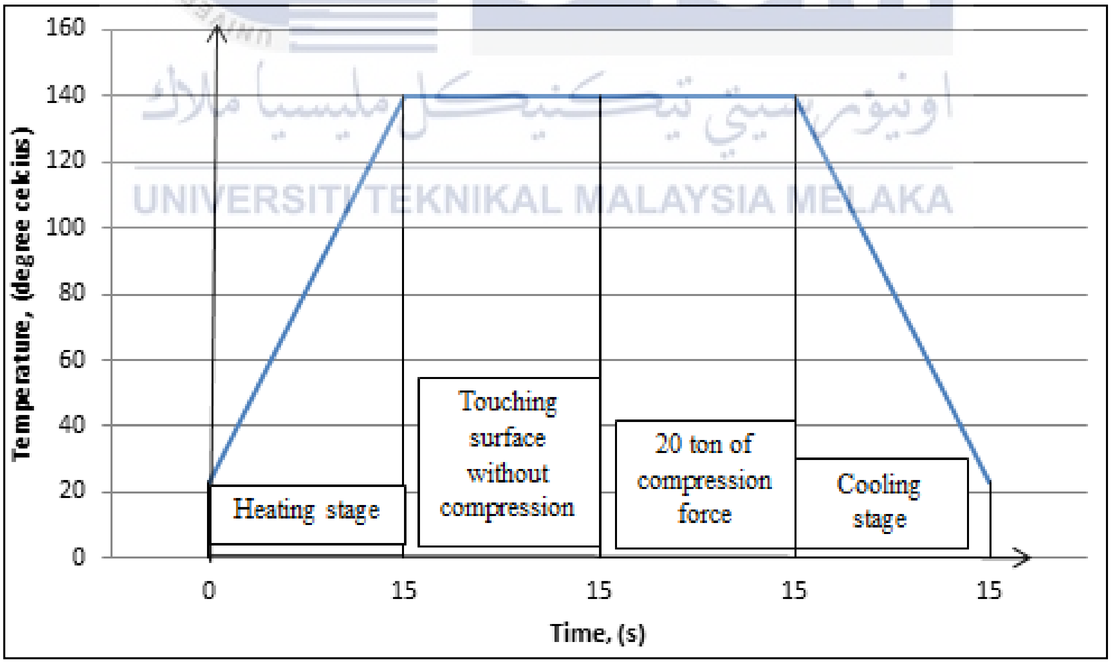

Figure 4.2 Trial 1 compression process

4.1.2 Second trial of sample preparation

The method of process to produce each layer is same as in trial 1. In trial 2 is focus on the length of fibers. The length of fibers used is below 2mm. Sieve checker machine is used to measure the length of kenaf fibers. The process to develop hybrid composite will conduct at temperature 140°C. In first 15 minutes the layering material will only touch the surface without compression. After that, the material will be compress into 10 ton for 15 minutes. Then, for final compression will be compress 20 ton pressure for other 15 minutes. Finally, the material will be cool down.

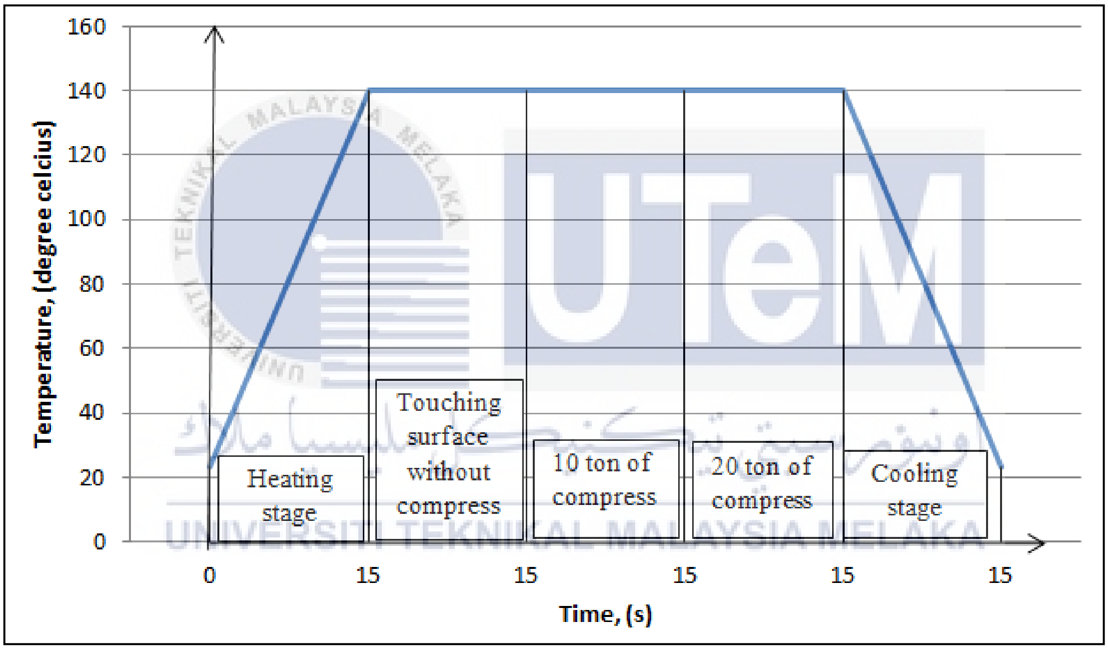

Figure 4.3 Trial 2 compression process

4.1.3 Third trial of sample preparation

The method for third trial is same as the trial 2. But for the trial three will be investigate on the change of length of fibers. The length of fibers is sieve into the range of 1 mm to 5 mm long. The same process is run to produce the hybrid composite material for testing.

4.1.4 Results of samples layering sequence preparation

In discussion will be discussing about of preliminary result. From the three experiment trial of sample preparation result obtain good sample preparation at the beginning. From the observation, trial 2 sample is the better performance from trial 3 and trial 2. The sample of trial 1 is noticed the air is entering into the sample. Therefore, the sample can be observe are bloated because of air.

Figure 4.4 Sample trial preparation

The sample is cut into standard ASTM flexural D770 with the size 12.7 mm x 127 mm x 3 mm dimension by using cutting machine. After the sample is cut into dimension requirement, the sample is identifying as fail. The inner of material is not adhesion well between HDPE and kenaf fibers.

Figure 4.5 Cutting sample

Based on Figure 4.5, it can be observed that the layering of fiber were not adhesion well. Delamination failure happened for the the samples prepared due to low adhesion between the matrix and the fibers. The HDPE is not fully filled the layering fiber to have strong bond. Maybe the content of fiber is high that resist the HDPE to fill the fiber in the center of layering fiber.

In conclusion, the trial sample is failed to achieve good sample material maybe because of unsuitable of fiber content. The content of fiber for 40% maybe is too much for adhesion between fiber and HDPE. Therefore, the content of fiber should be reducing to get the good sample outcome. In addition, there are two methods that can be used to solve this problem. The first method is by using compounding process to mix the matrix and the fibers before hot compression molding process. The second method is by using coupling agent such as MAPE to increase the adhesion performance between the fibers and the matrix. Natural fibers are hydrophilic in nature, while HDPE is hydrophobic in nature. Thus, adding coupling agent will create stronger bond between the two materials or using compounding method process such as internal mixing process to developed new sample.

4.2 Compounding sample preparation

The hybrid material sample of OPEFB, kenaf and HDPE is prepared with 5 different compositions. Each composition has different content of weight percentage of OPEFB. Therefore, 5 sample need to be prepared with varying the weight content of OPEFB proposed to test in impact testing and study the performance of impact properties of materials.

Table 4.2 weight content percentage of HDPE and fiber

	HDPE (wt%)	Kenaf (wt%)	OPEFB (wt%)	OPEFB ratio percentage %
Sample 1	60	0	40	100%
Sample 2	60	10	30	75%
Sample 3	60	20	20	50%
Sample 4	60	30	10	25%
Sample 5	60	40	0	0%

Table 4.3 Mass of HDPE and fiber in sample

	HDPE (g)	Kenaf (g)	OPEFB (g)	OPEFB ratio percentage %
Sample 1	30	0	20	100%
Sample 2	30	5	15	75%
Sample 3	30	10	10	50%
Sample 4	30	15	5	25%
Sample 5	30	20	0	0%

4.2.1 Internal Mixer Process

Table 4.4 Summary of mixing process

Author	Year	NF/Polymer	Parameter		
			T (°C)	Time, (min)	Speed, (rpm)
(Wu et al., 2014)	2014	Basalt/HDPE	160-182	-	50
(Liu et al., 2009)	2009	Jute/PBS	120	15	80
(Akhtar et al., 2016)	2016	Kenaf/PP	180	25	35
(Ou et al., 2010)	2010	Kevlar/WPC (HDPE)	150	8	40(twin) 20(single)
(Taib et al., 2014)	2014	Kenaf/PLA	190	15	50

Mixer process is taken 10 minutes for overall processing mixing sample. The process temperature restricted at low temperature 200°C to avoid thermal degradation of natural fiber. Therefore, the temperature of process is setup at 160°C that less than 200°C in this process. The speed of rotation is setting at constant speed 50 rev/s for overall process method. In the beginning of process, HDPE is inserted to let it melt for first 3 minutes. Then the kenaf fiber and OPEFB will insert after 3 minutes of process is passed.

Figure 4.6 Internal Mixer Machine

Figure 4.7 Sample after mixing process

4.2.2 Hot compression process

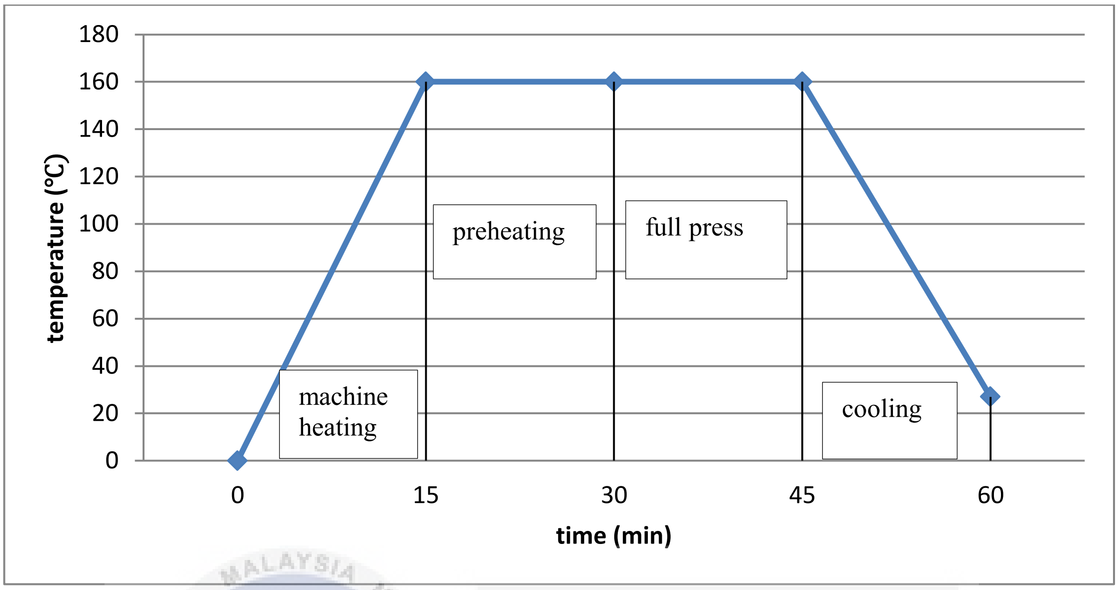

Figure 4.8 Hot press process

The hot press machine is opened and start to heat up to 160°C for 15 minutes times taking. The sample is insert in the mold and let the preheat process taking for 15 minutes. After that, the sample is been heat press at 20 ton which is 9.8 MPa. The pressing process is taking 15 minutes before enter the cooling process for another 15 minutes to complete one full sample preparation.

Figure 4.9 Hot compression molding machine

Figure 4.10 Sample after complete hot press process

4.2.3 Overall compounding process

OPEFB, kenaf and HDPE is mix together by using internal mixer. There are 5 different type of OPEFB composition which is 0, 10, 20, 30 and 40 wt % hybrid composite with kenaf fiber. Melt-mixing was performed at 160℃ for 10 minutes at rotor speed of 50 rpm. Composition of OPEFB is prepared by (200 x 100 x 3.2) mm mold plate using Hydraulic Hot Molding Machine. The hot compression molding machine is operated at 160℃. The material was first preheated for 15 minutes. Then, the material will compress under pressure of 9.8MPa for another 15 minutes. After that, the compressed material is cooled in compress by circulate tap water of machine. Test samples are refer to standard ASTM D256 for Izod impact testing. The samples are cut by using Vertical Band Saw Machine into dimension (64 x 12.7 x 3.2) mm.

Figure 4.11 Sample 100% OPEFB

Figure 4.12 Sample 75% OPEFB

Figure 4.13 Sample 50% OPEFB

Figure 4.14 Sample 25% OPEFB

Figure 4.15 Sample 0% OPEFB

4.2.4 Cutting process

Figure 4.16 Vertical Band Saw Machine

Figure 4.17 Cutting Process Activity

The each sample composition is cut into 10 specimens according to standard Izod Impact test samples size ASTM D 256 which is (64 x 12.7 x 3.2) mm by using Vertical Band Saw Machine in Faculty of Manufacturing, UTeM. The sample need to be mark before cutting to make sure the sample is cut with correct dimension.

4.3 Izod Impact Test 1 in FKP Laboratory

Every sample parameter is measured by using vernier caliper and recorded. The size of sample must have the tolerance limit close to size samples according ASTM D 256 which is (64 x 12.7 x 3.2) mm

Table 4.5 Sample 1 parameter for 100% OPEFB content

unit cm	L1	L2	L3	C1	C2	C3	C4	R1	R2	R3
Length	6.70	6.79	6.79	6.79	6.80	6.80	6.80	6.80	6.80	6.80
Thick	0.33	0.31	0.32	0.32	0.33	0.34	0.32	0.33	0.33	0.33
Width	1.46	1.32	1.46	1.34	1.43	1.44	1.42	1.40	1.46	1.30

Table 4.6 Sample 2 parameter for 75% OPEFB content

unit cm	L1	L2	L3	C1	C2	C3	C4	R1	R2	R3
Length	6.70	6.70	6.66	6.66	6.66	6.70	6.70	6.66	6.66	6.66
Thick	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
Width	1.40	1.45	1.33	1.45	1.44	1.30	1.46	1.46	1.30	1.30

Table 4.7 Sample 3 parameter for 50% OPEFB content

unit cm	L1	L2	L3	C1	C2	C3	C4	R1	R2	R3
Length	6.50	6.56	6.56	6.55	6.54	6.55	6.56	6.56	6.56	6.60
Thick	0.33	0.34	0.33	0.34	0.34	0.34	0.34	0.34	0.34	0.34
Width	1.44	1.35	1.40	1.39	1.40	1.40	1.37	1.48	1.34	1.35

Table 4.8 Sample 4 parameter for 25% OPEFB content

unit cm	L1	L2	L3	C1	C2	C3	C4	R1	R2	R3
Length	6.53	6.56	6.55	6.55	6.56	6.58	6.60	6.63	6.63	6.61
Thick	0.34	0.34	0.34	0.36	0.35	0.35	0.35	0.35	0.36	0.36
Width	1.47	1.40	1.40	1.40	1.41	1.34	1.38	1.37	1.40	1.47

Table 4.9 Sample 5 parameter for 0% OPEFB content

unit cm	L1	L2	L3	C1	C2	C3	C4	R1	R2	R3
Length	6.80	6.82	6.82	6.80	6.80	6.81	6.82	6.82	6.82	6.81
Thick	0.31	0.31	0.31	0.31	0.32	0.32	0.32	0.34	0.34	0.34
Width	1.50	1.40	1.46	1.44	1.27	1.48	1.41	1.43	1.37	1.26

Impact testing is running in Faculty of Manufacturing (FKP) of UTeM laboratory. First Izod impact test is run by using first batch sample. Based on standard ASTM D256, average testing result at least needed 5 repetitions for each test to get precise data. For the test in FKP, each sample composition is tested with 10 repetitions to obtain accurate data. The impact tester machines need to be test without sample for a few times to know the accuracy of this machine can give a good data. Each free impact is read to identify the error of machine give. The tolerance limit of the impact tester is analyzed and the testing is begins.

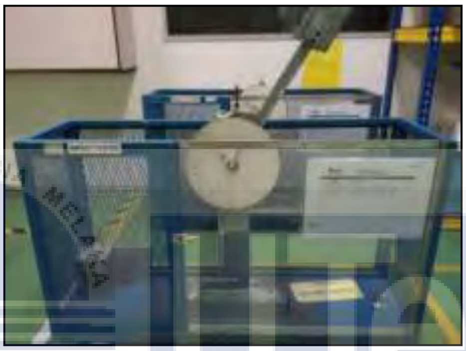

Figure 4.18 Impact Tester Machine

Table 4.10 Izod Impact testing 1 result in FKP Laboratory

unit J/m	L1	L2	L3	C1	C2	C3	C4	R1	R2	R3	Ave.
100% OPEFB	2.00	1.00	1.25	1.00	1.50	0.50	1.50	1.00	1.25	1.25	1.225
75% OPEFB	2.00	2.00	2.00	2.25	2.00	1.75	1.75	2.25	2.25	1.75	2.000
50% OPEFB	2.00	2.00	2.00	2.50	2.00	2.25	2.00	2.50	2.50	2.25	2.200
25% OPEFB	2.50	2.50	2.50	3.00	2.50	2.00	2.25	2.00	2.50	1.75	2.350
0% OPEFB	1.75	1.50	1.25	2.25	1.75	2.00	2.25	2.00	2.00	2.00	1.875

From the results data, scatter graph is plotted to minimize the error and accuracy in reading. 5 samples are eliminated from the scatter graph. The best 5 samples results are selected and the average reading data is calculated. Then the bar graph is plotted to determine the best performance of sample compositions after testing.

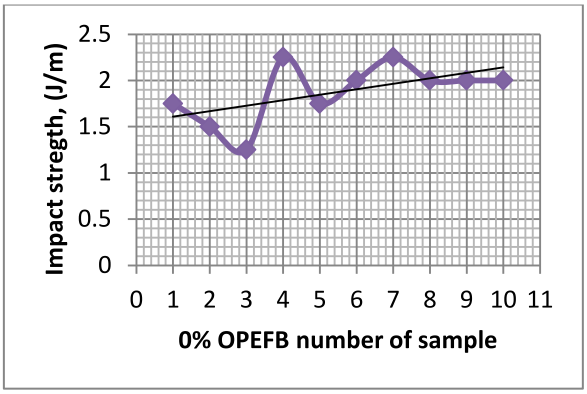

Figure 4.19 Scatter graph for 0% of OPEFB test 1

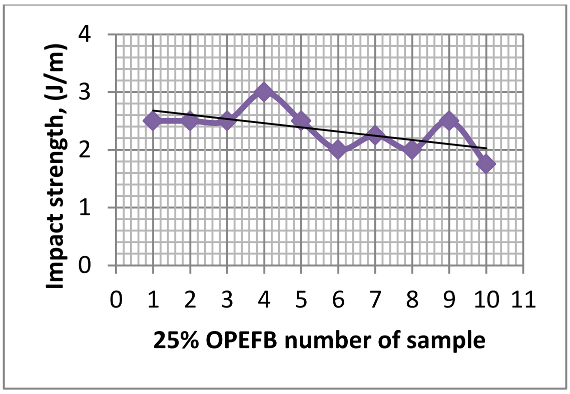

Figure 4.20 Scatter graph for 25% of OPEFB test 1

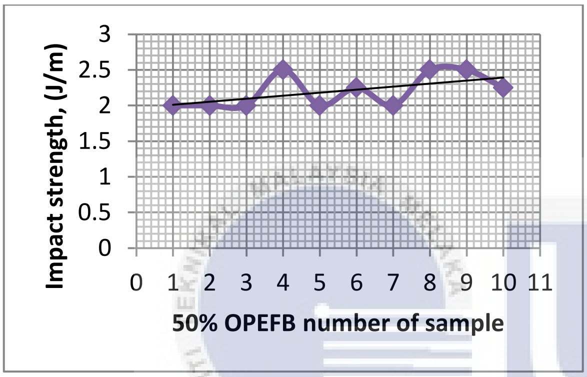

Figure 4.21 Scatter graph for 50% of OPEFB test 1

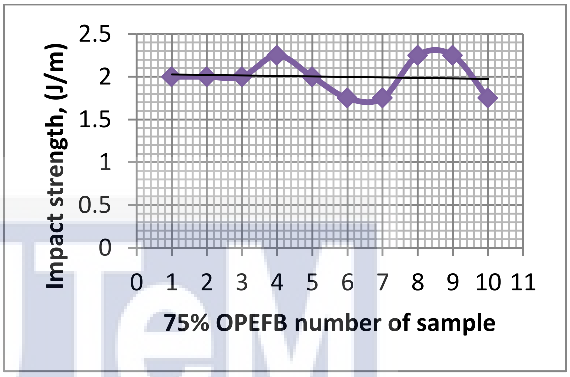

Figure 4.22 Scatter graph for 75% of OPEFB test 1

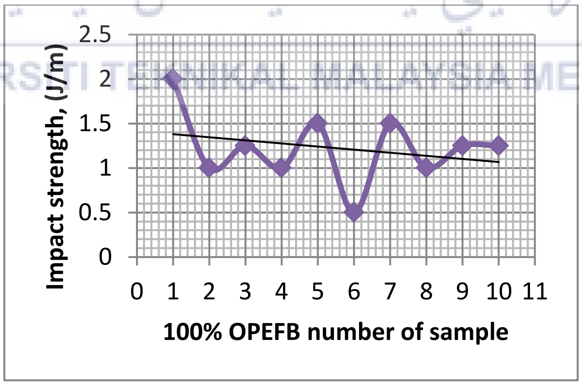

Figure 4.23 Scatter graph for 100% of OPEFB test 1

Table 4.11 Izod Impact Test 1 Average Minimization

OPEFB percentage (%)	Average, (J/m)
0% OPEFB	1.95
25% OPEFB	2.45
50% OPEFB	2.10
75% OPEFB	1.95
100% OPEFB	1.25

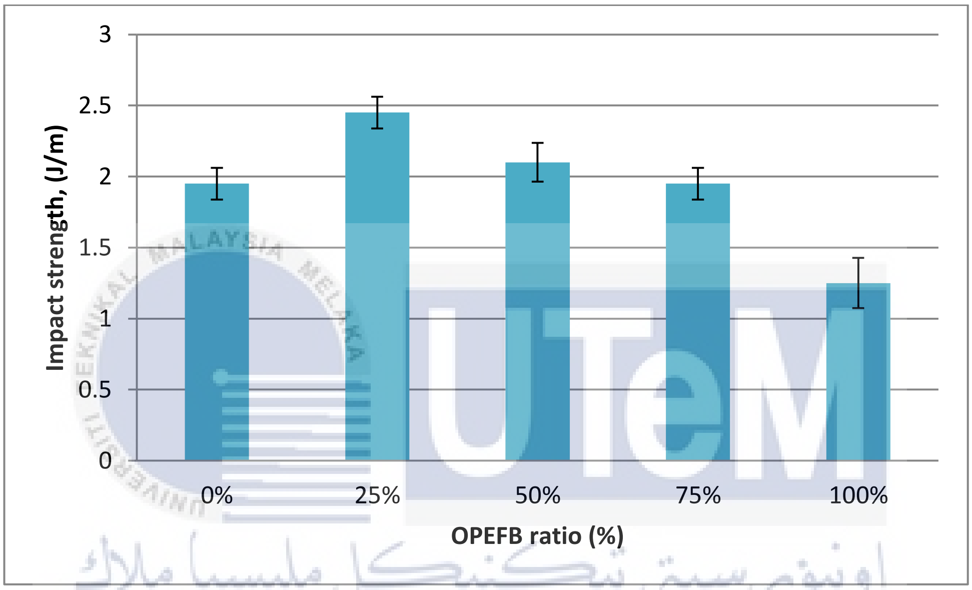

Figure 4.24 Izod Impact test 1 trend result

The graph shows the result of izod impact test in FKP laboratory. Kenaf fiber has high impact strength than OPEFB. Based on (Jawaid et al., 2010), pure OPEFB give high impact strength which is 92.7 J/m because of ductility characteristic greater than pure Jute that show in result is 32.0 J/m only. The result of impact test of OPEFB is different than expected result but the result show in graph above is unexpected resulted. Suspected the parameter may affect the test results based on (ASTM International, 2010) are its affected by fabrication method process or molding conditions and design, thermal treatments not suitable, and environment conditioning not suitable. Referring result test in FKP laboratory, 25% ratio percentage of OPEFB content give best impact strength which is 2.35 J/m.

Based on (Razak & Kalam, 2012), the formulation they used to make composites material with 78 (wt%) PPnanoclay/PP and OPEFB powder is added to 20 (wt%) of OPEFB with treatment 2 (wt%) of Maleic anhydride grafted polypropylene (MAPP). The study is on four different sizes of fibers in notch and un-notch impact testing conditions. The un-notch results give no change in impact strength however the notch condition impact strength is increase when the size of fiber is increase. Therefore, the size of fiber it can include in the parameter that can affect the results of impact strength.

(Yahaya et al., 2015) also state that the layering sequence method is affected the impact strength of composites material. The results show that the impact strength is increase by increasing the layering from three layers to for layer method. The impact strength of fuor layer woven kenaf hybrid with kevlar reinforced epoxy show the highest impact energy 4.00J in the study compared to three layers which 3.50J impact energy.

In another study of hand lay-up technique method show that the impact strength of kenaf fiber reinforced with epoxy is increased by adding 8% of nano OPEFB filler in the composites material. The impact strength is increase to 28.3% by adding 8% nano OPEFB filler (Saba et al., 2016). This study shows the hybrid composites material is contributes in improvement of mechanical properties. Therefore, by adding 10% (wt%) of OPEFB in hybrid composites OPEFB/kenaf/HDPE can obtained higher impact strength which is 2.45J/m.

4.3.1 Visual Observation on Specimen after Impact Testing 1

Figure 4.25 Sample 100% OPEFB test 1

Figure 4.26 Sample 75% OPEFB test 1

Figure 4.27 Sampke 50% OPEFB test 1

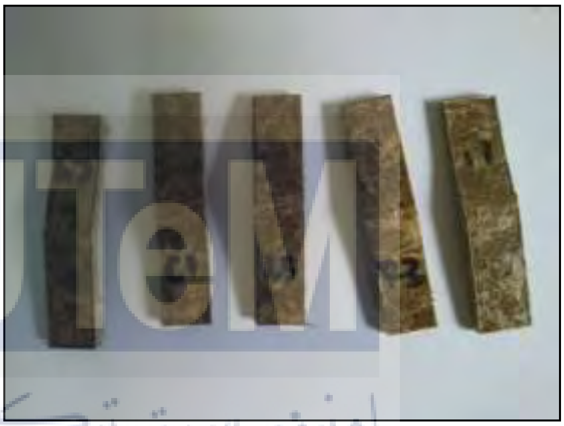

Figure 4.28 Sample 25% OPEFB test 1

Figure 4.29 Sample 0% OPEFB test 1

Based on visualize observation on specimen after Izod impact test at FKP laboratory shown that the all the 10 specimen of pure OPEFB is not breakable sample. This is proved that the OPEFB is the ductile category. Then, the result of ratio 100% kenaf content shows that the entire 10 specimen is complete breakable. This is completely proved that the pure kenaf is brittle category. For ratio 75% content of OPEFB show only 4 specimens still partial break and the other 6 specimen is completely break into two parts. Furthermore, for 50% ratio of OPEFB content has 5 specimen partial breaks as figure above shown. Lastly, the 25% ratio of OPEFB content is observed after testing has 5 samples is completely broken. The other 5 sample just hinge break occur.

4.4 Izod Impact Test 2 in FKP Laboratory

Table 4.12 Sample parameter 1 Izod Impact Test 2 for 100% OPEFB

Unit cm	7	8	9	10	11	12
Thick	0.34	0.34	0.35	0.35	0.34	0.34
Length	6.42	6.43	6.43	6.44	6.43	6.45
Width	1.24	1.25	1.20	1.20	1.25	1.20

Table 4.13 Sample parameter 2 Izod Impact Test 2 for 75% OPEFB

Unit cm	7	8	9	10	11	12
Thick	0.33	0.34	0.34	0.34	0.35	0.35
Length	6.41	6.46	6.44	6.44	6.44	6.44
Width	1.22	1.22	1.27	1.26	1.25	1.25

Table 4.14 Sample parameter 3 Izod Impact Test 2 for 50% OPEFB

Unit cm	7	8	9	10	11	12
Thick	0.34	0.33	0.33	0.33	0.33	0.33
Length	6.43	6.40	6.37	6.43	6.40	6.40
Width	1.30	1.32	1.32	1.26	1.24	1.30

Table 4.15 Sample parameter 4 Izod Impact Test 2 for 25% OPEFB

Unit cm	7	8	9	10	11	12
Thick	0.34	0.34	0.34	0.34	0.34	0.34
Length	6.50	6.51	6.54	6.50	6.51	6.51
Width	1.27	1.22	1.14	1.20	1.26	1.22

Table 4.16 Sample parameter 5 Izod Impact Test 2 for 0% OPEFB

Unit cm	7	8	9	10	11	12
Thick	0.33	0.34	0.34	0.34	0.34	0.34
Length	6.50	6.50	6.47	6.47	6.47	6.47
Width	1.14	1.15	1.29	1.24	1.25	1.27

Table 4.17 Izod Impact testing 2 result in FKP Laboratory

Unit J/m	7	8	9	10	11	12	Ave.
100% OPEFB	1.50	1.50	1.75	2.00	1.50	2.00	1.710
75% OPEFB	1.50	1.75	1.75	1.75	2.00	1.00	1.625
50% OPEFB	2.00	2.00	2.00	2.00	2.00	2.50	2.080
25% OPEFB	2.25	2.00	2.00	1.75	2.00	2.00	2.000
0% OPEFB	1.50	2.00	2.25	1.75	1.50	2.00	1.830

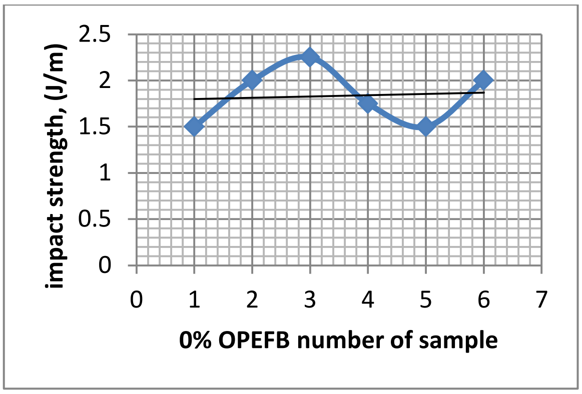

Figure 4.30 Scatter graph for 0% of OPEFB test 2

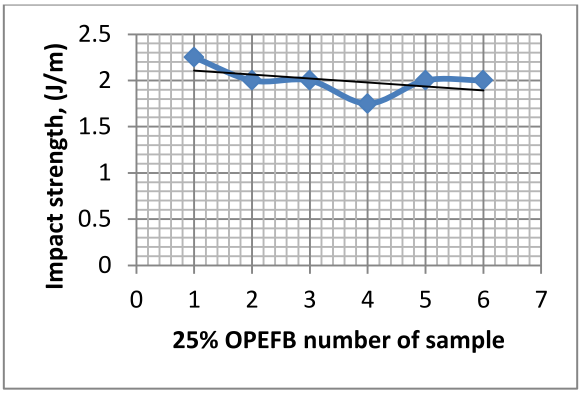

Figure 4.31 Scatter graph for 25% of OPEFB test 2

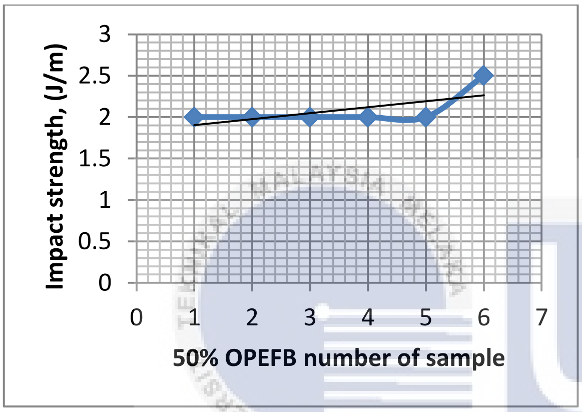

Figure 4.32 Scatter graph for 50% of OPEFB test 2

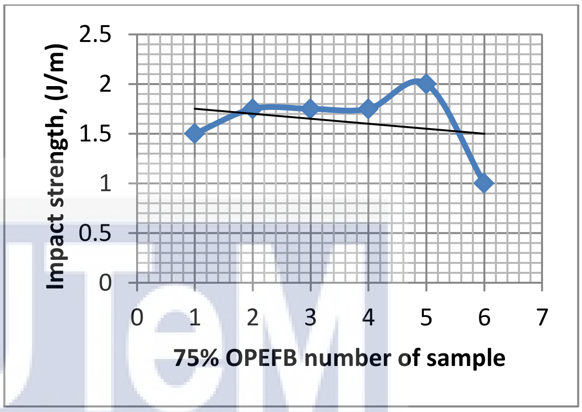

Figure 4.33 Scatter graph for 75% of OPEFB test 2

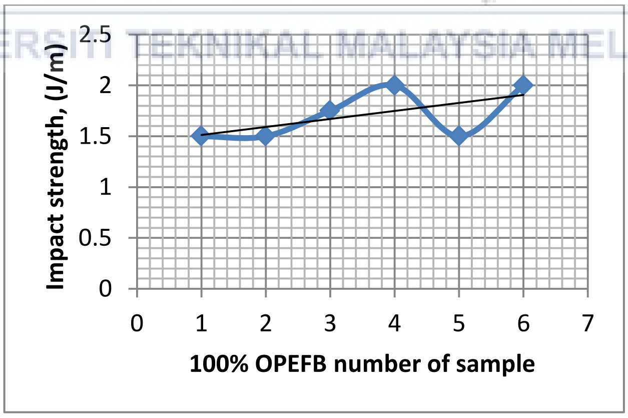

Figure 4.34 Scatter graph for 100% of OPEFB test 2

Table 4.18 Izod Impact Test 2 Average Minimization

OPEFB percentage (%)	Average, (J/m)
0% OPEFB	1.75
25% OPEFB	2.05
50% OPEFB	2.00
75% OPEFB	1.75
100% OPEFB	1.70

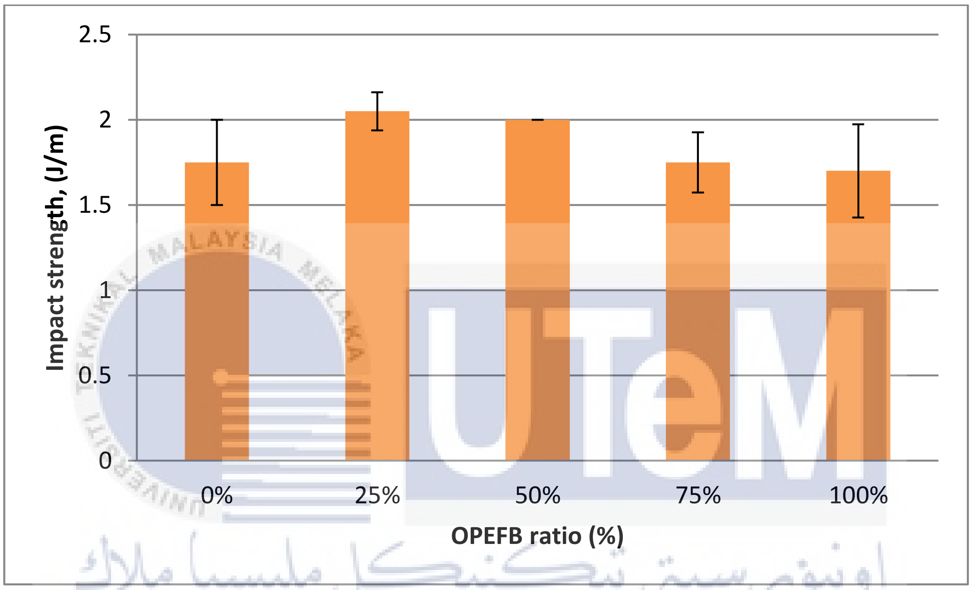

Figure 4.35 Izod Impact Test 2 trend results

4.4.1 Visual Observation on Specimen after Impact Testing 2

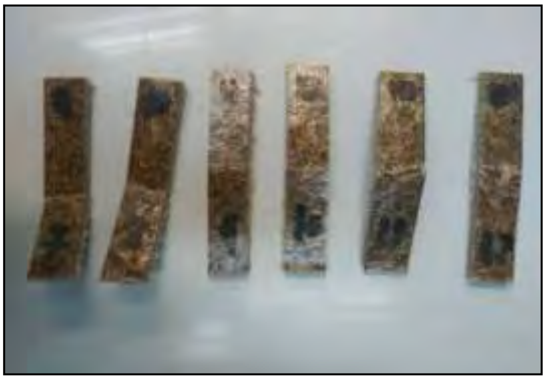

Figure 4.36 Sample 100% OPEFB content for test 2

Figure 4.37 Sample 75% OPEFB content for test 2

Figure 4.38 Sample 50% OPEFB content for test 2

Figure 4.39 Sample 25% OPEFB content for test 2

Figure 4.40 Sample 0% OPEFB content for test 2

4.5 Izod Impact test 1 and 2 Analysis

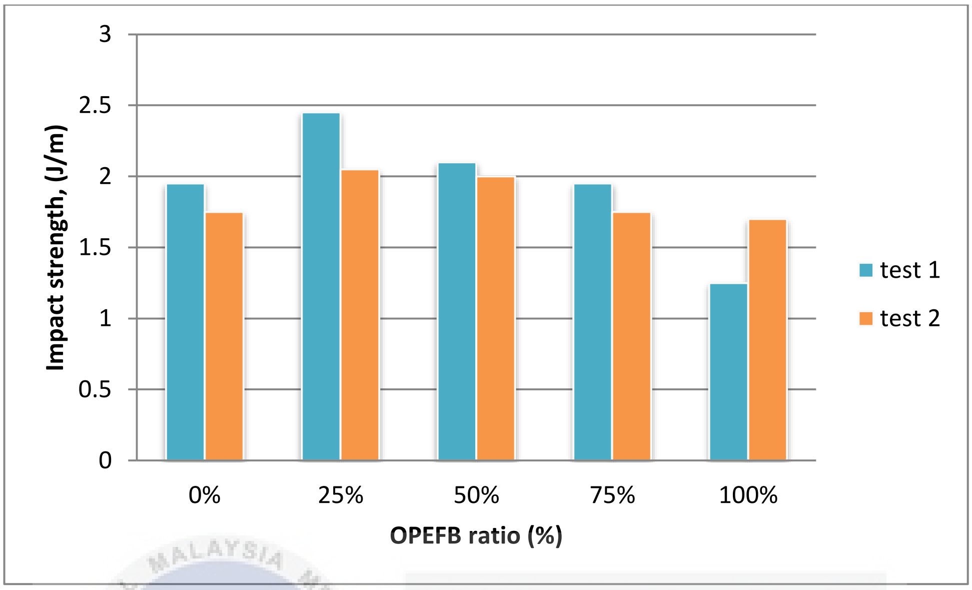

Figure 4.41 Impact test batch 1 versus Impact test batch 2 trend

Test 1 represented the Izod impact test of batch 1 sample and test 2 is the second batch sample preparation. The test is conducted in same placed at FKP laboratory. The graph above shows the results for both tests in FKP laboratory. The trend of the graph given the both test have same trend in results. 10% weight percentage of OPEFB is given the higher impact strength properties which are 2.45 J/m for batch 1 sample and 2.05 J/m for batch 2 samples. The 40% weight percentage OPEFB added in sample are given the lower impact strength. From the test observation, sample from batch 1 are given the higher impact strength data and also 40% (wt%) of OPEFB ratio is lower 1.25 J/m compare to batch 2 sample which is 1.70 J/m.

4.6 Izod Impact Test Water Absorbtion in FKP

Table 4.19 Sample parameter 1 Izod Impact Test Water Absorbtion for 100% OPEFB

Unit cm	1	2	3	4	5	6
Thick	0.34	0.34	0.35	0.36	0.35	0.35
Length	6.30	6.35	6.30	6.34	6.30	6.40
Width	1.27	1.24	1.29	1.28	1.25	1.26

Table 4.20 Sample parameter 2 Izod Impact Test Water Absorption for 75% OPEFB

Unit cm	1	2	3	4	5	6
Thick	0.34	0.34	0.34	0.34	0.32	0.32
Length	6.38	6.38	6.40	6.40	6.40	6.46
Width	1.30	1.34	1.20	1.16	1.27	1.25

Table 4.21 Sample parameter 3 Izod Impact Test Water Absorbtion for 50% OPEFB

Unit cm	1	2	3	4	5	6
Thick	0.34	0.34	0.34	0.34	0.33	0.33
Length	6.37	6.38	6.38	6.39	6.45	6.44
Width	1.27	1.27	1.26	1.17	1.20	1.29

Table 4.22 Sample parameter 4 Izod Impact Test Water Absorption for 25% OPEFB

Unit cm	1	2	3	4	5	6
Thick	0.34	0.34	0.35	0.35	0.33	0.32
Length	6.54	6.54	6.54	6.55	6.55	6.55
Width	1.45	1.14	1.30	1.24	1.12	1.22

Table 4.23 Sample parameter 5 Izod Impact Test Water Absorption for 0% OPEFB

Unit cm	1	2	3	4	5	6
Thick	0.32	0.33	0.34	0.31	0.34	0.34
Length	6.57	6.51	6.54	6.54	6.51	6.52
Width	1.22	1.15	1.28	1.28	1.10	1.23

Figure 4.42 Water Absorption process

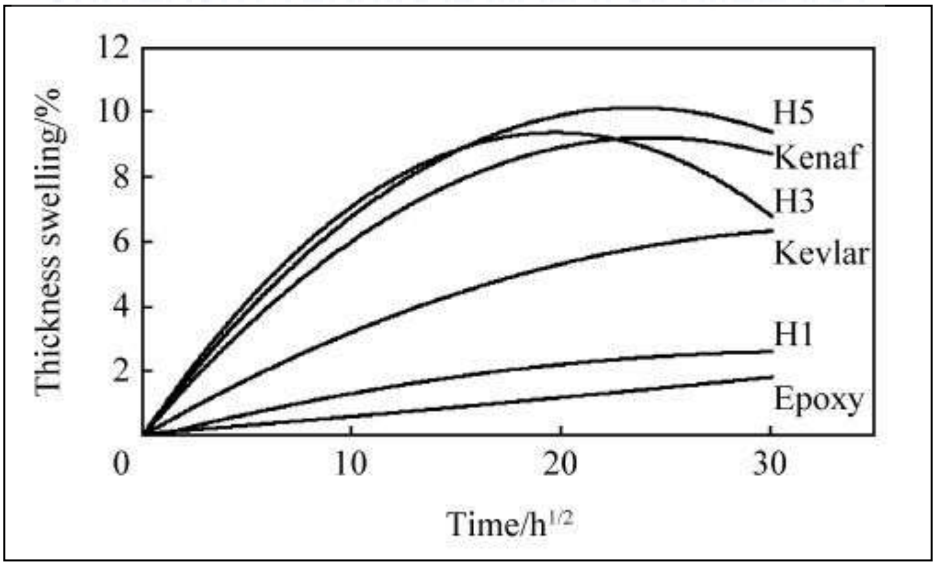

Figure 4.43 thickness swelling of hybrid composites (Yahaya et al, 2015)

Based on the thickness swelling test by (Yahaya et al, 2015) kenaf fiber give the highest rate percentage thickness swelling 8.5% after water absoption test is run in $30h^{\frac{1}{2}}$. The peak of thickness swelling can be read from the graph which is 9% at $26.4h^{\frac{1}{2}}$. Prediction is make that natural fiber has its peak to absorp the water until 29 days. Therefore water absorption process is taking 29 days of duration. The samples are put in the 200 ml beaker with labeling each beaker depends on sample OPEFB varying weight. Furthermore, 200 ml of distilled water is filled into beaker and the samples are soaked in the beaker for 29 days. The weight of each samples are recorded before samples is soak into water and after the days the samples is taking out from beaker.

Table 4.24 Mass of specimen before water absorption day 1

Unit (g)	1	2	3	4	5	6
100% OPEFB	2.7	2.6	2.8	2.5	2.5	2.8
75% OPEFB	2.7	2.6	2.6	2.4	2.6	2.6
50% OPEFB	2.7	2.7	2.5	2.5	2.6	2.9
25% OPEFB	3.2	2.6	2.8	2.8	2.5	2.6
0% OPEFB	2.7	2.5	2.8	2.7	2.4	2.7

Table 4.25 Mass of specimen before water absorption day 29

Unit (g)	1	2	3	4	5	6
100% OPEFB	3.05	2.97	3.12	3.11	2.80	3.09
75% OPEFB	3.10	2.99	2.94	2.68	2.96	2.81
50% OPEFB	2.91	3.00	2.59	2.73	2.80	3.16
25% OPEFB	3.47	2.79	3.11	3.04	2.70	2.88
0% OPEFB	2.85	2.64	3.00	2.89	2.55	2.88

Table 4.26 Izod Impact Test Water Absorption in FKP

Unit J/m	1	2	3	4	5	6	Ave.
100% OPEFB	2.00	1.75	1.75	2.25	1.50	2.00	1.875
75% OPEFB	1.75	1.50	2.00	2.00	2.25	2.00	1.917
50% OPEFB	2.50	2.25	2.25	1.75	2.25	2.00	2.170
25% OPEFB	2.25	2.00	2.75	2.5	2.25	2.50	2.375
0% OPEFB	2.25	2.00	2.00	2.00	2.25	2.25	2.125

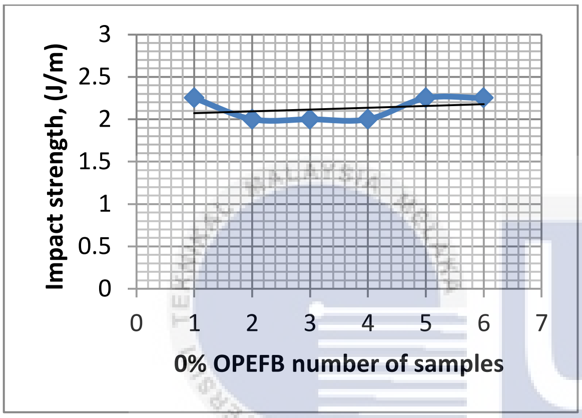

Figure 4.44 Scatter graph for 0% of OPEFB test 3

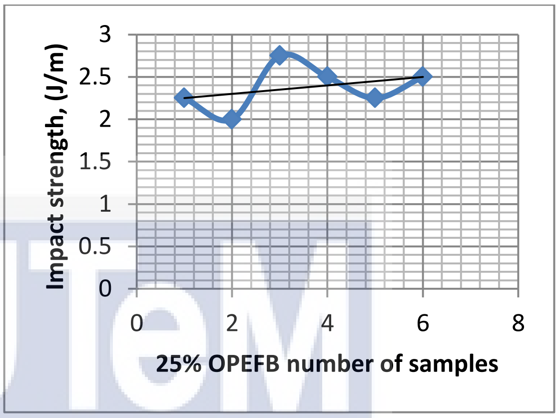

Figure 4.45 Scatter graph for 25% of OPEFB test 3

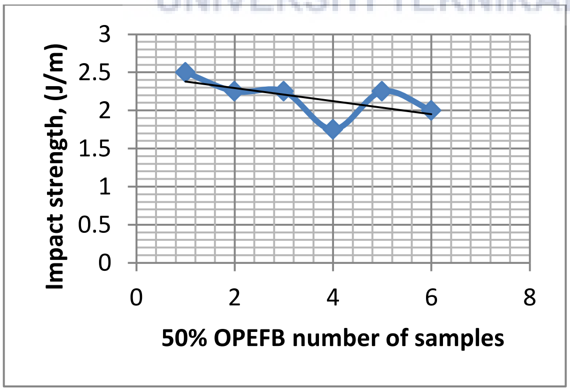

Figure 4.46 Scatter graph for 50% of OPEFB test 3

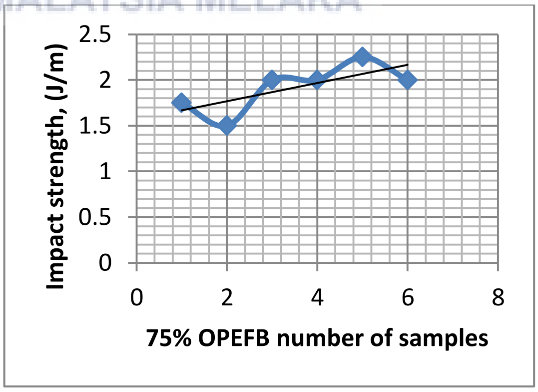

Figure 4.47 Scatter graph for 75% of OPEFB test 3

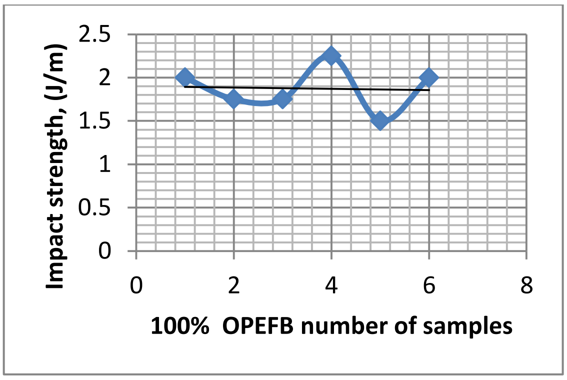

Figure 4.48 Scatter graph for 100% of OPEFB test 3

Table 4.27 Izod Impact Test Water Absorption Average Minimization

OPEFB percentage (%)	Average, (J/m)
0% OPEFB	2.10
25% OPEFB	2.30
50% OPEFB	2.25
75% OPEFB	2.00
100% OPEFB	1.95

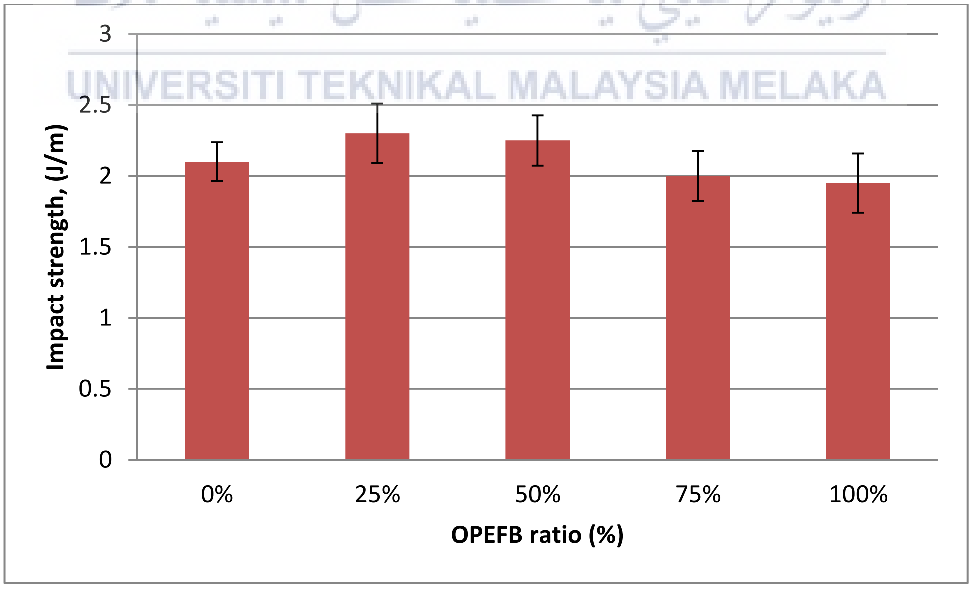

Figure 4.49 Izod Impact Test Water Absorption trend results

4.6.1 Visual Observation on Specimen after Water Absorption Impact Testing

Figure 4.50 Sample 100% OPEFB content for test 3

Figure 4.51 Sample 75% OPEFB content for test 3

Figure 4.52 Sample 50% OPEFB content for test 3

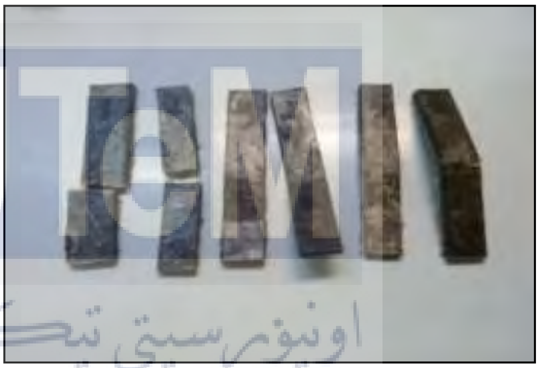

Figure 4.53 Sample 25% OPEFB content for test 3

Figure 4.54 Sample 0% OPEFB content for test 3

4.7 Izod Impact Test 2 and Water Absorption Impact Test

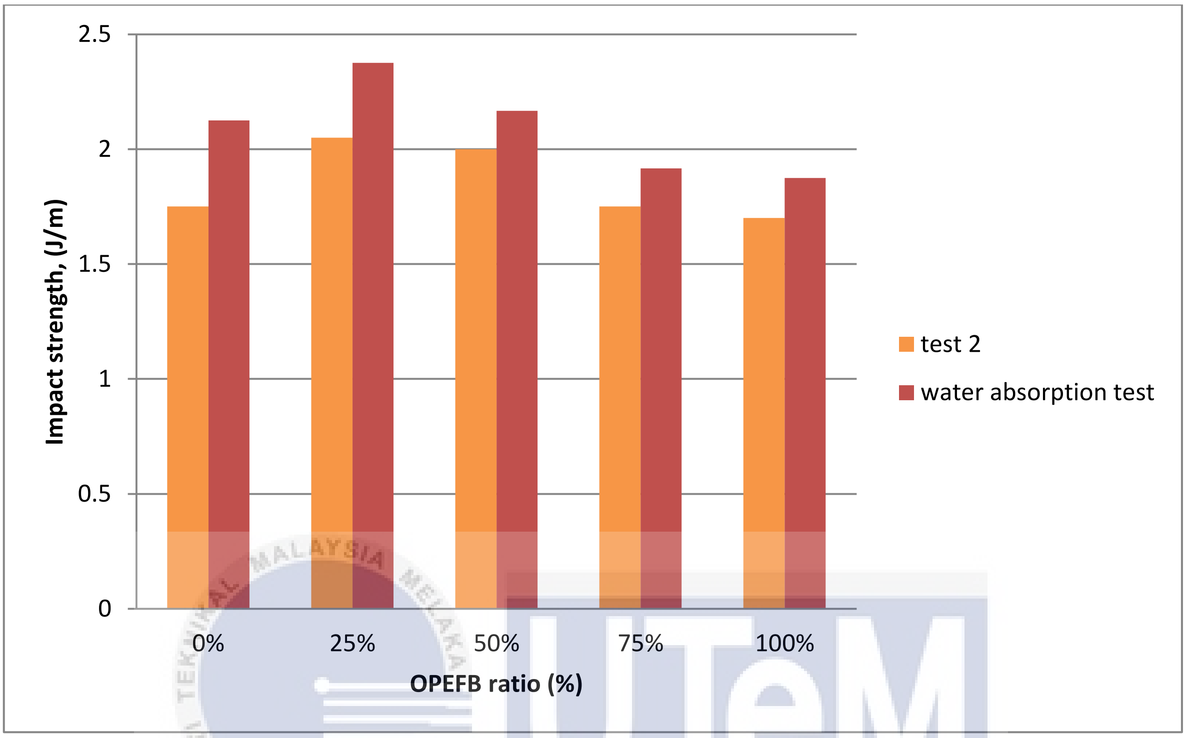

Figure 4.55 Comparison Izod Impact test 2 and Water absoption impact test

Table 4.28 impact energy increase percentage

OPEFB content	Water absortion impact test, (J/m)	Impact test 2, (J/m)	Increase impact energy (%)
0%	2.10	1.75	16.7
25%	2.30	2.05	10.9
50%	2.25	2.00	11.1
75%	2.00	1.75	12.5
100%	1.95	1.70	12.8

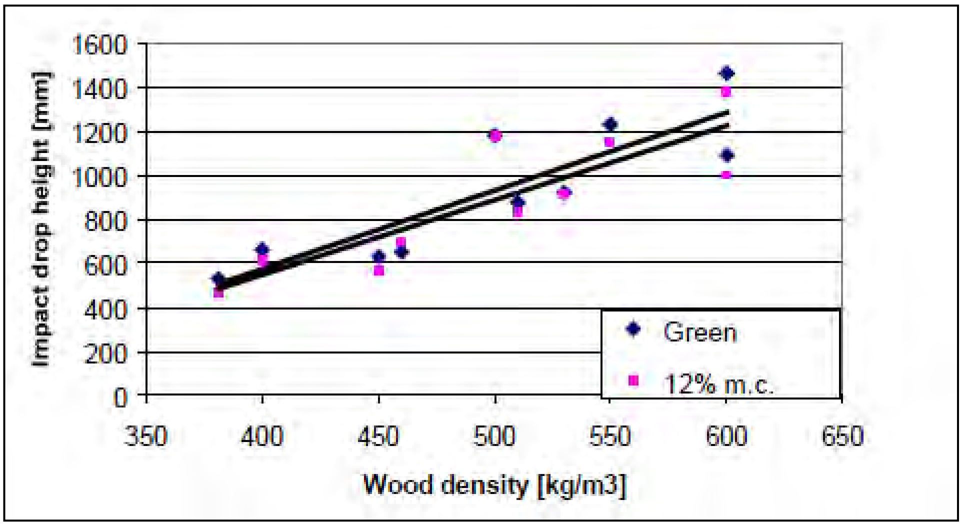

Figure 4.56 Wood density versus impact drop height, based on Wood Handbook 1999

According to Wood Handbook 1999, the higher density the higher impact drop height required to break the wood. Based on, $\rho = \frac{m}{V}$ formulation the higher the density shown the high mass of woods. In composite material cased, natural fiber can be assumed as classified in wood family because came from same natural plant. Therefore the analysis of wood handbook is applied to the impact test water absorption. After 29 days the specimen immerse in the water, the weight is measured is increase. In prediction, the impact energy needs to to break the sample is less than without water absorption testing. However, the result shown the impact strength is increase while the sample is immerse in water and also increase the weight specimen after immerse in water. From the assumption, these phenomena can happen because of the type of impact force applied to sample is different type as tension and compression force. For the situation free falling impact test is assumed person who jump into pool. The higher he jumped into water the deeper he goes it. However, if the person jumped fall flat to water it really hurt the body and stop quickly when start touch the surface of water after jump rather than jump into water vertically. This is relate to area contact to the surface of water and the density of water is slow down the movement. From these physic phenomena it can be assumed the water absorption is increase the impact properties because it has own density that slow down impact pendulum and act as impact resistance in this cased. In addition, the type of Izod impact test sizing pendulum used in test also affect the results.

4.8 Sample break observation

Figure 4.57 Sample 0% OPEFB fracture results

Figure 4.58 Sample 25% OPEFB fracture results

Figure 4.59 Sample 50% OPEFB fracture results

Figure 4.60 Sample 75% OPEFB fracture results

Figure 4.61 Sample 100% OPEFB fracture results

There are several classifications of specimen failure categories. First is complete break which is the specimen is completely separate into two. Next is hinge break which is the part is incomplete break. The bending of specimen is less than 90°. Partial break is incomplete break but at least fracture 90%. Lastly is non-break failure an incomplete break which fracture is less than 90%.

Table 4.29 Samples break classification based observation

OPEFB content	**0%OPEFB**	**25%OPEFB**	**50%OPEFB**	**75%OPEFB**	**100%OPEFB**
Type of break	Complete break	Non-break	Complete break	Complete break	Partial break

Based on observation make, all the 0% ratio percentage OPEFB content is having complete break after test. The material has shown the kenaf fiber is brittle characteristic compared to OPEFB which is ductile. OPEFB reinforced HDPE having partial break from observation. In term of impact strength comparison 100% OPEFB ratio content is less impact strength need to break compare to 0% ratio percentage of OPEFB because OPEFB is weak and easy to bend when applied the impact force from the sided of materials. From impact test result, 25% OPEFB ratio content is the higher impact required to break the samples. Furthermore, the observations make on the sample with 25% ratio OPEFB content are half of samples having less than 90% of fracture after testing.

4.9 Digital Microscopy Image Analyser

Figure 4.62 Sample 0% OPEFB observed at 50X optical magnification

Figure 4.63 Sample 25% OPEFB observed at 50X optical magnification

Figure 4.64 Sample 50% OPEFB observed at 50X optical magnification

Figure 4.65 Sample 75% OPEFB obseved at 50X optical magnification

Figure 4.66 Sample 100% OPEFB observed at 50X optical magnification

Figure 4.67 Digital Microscopy Image Analyser

The image in figure 4.63, figure 4.64, figure 4.65, figure 4.66 and figure 4.67 is taken by using Digital Microcopy Image Analyser to study the impact fracture of OPEFB/kenaf/HDPE hybrid composites materials instead by using scanning electron morphology (SEM). It is because some of the sample is not fully break by the impact test. SEM cannot be test with unbreakable material and need to proceed with using the Digital Microscope.. Usually this study to examined and understand the failure modes of hybrid composite materials. The picture is observed at 100X optical magnification. From observation at sample fracture, HDPE is elongate at optimum which forces to fracture by impact force. In addition, the break is occurs at the area orientation of kenaf fiber from tip to tip which no fiber to hold. Furthermore, clearly evident show the kenaf fiber is occur fiber pull-out that makes the sample to break in figure 4.63. The fiber and matrix incompatibility in image is the failure mode happened that drag to facture of composites materials. Overall observation can be make that the failure mode hybrid composite of OPEFB/kenaf/HDPE is cause by fiber pull-out, fiber-matrix incompatibility, and matrix cracking.

4.10 Izod Impact Test 1, Test 2 and Water Absorption Test

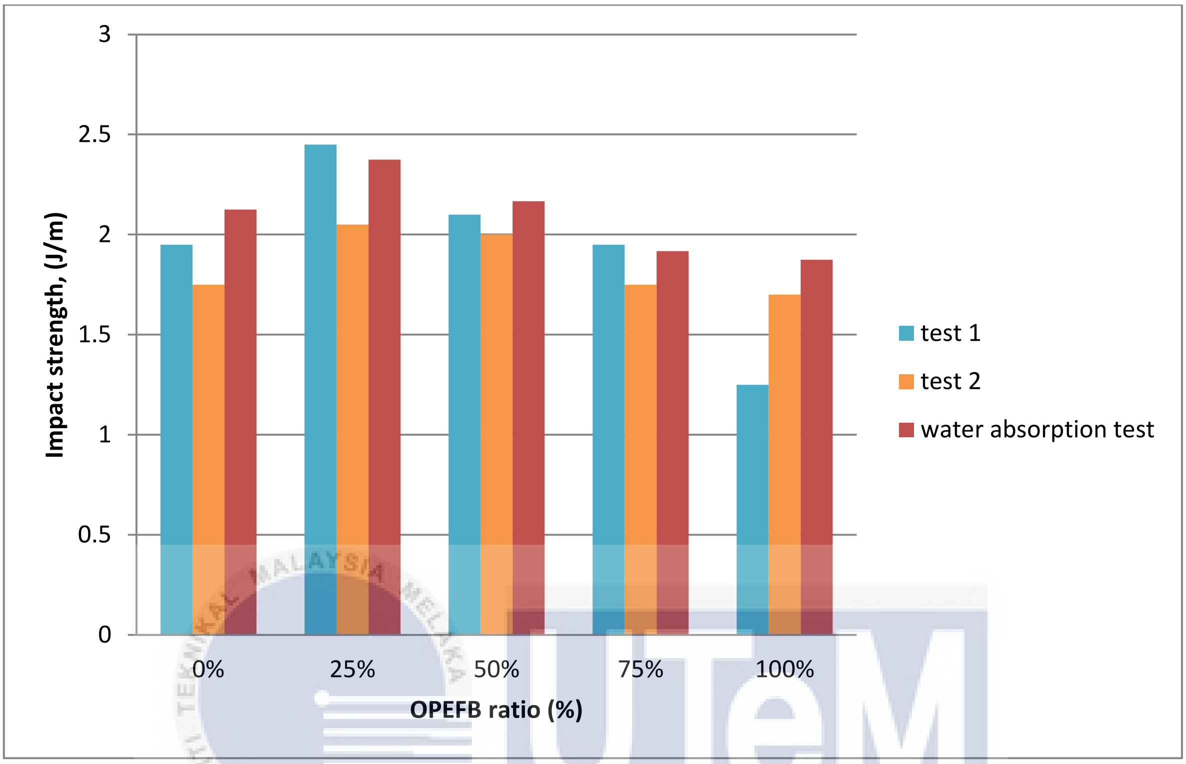

Figure 4.68 Izod Impact Test 1, Test 2 and Water Absorption Test

The Izod impact test is run three times. Test 1 and test 2 is run by using different batch of samples. While test 2 and water absorption impact test is run by using same batch of samples. The graph trend develops give consistent results for all three Izod impact testing. The different result outcome on impact test 1 and impact test 2 as predicted because of different batch of samples make from hot compression molding process. The method and parameter is same but the environment condition, molding condition and thermal treatment may affect the samples during fabrication.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In this present study on impact properties of hybrid oil palm empty fruit bunch with kenaf reinforced high density polyethylene for automotive application. The results from the study reveal that method of fabrication such as molding condition, thermal treatment, test specimen thickness and environment conditioning parameter is effect OPEFB with kenaf reinforced HDPE composites test results. Izod Impact testing 1 for batch samples 1 and Izod impact testing 2 for batch samples 2 showed the different on impact strength properties. Furthermore, by varying the fiber contents can effect to impact properties of OPEFB with kenaf reinforced HDPE composites. To have best performance of impact properties on OPEFB with kenaf reinforced HDPE composites by adding 25% percentage of OPEFB fiber content from study showed. In water absorption on impact properties, OPEFB with kenaf reinforced HDPE composites is affected to water from evaluation data. The impact properties of hybrid composites are improved after absorption the water in 29 days duration. The improvement in impact strength can achieved to 12.8% averages. Thus it can be concluded that the development of hybrid composites OPEFB with kenaf reinforced HDPE can help to produces low cost of hybrid composites material, environmental friendly, and lightweight to use for automotive application as good in impact properties. However, study in water absorption on impact properties is still new on this field. Therefore, recommended for other researchers to study in water absorption on impact properties for hybrid composites material.

5.2 Recommendation

Several recommendations for future works on this project are listed as below:-

i. Study the impact properties on OPEFB with kenaf reinforced HDPE by using hand lay-up 4 layering sequence method.
ii. Study the behavior of impact properties on hybrid composites OPEFB with kenaf reinforced HDPE by using treatments on fibers.
iii. Study water absorption of impact properties on hybrid composites OPEFB with kenaf fiber reinforced HDPE by using hand lay-up method

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