APPLICATION OF KENAF FIBER-PP COMPOSITE FOR FABRICATION ON INTERIOR PART OF AUTOMOTIVE COMPONENT

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SUPERVISOR DECLARATION

I have checked this report and the report can now be submitted to JK-PSM to be delivered back to supervisor.

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I declare that this project report entitled “Application of Kenaf Fiber-Pp Composite for Fabrication On Interior Part of Automotive Component” is the result of my own except as cited in the references

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ABSTRACT

Nowadays, sustainability of materials and manufacturing, cost and energy consumption, environment and health issue, are the factors that affect the rate of production. Due to that factor, most of the company widely use natural fiber to overcome that difficulty. Furthermore, Kenaf fibre which is one of the natural fibre can be a potential to act as reinforcement with polypropylene (PP) as matrix to create a composite material. In order to make that happen, the mechanical properties and physical properties of this composite material have to be identify. Kenaf fibre and PP are compound together with different fibre composition on each sample. It started with, the natural fibre which is kenaf prepared from raw and then undergoes alkaline treatment. Kenaf is cut into 1 cm and then mixed with PP into the mould and is compressed with hot press and cooling machine in specified parameter of temperature, pressure and time. After the sample is prepared, it will undergo several type test which is tensile test (ASTM D3039), density test (ASTM D792) and hardness test (ASTM D2240). For microstructure analysis, Dino-Lite digital microscope is used to analyse the composition of fibre for each sample. According to the result from tensile test, it shows that maximum load on Kenaf fibre/PP was decreasing linearly with increasing content of fibre. For hardness test, it was found that there is increasing of hardness with the increment of fibre content. However, the trend of density was increasing as the increasing of fibre content in sample.

ABSTRAK

Pada masa kini, kemampanan bahan dan pembuatan, kos dan penggunaan tenaga, persekitaran dan isu kesihatan, adalah faktor yang mempengaruhi kadar pengeluaran. Oleh sebab itu, kebanyakan syarikat menggunakan serat semulajadi untuk mengatasi kesukaran tersebut. Selain itu, serat Kenaf yang merupakan salah satu daripada serat semulajadi boleh menjadi potensi untuk bertindak sebagai tetulang dengan polipropilena (PP) sebagai matriks untuk menghasilkan bahan komposit. Untuk membuatnya berlaku, sifat mekanikal dan sifat fizikal bahan komposit ini perlu dikenalpasti. Serat Kenaf dan PP akan digabunganakan bersama dengan komposisi serat yang berbeza pada setiap sampel. Ia bermula dengan, serat semula jadi iaitu kenaf disediakan dari kulit kenaf yang asli dan kemudian menjalani rawatan alkali. Kenaf dipotong menjadi 1 cm dan kemudian dicampurkan dengan PP ke dalam acuan dan dimampatkan dengan mesin akhbar panas dan penyejuk pada parameter suhu, tekanan dan masa yang ditentukan. Selepas sampel disediakan, ia akan menjalani beberapa ujian jenis iaitu ujian tegangan (ASTM D3039), ujian ketumpatan (ASTM D792) dan ujian kekerasan (ASTM D2240). Untuk analisis mikrostruktur, mikroskop digital Dino-Lite digunakan untuk menganalisis komposisi serat untuk setiap sampel. Menurut hasil ujian tegangan, ia menunjukkan bahawa beban maksimum pada serat Kenaf / PP menurun secara linear dengan peningkatan kandungan serat. Untuk ujian kekerasan, didapati terdapat penurunan kekeruhan dalam meningkatkan kadar serat. Walau bagaimanapun, trend ketumpatan semakin meningkat apabila peningkatan kandungan serat dalam sampel.

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, sustainability of materials and manufacturing, cost and energy consumption, environment and health issue, are the factors that affect the rate of production. Due to that factor, most of the company widely use natural fiber to overcome that difficulty. Natural fibers have gained interest to automotive industries to increase their production of interior parts. There were three types of natural fiber that can be classified which is animal, plant and mineral fiber. Between these three type of fiber, the natural plan fiber is most potential fiber to be choose because of its advantages. These advantages include low density, high mechanical properties, specific strength, low cost and low in uses on now renewable resources (Fatihou & Zouzou, n.d.). Moreover, it is suitable to be most of interior parts in automotive because it can decrease in weight of vehicles due to its low in weight. Natural plant fiber has been used as interior part of automotive component such as seat backs, door panels, package trays and dashboard (Ishak, Leman, Sapuan, Edeerozey, & Othman, 2010).

One of the most widely used natural plant fiber is kenaf fiber which is the most potential and suitable to use. Kenaf (ie. hibiscus cannabinus), is in the genus hibiscus and easily found and popular in southern Asia.The fibers in kenaf are found in the bast (bark) and core (wood). Bast fibers have low density and high in mechanical properties, make its suitable to be reinforcements in lightweight impact. Moreover, kenaf fiber is one of the environmentally friendly material, ecofriendly, low in cost and weight that causes it can be in of the automobile part reinforcement in lightweight impact. Not only that, this fiber also has better sound absorption and can act as noise level reduction (Kumaresan, Satish, & Karthi, 2015). Furthermore, its high specific strength and modulus materials, low price, recyclable, renewable, easily to found in certain countries (Hassan, Zulkifli, Ghazali, & Azhari, 2017).

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1.2 Problem statement

Natural fiber such as kenaf fiber is widely used in automotive industries as interior parts in vehicle. This type of fiber is use due to its properties such as cheap, recyclable, renewable, high mechanical properties, specific strength and good sound absorption. Moreover, kenaf fiber are lower in costs that make this fiber a very efficient structural design. However, there is a problem that can consider as major problem which level of durability on impact. On the previous experiment, the result of strength and hardness for kenaf fiber is still low (Kumaresan et al., 2015). This research work was intended to investigate the strength and hardeness of kenaf fiber and level of durability on impact. In this research work, kenaf fiber will mixed with PP polymer and undergo in several tests. Test that include in this research work are tensile test, density test, microstructure test and hardness test.

1.3 Objective

This research is to study the application of kenaf fiber-pp composite for fabrication on interior part of automotive component. Main objective of this research are:

1. To determine the tensile strength and hardness of kenaf fiber-pp composite
2. To study the properties of kenaf fiber-pp composite such as density and microstructure.

1.4 Scope of project

Kenaf manually opened and chopped into small pieces and mixed with PP fiber at 10%, 20%, 30%, and 40% fiber contents. Then the mixture was paced into mold with dimension (140 x 60) mm. Next, the mold is placed between two aluminum plates. This two plates were then pressed between two platens heat compressions machines with gauge length at 2 mm thickness. The temperature, time and pressure of the heat compression were set at 170°C, 5 mins and 2.5 MPa respectively. The 2 mm kenaf fiber-pp sample were then cut into one sample sizes which was (140 x 25 x 2) mm. the sample was prepared in 15 sample with same dimension but different ration of fiber. After that, all the sample is going through 4 type of tests which was density test, microstructure test, tensile test and hardness test.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this era, most of automotive industry uses the natural fiber composites as reinforcement in interior part of automotive component. Composite material can be defined as a material that from two or more materials with different physical or chemical properties combined together in order to become stronger and better. The matrix is the key component in the composite material.

There are two categories of material which is matrix and reinforcement. Function of matrix material is to support the reinforcement materials by maintaining the reinforcements in place and transfer stress between the fibres and the reinforcement material impart its physical and mechanical properties to enhance the matrix properties. One of the good example of composite material is sandwich-structured composite. A sandwich-structured composite is a special class of composite material that is fabricated by attaching two thin but stiff skins to a lightweight but thick core. The core material is normally low strength material, but its higher thickness provides the sandwich composite with high bending stiffness with overall low density.

Based on studies by (Mahajan, Aher, Student, & Sangamner, 2012) has stated that the term composite could mean almost anything if taken at face value, since all materials are composed of dissimilar subunits if examined at close enough detail. But in modern materials engineering, the term usually refers to a “matrix” material that is reinforced with fibres. For instance, the term “FRP" (Fiber Reinforced Plastic) usually indicates a thermosetting polyester matrix containing glass fibres, and this particular composite has the lion's share of today's commercial market.

Recent studies by (Lopresto et al, 2016) has mentioned that composite materials are made of two or more different materials to create properties that cannot be obtained from any one material component alone. In the composite, one of the materials is performed as matrix while the other one is performed as reinforcement. The properties of composite material are depends on the nature reinforcement and matrix. However, the composite is the combination between two materials but they do not dissolve or blend into each other easily, the materials need to undergoes several process before it become a new composite material.

Refer to the (US Department of Energy, 2015), a composite can be defined as a combination of two or more materials that retain their macro-structure 50 resulting in a material that can be designed to have improved properties than the constituents alone.2 51 Fiber-reinforced polymer (FRP) composites are made by combining a polymer resin with strong, 52 reinforcing fibers. These lightweight composites enable many applications where the potential energy 53 savings and carbon emissions reduction occurs in the use phase.

2.2 Natural Fibre

The definition of fibre is a form a class of hair-like materials that occur as continuous filaments or in discrete elongated pieces alike to pieces of thread. They are of two types which is natural fibers and synthetic fibers. Fibers are of great importance in the biology of both plants and animals, for holding tissues together. Humans use natural and synthetic fibers for diverse purposes. For instance, some fibers are spun into filaments, thread, string or rope. Some are components of composite materials. In this research, natural fibres work as reinforcements, providing the required strength and stiffness to the final composite part.

Natural fibre can be defined as substances that hairlike raw material directly obtainable from an animal, plant, vegetable, or mineral source that can be spun into filament, thread or rope. The most viable structural fibres typically derive from specifically grown textile plants and fruit trees. Nowadays, natural fibres are more up-to-date than they have ever been, as they show outstanding mechanical properties and are 100% sustainable. Natural fibre composites with significant reduction in weight became a serious alternative to conventional composite materials like glass and carbon fibres. In recent years, natural fibers are being increasingly used in the textile, building, plastics, and automotive industries. Those from plant sources include cotton, flax, hemp, sisal, jute, kenaf, and coconut.

(Bongarde & Shinde, 2014) has stated that natural fiber composites include coir, jute, baggase, cotton, bamboo, hemp. Natural fibers come from plants. These fibers contain lingo cellulose in nature. Natural fibers are eco-friendly; lightweight, strong, renewable, cheap and biodegradable. The natural fibers can be used to reinforce both thermosetting and thermoplastic matrices. Thermosetting resins such as epoxy, polyester, polyurethane, phenolic are commonly used composites requiring higher performance applications. They provide sufficient mechanical properties in particular stiffness and strength at acceptably low price levels.

Natural fibres can be classified according to their origin and grouped into leaf: abaca, cantala, curaua, date palm, henequen, pineapple, sisal, banana; seed: cotton; bast: flax, hemp, jute, ramie; fruit: coir, kapok, oil palm. Among them flax, bamboo, sisal, hemp, ramie, jute, and wood fibres are of particular interest(Cristaldi, Latteri, & Cicala, 2010) The most important physical and mechanical properties are summarized in Table 2.1.

Plant fibre	Tensile strength (MPa)	Young's modulus (GPa)	Specific modulus (GPa)	Failure strain (%)	Length of ultimates, l (mm)	Diameter of ultimates, d (μm)	Aspect ratio, l/d	Microfib angle, θ (°)	Density (kg.m^{-3})	Moisture content (eq.) (%)
Cotton[s]	300-700	6-10	4-6.5	6-8	20-64	11.5-17	2752	20-30	1550	8.5
Kapok[s]	93.3	4	12.9	1.2	8-32	15-35	724	-	311-384	10.9
Bamboo[b]	575	27	18	-	2.7	10-40	9259	-	1500	-
Flax[b]	500-900	50-70	34-48	1.3-3.3	27-36	17.8-21.6	1258	5	1400-1500	12
Hemp[b]	310-750	30-60	20-41	2-4	8.3-14	17-23	549	6.2	1400-1500	12
Jute[b]	200-450	20-55	14-39	2-3	1.9-3.2	15.9-20.7	157	8.1	1300-1500	12
Kenaf[b]	295-1191	22-60	-	-	2-61	17.7-21.9	119	-	1220-1400	17
Ramie[b]	915	23	15	3.7	60-250	28.1-35	4639	-	1550	8.5
Abaca[l]	12	41	-	3.4	4.6-5.2	17-21.4	257	-	1500	14
Banana[l]	529-914	27-32	20-24	1-3	2-3.8	-	-	11-12	1300-1350	-
Pineapple[l]	413-1627	60-82	42-57	0-1.6	-	20-80	-	6-14	1440-1560	-
Sisal[l]	80-840	9-22	6-15	2-14	1.8-3.1	18.3-23.7	115	10-22	1300-1500	11
Coir[f]	106-175	6	5.2	15-40	0.9-1.2	16.2-19.5	64	39-49	1150-1250	13

Table 2.1: Natural fibre properties Source: Natural fibre'09 Proceedings (Cristaldi et al., 2010)

Based on research by (Rask, 2012), natural fibres can be derived into several different plant species as shown in Figure 2.1. Bast fibres are found in the stems of the corresponding plants. In the plant, the fibres serve the purpose of keeping the plant stem erect, so the top of the plant is high above the ground. Therefor the fibres are stiff and elongated. The fibres in a stem are arranged in 30-40 bundles each containing 10-40 elementary fibres, with pectin cementing the elementary fibres together, to form the bundles.

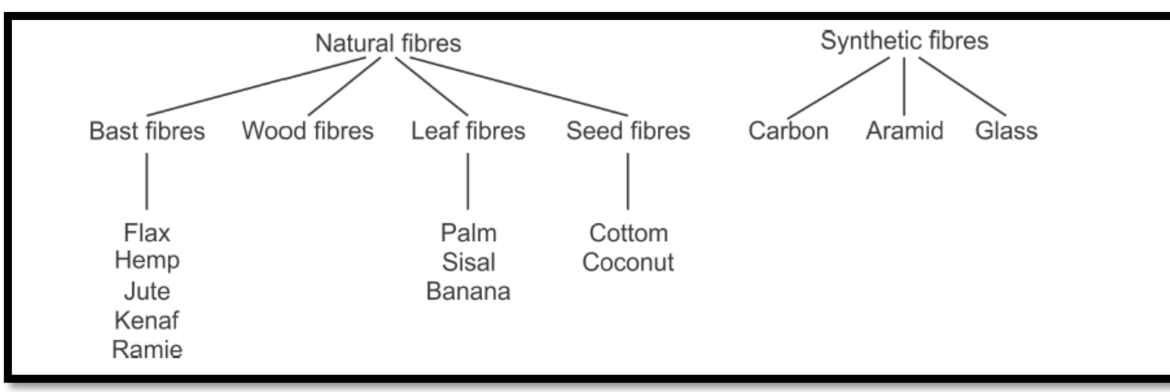


Figure 2.1: Overview of variety of fibres (Rask, 2012)

Refer to previous research by (Jeyanthi & Janci Rani, 2012), the natural fiber-reinforced composite has growing rapidly due to their mechanical properties, low cost, processing advantages and low density. The availability of natural fibers such as kenaf in Asia is more and also has some advantages over traditional reinforcement materials in terms of cost, density, renewability, recyclability, abrasiveness and biodegradability. The performance of the fiber reinforced composites mainly depends on the fiber matrix and the ability to transfer the load from the matrix to the fiber.

2.3 Kenaf

Kenaf as known as (Hibiscus cannabinus L.) is a fiber plant that are native from east-central Africa where it has been grown for several thousand years for food and fiber. It is a common wild plant of tropical and subtropical Africa and Asia. It can grow to 1.5-3.5 m tall with a woody base and the stems are 1–2 cm diameter. The leaves are 10–15 cm long, variable in shape, with leaves near the base of the stems being deeply lobed with 3-7 lobes.

The fibres in kenaf are found in two type which is bast (bark) and core (wood) as shown in Figure 2.2. The bast constitutes 40% of the plant. "Crude fibre" separated from the bast is multi-cellular, consisting of several individual cells stuck together. The individual fibre cells are about 2–6 mm long and slender. The cell wall is thick (6.3 µm). The core is about 60% of the plant and has thick (≈38 µm) but short (0.5 mm) and thin-walled (3 µm) fibre cells. Paper pulp is produced from the whole stem, and therefore contains two types of fibres, from the bast and from the core. The pulp quality is similar to hardwood. The kenaf plant characteristic are shown in figure 2.2.

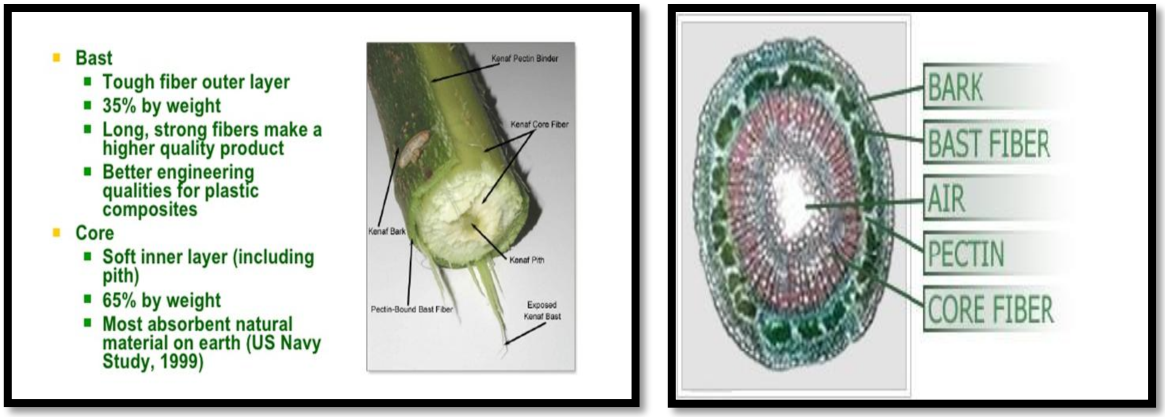


Figure 2.2: Characteristic of kenaf plant

There are many uses of kenaf fibre such as engineered wood, soil-less potting mixes, insulation, clothing-grade cloth, packing material, and material that absorbs oil and liquids. Additionally, as part of its overall effort to make vehicles more sustainable, Ford and BMW are making the material for the interior parts for automobile from kenaf. The first implementation of kenaf within a Ford vehicle was in the 2013 Ford Escape. The BMW i3 uses kenaf in the black surrounds.

According to previous research from (Kumaresan et al., 2015), automotive manufacturing has use kenaf fiber because it can provide lower density and has resulted in lightweight and eco-friendly automotive interiors. Moreover, it has been shown that this fibre has better sound absorption and noise level reduction. Not only that, the sandwich layer of this fibre is a very efficient structural design with the benefit of being lower in cost. Another example for automotive industry, as (Mcrandal & Mcnulty, 2015) start that the 1996 Ford Mondeo which sold abroad features interior automobile panels made of kenaf fibre. Kenaf international supplies the fibre, which is processed by the supplier to Ford. The company expects that sales to European automobile manufacturers will steadily increase as the industry becomes comfortable with the product and the kenaf products from automotive group are capable of meeting required demand.

Several research has been run from time to time. The mechanical properties of kenaf have been researched and vary from study to study. This is most likely due to the non-uniformity of kenaf. Kenaf is not processed like carbon and glass fibers and therefore each individual fiber is very different from the other. The density of kenaf was researched and a range of 1130 kg/m^3 to 1500 kg/m^3 was found.

By referring the research from (Loveless, 2015), its stated that University of palermo has tested to get kenaf fiber's mechanical properties. The tests were performed with a tensile tester and were statistically analyzed due to the high scatter of data. The tensile modulus was found to be around 40 GPa and the ultimate stress was found to be between 350 MPa – 600 MPa. They also tested unidirectional and mat kenaf composites with epoxy resin. The flexural tests reported a flexural modulus of 3.75 MPa for untreated kenaf and 4.2 MPa for treated 5 kenaf mat composites.

By using kenaf fibres as a material, there are many advantages such as low density, low production cost, minimal wear to machinery, good damage resistance and high specific strength compare to any other natural fibres (Fernando, 2009). Figure 2.3 shows the experimental result of tensile strength that run by (Ishak, Leman, Sapuan, Edeerozey, & Othman, 2010). on this research, the study was to compare the mechanical properties of kenaf bast and core fibre reinforced unsaturated polyester composites with variable of fibre weight fraction by 0%, 5%, 10%, 20%, 30% and 40%. It shows that kenaf fibre has proven that the composite of 20% fibre content showed the highest tensile strength for kenaf bast and core fibre.

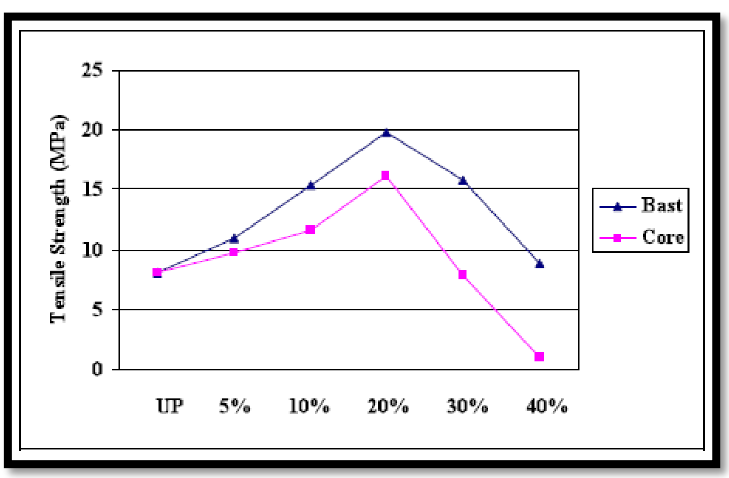


Figure 2.3: Tensile strength of kenaf and core fibre reinforced unsaturated polyester composite (Ishak et al., 2010)

2.4 Polypropylene (PP)

Polypropylene (PP) is a thermoplastic material and made from the combination of propylene monomer. PP has remarkable properties such as low density (weight saving), high stiffness, it has a lower impact strength, but superior working temperature and tensile strength and recyclability that makes it wide range of application in industry. There are variety of applications from this thermoplastic polymer including packaging and labeling, textiles, plastic parts and reusable containers of various types, laboratory equipment, automotive components, and medical devices. PP have the density which is between 0.895 and 0.92 g/cm³. Therefore, PP is the plastic product with the lowest density. Because of its lower density, moldings parts with lower weight and more parts of a certain mass of plastic can be produced. The Young's modulus of PP is between 1300 and 1800 N/mm².

PP is an economical material that have good mechanical, chemical, thermal and electrical properties compare to other thermoplastic. PP also light in weight, good stain resistance and low moisture absorption rate. Other advantages are excellent dielectric properties, resists stress cracking, easily fabricated, resists most alkalis and acids, non-toxic and high heat resistance. This thermoplastic material can be fabricated through several techniques such as hot gas welding, machining with wood or metal working tools, vacuum forming, and ultra-sonic sealing. Table 2.2 shows all the properties according to its standards.

ASTM or UL test	Property	Homopolymer	Co-Polymer	Flame Retardant
	PHYSICAL			
D792	Density (lb/in³) (g/cm³)	0.033 0.905	0.033 0.897	0.035 0.988
D570	Water Absorption, 24 hrs (%)	<0.01	0.01	0.02
	MECHANICAL			
D638	Tensile Strength (psi)	4,800	4,800	4,300
D638	Tensile Modulus (psi)	195,000	-	-
D638	Tensile Elongation at Yield (%)	12	23	28
D790	Flexural Strength (psi)	7,000	5,400	-
D790	Flexural Modulus (psi)	180,000	160,000	145,000
D695	Compressive Strength (psi)	7,000	6,000	-
D695	Compressive Modulus (psi)	-	-	-
D785	Hardness, Rockwell R	92	80	-
D256	IZOD Notched Impact (ft-lb/in)	1.9	7.5	0.65
	THERMAL			
D696	Coefficient of Linear Thermal Expansion (x 10^{-5} in./in./ºF)	6.2	6.6	-
D648	Heat Deflection Temp (ºF / ºC) at 66 psi at 264 psi	 210 / 99 125 / 52	 173 / 78 110 / 43	 106 / 41 57 / 14
D3418	Melting Temperature (ºF / ºC)	327 / 164	327 / 164	327 / 164
-	Max Operating Temp (ºF / ºC)	180 / 82	170 / 77	180 / 82
C177	Thermal Conductivity (BTU-in/ft²-hr-ºF) (x 10^{-4} cal/cm-sec-ºC)	 0.76-0.81 2.6-2.8	 - -	 - -
UL94	Flammability Rating	HB	n.r.	V-O
	ELECTRICAL			
D149	Dielectric Strength (V/mil) short time, 1/8" thick	500-660	475	500-650
D150	Dielectric Constant at 1 kHz	2.25	2.2-2.36	2.3
D150	Dissipation Factor at 1 kHz	0.0005-0.0018	0.0017	-
D257	Volume Resistivity (ohm-cm) at 50% RH	8.5 x 10^{14}	2 x 10^{16}	10^{15}
D495	Arc Resistance (sec)	160	100	-

Table 2.2: Properties of polypropylene according to standards.

According to research by (Technologies & Republic, 2010), the automotive industry nowdays, polymer composite and plastic is one of the big role this industry. The average vehicle uses about 150 kg of plastics and plastic composites versus 1163 kg of iron and steel. Automotive engineers are keep designing to optimize other systems such as injection and blow molded parts offering a better product without expensive assembly work. Tank fuel system is one of the most complicated design problem and it has been solved because of this material. There are four parts that requires priority research and development using plastic materials which are interior, body and exterior, powertrain and chassis, and lightweighting. Focusing on interior, improving safety in passenger compartment was taking priority. Moreover, designing for increased vehicle compatibility, more efficient manufacturing capabilities, accommodating an aging driver population, including more safety features in reduced package space, and enhancing safety belt designs.

(Dibaei, Abdouss, Torabi, & Haji, 2013) has stated that polypropylene (PP) is a crucial thermoplastic material because it has high strength, chemical resistance, and low cost. Because of that properties, this material has been a choice as a material for interior auto parts and other component applications. However, higher of stiffness and strength of polypropylene, but low in scratch resistance. A wide range of inorganic materials, such as glass fibers, calcium carbonate and clay minerals have been used as a reinforcement to improve the stiffness and strength of polypropylene.

Refer to (Technologies & Republic, 2010), stated that polypropylene is highly chemically resistant and almost completely resistant to water. Black has the best UV resistance and is increasingly used in the construction industry. It also has widely application such as automotive bumpers, chemical tanks, cable insulation, battery boxes, bottles, petrol cans, indoor and outdoor carpets, carpet fibers. Table 2.3 shows several components that use polymers plastic as it materials. From that table it shows up to 13 different polymers may be used in a single car model but there are three types of plastics majority uses which is 66 % of the total plastics used in a car: polypropylene (32 %), polyurethane (17 %) and PVC (16 %).

Component	Main types of plastics	Weight in av. car (kg)
Bumpers	PS, ABS, PC/PBT	10,0
Seating	PUR, PP, PVC, ABS, PA	13,0
Dashboard	PP, ABS, SMA, PPE, PC	7,0
Fuel systems	HDPE, POM, PA, PP, PBT	6,0
Body (incl. panels)	PP, PPE, UP	6,0
Under-bonnet components	PA, PP, PBT	9,0
Interior trim	PP, ABS, PET, POM, PVC	20,0
Electrical components	PP, PE, PBT, PA, PVC	7,0
Exterior trim	ABS, PA, PBT, POM, ASA, PP	4,0
Lighting	PC, PBT, ABS, PMMA, UP	5,0
Upholstery	PVC, PUR, PP, PE	8,0
Liquid reservoirs	PP, PE, PA	1,0
Total		**105,0**

Table 2.3: Types of plastic use in a typical car (Technologies & Republic, 2010)

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, it will explain about a system of methods used in this research. The workflow that to handle this research is describe in the flow chart as shown as Figure 3.1. It starts with literature review about this research which is natural fibre and polymer. After that, the material used for this research which is kenaf and polypropylene is identify and then followed by preparing the sample. Next the sample was performed several type of testing such as density test, microstructure test, tensile test and hardness test.

This chapter is a combination of three basic stages:

i. Raw material preparation
ii. Sample preparation
iii. Testing

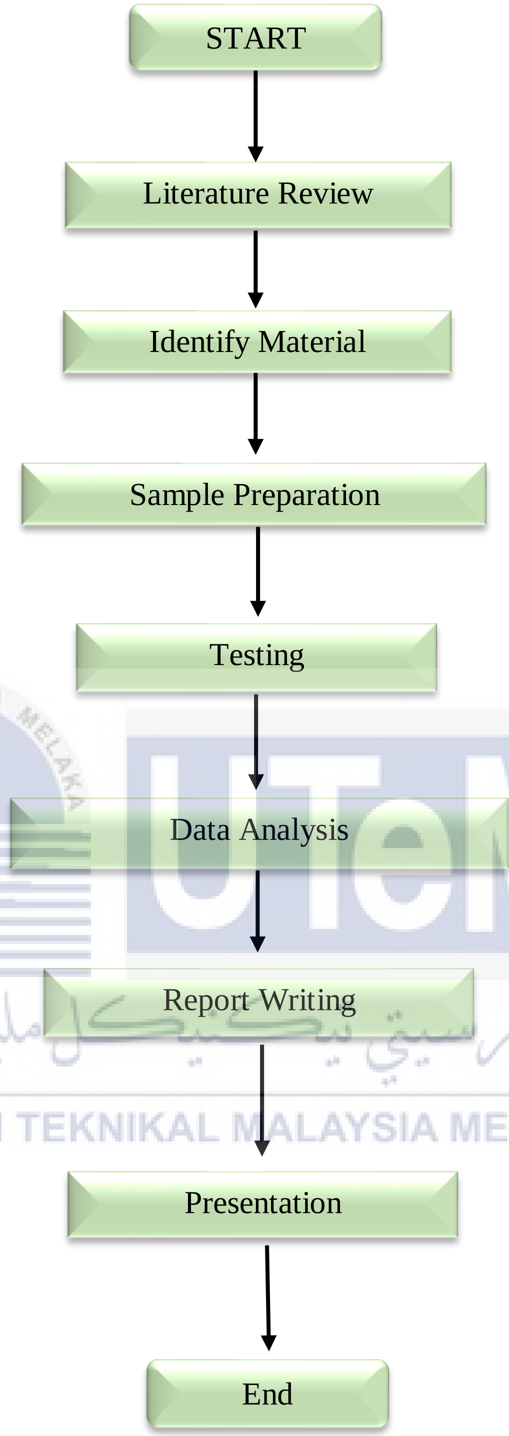


Figure 3.1: Flow chart of the methodology

3.2 Raw Material Preparation

3.2.1 Preparation of Kenaf Fibre

Kenaf fibre used in this research was collected from Kelantan. First step for raw material preparation is kenaf fibre was extracted by using decortication machine as shown in Figure 3.2. After the extraction process complete, the fibre was washed using tab water and the fibre was dried out under the sun until its fully dried.

Figure 3.2: Decortication machine

Next, the dried fibre were underwent and alkaline treatment process. This process is done by soaking 5% of aqueous sodium hydroxide (NaOH) for 1 hour at room temperature as shown in Figure 3.3. This alkaline treatment was conducted to enhance the properties. Then the kenaf fibre was washed up by distilled water and dried it under the sun and oven which is 60° for 24 hours. Lastly, the fibre was cut into desire length which is 1 cm as shown in Figure 3.4.

Figure 3.3: Kenaf fibre were soaked in NaOH solution

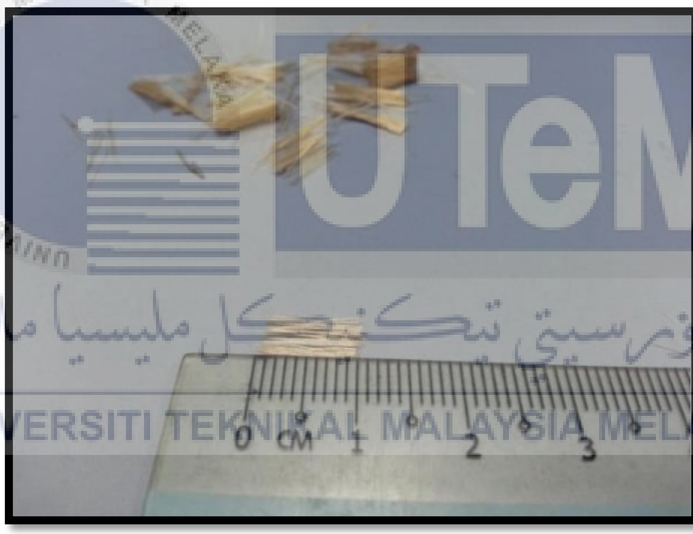


Figure 3.4: Kenaf fibre were cut into 1 cm length

3.2.2 Preparation of Polypropylene (PP)

Polypropylene (PP) is thermoplastic material that gives outstanding physical and mechanical properties and this is the reason why this material a widely used for automotive interior parts. Function using PP in this research is as reinforce for kenaf fibre. First step to prepare this material is PP is weighted 10g and then crushed using pulverizer machine as shown in Figure 3.5 for 1000 minutes. After that, PP is blended by blender machine until it become powder as shown in Figure 3.6.

Figure 3.5: Pulverizer machine is used to crush PP

Figure 3.6: PP in form of powder

3.3 Sample Preparation

For this research, 5 sample of Kenaf fibre/PP composite with different ratio needed to prepare to conduct several test.

Kenaf Fibre/PP	Weight Percentage (Kenaf Fibre/PP)
0/100	0g/16.0g
10/90	1.6g/14.4g
20/80	3.2g/12.8g
30/70	4.8g/12.8g
40/60	6.4g/9.6g

Table 3.1: The ratio of Kenaf fibre-PP composite sample

The table above shows the ratio of Kenaf fibre/PP for each sample based on weight percentage. There is 4 sample of total weight 16g for each sample need to provide for each ratio and there is several step to prepare each sample. First, the Kenaf/PP was weighted by weight percentage as shown in table 3.1. Then, Kenaf fibre and PP was mixing up by using manual mixer method. In this process, the Kenaf fibre and PP were mixed into a mixing container and stir it until it well mixture. After that, that mixture was keep into labelled container.

Next, the mixture of Kenaf fibre/PP was filled into the mould that has diameter of 140mm x 25mm x 2mm as shown on Figure 3.7. After that, the mould was placed and pressed by hot press machine as shown on figure 3.8. The hot press machine was set by the parameter as shown in table 4. After hot compress complete, the mold was moved to cooling for 15 minutes.

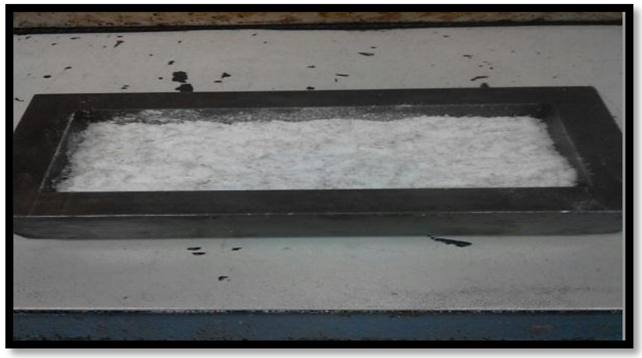


Figure 3.7: Kenaf fibre/PP was filled into mold

Figure 3.8: Hot press machine that use to compress the mixture

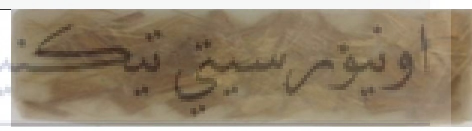
Temperature	170
Preheat	5 minutes
Hot press	5 minutes
Pressure	2.5 Mpa

Table 3.2: Parameter for hot press machine.

After hot compress and cooling process is done, the mould was placed to the mould opener machine as shown in Figure 3.9. Funcition of mould opener machine is to take the Kenaf fibre/PP composite out from the mould. Lastly, the sample were cut to the required dimension according to standards of testing sample.

Figure 3.9: The mould opener machine

Table 3.3: Samples of kenaf fibre/PP composite for each composition

Kenaf fibre/PP weight percentage (%)	Composite
0/100	
10/90	
20/80	
30/70	
40/60	

3.4 Testing

The study for this research is to analyze data about the properties of Kenaf fibre/PP composite material. There are four type of testing based on American Standard Testing Method (ASTM) need to conduct in order to get the data. These test are Tensile Test (ASTM D3039), Density Test (ASTM D792), Hardness Test (ASTM D2240) and Microstructure analysis (SEM).

3.4.1 Tensile Test (ASTM D3039)

Tensile test (ASTM D3039) is conduct to measure the required force that can break and extend this composite specimen. The test is performed to find out which specimen stretch or elongates to that breaking point.

To conduct this test, kenaf fibre/PP composite were cut into the required dimension which is 140 mm length, 25 mm width and 2 mm thickness. The sample is mounted in the grips of Instron Universal Testing Machine (Model 5585H) as shown in Figure 3.10 controlled by Bluehill 2 software with constant head speed test of 1mm/min. Then the data such as tensile stress, tensile strain, and percentage of elongation can be obtained from the stress-strain curve diagram.

Figure 3.10: Instron Universal Testing Machine

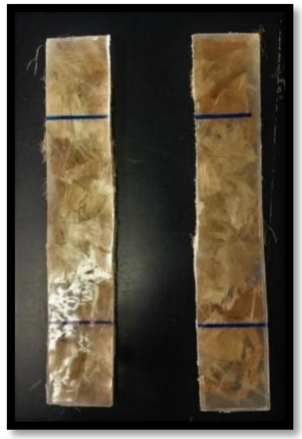


Figure 3.11: Kenaf Fibre/PP composite sample already cut into required dimension

Figure 3.12: Sample rapture after tensile test

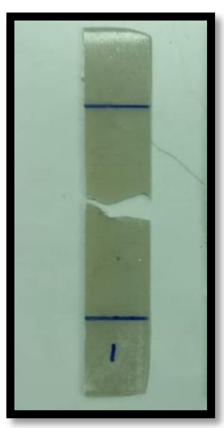


Figure 3.13: Kenaf fibre/PP composite sample ruptured after tensile test

3.4.2 Density Test (ASTM D792)

Density test (ASTM D792) is run to determine the specific gravity and density of solid plastic. This test is conduct by using digital electronic densimeter (MD-300S) as shown in Figure 3.14. The specimen is place into digital electronic densimeter (MD-300S) and then, the mass of the specimen can be obtained. While the specimen was immersed in liquid, the value of specific gravity and volume can be obtained.

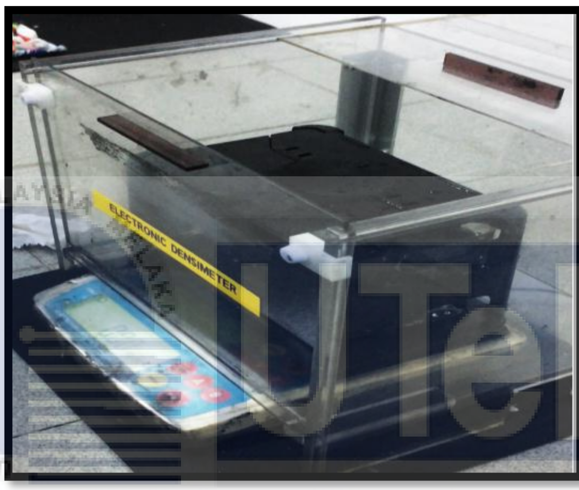


Figure 3.14: Digital electronic densimeter (MD-300S)

Figure 3.15: The apparent mass of Kenaf Fibre/PP composite specimen was measured

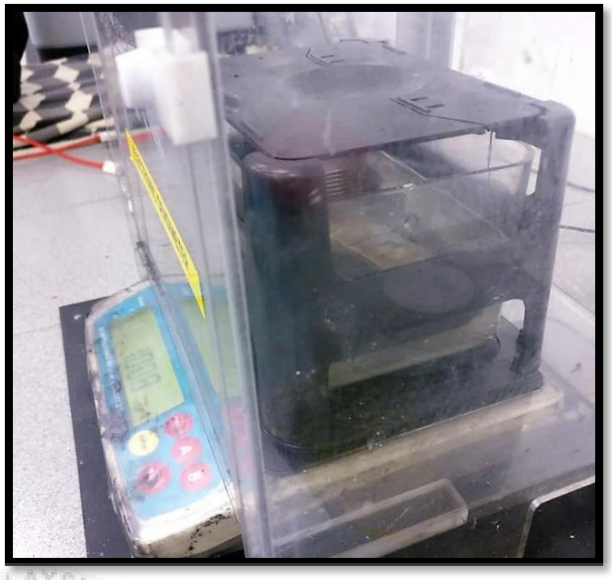


Figure 3.16: The Kenaf Fibre/PP composite specimen was immersed in the water

3.4.3 Microstructure Analysis

This test is conduct to study the microstructure of kenaf fibre/PP composite material and also the condition of fibre in different weight percentage of natural fibre with PP. the microscope use to obtain the image of microstructure is Dino-Lite Digital Microscope as shown in figure 3.17.

Figure 3.17: Dino-Lite Digital Microscope

To run this microstructure analysis, the sample was mount at the flat surface of microscope. The image was magnified to 200x and laser intensity was adjusted until the clear image were seen in monitor. The clear image was captured and saved.

3.4.4 Hardness Test (ASTM D2240)

Hardness Test (ASTM D2240) is performed to measure the depth of the indentation of the samples and empirical hardness value can be obtained. In order to conduct this test, analogue Shore scale "D" type Durometer based on ASTM D2240 as shown in Figure 3.18 is used. To conduct this test, the surface of sample must be flat and have thickness of 2.0 mm.

Figure 3.18: The Analogue Shore Scale D-type Durometer

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter covers the mechanical properties, physical properties and analysed the microstructure of kenaf fibre PP composite.

4.2 Effect of Mechanical Test

One of the objectives in this research was to study the mechanical properties of kenaf fibre PP composite.

Table 4.1: Tensile properties of the samples

Weight percentage Kenaf Fibre/PP (%)	**Maximum Load (N)**	**Tensile stress, σ (MPa)**	**Tensile strain, Ɛ**
0	1244.94	24.90	0.05525
10	1079.83	21.60	0.04080
20	861.83	17.24	0.02365
30	785.40	15.71	0.02090
40	581.18	11.62	0.01795

Table 4.1 shows the result obtained for the tensile test of the Kenaf Fibre/PP composite sample according to the percentage loading. The value of maximum load, tensile stress and tensile strain can be identified from this tensile test. All the values are different according to the ability of percentage loading when undergoes elongation or stretched process.

Figure 4.1 shows the result between maximum load and percentage loading in natural fibre composite during tensile test. Based on the graph, the maximum load for 0 % of weight percentage Kenaf Fibre/PP is the highest value among others which is 1244.94 N while the 40% of weight percentage Kenaf Fibre/PP is the lowest, 581.18 N. On the weight percentage which is 10%, 20% and 30% of Kenaf Fibre/PP are 1079.83N, 861.83 N and 785.40 N respectively. The pattern for this graph is decreasing due to the less fibre content can withstand higher maximum load compare to more fibre content on the composite. Maximum load is highest at 0 % of weight percentage because this sample does not consist fibre. So, this sample can withstand higher maximum load to fracture due higher elasticity compare to other sample. The sample of 40% of weight percentage Kenaf Fibre/PP which has lowest maximum load due to excessive of fibre in the composite and cause PP matrix hard to flow through the fibre. Therefore, this composite sample having composition difficulty and this sample become brittle.

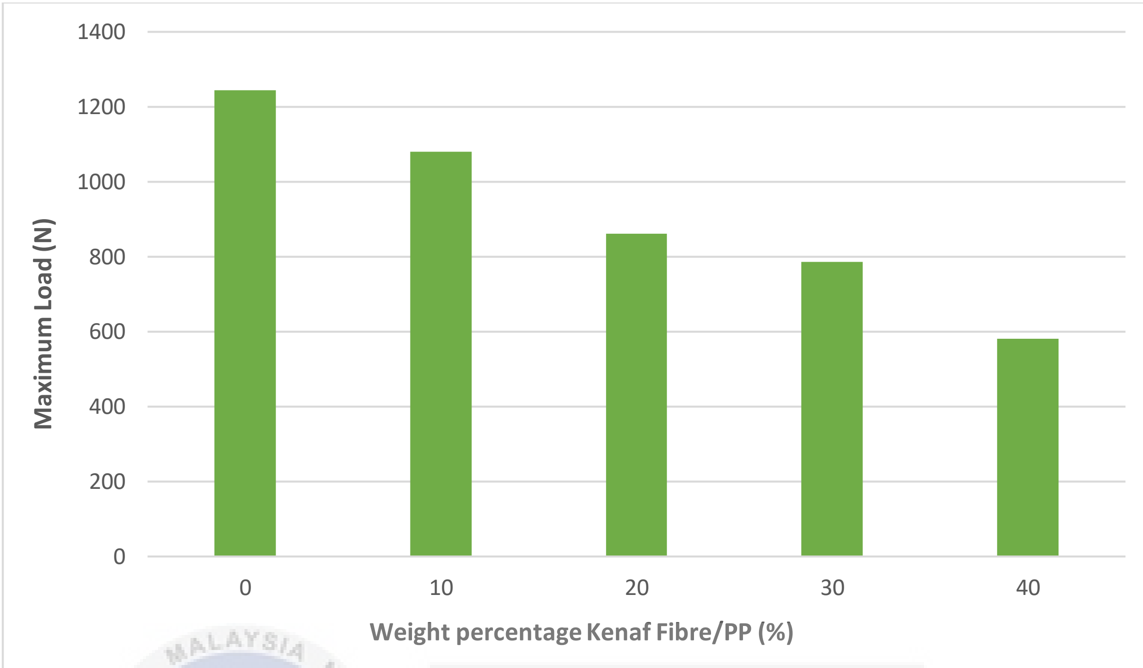


Figure 4.1: The Graph of Maximum Load (N) against Weight percentage Kenaf Fibre/PP (%)

The result for tensile stress at maximum load (MPa) against Weight percentage Kenaf Fibre/PP (%) were shown on Figure 4.2. Based on that graph, it shows that the highest tensile stress value which is 24.90 MPa are at 0% of Weight percentage Kenaf Fibre/PP. However, tensile stress at maximum load of 40% Weight percentage Kenaf Fibre/PP is the lowest value which is 11.62 Mpa. For the weight percentage of 10%, 20% and 30% of Kenaf Fibre/PP are 21.60 MPa, 17.24 MPa and 15.71 MPa respectively. The pattern of the graph showed that decreasing in tensile stress due to increasing the fibre loading in the composite. This is because, lesser contains of kenaf fibre in the composite are higher elastic compare to more contains of fibre in the composite. Moreover, the presence of fibre are disturbing the PP segment mobility. Thus, the composite turns to be more brittle.

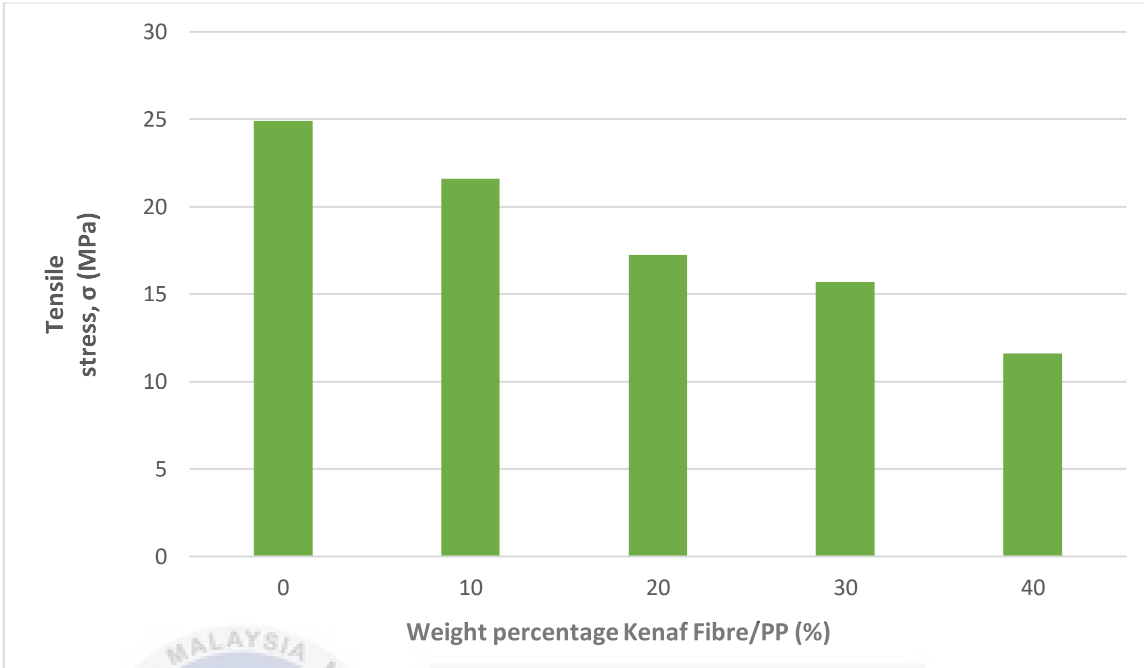


Figure 4.2: The Graph of Tensile Stress at Maximum Load (MPa) against Weight percentage Kenaf Fibre/PP (%)

Based on the Figure 4.3 below, shows the result between Load (N) against Extension (mm) during tensile test for the Kenaf Fibre/PP composite sample with different weight percentage (%). Based on the graph below, the result showed that the different pattern according to different weight percentage of fibre. 0 % of weight percentage of fibre shows the highest pattern for this graph, second higher is 10 %, third is 20 %, followed by 30% and the lowest value is 40 %. This result shows that the ductility level is the highest on 0 % of fibre. According to (Fatihou & Zouzou, n.d.), the reasons why higher composition of fibre has lower mechanical properties compare to lower composition was the amount of resin which is PP was not enough to wet the fibre. Therefore, it leads to bad interface between the fibre and PP.

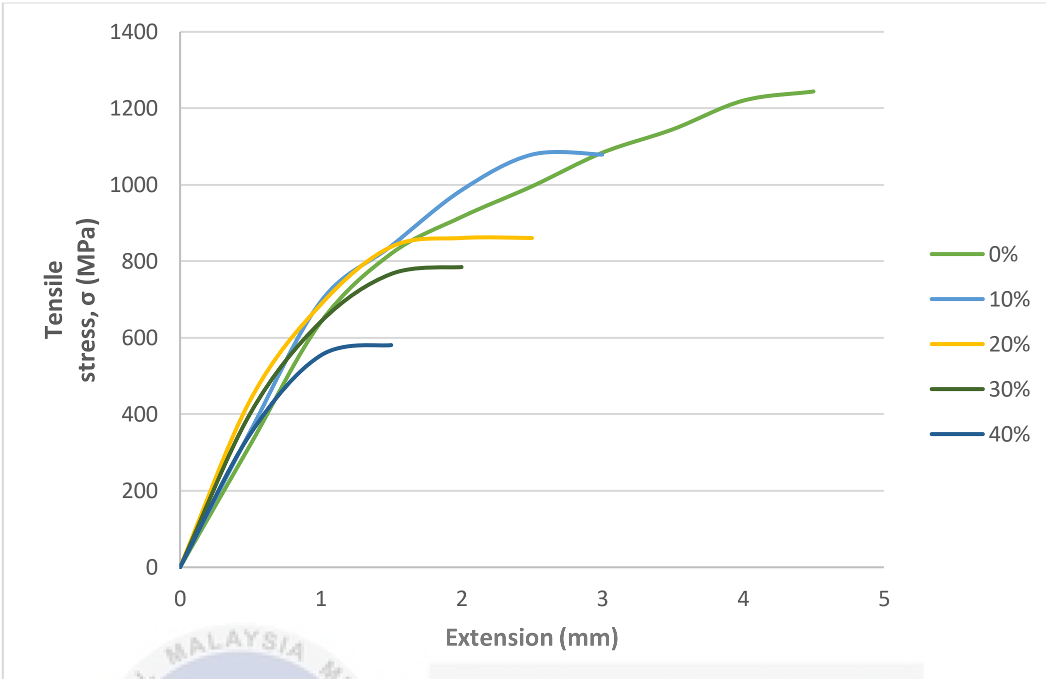


Figure 4.3: The Graph of Load (N) against Extension (mm) with the different weight percentage of Kenaf Fibre/PP (%).

Based on the Figure 4.4 below, the graph shows the result of tensile test between tensile stress (MPa) against strain stress which to define the mechanical properties of Kenaf Fibre/PP composite. The pattern of the graph shows that Stage i indicate the strain range between fibres and matrix facing elastic deformations. For the Stage ii, is a region which fibres deform elastically while the matrix deformed plastically. After a few seconds, the fibres show a brittle failure due to low ductility.

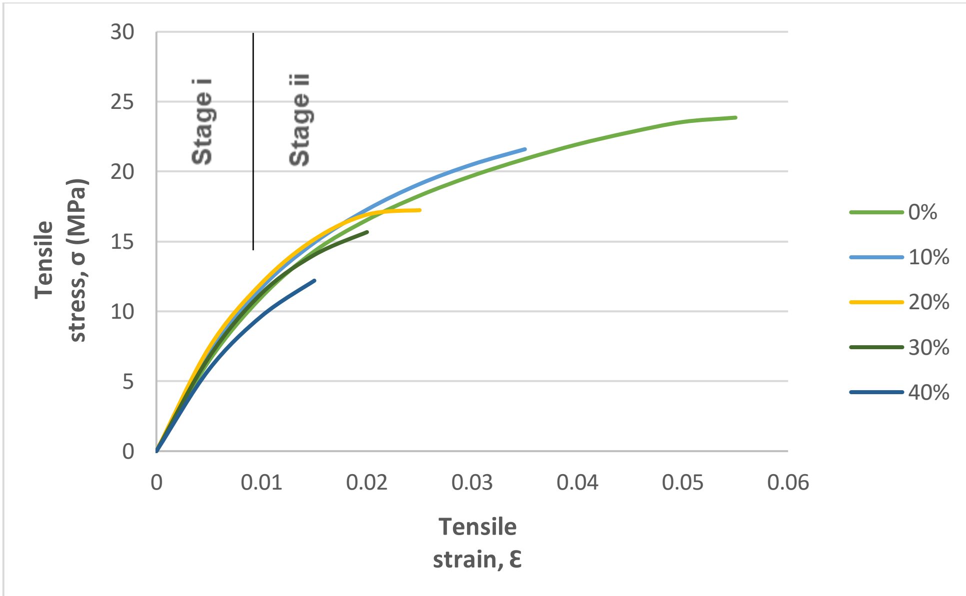


Figure 4.4: The Graph of Tensile Stress (MPa) against Tensile Strain with the different weight percentage of Kenaf Fibre/PP (%)

4.3 Effect of Physical Test

Furthermore, another objective in this research was to study the physical properties of kenaf fibre/PP composite. Type of test involve in this section are density test, hardness test and microstructure test.

Table 4.2 and Figure 4.5 show the results of density (g/cm3) and weight percentage for kenaf fibre/PP composite. Based on the table below, the result shows that the value of density increases with the increment of weight percentage for kenaf fibre. For the 0 % of and weight percentage for kenaf fibre/PP has the lowest value of density which is 0.973 g/cm3 while 40% of weight percentage for kenaf fibre/PP got the highest density, 0.985 g/cm3. This increasing trend obtained due to the increment of fibre content. This because, the space between fibre and matrix are much closer due to higher fibre content. (Kasim et al., 2016) stated that due to close packing of the fibre, the density of the composite has been increased.

WEIGHT PERCENTAGE KENAF FIBRE/PP (%)	DENSITY (G/CM3)
0	0.973
10	0.976
20	0.979
30	0.981
40	0.985

Table 4.2: Density properties of the samples

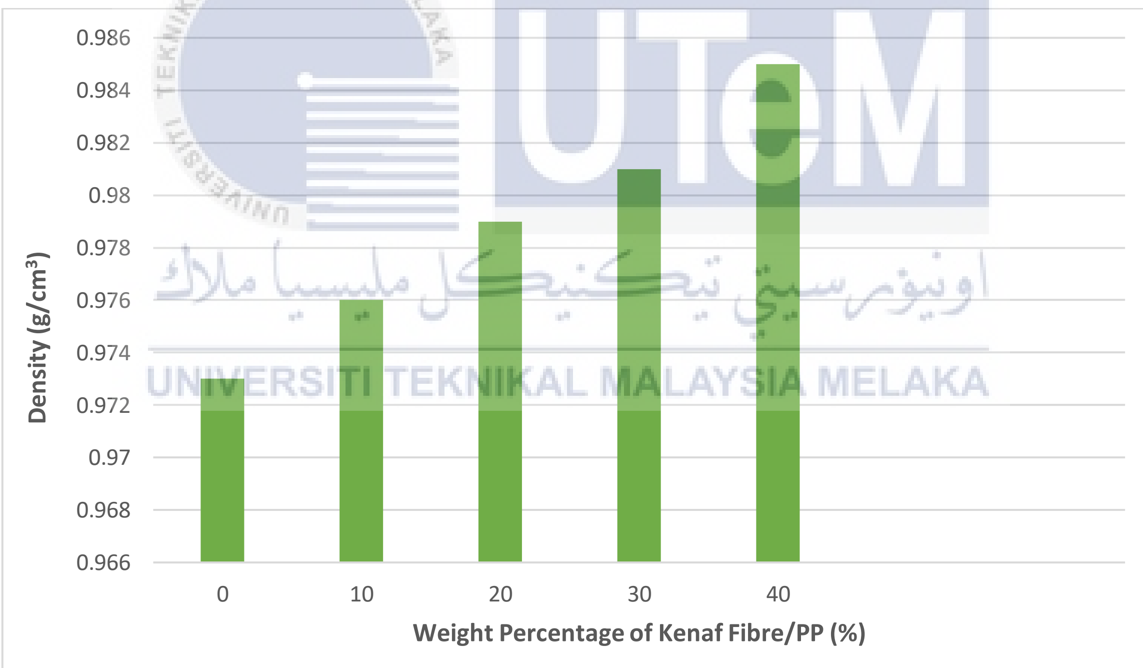


Figure 4.5: The Graph of Density (g/cm3) against weight percentage Kenaf Fibre/PP (%)

Meanwhile, the Table 4.3 and Figure 4.6 show the results of hardness and the weight percentage of Kenaf Fibre/PP (%). Based on the table, shows that the pattern of the graph is increase with the increment of fibre content. The 40% of weight percentage

Kenaf Fibre/PP got the highest value of hardness which is 64.64 while 0% weight percentage (Kenaf Fibre/PP) wt% is the lowest value of hardness, 57.10. the pattern of chart show that the increment of fibre content, the hardness value increase. Based on (Girimath et al., 2017), stated that the increment of weight percentage of the fibre, increase the ductility of material which offers resistance for indentation.

WEIGHT PERCENTAGE (KENAF FIBRE/PP) (%)	HARDNESS
0	57.10
10	58.20
20	59.20
30	64.30
40	64.64

Table 4.3: Hardness properties of the samples

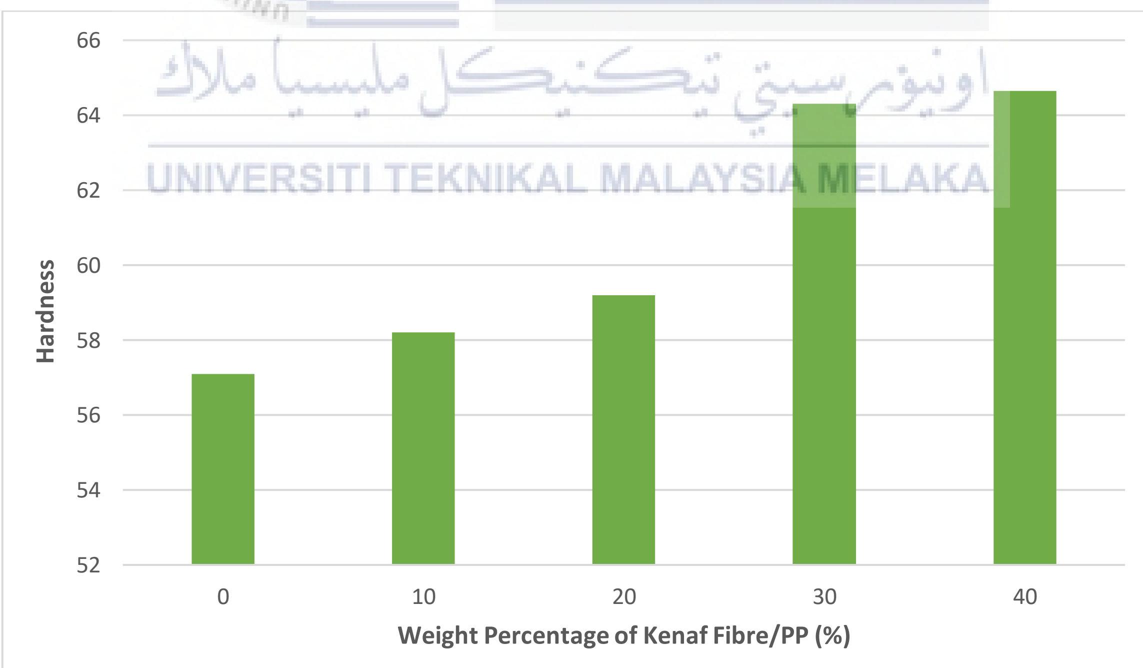


Figure 4.6: The Graph of Hardness against weight percentage Kenaf Fibre/PP (%)

4.4 Microstructure Analysis

4.4.1 Magnification 200x

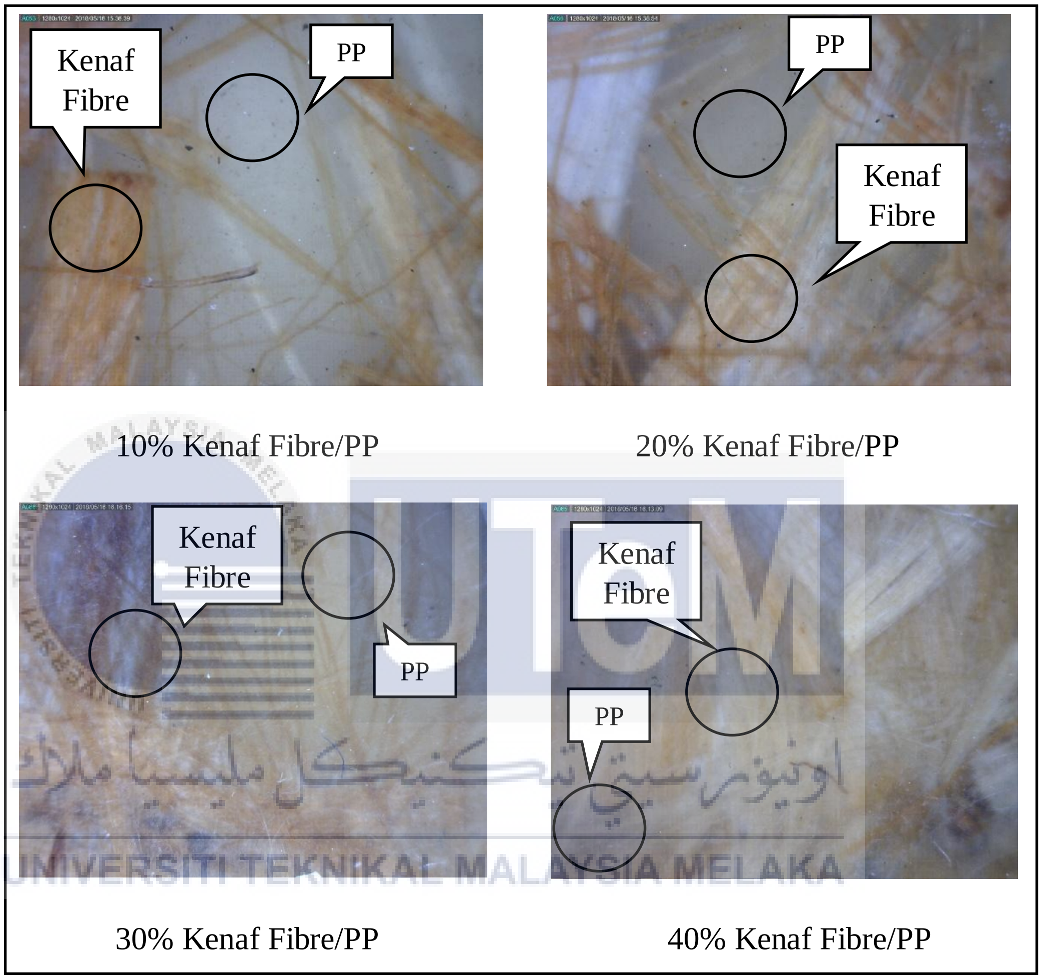


Figure 4.7: The microstructure image according to weight percentage of Kenaf Fibre/PP.

Based on the Figure 4.7 which is about the image under the microscope towards the Kenaf fibre/PP composites with magnification of 40. From these figure can be analyzed that there is difference in fibre content according to its weight percentage. Sample with 10% weight percentage kenaf fibre/PP has less fibre contents, compared to sample which is 40 % weight percentage has highest fibre content. In this composite material, the composition between reinforcement which is natural fibre and matrix are become closer and packed due to increment of fibre content.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This research is to study about production of composite material that are compounding between natural fibre and thermoplastic. In this research, Kenaf fibre and polypropylene (PP) has been use as the material.Kenaf fibre was act as reinforcement, whereas PP as a matrix. The application of this natural fibre composite material are on manufacturing of automotive industry. Therefore, the objective of this research is to determine the mechanical properties of kenaf fiber-pp composite material such as tensile strength and hardness. Another objective is to identify the physical properties of this composite material such as density and microstructure analysis.

In this research, the result was obtained for mechanical properties which is undergoes tensile testing shows that there is linearly decreasing pattern with the increment of weight percentage of natural fibre in the composite material. The highest value of tensile strength was at 0% of weight percentage of kenaf fibre/PP which is 24.90 MPa. However, 40% of weight percentage of kenaf fibre/PP shows the lowest value of tensile strength which is 16.62 MPa. Moreover, for the hardness result, 40% of weight percentage of kenaf fibre/PP have the highest value which is 64.64. The result physical properties which is from undergoes density test, the highest value of density is 40% of weight percentage of kenaf fibre/PP which is 0.985 g/cm^3. Based on the result obtained, this research can identify that the weight percentage of natural fibre in the composite were effected the mechanical and physical properties of natural composite.

In the nutshell, this can be concluded that by lowering the weight percentage of natural fibre can be advantage to compound the fibre in the composite material. The right amount of natural fibre which is act as reinforcement can effected the strength of composite material.

5.2 Recommendation

In this research, there are some error occurred when preparing and fabricating the sample. Thus, for further research several recommendations to improve the result for mechanical properties of this composite material. The recommendations are about preparing the raw material and fabricating the sample. For preparing the raw material, the natural fibre must be not drying too long. The quantity Pulverizer machine to crushed PP on the faculty must increase in order save student time.

For fabrication the sample, the temperature, pressure and time must follow the standard parameter. Moreover, when mixing the fibre and matrix into mould, any excess of pieces must be cleaned before put it into the hot press machine in order to make mould easily opened.

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APPENDIX

APPENDIX A

SAMPLE

Sample 1

Sample 1 of 0% weight percentage of Kenaf fibre/PP

Sample 2

Sample 2 of 10% weight percentage of Kenaf fibre/PP

Sample 3

Sample 3 of 20% weight percentage of Kenaf fibre/PP

Sample 4

Sample 4 of 30% weight percemtage of Kenaf fibre/PP

Sample 5

Sample 5 of 40% weight percentage of Kenaf fibre/PP

APPENDIX B

TABLE OF PROPERTIES

	Tensile strength (MPa)		Break strain [%]		Modulus of elasticity (MPa)	
Composites	PP	RPP	PP	RPP	PP	RPP
Kenaf	16.85	14.87	2.09	1.99	1156	971.9
Acacia	13.03	15.36	1.56	1.93	972	1018.0
Water hyacinth	14.72	13.69	1.75	1.99	1106	999.7
Banana	16.18	16.39	1.85	2.25	1115	1075.2
EFB	13.61	14.36	1.79	2.11	959	958.3
Polymer	30.71	28.86	11.00	12.00	791	866.91

Table of mechanical properties for fibre with PP

Properties	Value
Density (g/cm^3)	1.2 to 1.5
Young modulus (GPa)	1.5 to 3.5
Tensile strength (MPa)	5 to 12

Table of mechanical and physical properties of PP

APPENDIX C

ASTM STANDARDS