THE APPLICATION OF PINEAPPLE FIBRE POLYPROPYLENE (PP) COMPOSITE FOR FABRICATION ON INTERIOR PART OF AUTOMOTIVE COMPONENT

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Draft Report

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SUPERVISOR'S DECLARATION

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

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APPROVAL

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

Signature : ....

Name of Supervisor : ....

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DEDICATION

To my beloved mother, father, all my family members and my fellow friends.

Thank you so much for the support and sacrificing.

ACKNOWLEDGEMENT

Alhamdulillah, thanks to Allah S.W.T for giving me a chance to complete my research for this final year project with the title, “The Application of Pineapple Fibre Polypropylene (PP) Composite for Fabrication on Interior Part of Automotive Component”.

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ABSTRACT

Recently, natural fibre existed as outstanding materials which become an importance material to replace the luxurious and nonrenewable synthetic fiber. In recent years, many natural fibres such as sisal, banana, kenaf, oil palm and jute have been used as reinforcement in the thermoplastic composite. Furthermore, the process of compounded materials between natural fibre and thermoplastic are for the applying it in the manufacturing of automotive, construction, furniture and goods industry. Also, Pineapple leaf fibre (PALF) is the one of natural fibres which is having a good potential to reinforce with thermoplastic materials and create a new superior composite materials. Therefore, this phenomenon related with this research which is purposely to investigate the mechanical properties PALF reinforced with polypropylene (PP) as a matrix with varying fiber weight fraction, to identify the physical properties of PALF reinforced with PP and to analyze the microstructure of PALF/PP composite. The process was starting with preparation from raw pineapple leaf and then treated with alkaline treatment. PALF and PP were compounded using hot compression process by using hot press and cooling machine to create a sample. The samples were prepared according to the standard requirement to perform for tensile test (ASTM D3039), density test (ASTM D792) and hardness test (ASTM D2240). For scanning electron microscope (SEM), is used to investigate the composition structure between fibre and matrix composite. Based on the result, it was found that tensile test and maximum load towards PALF/PP composite was decreasing linearly with increment of fibre loading. However, the trend for hardness and density was increasing linearly as the fibre loading increased. From this study, can be identified that 10 wt% of fibre loading is the best achiever for the composition structure of PALF/PP composite.

ABSTRAK

Sejak kebelakangan ini, gentian asli telah muncul dan dikenali sebagai bahan yang terunggul di mana menjadi bahan yang terpenting dalam menggantikan gentian sintetik yang mahal serta tidak boleh diperbaharui. Sejak kebelakangan baru-baru ini, Banyak gentian asli seperti sisal, gentian daripada pisang , kenaf, gentian daripada kelapa sawit dan jut telah digunakan sebagai bahan pentetulang di dalam komposit termoplastik. Tambahan lagi, proses menyebatikan bahan-bahan di antara gentian asli dan termoplastik adalah untuk diaplikasikan di dalam proses pembuatan industri automotif, pembinaan, perabot dan barang-barang keperluan. Juga, Gentian daun nenas (PALF) adalah salah satu daripada gentian asli yang mepunyai potensi yang baik untuk dijadikan sebagai pentetulang untuk komposit termoplastik dan menghasilkan satu bahan komposit yang baru serta unik. Oleh itu, fenomena ini berkait dengan kajian ini yang bertujuan untuk mengkaji sifat-sifat mekanikal apabila PALF mengukuhkan polipropilin (PP) yang merupakan matrik berdasarkan kuantiti pecahan gentian yang berbeza, untuk mengenalpasti sifat-sifat fizikal apabila PALF mengukuhkan PP serta untuk menganalisis microstruktur komposite PALF/PP. Proses dimulakan dengan penyediaan daun nenas dan dirawat dengan rawatan alkali. PALF dan PP disebatikan dengan menjalani proses pemanasan pemampatan dengan menggunakan mesin pemanas dan penyejuk untuk menghasilkan sampel. Sampel-sampel disediakan mengikut keperluan piawaian untuk menjalani ujian ketegangan (ASTM D3039), ujian ketumpatan (ASTM D792) dan ujian kekerasan (ASTM D2240). Untuk mikroskop elektron pengimbas (SEM) telah digunakan untuk menyiasat komposisi struktur kompositdi antara gentian dan matrik. Berdasarkan kepada keputusan yang diperolehi, telah didapati bahawa ujian ketegangan dan pendayaan maksimum terhadap komposit PALF/PP mempunyai keputusan yang menurun selari dengan peningkatan muatan gentian. Walaubagaimanapun, tren untuk kekuatan dan ketumpatan meningkat selari dengan peningkatan muatan gentian. Daripada kajian ini, boleh dikenalpasti bahawa 10 wt% adalah muatan gentian yang paling terbaik untuk struktur komposisi komposit PALF/PP.

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LIST OF SYMBOLS AND ABBREVIATIONS

PP	-	Polypropylene
PS	-	Polystyrene
WPCs	-	Wood Plastic Composites
BD	-	Board Density
MR	-	Mixing Ratio
NaOH	-	Sodium Hydroxide
ASTM	-	American Society for Testing and Materials
SEM	-	Scanning Electron Microscopy
PMC	-	Polymer Matrix Composite
FRP	-	Fibre Reinforced Polymer
PUR	-	Polyurethane Thermoplastic
WPALFM	-	Woven Pineapple Leaf Fibre Mat
HIPS	-	High Impact Polystyrene
UV	-	Ultraviolet
PVA	-	Polyvinyl Alcohol
PALF	-	Pineapple Leaf Fibre
PALFs	-	Pineapple Leaf Fibres

CHAPTER 1

INTRODUCTION

1.1 Background

Natural fibres are generally known as vegetables fibres that are extracted from the fruit, phloem or leaf of the plant. Recently, many types of natural fibres being study to strengthen with polymer such as flax, hemp, jute, straw, wood fibre, rice hunks, cane for sugar and bamboo, grass, reeds, ramie, oil palm empty fruit bunch, sisal, coir, kapok, banana fibre, pineapple leaf fibre and papyrus. These natural fibres are the most widely used in the composite technology such as fabrication on interior part of automotive components and building construction material. People like to use these natural fibres to replace the synthetic materials which are not renewable and unfriendly environmental.

Natural fibres are gradually being used as reinforcement in thermoplastic and thermoset market. Many researchers have carried out studies about natural fibres to ensure the potential of these fibres to be reinforced in thermoplastics and thermoset which can be applied in industries. Generally, the most thermoplastics and thermoset that usually been used are polypropylene (PP), polystyrene (PS), polyester, epoxy, and polyethylene (PE). One of the studies that related about PP has been carried out by (Dikobe & Luyt, 2009)on morphology and properties of polypropylene was found out that polypropylene (PP) is one of the most product polymers and used in many areas, such as home appliances, automotive components and industrial applications. PP’s applications are often limited due to its low impact strength, Young’s modulus properties, low temperature and high temperature loading conditions. Hence, the effective way to improve the properties of PP by blending with different polymers is an economic.

Composites can be defined as combinations of two or more materials that for better results in properties than individual materials. The good things about combination of materials are their high strength and stiffness. (Campbell, 2010) carried out studies about composite materials has been found out reinforcement between fibre and polymer usually is harder, stronger, and stiffer than matrix. Fibres produce high strength composites because of their small diameter. However, polymers have low strength and stiffness but high ductility. In the studies, the composite materials between fibre and polymers shows a good results which is lighter weight, optimum strength and stiffness, improved fatigue life and corrosion resistance. (Falemara & Owoyemi, 2015) also found out on strength and sorption properties of bamboo (Bambusa vulgaris) wood fibres reinforced with plastic composites. The studies identified that wood plastic composites (WPCs) as sustainable materials, resistant to insects, marine borers and rot when used for structural members. In this study also found out, that WPCs produced at the highest Board Density (BD) 700kg/m^3 and highest mixing ratio (MR) of 3:1 showed as the highest dimensional stability and thickness reduction.

Pineapple is the second highest tropical fruit commercially produced in the world, around 25.1 million metric tonnes. The pineapple leaf fibre is one kind of fibre derived from the leaves of the pineapple plant. The leaf shape of pineapple look like a sword that taper at the ends with black and green colours on the edges of the leaves are sharp thorn. In addition, to obtain a strong fibre, soft and smooth, the selection should be done in pineapple leaves enough and protected from the sun. Pineapples leaf fibres reveal excellent properties which are high cellulose content and moderately low microfiber angle. Pineapple leaf fibres are a waste product of agriculture and can be obtained without high additional cost input for industrial purposes. Therefore, many researchers discover and carried out research to investigate effect and benefits of pineapple leaf fibres reinforce in thermoplastics and thermoset.

(M Asim et al., 2015) presented about mechanical properties of pineapple leaf fibres reinforced composites on a review on pineapple leaves fibre and its composites. In a study of stress behaviour of pineapple leaf fibre reinforced polyethylene composite, stress is inversely proportional fibre content. The tensile and bending properties of composites are depending on volume fraction. This study showed very useful with high quality strength of composites. Recently, pineapple leaf fibres used in making for textile fabrics, sports item, automobiles, cabinets, and mats. This fibre also is used in making machinery parts such as belt cord, conveyor belt cord, transmission cloth, air-bag tying cords, and some cloth for industry uses. This fibre good in making carpet because its chemical processing, dyeing behaviour and appealingly pleasing fabric. The pineapple leaf fibre is the highest cellulosic content and also highest tensile strength which is suitable for its application such as building and construction materials, cabinets and automotive components.

(Saxena & Pappu, 2011) presented about recent trends and future potentials on composite materials from natural resources which discovered about benefits of natural fibre reinforce polymers composites. This substitution offer many advantages such as lower cost, energy saving, reduced tool wear and tear, high stability for manufactured parts, good insulation properties, renewable, easy to recycle, no toxicity material and reduced fossil fuels. This natural fibre also used in automobile for example trim parts, various panels, shelves and brake which are attracting in automobile industries because of its reduction in weight 10%, energy production 80% and cost reduction 0f 5%.

Based on the findings, pineapple leaf fibres as natural fibre have a good potential used as a reinforcement of polymer composites. Few researchers have presented composites by using natural fibre such as oil palm and bamboo fibre. Therefore, this research interest to study the mechanical properties of pineapple fibre PP composites that applied on fabrication on interior part of automotive components by verified the properties through physical and mechanical test.

1.2 Problem Statement

Nowadays, it is becoming a trends about people bought any kind of car from different brand and the popular brands of automobile also competes each other to launch new cars with diverse kind of sophisticated features. Mostly, automobile industries nowadays used synthetic materials for fabrication part of automotive components including iron, aluminium, plastic steels, glass, rubber, petroleum products, copper, steel and others. These parts are used to create dashboard needles, wiring, engine block and transmission gears. However, the important concerns about the synthetic materials are increasing price of petroleum and depletion of fossil fuels. All this problem can be solved by replace the synthetic materials with natural fibre composites which can reduce environmental stress. The natural fibre composites much more light weight, renewable, environmental friendly and low cost. Due to the advantages of natural fibres' properties, this research is all about to identify the mechanical and physical properties of natural composites if it is good or not to be applied in the automotive industry.

1.3 Objectives

1.3.1 To investigate the mechanical properties pineapple leaf fibre reinforced with polypropylene (PP) as a matrix with varying fibre weight fraction

1.3.2 To identify the physical properties of pineapple leaf fibre reinforced with polypropylene (PP)

1.3.3 To analyse the microstructure of PALF/ PP composite

1.4 Scope

The scopes of research are:

1.4.1 Preparation of pineapple leaf fibre (PALF) – fibre extraction from leaf

1.4.2 Treatment of fibre – alkaline treatment (NaOH solution)

1.4.3 Preparation of polypropylene(PP)

1.4.4 Preparation of sample (composite material) - Compounding of PALF and polypropylene polymer by using manual mixer and hot press machine

1.4.5 Testing to find out mechanical properties

i. Tensile test (ASTM D3039)

1.4.6 Testing to find out physical properties

i. Density test (ASTM D792)

ii. Hardness test (ASTM D2240)

iii. Microstructure analysis (SEM)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Definition a composite material is a combination of two or more different materials to create unique and superior materials. There are several composite of classifications. The most common is Polymer Matrix Composite (PMC) or Fibre Reinforced Polymers (FRP). For this classification, polymer is used as the matrix and natural fibre as reinforcement. The fibres are usually glass, carbon and natural fibres. For the polymers that commonly used are polypropylene, polyethylene (thermoplastics) and epoxy, polyester (thermosets).

(Mrazova, 2013) carried out study about advanced composite materials of the future in aerospace industry which have mentioned there that composite material is a material that consists of strong carry load materials that reinforced with some weaker material. The stronger one is referred to the reinforcement while the weaker is referred to matrix. The role of reinforcement is to provide the strength and stiffness which helps to support the structural load. However, the matrix is responsible in maintaining the position and orientation of the reinforcement.

Table 2.1: Advantages and disadvantages of composite materials (Mrazova, 2013)

Advantages	Disadvantages
i. Weight reduction which saving in the range 20% to 50%	i. Some higher recurring cost
ii. Mechanical properties can be tailored with tapering thicknesses of reinforcing cloth and cloth orientation	ii. Higher nonrecurring costs
iii. High impact resistance for armor shields planes which reducing accidental damage to the engine pylons	iii. Higher material costs
iv. High damage tolerance improves accident survivability	iv. Non visible impact damage
v. Galvanic electrical can avoided the corrosion problems which would occur when two dissimilar metals are in contact. Here nonconductive glass fibre plays a roll.	v. Isolation is needed to prevent adjacent aluminium part galvanic corrosion.
	vi. Repairs are different than those to metal structure

Based on the 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 can be tell they are 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 (Aparecido et al, n.d.) study, the use of natural composites can provides many benefits when applied it towards technologies industry. Nowadays, automotive industry is shifting to Eco green outlook which to fulfil the customer requirement that is looking for ecologically vehicles. Materials that applied on car are renewable natural resources, biodegradable and recyclable. In addition, in the automotive industry, the application for this natural composite has grown so fast which are not structural components only but also in finishing parts.

Recent research and development (Aková, 2013) shown that composite materials are increasingly used in the automotive and construction industries. The composite materials are chemically treated to highly cross linked or three dimensional network structure which is highly solvent resistant, tough and creep resistant. Thermoplastics are more advantageous than thermoset because it has low processing cost, ease of moulding complex parts, flexible, tough and show good mechanical properties.

Table 2.2: The Applications of Natural Fibres in Automotive Industry (Aková, 2013)

Automotive Manufacturer	**Model Applications**
i. AUDI	A2, A3, A4, A6, A8, Roadster, Coupe, Seat backs, side and back door panels, boot lining, hat rack, spare tyre lining
ii. BMW	3, 5, 7 series Door panels, headliner panel, boot lining, seat backs, noise insulation panels
iii. CITROEN	C5 Interior door panelling
iv. FIAT	Punto, Brava, Marea, Alfa Romeo 146, 156

v. LOTUS	Eco Elise Body panels, spoiler, seats, interior parts
vi. PEUGEOT	406 Seat backs, parcel shelf
vii. RENAULT	Clio, Twingo Rear parcel shelf
viii. ROVER	2000 and others Insulation, rear storage shelf/panel
ix. SEAT	Door panels, seat backs
x. TOYOTA	Brevis, Harrier, Celsior, Raum Door panels, seat backs, spare tyre cover
xi. VOLKSWAGEN	Golf, Passat, Bora Door panel, seat back, boot lid finish panel, boot liner
xii. VOLVO	C70, V70 Seat padding, natural foams, cargo floor tray
xiii. FORD	Mondeo CD 162, Focus

Based on table above, natural fibre composites are commonly used for manufacturing many components in the automotive sector. This is because the characteristic of natural composite fibre composites are highly ultimate breaking force and higher impact strength. Plant fibres are mainly used in this manufacture because of its reduction in weight about 10%, energy production of 80% and 5% cost reduction. (Aková, 2013)

2.2 Natural Fibre

Fibre can be defined as hair-like materials that are continuous filament or discrete elongated pieces which is similar to pieces of thread. The fibres can be spun into filaments, thread, rope and also be matted into sheets to make paper or felt. Fibres can be used as a component of composite materials. Fibres consists two types; there are natural fibres and synthetic fibre. For this research, just focus on natural fibres as constituent for composite materials.

Natural fibres is a substance that produced by plants and animals. The most viable structure fibres typically derive from specifically grown textile plants and fruit trees. Nowadays, natural fibres are more modern than they have ever been as they exposed their outstanding mechanical properties and 100% sustainable. Natural fibre composites with important reduction in weight became a serious alternative to conventional composite materials like glass and carbon fibres. However, natural fibre reinforced composites are more or less sensitive to humidity through absorption of water which is leading to physical degradation such as differential swelling between fibres and resin.

Refer to the research by (Ticoalu et al, 2010) shown that fibre composites offer many advantages such as high strength, light weight, water resistance, chemical resistance, high durability, electrical resistance, fire resistance and corrosion resistance. Natural fibres can be source from plants or animals that are not synthetic. Natural fibre reinforced thermoplastic have been used in automotive application while for infrastructure mostly made out of thermoset resin. From this research, there are several reviews about natural fibre composite for structural and infrastructure applications. One of them is application of natural fibre composite in the development of structural beams and pedestrian bridge which requires low to moderate design loads. By applying the natural fibre composite can lower the density, cost and environmental benefits.

From (Joshi et al, 2004) research, natural fibre composites is environmentally superior in most application. Natural fibre composite also has higher fibre content for equivalent performance which reduces the amount of polluting base polymers. In auto applications, lower weight of natural fibre composites improve fuel efficiency and reduce emission of components. In the future, the natural fibre composites can be more popular in every sector because they are cheaper, lighter and environmental friendly. Therefore, the future research should focus on achieving equivalent or superior technical performance and component life.

Based on (Sanjay et al, 2016) research in the title of applications of natural fibres and its composites shows that the application natural fibres widely used in many sectors such as automobile, furniture, packing and construction due to their advantages which are low cost, low weight, less damage to processing equipment, improve surface finish of moulded parts composite, good relative mechanical properties, abundant and renewable resources. The natural fibres qualities strongly is because of growing environment, age of plant, species, temperature, humidity and quality of soil. Furthermore, in the United States, straw bales as composite materials are being used in construction of building. For automotive sector, many components of car mainly based on polyester or polypropylene and fibres like flax, hemp or sisal. The uses of natural fibre in the automotive industry, because of price, weight reduction and marketing. In German, the auto manufacturers have taken natural fibres composites for interior and exterior applications such as 35% Baypreg F semi rigid polyurethane thermoplastic (PUR) elastomer from Bayer and 65% blend of flax, hemp and sisal.

2.3 Pineapple Leaf Fibre (PALF)

PALF is referred to vegetable fibre that extracted from the leaves. The surface of this fibre is rough and rough. This fibre was obtained from the leaf of the plant *Ananas cosomos* belonging to *Bromeliaceae* family. PALF is showing superior mechanical properties, they have potential as reinforcing in thermoset, thermoplastics and elastomers. These fibres show high ultimate tensile strength and initial modulus because they have high cellulose content and low microfiber angle. PALF can easily obtained and possess excellent mechanical properties.

(Mohammad Asim et al, 2016) carried out study that PALF are consisted by cellulose (70% - 82%), lignin (5% - 12%), and ash (1.1%). PALF are capable for making high quality of polymer composites because they have good mechanical properties which are tensile flexural and impact strength.

Based on (Kottaisamy et al, 2015) research, they have stated about the mechanical properties for the different type of woven pineapple leaf fibre mat (WPALFM) reinforced plastic composites as shown at Table 2.3.

Table 2.3: Mechanical Properties of the WPALFM fibre reinforced plastics (Kottaisamy et al., 2015)

Specimen Code	**Tensile strength, MPa**	**Flexur strength, MPa**	**Shear strength, MPa**
WPALFM (Water treated)	31.15	58.73	13.06
WPALFM (NaOH treated)	48.59	96.86	23.48
WPALFM (Oxalic treated)	35.65	69.86	17.79
WPALFM (NaOH + Oxalic acid treated)	41.19	83.70	19.31

(Panyasart et al, 2014) have mentioned on their research that natural fibre commonly consist cellulose, hemicellulose and lignin. Cellulose is a group of micro fibrils formed from D-glucose units joined by β-1,4-glycosidic linkage and held between chains by hydrogen bond giving its high ordered structure and strong properties. Hemicellulose is a supportive part for micro fibril. Lignin consists of phenolic component to stabilize and protects micro fibril. The purpose of alkaline treatment is to remove hemicellulose and lignin from natural fibre to get better purified cellulose result. Furthermore, this treatment also to increase the surface roughness which can strengthen the physical interlocking between fibre and matrix that can affects mechanical properties of composites. From this research, the raw PALF were immersed and stirred continuously in 5%wt NaOH (Sodium hydroxide) for 5 hours at room temperature. The weight ratio NaOH solution per fibre is

30:1. Then, the mixture was neutralized by adding of 5%wt acetic acid solution and washed by tab water until no alkalinity. After that, washed by distilled water and then dried in an over at 70^{o}C for 24 hours. The results show that fibre surface roughness and surface area increase by doing the treatment.

Refer to the research by (Threepopnatkul et al, 2009) for alkaline treatment, PALF were washed and immersed in water for 24 hours at room temperature. Then, the fibres were washed with acetone and dried in an oven at 120^{o}C for 3 hours. After that, PALF immersed in NaOH 5%wt solution in water bath at 30^{o}C for 5 hours. Next, the fibres were washed with distilled water until no alkalinity. Finally, the fibres dried in an oven at 60^{o}C for 3 hours. From this treatment, the results show that the surface of PALF is relatively smooth than the silane treatment.

(Siregar et al, 2010) state that mechanical properties of natural fibre composite is depend on parameter, modulus, fibre length and orientation due to the interfacial bond strength between fibre-matrix. For this study, the short PALF were soaked in different concentration (0%,2% and 4%) of NaOH solution in water bath for 1 hour at room temperature. The ratio is 20:1 (w/v). After that, the fibres were washed with distilled then, dried in an oven at 80^{o}C for 24 hours. The increased concentration alkaline treatment, increased the mechanical properties of PALF/HIPS composites.

Table 2.4: The effect of alkali treatment of short PALF on the mechanical properties of short PALF/HIPS (High impact polystyrene)
(Siregar et al., 2010)

Mechanical property	**NaOH concentration, %**		
	0	**2**	**4**
Tensile strength (MPa)	22.640 (1.250)	25.717 (1.251)	29.955 (1.356)
Tensile modulus (MPa)	824.646 (156.374)	1197.751 (66.431)	1284.845 (133.881)

Flexural strength (MPa)	31.661 (3.251)	34.371 (1.832)	40.789 (2.496)
Flexural modulus (MPa)	4294.024 (399.515)	4464.058 (122.408)	4559.339 (280.989)
Notched impact (J/m)	24.39 (1.342)	47.164 (3.187)	52.417 (1.580)
Unnotched impact (J/m)	45.460 (2.764)	64.615 (1.124)	76.959 (5.535)
Hardness scale L	84.120 (0.614)	89.260 (1.124)	90.820 (0.709)

2.4 Polypropylene (PP)

Polypropylene (PP) is a thermoplastic polymer used in a varied of applications. The saturated addition polymer is made from the monomer polymer. PP is rugged and unusually resistant to many chemical solvents, base and acids. Also, PP is a strong, lightweight, outstanding toughness, rigidity and resistance to thermal deformation. The team of designers and fabricators value these characteristics to consider PP is the one of the most valuable and satisfactory thermoplastic resins to be applied in any applications. The versatility of this polymer make it well suited for film and fibres requiring superior strength, optical qualities, grease resistance and moisture barrier properties.

Based on her studies (Dakina, 2012), glass fibres as reinforcement for polymer matrix composites due to their characteristics, high electrical insulating properties, low susceptibility to moisture and high mechanical properties. Also, PP is a valuable property because it is lightweight materials, durable, moderately inexpensive and chemical resistant. The glass fibre PP composites undergo two test which is impact test (ASTM-E23) and three point test (ASTM-D618). From the test results, there is improvement of mechanical properties of car bumpers after reinforcement by glass fibre which is impact strength increased from ($85Kj/m^2$) to ($498Kj/m^2$) and compressive strength from (51MPa) to (310MPa). The optimum reinforcing percentage was 70%.

(Bledzki et al, 2007) carried out study about abaca fibres reinforced PP thermoplastics that was patented by Daimler Chrysler's researchers and manufacturing process by Rieter Automotive. Abaca fibres can be described it has high tensile strength, resistant to rotting and flexural strength nearly similar to the glass fibre. Due to these characteristic, abaca fibre has desirable to fulfil the quality requirement for components applied on the exterior of road vehicles which is resistance to influence. Abaca fibre reinforced PP has got outstanding interest in automobile industries because of low cost availability, high flexural, high tensile strength, good abrasion and good resistance to UV rays. The results from the test showed in their studies that 40 wt% was optimal fibre loading for abaca fibre PP composite. Flexural and tensile strength increased 30% to 80% and damping properties improved 30% to 120% for different loading.

(Nam et al, 2014) research is about the effect of natural fibre reinforced PP composite using resin impregnation. In their research have mentioned that thermoplastic resins have high viscosity liquid form or solid form which to permeate into reinforced materials. The thermoplastic polymer PP has specific gravity of 0.90-0.91, the melting point temperatures is 165^oC – 171^oC and crystallinity of 82%. In their research, resin impregnation was added during treatment process. From the mechanical testing, the tensile strength of the kenaf PP composites increased with resin impregnation and also bending test result shows PVA (Polyvinyl alcohol) as resin impregnation got 10% higher than others. It was observed from the results, that resin impregnation could increase tensile strength, flexural strength and elongation break of composites. This resin impregnation was used to improve the mechanical properties of natural fibres.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The flow chart as shown below in Figure 1 is describing the workflow to handle this project for these two semesters. The flow chart starts by studying the literature review about the natural composite, natural fibre and polymer. Next, the materials were prepared such as pineapple leaf fibre and polypropylene for this project and undergo several processes to get the sample. The samples were being tested and analysed to obtain the result about the sample properties.

This chapter is a combination of three basic stages:

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

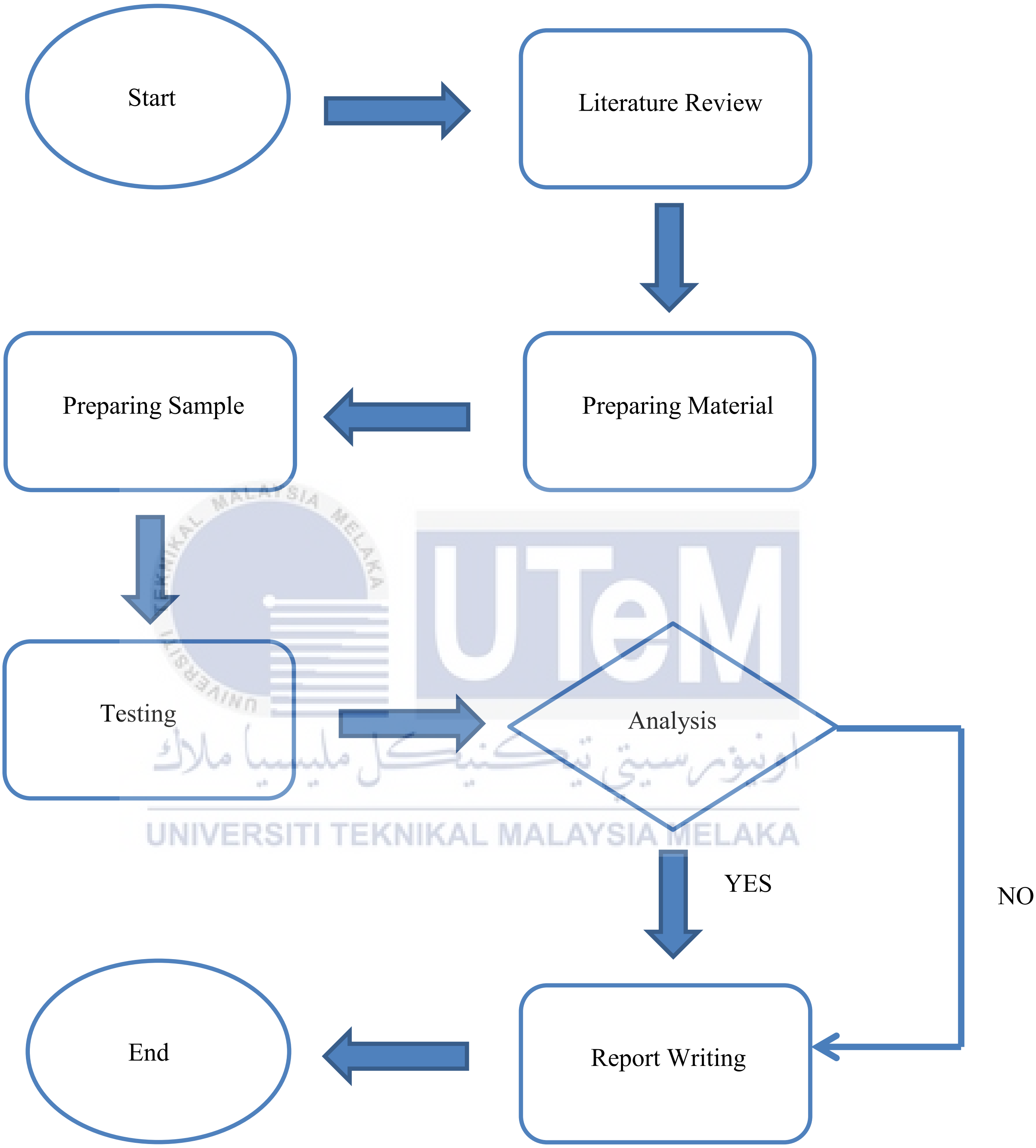

Figure 3.1: Flow chart of the methodology

3.2 Raw Material Preparation

3.2.1 Preparation of Pineapple Leaf Fibre (PALF)

For this research, PALF is a waste pineapple leaves that was collected from Muar, Johore. Separation process for pineapple fibre from the leaves can be done in two ways which is manual and mechanical method. However, for this research manual method was been chosen because this method is more effective than the other one. In this process, microorganisms play an important role to separate Gummy substance which surrounds the pineapple leaves and this process can separate the fibre from the leaves more easily.

For the first step, the leaves were cut one by one from the pineapple tree. Then, a piece of wood is used to break the structure of leaves. After that, the leaves were soaked in the tab water for a few minutes. The next process is the process of using hairbrush to remove the skin leaves which still attached to the fibre surface. Lastly, washed the fibre by using tab water and dried under the sun until the fibre is fully dried.

Figure 3.2: Break and extract the fibre from the leaves

Figure 3.3: PALF after fully dried

For the alkaline treatment, the fibre must treated with chemical agent which is sodium hydroxide (NaOH) solution to remove hemicellulose and lignin components from natural fibre to get better purified cellulose result. This treatment also can increase fibre surface roughness providing physical interlocking between fibre and matrix which affected the mechanical properties of the composites.

Figure 3.4: Sodium hydroxide (NaOH) in pallets form

The fibres were treated with immersed it in 5% aqueous alkali (NaOH) for 30 minutes. After that, washed the fibres several times with distilled water and dried it at 60°C for 24 hours by using oven and under the sun. When PALFs were fully dried, the excess lignin and cellulose fibre are removed manually.

Figure 3.5: PALFs were immersed in NaOH solution

Figure 3.6: PALFs already cleaned and fully dried

When PALFs were fully dried and cleaned, the fibres were chopped less than 1 cm by using scissors which help to gain a smaller size or random – discontinuous form. Figure 3.8 shows the chopped of PALF.

Figure 3.7: PALF were chopped less than 1 cm

Figure 3.8: PALF already chopped

3.2.2 Preparation of Polypropylene (PP)

Polypropylene (PP) is a thermoplastic polymer used in a wide variety of applications including packaging, labelling and textiles. For this research, PP is used as a matrix to reinforce with the fibre to create new materials. PP was undergoes several processes before compounding with fibre.

First process, the raw shape of PP was weighed by using electronic weigh balance machine to get the weight around 10g and then crushed it into pulverizer machine for 1000 seconds. After crushed, the PP was turn to the flakes shape. Then, PP was blended by using a blender machine to get the powder shape and filtered it by using a normal sieve to get the uniformly size. The process was repeated until the PP weighed around 64g for this research.

Figure 3.9: Electronic weighing balance machine

Figure 3.10: The raw shape of Polypropylene (PP) polymer

Figure 3.11: Pulverizer machine

Figure 3.12: The Polypropylene (PP) turn to flake shape after crushed

Figure 3.13: Blender machine

Figure 3.14: Normal sieve

Figure 3.15: Sieved the PP by using normal sieve to obtain powder form

Figure 3.16: The Polypropylene (PP) turns to powder form after blended and filtered

3.3 Sample Preparation

3.3.1 PALF/PP Composite Preparation

In this research, need to provide four sample PALF/PP composite with different ratio.

Table 3.1: The ratio of PALF-PP composite sample

PALF/PP	Weight Percentage (PALF/PP)
10/90	1.6g/14.4g
20/80	3.2g/12.8g
30/70	4.8g/11.2g
40/60	6.4g/9.6g

The ratio for each sample as table above is based on weight percentage. The PALF/PP was mixing up by using manual mixer method. In this process, the PALF and PP were mixed into a medium size container and shake it until it well mixture. Then, weighed the mixture according to weight percentage for each sample and keep it into plastic bag that labelled with A, B, C, and D.

Figure 3.17: The PALF/PP mixture with different ratio

Next, PALF/PP mixture was filled into the mould. The size of mould is 140mm x 60mm. Then, the compounded composites were pressed by using hot press machine to fabricate sample with thickness of 2.0 mm according to the specification that are required in testing sample. The melting point temperature of PP is 170^{o}C. The time of preheat is 5 minutes which to transfer the heat to the mould and the time for compress also is 5 minutes under a pressure 2.5 MPa. The time for cooling is 15 minutes.

Figure 3.18: The shape of mould used for hot press

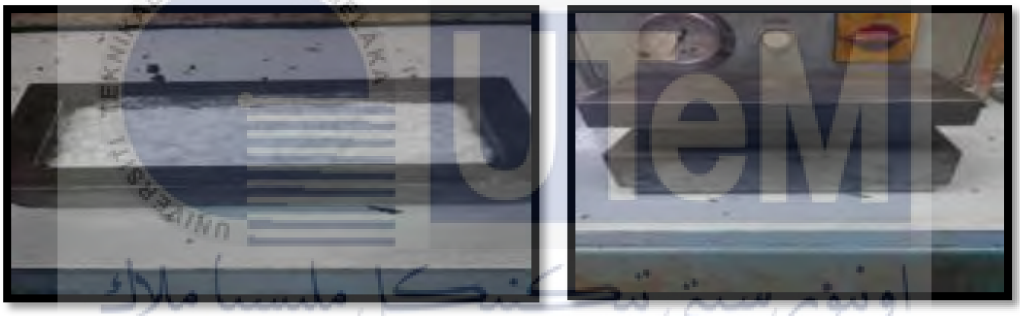

Figure 3.19: PALF/PP mixture were filled into the mould

Figure 3.20: The compounded of PALF/PP composite were compress and cooling by using this hot press and cooling machine

After done with hot compress and cooling process, the mould that filled with compounded composite were removed from the machine and placed it to the mould opener machine, to take out the PALF/PP composite sample from the mould. The size of PALF/PP composite sample that were obtained from the fabrication process is 140 mm x 60 mm x 2 mm.

Figure 3.21: The mould opener machine

Figure 3.22: The samples of PALF/PP composite

Table 3.2: Samples of PALF/PP composite for each composition

PALF/PP (wt%)	Composite
10/90	
20/80	
30/70	
40/60	

3.3.2 Testing Sample Preparation

PALF/PP Composites samples with thickness 2.0 mm were prepared for tensile test specimens, density test specimen, hardness test specimen and microstructure analysis. These entire samples were cut to the shape that is required according to standards of testing sample.

3.4 Testing

There are four testing methods that were used in this study based on American Standard Testing Methods (ASTM) which 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 is performed based on ASTM D3039 towards the composite specimen to measure the force that required break and extend a polymer composite (PALF-PP composite) specimen to find out which specimen stretch or elongates to that breaking point.

For this testing, PALF/PP composite samples were cut into the dimension that required for this testing. A thin flat strip of material composite specimen having a dimension of 140 mm length, 25 mm width, and 2 mm thickness is mounted in the grips of Instron Universal Testing Machine (Model 5585H) controlled by Bluehill 2 software with a 1 kN load test and activated at constant head-speed tests of 2 min/mm.

Specimens were placed and fixed it in the grips of Instron Universal Test Machine at a specified grip separation and pulled until rupture occured. The test speed can be determined the specification time of time to failure (1 to 10 minutes) of materials. Then, the values of tensile stress, tensile strain and the percentage of elongation were obtained from the stress-strain curve diagram.

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Figure 3.23: The PALF/PP composites samples were cut into specified dimension

Figure 3.24: PALF/PP composite samples already cut into specified dimension

Figure 3.25: Instron Universal Testing Machine

Figure 3.26: PALF/PP composite samples ruptured after tensile test

3.4.2 Density Test (ASTM D792)

Density test described the determination of the specific gravity and density of solid plastics. This testing method actually, to determine the mass of a specimen of the solid plastic in air. The thickness of specimen is 2 mm. The specific gravity is calculated because to identify a material, to follow physical changes in a sample and to indicate degree of uniformity among different specimens.

The specimens were testing by using a digital electronic densimeter (MD-300S). Firstly, the specimens apparent mass were measured and then, the specimens were immersed in a liquid. The value of specific gravity and volume can be obtained.

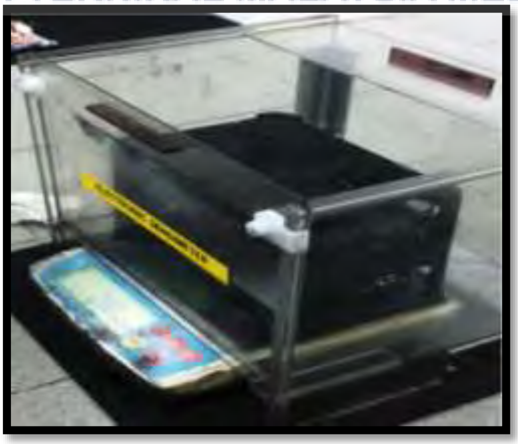

Figure 3.27: Digital Electronic Densimeter

Figure 3.28: The apparent mass of PALF/PP composite specimen was measured

Figure 3.29: The PALF/PP composite specimen was immersed in the water

3.4.3 Hardness Test (ASTM D2240)

The hardness test is measured by using the analogue Shore scale "D" type Durometer based on ASTM D2240. This method measures the depth of the indentation of the samples and provides an empirical hardness value. The surface of the specimen shall be flat and the thickness at 2.0 mm. The measurement should be taken at least 12 mm from the edge of the sample because the hardness characteristics tend to change at the edge of the sample.

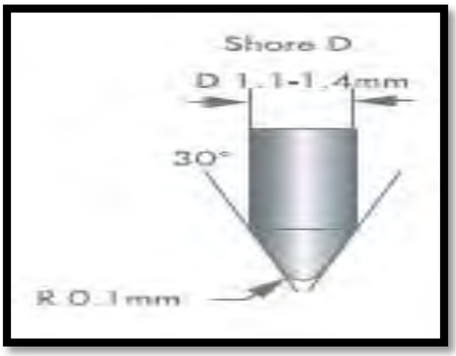

Figure 3.30: The type D indentor

Figure 3.31: The Analogue Shore Scale D-type Durometer

3.4.4 Microstructure Analysis (SEM)

The most commonly used microscope is the conventional light microscope. However, not all material transmits light, so the researcher decided to look at the surface of the specimen with an optical microscope, namely Scanning Electron Microscope (SEM).

SEM was used to expose the orientation of fibre reinforced thermoplastics and also to obtain information about the formation of bonding between fibres and matrix. The surface was examined and scanned with an electron beam. SEM can produce a visual image of a large magnification scale which allows the irregular surface of materials to be observed.

In this research, SEM was used to study the formation bonding between matrix and fibre, the orientation of fibre reinforced thermoplastic and also the condition of fibre in different percentage loading reinforced with thermoplastic. SEM that was used in this research is JEOL JSM-6010PLUS/LV. Before performing SEM, the samples for each percentage loading were cut into dimension 10mm x 10mm. Then, the samples with different percentage loading were tied together and placed on a stub or auto fine coater (JEOL JEC-3000FC), coated with platinum. In the auto fine coater, the samples were vacuumed to prevent interference of scanning picture due to the existence of air. After that, the samples were inserted into the scanning barrel. Next, through the monitor screen, the magnification, brightness and contrast can be adjusted to obtain the best visual image.

Figure 3.32: Auto Fine Coater

Figure 3.33: The condition of sample after coated with platinum

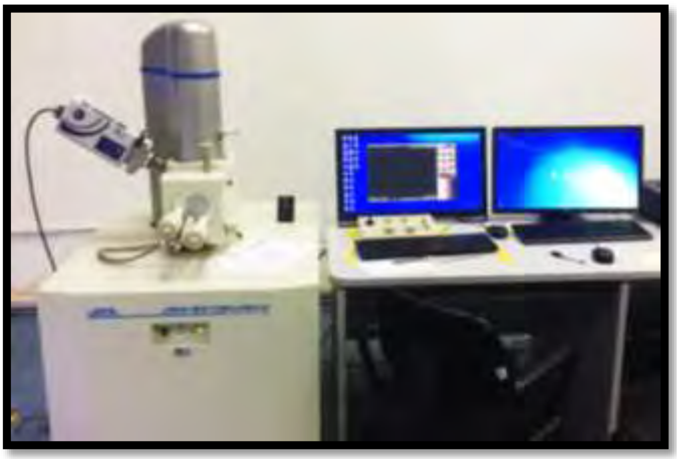

Figure 3.34: Scanning Electron Microscope (JEOL JSM-6010PLUS/LV)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

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

4.2 Effect of Mechanical Test

One of the objectives in this research was to study the mechanical properties of pineapple leaf fibre (PALF) reinforced PP composite.

Table 4.1: Tensile properties of the samples

PALF Loading (wt%)	Maximum Load (N)	Tensile stress, σ (MPa)	Tensile strain, Ɛ (mm/mm)
10	1262.69	25.26	0.03655
20	1194.74	23.90	0.02457
30	1176.59	23.54	0.02038
40	1072.68	21.46	0.01623

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Table 4.1 shows the result obtained for the tensile test of the PALF/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 10 wt% loading percentage of PALF is the highest value among others which is 1262.69 N while the 40 wt% loading of PALF is the lowest, 1072.68 N. For the others percentage loading 20 wt% and 30 wt% of PALF are 1194.74 N and 1176.59 N. The pattern for this graph is decreasing because the PALF/PP composite that has less fibre contents can carried out high maximum load than PALF/PP composite that filled with more fibre contents. Maximum load is highest at 10 wt% loading because this sample has low quantity of fibre thus the elasticity is the highest than others. So, it can withstand higher maximum load for a long time to fracture. The sample that has 40 wt% of fibre was a bit excessive and PP matrix have hard situation to flow through every fibre while the fibre are more easily revealed to the environmental degradation. Thus, this situations were occurred the composition difficult to produce and composite become brittle.

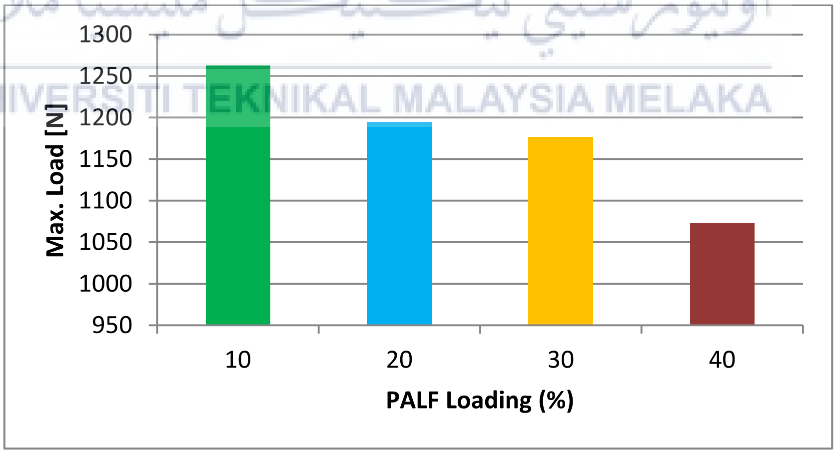


Figure 4.1: The Graph of Maximum Load (N) against The Percentage of PALF Loading(%)

Figure 4.2 shows the result between the tensile stress at maximum load (MPa) against the percentage loading of PALF (wt%). According to the results obtained, tensile stress at maximum load for 10 wt% loading of PALF is the highest value which is 25.26 MPa. However, for 40 wt% loading of PALF fibre is 21.46 MPa which is the lowest value of tensile stress at maximum load. For the 20 wt% and 30 wt% loading percentage of PALF, the values are 23.90 MPa and 23.54 MPa. The pattern of the graph showed that increasing the fibre loading reduced the tensile strength. This is because the PALF/PP composite that have less fibre are more elastic than PALF/PP composite that have more fibre. Also, the addition of fibres were disturbing the PP segment mobility and causing the plastic turn to be more brittle.

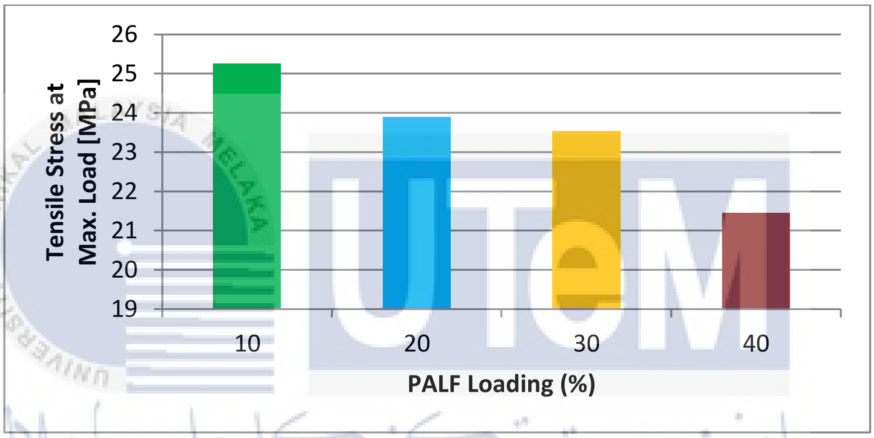


Figure 4.2: The Graph of Tensile Stress at Maximum Load (MPa) against The Percentage of PALF Loading(%)

Based on the Figure 4.3 shows the result between Load (N) against Extension (mm) during tensile test for the PALF/PP composite sample with different percentage of loading (wt%). According to the graph below, the result stated the different pattern for the different percentage loading. 10 wt% shows the highest pattern for this graph, second higher is 20 wt%, third is 30 wt% and the lowest value is 40 wt%. For the 10 wt% have the lowest value of fibre in the PALF/PP composite sample. Thus, the ductility level is the highest, so it can be extended with the highest maximum level than others percentage fibre loading before it ruptured. The samples that have more percentage loading of fibre tend to easily ruptured because of their low ductility.

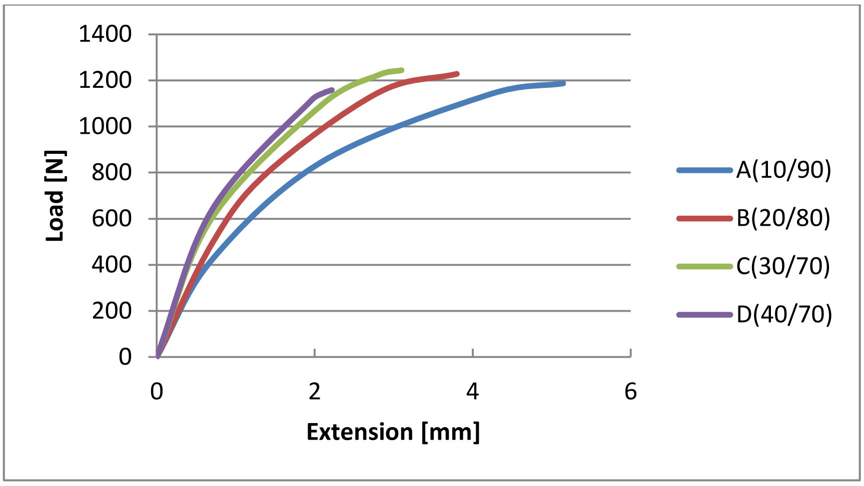


Figure 4.3: The Graph of Load (N) against Extension (mm) with the different percentage of fibre loading (wt%)

Based on the Figure 4.4 below, the graph shows the result of tensile test between tensile stress (MPa) against strain stress (mm/mm) which to define the mechanical properties of PALF/PP composite. According to the pattern of the graph, Stage I shows the strain range between fibres and matrix facing elastic deformations and in the tensile plot is observed as straight line. For the Stage ii, is a region which fibres deform elastically while the matrix deform plastically. After a few seconds, the fibres show a brittle failure because of low ductility.

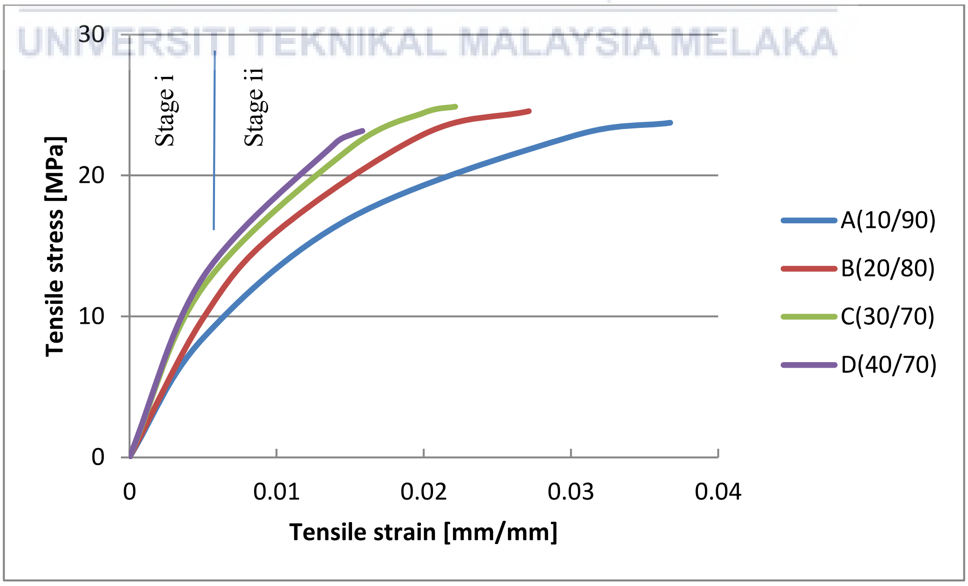


Figure 4.4: The Graph of Tensile Stress (MPa) against Tensile Strain (mm/mm) with the different percentage of fibre loading for the PALF/PP composite samples

4.3 Effect of Physical Test

Furthermore, another objective in this research was to study the physical properties of pineapple leaf fibre (PALF) reinforced PP composite.

Table 4.2 and Figure 4.5 show the results of density (g/cm^3) and the percentage of PALF loading for PALF/PP composite. Based on the table below, the result shows that the value of density increases with the increment of PALF loading. For the 10 wt% of PALF loading has the lowest value of density which is 0.9940 g/cm^3 while 40 wt% of PALF got the highest density, 1.0045 g/cm^3. For the 20 wt% and 30 wt%, both of them have the constant value of density which is 0.9970 g/cm^3. This increasing trend obtained due to the increment of fibre content that effect the composition in the composite. When there are many fibres content, the space between fibre and matrix are much closer which indicate the composition is more pack. Therefore, it causes the PALF/PP composite which has high fibre content is denser than water.

Table 4.2: Density properties of the samples

PALF loading (wt%)	Density (g/cm^3)
10	0.9940
20	0.9970
30	0.9970
40	1.0045

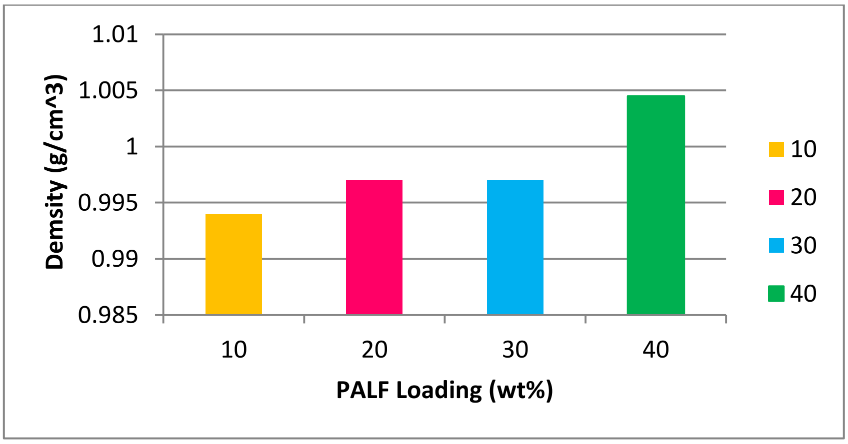


Figure 4.5: The Graph of Density (g/cm^3) against PALF loading (wt%)

Meanwhile, the Table 4.3 and Figure 4.6 show the results of hardness (Shore-D) and the percentage of PALF loading (wt%). Based on the table, shows that the pattern of the graph is increase due to the increment of fibre content. The 40 wt% of PALF loading has the highest fibre content got the highest value of hardness which is 71.50 (Shore-D) while 10 wt% of PALF loading is the lowest value of hardness, 69.00 (Shore-D). This pattern obtained due to the increment of fibre content. When the quantity of fibre content is high, the composite is stronger than less fibre content. High fibre content can increase the bonding and the composition between fibre and matrix.

Table 4.3: Hardness properties of the samples

PALF loading (wt%)	Hardness (Shore-D)
10	69.00
20	69.70
30	70.00
40	71.50

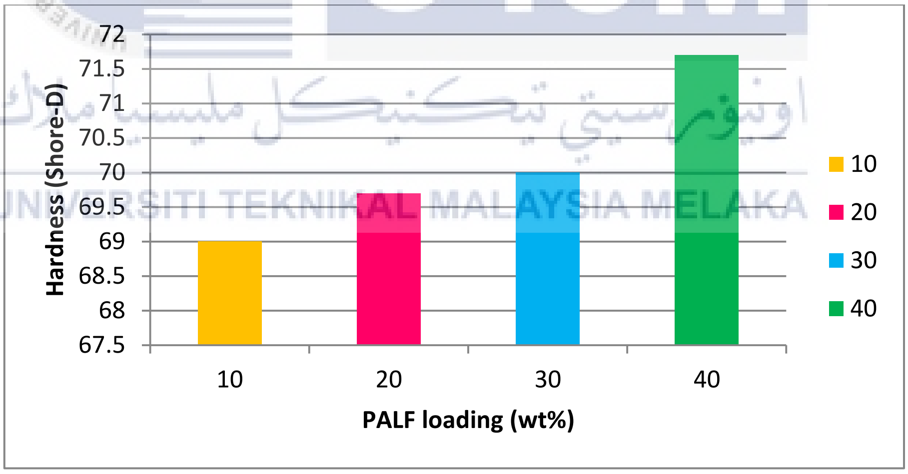
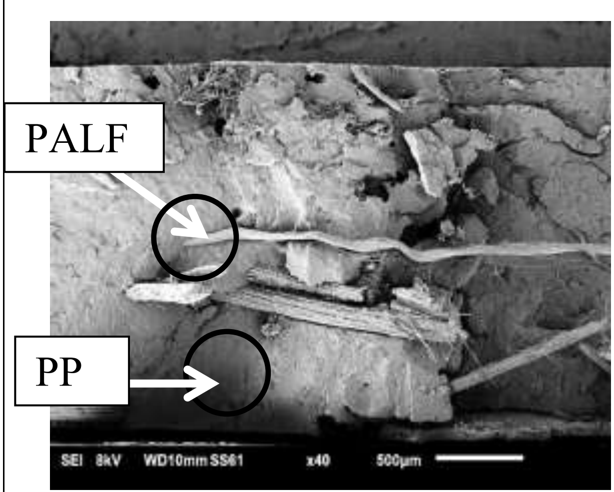


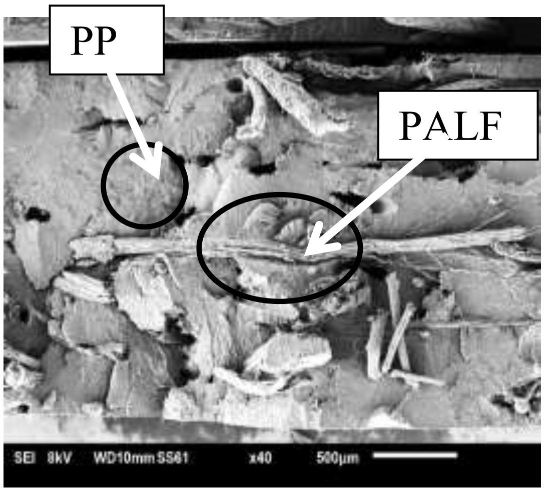
Figure 4.6: The Graph of Hardness (Shore-D) against PALF Loading (wt%)

4.4 Microstructure Analysis (SEM)

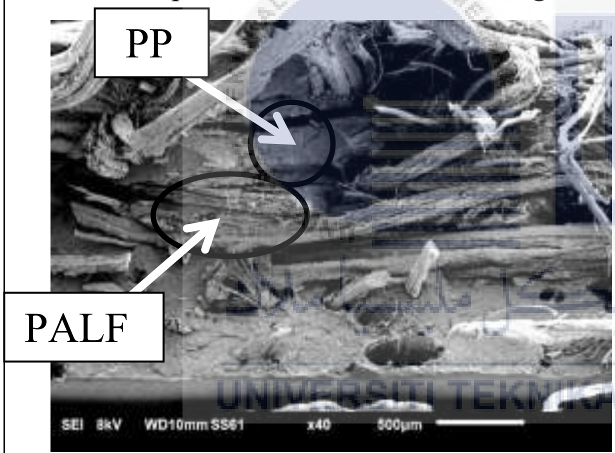
4.4.1 Magnification x40



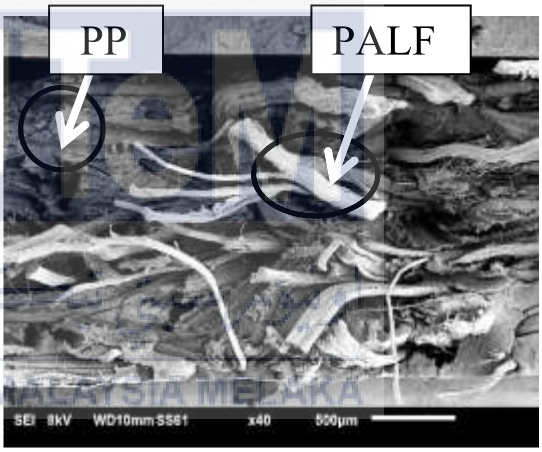
Sample A: 10 wt% PALF loading



Sample B: 20 wt% PALF loading



Sample C: 30 wt% PALF loading



Sample D: 40 wt% PALF loading

Figure 4.7: The microstructure analysis for percentage loading of fibre in PALF/PP composite

Based on the Figure 4.7 which is about the scanning electron microscope towards the PALF/PP composites with magnification of 40. From these figure can be analyzed that sample A with 10 wt% PALF loading has less fibre contents, compared to the sample D which is 40 wt% of PALF loading and has highest fibre contents. Can be seen there is a difference pattern based on the increment of fibre contents. When the quantity of fibre is higher due to the increment of percentage fibre loading, the composition between fibre and matrix in the composite are become closer and packed.

4.4.2 Magnification x100

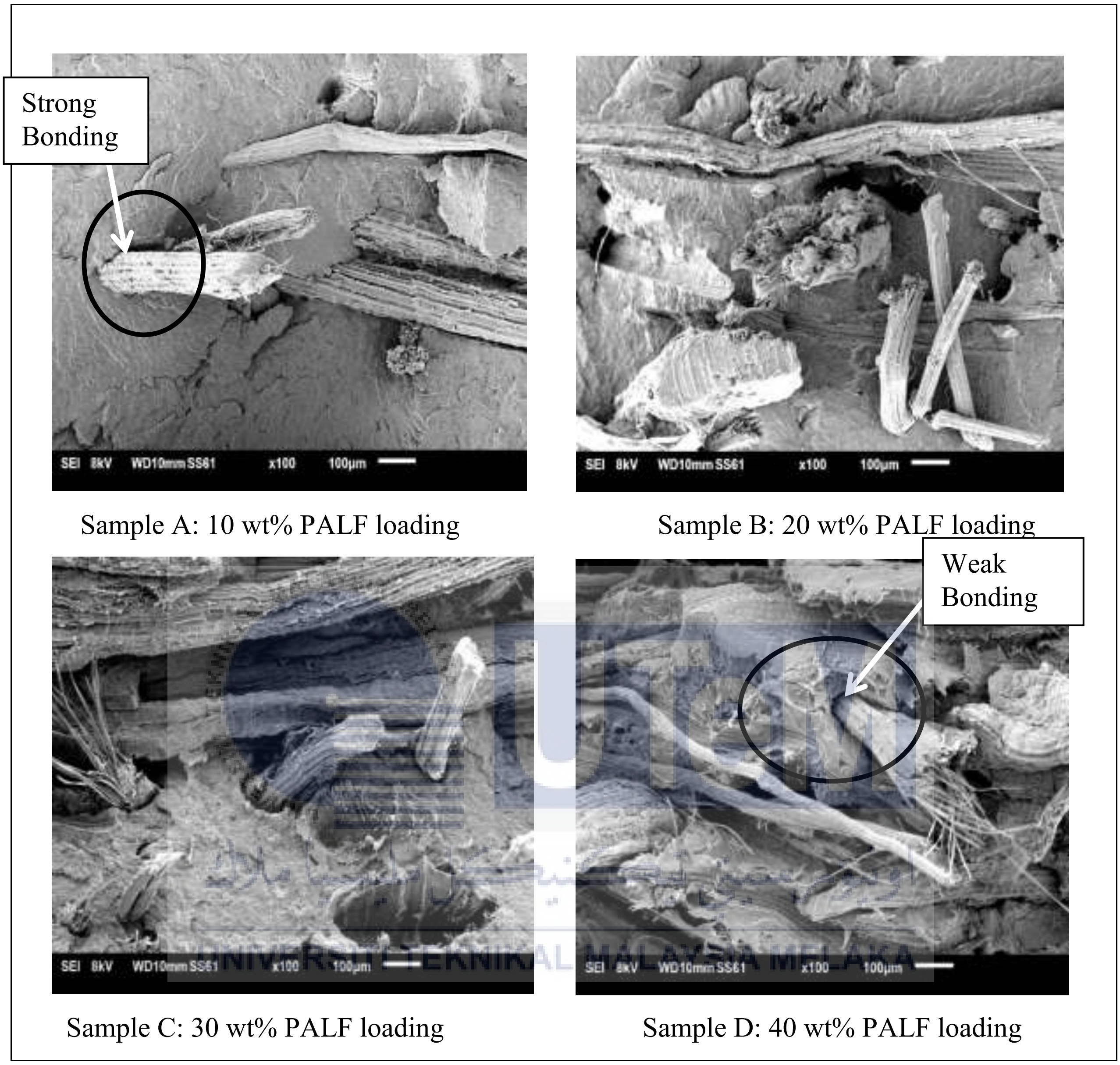
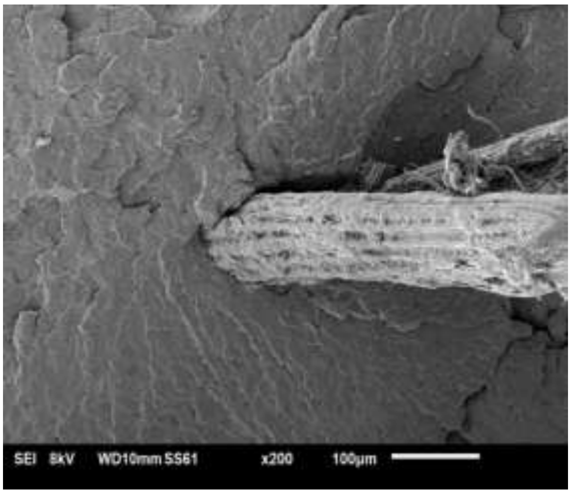
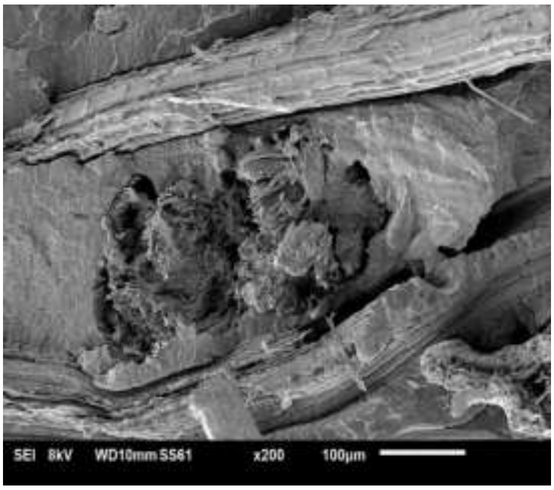


Figure 4.8: The microstructure analysis for interfacial bonding in PALF/PP composite

Based on the Figure 4.8 which is about the scanning electron microscope towards the PALF/PP composites with magnification of 100. From the figure above can be analysed that 10 wt% has highest strength adhesion bonding between fibre and matrix because the fibre is not fully pull out when undergoes tensile test. Less fibre contents in the composition caused the fibre got less competition for the space and have stronger bonding between matrix and fibre. For the 40 wt% of PALF loading, the adhesion bonding between the fibre and matrix tends to weak due to the higher fibre contents in the composition.

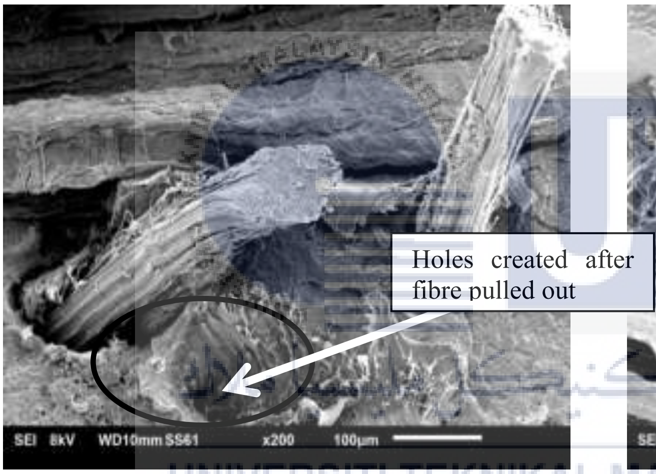
4.4.3 Magnification x200

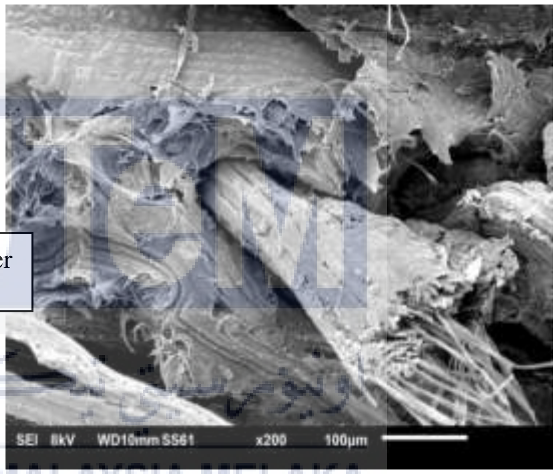




Sample A: 10 wt% PALF loading

Sample B: 20 wt% PALF loading





Sample C: 30 wt% PALF loading

Sample D: 40 wt% PALF loading

Figure 4.9: The microstructure analysis in PALF/PP composite

Meanwhile for this Figure 4.9 which is about the microstructure analysis in PALF/PP composite with magnification x200. From this figure also shows the holes were created after fibre was pulled out. These figures show that the pull out pattern can be seen in these four figures. All of them have different pattern direction of pull out. These pull outs fibre can be noticed with the holes left in the matrix surface after the clear cut during tensile test. For the sample C, can be seen that there are many holes left in the matrix surface because of weak adhesion interface bonding between matrix and fibre. The increment of percentage fibre loading caused the structure between fibre and matrix is not aligned.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This project is actually to study about how to produce a natural composite from the compounding between natural fibre and thermoplastic. The materials that have been used in this project are Pineapple leaf fibre (PALF) and polypropylene (PP). PALF was act as reinforcement while PP as a matrix. The PALF/PP composite also can be used for the application in the manufacturing of automotive industry. Hence, the main objective for this project is to identify the mechanical and physical properties of PALF/PP composite and also to analyse the microstructure of PALF/PP composite

From the results obtained in this research, the mechanical properties which undergoes tensile testing shows that decreasing pattern linearly with the increment of percentage fibre loadings. 10 wt% of fibre loading shows the highest value of tensile strength which is 25.26 MPa. Moreover, for the hardness and density result, 40 wt% shows the highest result which are 71.50D and 1.0045g/cm^3. According to the result, can be identified that, the percentage of fibre loading were effected the mechanical and physical properties of natural composite.

Lastly, can be concluded that the deducted of percentage fibre loading will give beneficial for mixed properly with the fibre. Also, easier to melt and mixed each other during fabrication process. Thus, can be classified that the natural composite that have less percentage of fibre loading would become a good potential to produce the superior composite materials.

5.2 Recommendation

For the further research of this study, there are few recommendations to improve the result for the mechanical properties of PALF/PP. The key points in this recommendation basically about the preparation of materials, treatment process, and also fabrication process which are needed to be improve step by step when handling this process for the better result in the future. The recommendations are listed as below:

5.2.1 Preparation to obtain raw materials

In order to obtain fibre that has higher strength, get the leaves which are still fresh enough to obtain a good result in the future. During undergoes drying process make sure PALF not drying under the sun for too long. Furthermore, there is a suggestion to analyse fibre with different length in the future to find out the relation between length and its properties.

5.2.2 Treatment process towards the PALF

During treatment process, there is suggestion can be used to improve the process of treatment. Firstly, the fibre should be treated half by half portion. By doing this method, the fibre would be fully treated and immersed in alkaline solution. Then, when cleaning the fibre with distilled water makesure the fibre is cleaned from any cellulose or lignin. During drying process, the fibre should not be dried under the sun for a long time because it can remove the properties in the fibre. Also, in the future analysis, there is a suggestion to treat the fibre with different percentage of concentration.

5.2.3 Fabrication process of the sample

When carry out fabrication process, makesure the temperature, pressure and time are following the standard rules specification. For the temperature, makesure the temperature not more than temperature that already stated in the standard rules because it would be affected the structure of the composite. Also, when fill up the mixture between fibre and matrix into the mould, makesure there are no any pieces left around the mould. If they are still existed, clean up first and then put it into the hot press machine. This cases can tend to the mould is difficult to open it after the fabrication process is done.

5.2.4 Testing

To improve this research, more mechanical and physical testing can be done. So, many physical and mechanical properties can be studied in this research. In the future research, testing like impact test and water absorption test can be done for further analysis.

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APPENDICES

APPENDIX A : ASTM Standard