UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF OIL PALM TRUNK (OPT) AND OIL PALM FROND (OPF) FIBER TO PHYSICAL AND MECHANICAL PROPERTIES OF POLYURETHANE (PU)

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Engineering Technology (Maintenance Technology)(Hons.)

by

MUHAMMAD NUR ASYRAF BIN AB RAZAK

B071310276

910616-04-5227

FACULTY OF ENGINEERING TECHNOLOGY

2016

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **THE EFFECT OF OIL PALM TRUNK (OPT) AND OIL PALM FROND (OPF) FIBER TO PHYSICAL AND MECHANICAL PROPERTIES OF POLYURETHANE**

SESI PENGAJIAN: **2016/17**

Saya **MUHAMMAD NUR ASYRAF BIN AB RAZAK**

Mengaku membenarkan Laporan PSM ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Laporan PSM adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan laporan PSM ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☐	TIDAK TERHAD	

Disahkan oleh:

_________________________ _________________________

Alamat Tetap:
SU 515 – A Jalan Mawar,
Taman Sungai Baru, 78300
Masjid Tanah, Melaka.

Cop Rasmi:

Tarikh: _________________________

Tarikh: _________________________

**Jika Laporan PSM ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/ organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

DECLARATION

I hereby, declared this report entitled “Effect of Oil Palm Trunk (OPT) and Oil Palm Frond (OPF) Fiber to Physical and Mechanical Properties of Polyurethane (PU)” is the results of my own research except as cited in references.

Signature	: …………………………………………….
Author’s Name	: MUHAMMAD NUR ASYRAF BIN AB RAZAK
Date	: 09.01.2017

APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours. The member of the supervisory is as follow:

Dr Abdul Munir H.S. Lubis

(Project Supervisor)

ABSTRAK

Pada masa kini, industri kelapa sawit menjana sejumlah besar sisa pertanian di Malaysia seperti batang kelapa sawit (OPT), pelepah kelapa sawit (OPF) dan tandan buah kelapa sawit (EFB). Baki terdiri daripada biomass boleh dibangunkan komposit bahan baru, di mana (OPT) dan (OPF) digunakan sebagai tetulang dan Poliuretana Termoplastik (TPU) yang digunakan sebagai matriks. Kajian ini menyiasat kesan batang kelapa sawit (OPT) dan serat pelepah kelapa sawit (OPF) sifat-sifat fizikal dan mekanikal Poliuretana Termoplastik (TPU). Sebelum fabrikasi, gentian telah dirawat dengan 2% natrium hidroksida (NaOH) rawatan dan dikeringkan di bawah matahari. Spesimen sampel komposit dengan empat pecahan jumlah berbeza serat kelapa sawit telah direka, (0% berat, 10 berat %, 20% berat dan 30% berat). Sampel telah disediakan oleh kaedah pengacuan mampatan. Sifat-sifat mekanik komposit telah disifatkan oleh ujian tegangan, ujian lenturan dan ujian hentaman. Interaksi antara gentian dan matriks diperhatikan dari mikrograf elektron imbasan mikroskop (SEM). Ujian tegangan dan ujian lenturan bagi komposit telah dijalankan menggunakan Instron 5960 ruangan dual dan ujian hentaman akan dijalankan oleh impak pendulum. Ketumpatan komposisi menunjukkan penurunan dengan jumlah 1.322 g/m³ pada 0% sehingga 1.186 g/m³ pada 30%. Jumlah tertinggi bagi ujian tegangan adalah 8.389 MPa pada 30% manakala jumlah terendah adalah 7.073 MPa pada 0%. Untuk kekuatan lenturan didapati menurun dengan jumlah 3.587 MPa pada 20% serat di dalam matrik. Ujian hentaman menunjukkan trend yang semakin meningkat dari 4.23 J/m pada 0% sehingga 6.0 J/m pada 30% serat di dalam matrik. Tegasan tegangan, tegasan lenturan dan ujian hentaman meningkat dengan ketara dengan peningkatan serat di dalam matrik.

ABSTRACT

Nowadays, an oil palm industry generates a huge amount of agricultural waste in Malaysia such as oil palm trunk (OPT), oil palm frond (OPF) and oil palm fruit bunch (EFB). The remaining consist of biomass can be developed new material composite, where the (OPT) and (OPF) used as a reinforcement and Thermoplastic Polyurethane (TPU) used as a matrix. This research investigates the effect of oil palm trunk (OPT) and oil palm frond (OPF) fiber to physical and mechanical properties of Thermoplastic Polyurethanes (TPU). Prior to fabrication, the fiber was treated with 2% sodium hydroxide (NaOH) treatment and dried under the sun. Composite sample with four different volume fractions of oil palm fiber were fabricated, (0 wt %, 10 wt %, 20 wt % and 30 wt %). The samples were prepared by compressive molding method. The mechanical properties of composites were characterized by tensile test, flexural test and impact test. Interaction between fiber and matrix was observed by the scanning electron microscope *(SEM)* micrograph. Tensile test and flexural test of the composites were carried out using Instron 5960 dual column tester and the impact tests were conducted by Pendulum Impact Testing Machine. The density composition shows decreasing trend from 1.322 g/m^3 at 0% to 1.186 g/m^3 at 30%. Tensile strength significantly increases with an increase in fiber loading. The highest value of tensile stress 8.389 MPa at 30% fiber loading and the lowest tensile stress 7.073 MPa at 0% fiber loading. For flexural strength was found decreased 3.587 MPa at 20% fiber loading. Impact energy shows the increasing trend from 4.23 J/m at 0% to 6.0 J/m at 30% fiber loading. Tensile strength, flexural strength and impact energy significantly increased with an increasing of fiber loading.

DEDICATION

Specially dedicated to my beloved father Ab. Razak Bin Ab. Rahim and beloved mother Nik Bte Ali, brothers and sisters, to all family members, lecturers and friends.

ACKNOWLEDGEMENT

Alhamdulillah, Thanks to Allah SWT, whom with His willing give me the opportunity to complete this Final Year Project. This final year project report was prepared for Faculty of Engineering Technology (FTK), University Technical Malaysia Melaka (UTeM), basically for student in final year to complete the undergraduate program that leads to the degree of Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honors. Firstly, I would like to express my deepest thanks to, Dr Abdul Munir H. S. Lubis my supervisor who had guided me a lot to finish this final year project. Deepest thanks and appreciation to my parents, family, special mate of mine, and others for their cooperation, encouragement, constructive suggestion and full of support for the report completion, from the beginning till the end. Also thanks to all of my friends, assistant instructor laboratory and everyone, that has been contributed by supporting my work and helps myself during the final year project till it was fully completed.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

OPT	-	Oil Palm Trunk
OPF	-	Oil Palm Frond
PU	-	Polyurethane
EFB	-	Empty Fruit Bunch
MMCs	-	Metal Matrix Composites
PMCs	-	Polymer Matrix Composites
CMCs	-	Ceramic Matrix Composites
nm	-	nano meter
FRP	-	Fiber Reinforced Plastic
wt%	-	Weight Percentage
MDI	-	Methylene Diphenyl Diisocynate
MEKP	-	Methyl Ethyl Ketone Peroxide
CO2	-	Carbon Oxide
FYP1	-	Final Year Project 1
FYP2	-	Final Year Project 2
UTM	-	Universal Testing Machine
ASTM	-	American Standard Testing Machine
MPa	-	Mega Pascal
J/m	-	Joule per Meter
g/m^2	-	Gram per Meter Square

CHAPTER 1

INTRODUCTION

1.0 Background of Study

Nowadays, oil palm industry grows up with quickly, almost very little room remains for any significant increase in oil palm plantations in Peninsular Malaysia. As such, all future growth is expected to be in Sabah and Sarawak. Nowadays, is the one biggest oil palm produce and presently creates around 6.5 million metric huge amounts of world palm oil generation, (Law and Jiang, 2001). Currently, a total of 3.5 million hectares of oil palm plantations, while the statistic of oil palms production for the year 2001 was 11.8 million tons (Hussin et al. 2002). Usually the lifespan of a palm tree has about 25 years; it can contribute high amount of agricultural waste in Malaysia. According to Khalid et al. (2008) the oil palm that dispersed all areas they had turned into an essential part in economy of the south east asia. However, oil palm industries produce a large amount of solid waste called biomass. Malaysia has produced about 70 million tons of oil palm biomass, including trunks, fronds and empty fruit bunches in 2006, (Yacob, 2007) and within a year millions of tons of oil palm biomass was produced by Malaysian palm oil industry. (Rozman et al. 2005).

An oil palm industry generates a huge amount to agricultural waste in Malaysia such as oil palm trunk (OPT), oil palm frond (OPF) and oil palm empty fruit bunch (EFB). In Malaysia oil palm trunk (OPT) and oil palm frond (OPF) biomass has many uses, because oil palm fiber are very multifunction and versatile, they can be processed into various dimensional grades to suit specific applications and can be used by manufactures to make various fiber composites such as furniture, infrastructures, mattress and many more. Other than that, Thakur et al. (2012) and

Bhowmick et al. (2012) stated that oil palm trunk (OPT) and oil palm frond (OPF) fibre is kind of natural fibres that very lightweight, can absorb a lot of water without congealing, renewable in nature, high modulus and specific strength properties. It also can withstand extremes temperature and moisture condition.

1.1 Problem Statement

Malaysia is the largest producer of palm oil in the world and through this activity, it produces huge production of biomass such as trunk, frond and empty fruit bunches. Therefore, huge quantities of these residues are generated and largely unutilized and cause problem to the environment. Thus, in order to manage the waste involved demand special attention from various segments of society. Currently, in Malaysia, we have about 7 million tons of oil palm trunks per year for replanting and burned, creating massive pollutions and economic problems. Sreekala et al. (1997) stated that when left on the plantation floor, these materials create great environmental problem. For this reason, economic utilization of these fibers will be beneficial. Therefore, with minimize and reuses the waste are important thing to recover the environmental problem. This project uses thermoplastic polyurethane (TPU) as the matrix for the composite. Polyurethanes are a standout amongst the most flexible plastic and adaptable materials, which demonstrate diverse practices by changing the proportion of their segments. Thermoplastic polyurethanes (TPU) are a subcategory of copolymers called thermoplastic elastomers (TPE). They were one of the first segmented copolymers to be made commercially available. To overcome this, the effect of oil palm trunk (OPT) and oil palm frond (OPF) fiber with addition of thermoplastic polyurethane (TPU) is still not much known. Not so many people nowadays discuss about the oil palm fibers and thermoplastic polyurethane (TPU). In several research had found with addition of composite to the natural fibres has given the highest tensile strength and flexural strength (Yusof et al. 2010). Other word, chance to find the use of palm fiber in the composite fiber will open a new market in the world for what would normally be considered waste or low value products.

1.2 Objective

Based on the introduction and problem statement above, the objective of this study are as follows:-

i. To investigate effect of different ratio of OPT/OPF fiber to tensile test properties of Thermoplastic Polyurethane (TPU)
ii. To investigate effect of different ratio of OPT/OPF fiber to flexural test properties of Thermoplastic Polyurethane (TPU).
iii. To investigate effect of different ratio of OPT/OPF fiber to impact test properties of Thermoplastic Polyurethane (TPU).

1.3 Scope

These scopes are determined in order to achieve the objective:-

i. Prepare the sample of oil palm trunk (OPT) and oil palm frond (OPF) fibres reinforced with thermoplastic polyurethane (TPU).
ii. Test the sample by performing the mechanical properties test such as: -
    - Test using tensile testing machine ASTM D638
    - Test using standard flexural testing machine ASTM D790
    - Test using notched bar impact testing machine ASTM D256

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Composite

Nowadays, composite materials have changed the world of materials uncovering materials which are unique in relation to basic heterogeneous materials. The composite material can be classified as a combination of two or more materials. Example of composite material to reinforcing phase is in the form of fibers, flakes, and particles. Besides that, another word for composite material embedded in other materials are known as matrix phase. According Jartiz A. E (1965) composites are multifunctional material frameworks that give qualities not possible from any discrete material. They are strong structures made by physically joining two or more good materials, distinctive in organization and qualities and once in a while in structure. In several study, the composites are compound materials which vary from combinations by the way that the individual parts hold their qualities yet are so joined into the composite as to take advantage just of their traits and not of their deficiencies, in order to obtain improved materials, (Nucleus et al. 1966). Van Suchetclan et al. (1977) explained clarifies composite materials as heterogeneous materials comprising of two or more strong stages, which are in intimate contact with each other on a minute scale. They can be likewise considered as homogeneous materials on an infinitesimal scale as in any bit of it will have the same physical property. Kelly A (1967) stated very clearly that the composites ought not to be viewed straightforward as a blend of two materials. In other word, the blend has its own specials properties. The reinforcing material and the matrix material can be metal, ceramic, or polymer. Composites typically have a fibers or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members.

Composites, the wonder materials are becoming an essential part of today's materials due to the advantages such as low weight, corrosion resistance, high fatigue strength, and faster assembly. They are extensively used as materials in making aircraft structures, transportation, aerospace, automotive industry, sport equipment, electronic packaging to medical equipment, and space vehicle to home building (M.K. Chryssanthopoulo, 2010). This is because the composite material has their own special properties. According F.C Cambell (2010) the main advantages of composite materials are many, including lighter weight, the ability to tailor the layup for optimum strength and stiffness, improved fatigue life, allowing for a weight reduction in the finished part, corrosion resistance, and with good design practice, reduced assembly costs due to fewer detail parts and fasteners. In terms of strength to resistance to heat or some other desirable quality, it is better than either of the components alone or radically different from either of them. According Callister W. D. (2007) stated that, most composites have been created to improve combinations of mechanical characteristics such as stiffness, toughness, and ambient and high-temperature strength.

2.2 Classification of Composite Materials by Matrix

According M. Neitzel (1998) based on its matrix; composite material can be classified into metal matrix composites (MMCs), ceramic matrix composites (CMCs), and polymer matrix composites (PMCs) as shown in the Figure 2.1. The classifications according to types of reinforcement are particulate composites (composed of particles), fibrous composites (composed of fibers), and laminate composites (composed of laminates). Fibrous composites can be further subdivided on the basis of natural/biofiber or synthetic fiber. Biofiber encompassing composites are referred to as biofiber composites. They can be again divided on the basis of matrix, that is, non biodegradable matrix and biodegradable matrix (Nicoleta, I. and Hickel, H. 2009). Bio-based composites made from natural/biofiber and biodegradable polymers are referred to as green composites. These can be further subdivided as hybrid composites and textile composites. Hybrid composites comprise of a combination of two or more types of fibers. Many different combinations of reinforcement and matrix materials are used to produce composite materials. Most composites comprise of a bulk material (matrix) and reinforcement or something to that affect, added basically to expand the quality and increase the strength and stiffness of the matrix. Depending on type of matrix used, the composite may be classified as: -

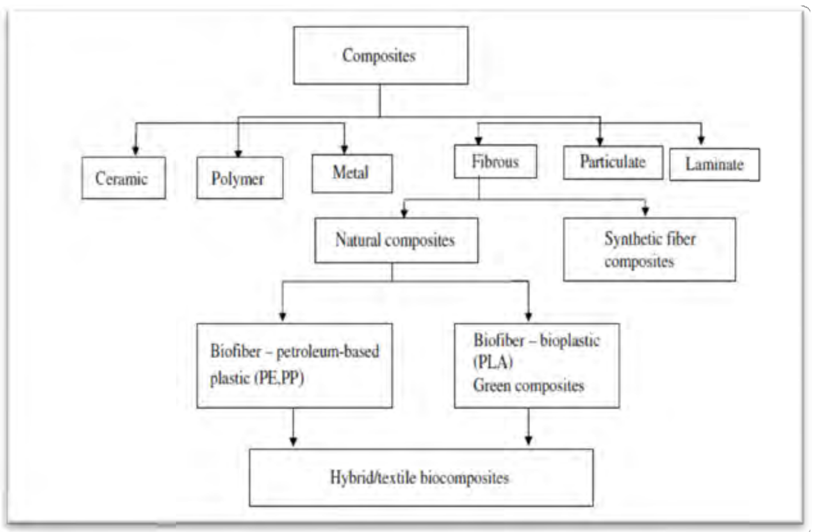

Figure 2.1: Classification of Composites (Bunsell, A.R. and Harris, B. 1974)

2.2.1 Metal Matrix Composite

Metal matrix composite materials have been so intensely researched over the past years that much new high strength to weight materials have been produced. Most of these materials have been developed for the aerospace industries, but some are being used in other applications such as automobile engines. Pradeep R et al. stated that metal matrix material has their own properties like hardness strength, fracture toughness and stiffness. Metal matrix can withstand elevated temperature in corrosive environment than polymer composites. Titanium, aluminium and magnesium are the popular matrix metals currently in vogue, which are particularly useful for aircraft applications. Because of these attributes metal matrix composites are under consideration for wide range of applications viz. combustion chamber nozzle (in rocket, space shuttle), housings, tubing, cables, heat exchangers, structural members etc. According D. Verma et al. (2012) metal matrix composites possess some attractive properties, when compared with organic matrices. Example attractive properties are great quality and good strength at higher temperature, higher transverse strength, excellent electrical and superior thermal conductivity, and higher erosion resistance. However, the major disadvantage of metal matrix composites is their higher densities and consequently lower specific mechanical properties compared to polymer matrix composites.

2.2.2 Ceramic Matrix Composite

Ceramic matrix composites have been developed recently with improved mechanical properties such as strength and toughness over the unreinforced ceramic matrix. Naturally it is hoped and indeed often found that there is a concomitant improvement in strength and stiffness of ceramic matrix composites. Ceramic materials are inorganic, non-metallic materials made from compounds of a metal and a non-metal. Ceramic materials may be crystalline or partly crystalline. They are formed by the action of heat and subsequent cooling. Clay was one of the earliest materials used to produce ceramics, but many different ceramic materials are now used in domestic, industrial and building products. According Callister W. D. (2007) ceramic materials tend to be strong, stiff, brittle, chemically inert and non-conductors of heat and electricity, but their properties vary widely. For example, porcelain is widely used to make electrical insulators, but some ceramic compounds are superconductors. Ceramic fibres, such as alumina and SiC (Silicon Carbide) are advantageous in very high temperature applications and also where environment attack is an issue. Since ceramics have poor properties in tension and shear, most applications as reinforcement are in the particulate form (e.g. zinc and calcium phosphate). Ceramic Matrix Composites (CMCs) used in very high temperature environments, these materials use a ceramic as the matrix and reinforce it with short fibres, or whiskers such as those made from silicon carbide and boron nitride.

2.2.3 Polymer Matrix Composite

A fibre reinforced polymer is a composite material consisting of a polymer matrix imbedded with high strength fibers, such as glass, aramid, and carbon. Generally, polymers can be classified into two classes, which is thermoplastic and thermosetting. . A very large number of polymeric materials, both thermosetting and thermoplastic, are used as matrix materials for the composites. Most commercially produced composites use a polymer matrix material often called a resin solution. There are many different polymers available depending upon the starting raw ingredients.

Polymer matrix composite PMC is the materials that consist of a polymer (resin) matrix combined with a fibrous reinforcing dispersed phase. Polymer matrix composites are very popular due to their low cost and simple fabrication method. Polymer matrix composites are very popular due to their low cost and simple fabrications methods. Using the non-reinforced polymer as structure materials is limited due to the low level of their mechanical properties: tensile strength of one of the strongest. Most commonly used matrix materials are polymeric. In general, the mechanical properties of polymers are inadequate for many structural purposes. In particular, their strength and stiffness are low compared to metals and ceramics. These difficulties are overcome by reinforcing other materials with polymers. Secondly the processing of polymer matrix composites need not involve high pressure and doesn't require high temperature. Today glass also equipment's required for manufacturing polymer matrix composites are simpler. For this reason, polymer matrix composites developed rapidly and soon became popular for structural applications. Today glass reinforced polymers are still by far the most popular composite materials in terms of volume advantages with the exception of concrete (F. L. Matthews, and R. D. Rawlings, 2002). There are also have disadvantage of PMCs. The main disadvantages are their low maximum working temperature, high coefficient of thermal expansion, dimensional instability, and sensitivity to radiation of moisture. Absorption of water from the environment may cause harmful effect which degrades the mechanical performance, including swelling, formation of internal stress and lowering of the glass transitions temperature (F. L. Matthews, and R. D. Rawlings, 2002).

2.3 Component of Polymer Matrix Composite

There are four major components in polymer composites; which are the matrix, filler, reinforcement and solid lubricant:-

2.3.1 Matrix

Most composites consist of a bulk material (matrix) and a reinforcement of some kind, added primarily to increase the strength and stiffness of the matrix (Verma et al. 2012). The matrix is the substance that available in the composite which the reinforcement embedded or two-phase microstructure in which a second phase is dispersed. In other words, that there is a path through the matrix to any point in the material, unlike two materials sandwiched together. The matrix phase of composite can may be a metal, polymer or ceramic.

In general, metals and polymer are used as a matrix when some ductility is desirable (F.L. Matthews, and R.D. Rawlings, 2002). The matrix isolates the fibres from one another in order to prevent abrasion and formation of new surface flaws and acts as a bridge to hold the fibres in place. A good matrix should possess ability to deform easily under applied load, transfer the load onto the fibres and evenly distributive stress concentration. According N K Gupta and R Velmurugan (2002) a good matrix for a composite material is thermally compatible, means both of fibers and matrix should have same co-efficient of thermal expansion. Others is chemically compatible (matrix shouldn't react with fibers) and physical compatible with both. The matrix gives compression strength to composite. The matrix material can be introduced to the reinforcement before or after the reinforcement material is placed into the mould cavity or onto the mould surface. The composite is designed so that the mechanical loads to which the structure is subjected in service are supported by the reinforcement. The function of the relatively weak matrix is to bond the fibers together and to transfer loads between them.