UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EMPTY FRUIT BUNCH FIBER COMPOSITE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) with Honours.

by

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2009/2010

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **EMPTYFRUIT BUNCH FIBER COMPOSITE**

SESI PENGAJIAN: 2009/10 Semester 2

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I hereby, declared this report entitled “Empty Fruit Bunch Fiber Composite” is the results of my own research except as cited in references.

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APPROVAL

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

……………………………….

(Principal Supervisor)

(Mr Yuhazri bin Yaakob)

ABSTRACT

The purpose of this research was to study and test a composite material for use in manufacturing product. The manufacturing of the product needs raw material that meet the specification such as stiff, safe to use, and easy to fabricate. In this research, thermoplastic that is Polypropylene resin with Maleic Polypropylene (MAPP) as additives is used to be studied so that a final specimens based on this material can be fabricated. Before fabricate the composite, the Empty Fruit Bunch Fibers (EFBF) as reinforcement was treated using alkali solution that is NaOH to removing the residual oil and contaminant. By using the Hydraulic Hot Press Machine, the plastic composite is produced in frame with size 25 cm X 25 cm x 0.3 cm and the melting temperature is 180º C. The effects obtained after the modification have been analyzed by mechanical and physical testing which are tensile, flexural, shore durometer hardness, flammability, water and moisture absorption were determined according to ASTM standards. In this study mechanical and physical properties will analyze to determine the best composition. It was observed that, the addition of EFBF content enhanced the physical and mechanical testing. From the test have been done, the best composition is S/N 1. Although this composition is the matrix, but it properties is the best in both of testing. For mechanical testing, S/N 1 is good in flexural strength, tensile strength, young modulus, with the higher value for flexural strength, tensile strength and young modulus are 30.76 Mpa, 18.46 Mpa and 14.81 Mpa. While for physical testing, S/N 1 best in water absorption and moisture absorption properties with the values are 0 percent.

ABSTRAK

Penyelidikan ini membincangkan tentang bahan komposit yang digunakan dalam bidang pengeluaran produk. Pengeluaran produk memerlukan bahan mentah bagi mencapai permintaan seperti kekakuan, selamat digunakan dan senang untuk dihasilkan. Dalam kajian ini, termoplastik iaitu resin Polipropelina dengan MAPP iaitu sebagai bahan penambah digunakan untuk menghasilkan produk akhir. Sebelum penghasilan komposit, tandan kosong kelapa sawit sebagai bahan penguat akan dirawat dengan menggunakan larutan alkali iaitu sodium hidroksida untuk menanggalkan sisa minyak dan bahan pencemaran. Dengan menggunakan mesin pemampatan berhidraulik, komposit akan dihasilkan dalam rangka yang bersaiz 25 cm X 25 cm x 0.3 cm dan suhu lebur ialah 180º C. Kesan yang terhasil selepas pengubahsuaian tersebut dianalisis dengan menggunakan ujian mekanikal dan fizikal seperti ujian keterikan, kelenturan, kekerasan, kebolehbakaran serta daya serapan air dan kelembapan yang dijalankan mengikut piawai ASTM. Dalam kajian ini, sifat-sifat mekanikal dan fizikal di analisis untuk menentukan komposisi yang terbaik. Daripada pemerhatian, penambahan komposit tandan kosong kelapa sawit ke dalam PP mampu meningkatkan ujian fizikal dan mekanikalnya. Daripada ujian yang dibuat, didapati komposisi yang terbaik ialah S/N 1. Walaupun komposisinya ialah bahan mentah, tetapi ianya mempunyai sifat mekanikal dan fizikal yang terbaik. Bagi ujian mekanikal, S/N 1 terbaik dalam sifat- sifat keterikan, kelenturan dan „Young Modulus‟ dengan nilai tertinggi bagi keterikan, kelenturan dan„Young Modulus‟ ialah 30.76 Mpa, 18.46 Mpa dan 14.81 Mpa. Semantara bagi ujian fizikal pula, S/N 1 terbaik dalam ujian serapan air dan kelembapan dengan nilai 0 peratus.

DEDICATION

Mom and dad

ACKNOWLEDGEMENT

Alhamdulillah, finally I have finished my Final Year Project for the fulfillment of Bachelor of Manufacturing (Engineering Material). First and foremost, I would like to dedicate my deepest gratitude to University Teknikal Malaysia Melaka, especially for Manufacturing Faculty for the provision of funding to carry out this research and my bachelor degree study. A special thanks to my supervisor En Yuhazri bin Yaakob for the supervision along the time I was doing this project. I greatly appreciate his consistent encouragement, advice and invaluable guidance throughout the course of this project. I also like to express my thanks to all technician staff at FKP Laboratory that helping me in gives the information that relate with my study especially about the machine that have in this lab. Finally I would like to express my deepest appreciation and gratitude to my family and members for their sacrifice, motivation and support given during the course of this project.

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LIST OF ABBREVIATIONS

PP	-	Polypropylene
POF	-	Palm Oil Fiber
EFB	-	Empty Fruit Bunch
MAPP	-	Maleic Anhydride Polypropylene
NaOH	-	Sodium Hydroxide

CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, natural fibers, which have many advantages, were investigated to replace synthetic fibers. It will be economical if it is used as reinforcement in polymer composites. An example of natural fibers is Empty Fruit Bunch Fibers (EFBF) that has good potential reinforced polymer composites. (Rowell, R.M., *et al.*, 1997).

The usages of EFBF as reinforcement in composite materials have gained interest among scientists especially those in the South East Asia region where oil palm is a major industrial cultivation. Pioneer work on the oil palm fibers were done by Sreekala, *et al.*, (1997). They conducted a thorough study on the morphology, chemical composition, surface modifications and mechanical properties of oil palm fibers alone.

With the increasing global energy crisis and ecological risks, plant fibers reinforced polymer composites have attracted more and more research interests owing to their potential of serving as alternative for artificial fiber composites (Bledzki, A.K., 2002). Accordingly, extensive studies on preparation and properties of thermoplastic and thermosetting composites filled with jute, bamboo, sisal, coir, hemp, flax, pineapple and leaves were carried out. Compared with conventional glass fibers or carbon fibers, plant fibers have many advantages like renewable, environmental friendly, low cost, lightweight, high specific mechanical performance.

Over the past decade there has been a growing interest in the use of lignocellulosic fibers as reinforcing elements in polymeric matrix (Hamadag, H., *et al.*, 1994). The specific properties of these natural fibers are low cost, lightweight, renewable character, high specific strength and modulus.

This study aims at introducing the natural fibers that used as fillers in a polymeric matrix enabling production of economical and lightweight composites for load carrying structures. In this study, it uses the EFBF in thermoplastic and not in thermoset because of their good processability and ability to be recycled. Fillers are added to the polymeric matrix with the aim of improving its thermal and mechanical properties. There are, however, some adverse effects like toughness, and ultimate elongation that polymers often suffer because of the addition of fillers.

Oil palm empty fruit bunch filled thermoplastic composites were studied by Rozman *et al.* (1998). In their study, they observed that as the oil palm empty fruit bunch filler loading increased in the high density polyethylene, the modulus of elasticity and modulus of rupture of the composite increased and decreased respectively. The tensile and impact properties were found to decrease with the increasing oil palm empty fruit bunch filler in the composite. In addition, smaller sized empty fruit bunch filler particles displayed higher modulus of elasticity and modulus of rupture compared to larger filler particle size

A properly selected interface has a significant effect on the dispersion quality and adhesion between the polymer and the filler. Natural hard fibers are gaining attention as a reinforcing agent in thermoplastic matrices (Herrera, *et al.*, 1997). Low density and a highly reduced wear of the processing machinery may be mentioned as attractive properties, together with their abundance and low cost. Cazaurang, *et al.*, (1997) pointed out these hard fibers posses mechanical properties that make them a suitable candidate to reinforce thermoplastic resins. Joseph, K., *et al.*, (1993) reported that hard fibers have been successfully incorporated into elastomers and thermoplastics

1.2 Problem Statement

Metal is one of the major structural applications on many fields in decades. Even though the metal is one of the outstanding mechanical properties, the cost of their raw material somehow overweigh inherits benefits. Nowadays, people always change into the lightweight materials.

This situation has open the prospect to discover the possibility of producing lightweight composite and at the same time try to improve the outstanding mechanical properties. The cost of manufacturing is also can be reduced significantly if the process of producing is in the simple step and they are produces locally within the country area which is Malaysia.

In this research, the main focus is to use natural fiber which is EFBF as one of the substitute materials for the steel, as the reinforcement in the polymer matrix in order to produce high strength composite but lightweight. Nowadays, the EFBF can be finding locally as one of the material to produce furniture like its counterpart the wood and bamboo. This scenario gives the opportunity to investigate on producing the lightweight composite since the cost for producing in Malaysia is in expensive compared to the metals. The exploration in the bio-composite industry has formulated its potential to be researched. So the usage of the metal is no longer viable due to the threat of over cost of the materials that heavily depend on natural source and mining activities

1.3 Objectives

The objectives of this research are:

(a) To study the mechanical and physical properties of EFBF as a filler or reinforcement in composite.

(b) To identify the best composition of EFBF.

1.4 Scope of Research

The scopes of this research are focuses to the materials, standard testing and suitable processing. Study of the mechanical properties of EFBF and the best composition of EFB fiber are important considerations in this research.

For the materials, it focuses to:

(a) Thermoplastic polymer like polypropylene (PP) as matrix for composite fabrication
(b) Empty Fruit Bunch (EFB) as the reinforcement or filler
(c) Maleic Anhydride (MA) as coupling agent in additive to improve the compatibility of interface reaction between plastic and EFB

For physical and mechanical properties of WPC, the standard testing is:

(a) Physical property test
  (i) Moisture absorption test
  (ii) Water absorption test
  (iii) Flammability

(b) Mechanical property test
  (i) Tensile strength
  (ii) Flexural test
  (iii) Hardness

For processing, the suitable machine is important with the right choices, which is:

(a) Hot Press Machine

1.5 Rational for Research

In this research, EFBF is being investigated to replace the synthetic fiber to EFB fibers. EFB is a waste fiber and have the criteria like the wood that is lignocelluloses. The use of EFB filled thermoplastic material (PP) and mixing with additives (MAPP) as a fabrication material or structural member has great potential. At the same time, using low cost of reinforcement (EFB) and matrix will have the best mechanical properties that improve the previous research in EFBF Composite application.

1.6 Thesis Frame

In this thesis frame, it explains the summary of each chapter from Chapter One to Chapter Five. In Chapter One, it include the background of the study, problem statement, objectives, scope and rational of research. For Chapter Two, the explanation of composite material is based on its history, classification, major properties, application and production processes. This chapter also covers the manufacturing technologies which involve material and sample preparation according to the types of process and machine selection. For Chapter Three, the methodology includes the whole activities before produce the final EFB composite. The procedure for this chapter is refer to the ASTM standard and the others resources. While for Chapter 4, contains brief explanation and about the results and analysis of the failure of the mechanical and physical properties of EFBF Composite, is. For Chapter 5 is Conclusion and Recommendation of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Composite Materials

Composites material consisting lignocellulosic fibers and synthetic thermoplastics have received substantial attention in scientific literature as well as industry primarily due to improvements in process technology and economic factor (Sanadi, A.R., *et al.*, 1992). The use of lignocellulosic in plastic composites is of particular interest because such fibers can serve as a good reinforce and or filler for synthetic polymers to enhance certain properties while reducing material cost (Kazayawoko, M., *et al.*, 1998).

2.1.1 Definition of Composite

Nowadays, composite materials are used in a wide variety of applications. According to Astrom (1997), the noun composite is derived from the Latin verb *componere* which means to put together. Therefore, a composite material can be considered as a material which is formed when two or more chemically distinct constituents are combined together on a macro scale (Astrom, 1977; Schwartz, 1992 and Jordan, 2002). Schwartz (1992) further stressed that the constituents in a composite material can be physically identified and exhibit an interface between one another.

A more detailed description of a composite material was given by Agarwal *et al.* (1981) who defined a composite as a material that consists of one or more discontinuous phases which are usually hard and strong embedded in a continuous phase. The continuous phase is called the matrix while the discontinuous phase is termed the reinforcement material.

Composite material is known as two or more materials to give a unique combination of properties. The concept of composites was not only invented by human beings but is already found in nature. An example, wood which is a composite of cellulose fibers in a matrix of natural glue called lignin. The main concept of composite is that it contains matrix material. Typically, composite material is formed by reinforcing fibers in a matrix resin (Sanjay, K.M., 2000).

Based on definition of a composite material, composites can be produced by any combination of two or more materials which can be metallic, organic or inorganic. Schwartz, J.A., (1992) cited that the most widely used constituent forms in a composite material are fibers, particles, lamina or layers, flakes, fillers and matrixes. Generally, composite materials are classified based on the morphology of reinforcement and also on the matrix material. Classifications of composite materials according to the reinforcement forms are particulate reinforced composites, fiber reinforced composites and structural composites.

2.1.2 Classifications of Composite Materials

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Generally, composite materials are classified based on the morphology of reinforcement and also on the matrix material. Classifications of composite materials according to the reinforcement forms are particulate reinforced composites, fiber reinforced composites and structural composites. Particles by definition are non-fibrous in nature and have roughly equal dimensions. Fiber reinforced composites are composed of reinforcing fibers which are a characterized as a long fine filament with an aspect ratio of greater than 10. Glass, carbon, aramid, boron and cellulose fibers are widely used as reinforcement in composite materials. Structural composites though, consist of laminate and sandwich composites, which are used in structural engineering applications.

In addition, classification of composite materials based on the type of the matrix can be grouped into there main categories such as metal matrix composites (MMC), polymer matrix composites (PMC) and ceramic matrix composites (CMC) (Schwartz, 1992; Hull *et al.*, 1996 and Reinhart, 1987). According to Hull *et al.* (1996) most composites in industrial use are based on polymeric matrices. The focus of this study is mainly on polymer matrix composite in cellulose fiber.

2.2 Matrices

Matrix can be defined as a material where the reinforcing system of a composite is embedded. The matrix serves as a binder which holds the reinforcing materials in its place. Besides that, when a composite is subjected to an applied load, the matrix deforms and transfers the external load uniformly to the fibers (Astrom, K.J., *et al.*, 1977). The matrix also provides resistance to crack propagation and damage tolerance owing to the plastic flow at crack tips (Shwartz, 1992). Furthermore, the matrix also functions to protect the surface of fibers from adverse environmental effects and abrasion especially during composite processing. Plastic matrices can generally be classified into two major types which are thermosets and thermoplastic

2.2.1 Thermoset

Thermoset resins are usually liquids or low melting point solids in their initial form. This liquid resin is then converted to a hard rigid solid by chemical cross-linking through a curing process which involves the application of heat and the addition of curing agents or hardeners. Once cured, a tightly bound three dimensional network structure is formed in the resin and hence the resin cannot be melted, reshaped and reprocessed by heating (Hull, D., *et al.*, 1996).

Therefore, during composite manufacturing, the impregnation process followed by the shaping and solidification should be done before the resin begins to cure (Mariatti, M., 1998). Thermoset resins are brittle at room temperature and have low fracture toughness. On the other hand, owing to its three dimensional cross linked structure, thermoset resins have high thermal stability, chemical resistance, high dimensional stability and also high creep properties (Matthews, E., *et al.*, 1999). In this study, thermoset is not used but study the thermoplastic resin.

2.2.2 Thermoplastic

Thermoplastic resins are linear or branched polymers which remain as a solid at room temperature. Unlike thermosets, thermoplastics do not form a three dimensional cross linking network. The monomer units in the thermoplastic are held by a weak Van der Wall"s forces which are easily broken by heat and stress (Dominick, D., 1997). As a result, thermoplastics are able to melt when heated and becomes a solid when cooled to room temperature.

Thermoplastic resins offer several advantages over their thermoset resin counterpart. Thermoplastic products can be recycled owing to the nature of the thermoplastics which can be repeatedly heated and shaped (Ruzaidi, 1999 and Matthews *et al.*, 1999). In addition, thermoplastics offer improved fracture toughness and low moisture absorption behavior.

The processing time of thermoplastics is shorter than most thermosets as the processing of thermoplastics only involve melting, shaping and cooling which can be achieved in a matter of few seconds whereas thermosets would take several hours to days to fully crosslink (Leong, K.H., 2003). Moreover, imperfect thermoplastic products can be reprocessed and flash or unused thermoplastics can be used for other applications.