EFFECT OF FIBER ORIENTATION AND COMPOSITION PERCENTAGE TO THE PROPERTIES OF PARTICLE BOARD FROM BANANA FIBER

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MASTER OF MANUFACTURING ENGINEERING (INDUSTRIAL ENGINEERING)

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NOR HAFIZAH BINTI ADNAN

A thesis submitted
in fulfillment of the requirements for the degree of Master of Manufacturing Engineering (Industrial Engineering)

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2018

DECLARATION

I declare that this thesis entitled “Effect of Fiber Orientation and Composition Percentage to the Properties of Particle Board from Banana Fiber” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Manufacturing Engineering (Industrial Engineering).

Signature :

Supervisor Name : Profesor Madya Dr Nur Izan Syahriah binti Hussien

Date :

DEDICATION

This thesis is proudly dedicated to my beloved parents and parents in law; Adnan, Hasnah, Mohd Jalil and Suriawati for their great support, pray, love and care. Second, for my beloved one Mohd Firdaus for his support, love, care and pray. Third, my lovely daughter and sons; Auni, Aniq and Ameer. Fourth, for my family; Azhar, Jamilah, Hisham, Shazleen, Amani, Fahmi, Akili, Zabidah and Farhana. Fifth, for my supervisor Profesor Madya Dr Nur Izan Syahriah bt Hussien for the great advice and support. The last for my friends and all people who have given me support, idea, care in the beginning until the last during my thesis writing.

ABSTRACT

Shortage of wood as a raw material has forced wood-based industries to find alternative local raw materials. The use of natural source is increase in this century to protect the green environmental. Hence, the use of natural fiber is highly recommended for industrial purpose. Banana plant, an old species is developed everywhere throughout the world. All kinds of banana plants have fibers in abundance. Banana fiber has the probability to be utilized for make paper, home decorative items, home furnishing items and handicrafts. In this study, banana fibers are used as reinforcement in epoxy resins to produce new particle board. The aim of this study is to investigate the strength of new particle board from banana fiber. Physical testing of particle board from banana fiber is water absorption. The particle board from banana fiber are mechanically tested including bending (flexural) and tensile. Two Level Factorial Design was used in this experiment to gather detailed data about the interaction between parameters. A good understanding of how interactions among the various factors influence the reading of particle board specimens was obtained. The composition of 50% of banana fiber and 0 degree orientation shows the best mechanical properties on tensile strength. But the composition of 40% of banana fiber and 0 degree orientation shows the highest flexural stress and a good performance in water absorption test. At the end of this research, it reveals that tensile strength and flexural stress were significant with fiber orientation and composition percentage. But water absorption was significant only with fiber composition, not with fiber orientation. Few suggestions were proposed for the further research.

ABSTRAK

Kekurangan kayu sebagai bahan mentah telah menyebabkan industri berasaskan kayu untuk mencari alternatif bahan mentah tempatan. Penggunaan sumber semula jadi adalah meningkat pada abad ini bagi memastikan alam sekitar hijau dilidungi. Justeru itu, penggunaan serat semula jadi amat disyorkan bagi tujuan industri. Tumbuhan pisang ialah spesies lama yang dihasilkan di serata dunia. Semua jenis tumbuhan pisang mempunyai serat yang melimpah. Serat pisang mempunyai kebarangkalian untuk digunakan bagi menghasilkan kertas, barangan hiasan rumah, barangan rumah dan kraf tangan. Dalam kajian ini, serat pisang digunakan sebagai tetulang dalam resin epoksi untuk menghasilkan papan partikel baru. Tujuan kajian ini adalah mengkaji kekuatan papan partikel daripada serat pisang. Ujian fizikal papan partikel daripada serat pisang ialah penyerapan air. Papan partikel ini diuji secara mekanikal melalui ujian lenturan dan tegangan. Reka bentuk dua faktorial digunakan dalam eksperimen ini untuk mengumpulkan data terperinci tentang interaksi antara parameter. Pemahaman yang baik tentang bagaimana interaksi antara pelbagai faktor mempengaruhi bacaan spesimen papan partikel diperolehi. Komposisi 50% serat pisang dan orientasi 0 darjah menunjukkan sifat mekanikal yang terbaik pada kekuatan tegangan. Tetapi komposisi 40% serat pisang dan orientasi 0 darjah menunjukkan tekanan lenturan tertinggi dan prestasi yang baik dalam ujian penyerapan air. Pada akhir kajian ini, ia mendedahkan bahawa kekuatan tegangan dan tegangan lenturan adalah signifikan dengan orientasi serat dan peratusan komposisi. Tetapi penyerapan air adalah signifikan hanya dengan komposisi serat, bukan dengan orientasi serat. Beberapa cadangan dicadangkan untuk penyelidikan selanjutnya.

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ρ	-	Density
m	-	Mass
v	-	Volume
p	-	Load
L	-	Length
b	-	Width
h	-	Depth
Δ	-	Deflection
E	-	Modulus of Elasticity
f	-	Frequency
k	-	Radius of Gyration
j	-	Constant Dependent

CHAPTER 1

INTRODUCTION

1.1 Background of Study

At present, the consumption of particle board development made with fiber reinforced composites increasing rapidly in developed countries. This happens because it is possible to produce lightweight particle board with this type of material, with good mechanical performance, low cost and environmental friendly. Banana, kenaf, sisal, hemp, flax, cotton, jute, sisal, pineapple, ramie and bamboo are natural plant that used from a long time ago as a source of lignocellulosic fibers, and more often applied as the reinforcement of composites.

Since banana trees fibre is considered as one of the renewable resources in Malaysia, it is worth to use and in the future the demand for banana stem fibre based will increase as green materials. Hemicellulose and lignin are the main chemical constituents of banana fibers. In banana fibers, cellulose and hemicellulose exist in the form of holocellulose which contributes more than 70% of the total chemical constituents present in banana fiber. Lignin is another important chemical constituents present in banana fiber. Lignin turns as a binder for the cellulose fibers and acts as an energy storage system.

Utilization of the banana stem fibre not only benefit the environment, but it will also reduce the overall resource consumption while sustaining national economic growth and introduction of green technology to the rural areas (Baharin et al, 2016).

1.2 Problem Statement

The demand for particleboards in the sectors of housing construction, furniture manufacturing and interior decoration (wall and ceiling paneling) has continued to increase (Pan et al, 2006). Particle board furniture is less dense and can easily get damaged while handling, quite weak compared to other kinds of engineered woods such as plywood. Apart from being low on strength, particle boards are also prone to getting damaged because of moisture and humidity. Being low on strength, particle boards are almost never used in applications where the boards will be subjected to heavy weights.

Banana is the second most consumed fruit in Malaysia. It is estimated that about 10 million banana trees are cut down every year to produce enough banana to meet the demand in Malaysia. When the banana fruit is harvested, a large amount of biomass remains because each banana plant cannot be used for the next harvest (Li et al, 2010). These banana trees are left to rot in the banana plantation and by product of the rotting process is methane gas which is one of the greenhouse gases (a pollutant) (Baharin et al, 2016). The existence of banana fibers provides an accountable contribution to thermoset polymer matrix composites (both polyester and epoxy) for the attainment of various properties such as mechanical, thermal degradation, swelling and dielectric properties (El-Meligy Magda et al, 2010).

Abdul Khalil et al. (2010) states that the wood based industries are currently facing problems regarding the shortage of wood resources as the trees keep losing their habitat to meet the human's need. Main issue is to trigger the usage of degradable constituents for the production of composites at the maximum possible extent according to societal concern and new environmental rules. In this regards, some of the engineering applications like sports articles, panel boards, gardening items and food packaging industries are developed

from the bio-composites with minimum ecological impact and also they do not require any excellent mechanical properties (Netravali and Chabba, 2003).

1.3 Objective of Study

The objectives of this study are:

i. To investigate the effect of fiber orientation and composition percentage to tensile strength, flexure strength and water absorption of banana fiber particle board.

ii. To propose the most suitable set of parameters to make new particle board from banana fiber.

1.4 Scope of Study

(a) Preparation of the Samples Formulation

To realize the objectives of this study, formulation of waste material, banana stem fiber, epoxy and hardener is used as the fiber, matrix and binder respectively. Based on the formulation the following stages are involved:

i. Fiber treatment with NaOH

ii. Compress board using hot pressing machine

(b) Properties Identifying

i. Tensile test is carried out using INSTRON 5982 Universal Testing Machine to establish average maximum strength of banana fiber particle board.

ii. Flexural test represents the highest stress experienced within the material at its moment of yield.

iii. Water absorption is used to determine the amount of water absorbed under specified conditions.

1.5 Significance of Study

The raw material used in this study is banana stem fiber. It has been selected on reason of being a waste material and abundantly available in Malaysia. Due to the analysis of tensile, flexural, and impact properties of these composites, banana fiber can be used as the reinforcing agents shown that composites with the good strength could be successfully developed. Thus, the high–strength pseudo-stem banana woven fabric reinforcement polymer composites can be used in a wide range of applications (Maleque et al., 2007).

In recent studies, the review of development in natural fibers and bio-composites, bio-polymers and various surface modifications of natural fibers manage to decrease the world concerns about the shortage of world resources problem. Natural fibers from the plants can be used to reinforce polymers to obtain slight and strong materials. Natural fibers which are to be used in production of composites are categorized according to their origin, which those are vegetables, minerals, or animals. Natural fibers also are renewable, biodegradable, easily available, low cost, low density and have satisfactory mechanical properties (Paul et al., 2010).

CHAPTER 2

LITERATURE REVIEW

2.1 Particle Board

Fibers are conventionally used include aramid fibers, polyethylene (UHMWPE), nylon fibers, and glass fibers as found in previous study (Azmi et al., 2017). American Heritage Dictionary (2016) defines fiber board as a building material composed of wood chips or plant fibers bonded together and compressed into rigid sheets. Webster's College Dictionary (2010) defines it as a building material made of plant fibers compressed and tiled into rigid sheets. Mohapatra et al. (2010) states that banana pseudo stem can produced paper fiber board, tissue paper and etc. Banana waste materials are rich in nutrients and mineral. The stem of banana plant gives a ligno-cellulosic fiber which is baste fiber with relatively good mechanical properties and has a complex structure (Mukhopadhyay et al., 2008). Ligno-cellulosic is generally consisting of helically wound cellulose micro in amorphous matrix of lignin and hemicellulose (Raghavendra et al., 2012) which are the mechanical properties and micro-fibril angles were decided by the cellulose content. Banana fibers are generally developed in many ways and products which one of them can be produced as a paper and furniture.

2.1.1 History of Particle Board

Natural fibers in simple definition are fibers that are not synthetic or manmade. They can be sourced from plants or animals (Ticoalu et al., 2010). Natural fibers are

abundantly available in nature and can be used to reinforce polymers to obtain light and strong materials. This is due to the composition of cellulose, lignin, and hemicellulose in most of natural fibers. The amount of cellulose, lignin and hemicellulose are known to be varying according to the species and age of the plant. The exact mechanisms and chemical nature of principal component of natural fiber are still obscure and need further research (Mohanty et al., 2001). There is also drawback for these characteristics which are natural fibers may be hydrophilic in nature which decreases the compatibility with the hydrophobic polymeric matrix (Seung-Hwan and Siqun, 2005).

Table 2.1: List the properties of selected natural fibers of hemp, flax, sisal and jute. (Wambua et al., 2003)

Property	Hemp	Flax	Sisal	Jute
Density (g/cm³)	1.48	1.4	1.33	1.46
Modulus (GPa)	70	60-80	38	10-30
Tensile Strength (MPa)	550-900	800-1500	600-700	400-800
Elongation to failure (%)	1.6	1.2-1.6	2-3	1.8

2.1.2 Effect Deforestation to Environment

Currently, there are increasing concerns on toxicological impact and possible hazard of free nanoparticles to human health and the environment (Munajat et al., 2017). The increasing environmental consciousness awareness also has triggered the swift towards the designation of materials by using the natural fibers (Mohanty et al., 2001). In fact, to care and concern about the environment is vital as it also become a priority for the researchers and scholars. From both environmental and economic point of view as an example, the simultaneous utilization of plastic and fiber from date palm leaf wastes for

producing fiber reinforced WPCs become an alternative to natural wood (Binhussain and El-Tonsy, 2013).

Natural fibers become the main role player in the sustainable development, especially amongst manufacturing industries until the natural fibers such as Kenaf, jute, sisal, hemp and bamboo are utilized and are sought for their potential within the manufacturing industry (Edynoor et al., 2017). Sapuan and Maleque (2005) and Sakthivei and Ramesh (2013) have both shown there are many advantages of natural fiber composites include lightweight, low-energy production, and environmental friendly. Natural fiber also is considerably lower in cost and weight and there are also the environmental and societal benefits from natural fiber as shown in previous study (Azmi et al., 2017).

Banana fibers are the natural fibers with the characteristics of strong moisture absorption quality, highly tensile strength, highly breathable, small elongation, light weight and biodegradable. Natural fibers have the properties of renewable, low density, environmentally friendly, low cost, high biodegradability and performance and existence of vast resources. The fineness and spin ability in Banana fiber is better than other natural fibers, and are currently considered as agricultural waste product.

2.2 Agricultural Waste/Non Wood

There are many materials and fibers have been innovatively manufactured by people to design and create many products. These agricultural wastes can be used to prepare fiber reinforced polymer composites as the marketable products, and this application of composite materials to structures has presented the need for the engineering analysis the present work focuses on the fabrication of polymer matrix composites by