SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis 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 (Structure & Materials)"

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Date : 28 JUNE 2013

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EFFECT OF BF LENGTH ON THE PROPERTIES OF BAMBOO/ POLYPROPYLENE COMPOSITE

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This thesis is submitted to Faculty of Mechanical Engineering as a requirement to get award of Degree of Mechanical Engineering (Structure & Materials)

Faculty of Mechanical Engineering
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JUNE 2013

ACKNOWLEDGEMENT

First of all, Alhamdulillah to Allah the Almighty for his gratefulness and kindness that has help me to do this project.

I wish acknowledge with thanks to University Teknikal Malaysia Melaka (UTeM) for giving me such a great opportunity to undergo my study on these "Projek Sarjana Muda".

The most important person that I would like to thank is to my supervisor, Dr. Mohd Zulkefli bin Selamat for his good advice and his guidance during the course of completion of this project. Secondly, I also like to express my appreciation to En. Mohd Shakir bin Ahmad, AJK PSM, to all my lecturer, technicians team from Faculty of Mechanical Engineering for their critics, guidance, opinion, advices and ideas during this project period.

I am most grateful for helps and support from the all course mates for their guidance, knowledge exchange and skill. Beside that, I would like to thanks to all my friends who are helping me directly or indirectly. Last but not list, my thanks to my parents and family for all their guidance and great support.

ABSTRACT

The reduction in harmful destruction of ecosystem and to produce low cost polymeric reinforced composites, our researchers in this country need to study about policies of manufacturing the composites using natural fibers which are entirely biodegradable. These policies had generated safe strategies to protect our environment. The natural fiber may play an important role in developing biodegradable composites to resolve the current ecological and environmental problems. The utilization of BF as reinforcement in composite materials has increased tremendously and has undergone high-tech revolution in recent years as a response to the increasing demand for developing biodegradable, sustainable, and recyclable materials. Therefore, in this study BF were used as a material to reinforce a polymer matrix in PP composite. The studied of the effects of BF length (4, 3, and 2 cm) on the mechanical properties of BF/PP composite had been carried out. The various ratio of BF/PP composite were selected. The ratio of composition in the BF/PP composite was fixed at, 70:30, 60:40 and 50:50. An alkaline treatment was conducted to extract thin bamboo fiber bundles and enhance the BF properties. The mechanical properties of BF/PP composite were determined using tensile test, flexure test, hardness test, density test and macrostructure analysis. The results show that 2 cm fiber length is the best because it gives the optimal results as compare to other BF length of 3 cm and 4 cm fiber length. Mechanical properties of samples were decreased with increasing the fiber length. Meanwhile for BF loading the 60:40 of composition ratio BF/PP is much better than 50:50 and 30:70 composition ratios.

ABSTRAK

Demi mengurangkan kemusnahan ekosistem dan menghasilkan komposit polimer bertetulang kos rendah , negara kita perlu untuk mengkaji tentang dasar pembuatan komposit menggunakan gentian semulajadi yang sepenuhnya terbiodegradasikan. Dasar ini telah menjana strategi yang selamat untuk melindungi alam sekitar kita. Serat semula jadi memainkan peranan penting dalam membangunkan komposit terbiodegradasikan bagi menyelesaikan masalah ekologikal dan alam sekitar. Penggunaan gentian buluh sebagai tetulang dalam bahan komposit telah meningkat dan telah menjalani revolusi berteknologi tinggi pada tahun kebelakangan, ini sebagai tindak balas kepada permintaan yang semakin meningkat untuk membangunkan bahan mampan terbiodegradasi dan boleh dikitar semula. Walau bagaimanapun, dalam kajian ini BF digunakan sebagai bahan untuk mengukuhkan matriks polimer PP komposit. Kajian terhadap kesan panjang gentian BF (4, 3, dan 2 cm) ke atas sifat-sifat mekanik BF/PP komposit telah dijalankan. Pelbagai nisbah gentian BF/PP komposit telah dipilih. Nisbah komposisi dalam rencam BF/PP telah ditetapkan pada, 70:30, 60:40 dan 50:50. Rawatan alkali telah dijalankan untuk mengekstrak BF dan meningkatkan ciri-ciri BF. Sifat-sifat mekanik BF/PP komposit telah ditentukan dengan menggunakan ujian tegangan, ujian lenturan, ujian ujian kekerasan, ujian ketumpatan dan analisis makrostruktur. Keputusan menunjukkan bahawa 2 cm panjang BF adalah yang terbaik kerana ia memberikan hasil yang optimum berbanding 3 cm dan 4 cm pànjang BF. Sifat-sifat mekanikal sampel telah menurun dengan peningkatan panjang BF. Selain itu, nisbah komposisi 60:40 BF/PP adalah lebih baik daripada 50:50 dan 30:70.

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LIST OF SYMBOL

PP	=	Polypropylene
BF	=	Bamboo Fiber
PE	=	Polyethylene
FRP	=	Fiber Reinforced Plastics
PMC	=	Polymer Matrix Composites
MMC	=	Metal Matrix Composites
CMC	=	Ceramic Matrix Composites
PVC	=	Polyvinyl Chloride
LDPE	=	Low Density Polyethylene
HDPE	=	High Density Polyethylene
UHMW	=	Ultra High Molecular Weight
AR glass	=	Alkali Resistant
MPa	=	Mega Pascal
GPa	=	Giga Pascal
m	=	Meter
cm	=	Centimeter
mm	=	Millimeter
g	=	Gram
/	=	Per
Tg	=	Glass Transition Temperature
^{o}F	=	Fahrenheit's
^{o}C	=	Degree Celsius
%	=	Percent

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

A "composite" is define as when two or more different materials are combined together to create a superior and unique material. Composite materials can be divided in to two main groups, which are filler/ reinforcement and matrix/binder/ resin. (http://composite.about.com)

The history of composites dates back to ancient times for construction applications; straw was mixed with mud to form a building material known as adobe. The straw provided the structure and strength, while the mud acted as a binder, holding the straw together in place. (http://composite.about.com)

Since the days of adobe, the use of composites has evolved to commonly incorporate a structural fiber and a plastic, this is known as Fiber Reinforced Plastics or FRP for short. Like straw, the fiber provides the structure and strength to the composite, while a plastic polymer holds the fiber together. The commonly type of fibers used in production of composite (FRP) are aramid, carbon, boron, basalt, fiber glass and also natural fiber. (http://composite.about.com)

In the case of fiberglass, hundreds of thousands of tiny glass fibers are compiled together and held rigidly in place by a plastic polymer resin. Common plastic resins used in composites include, epoxy, vinyl ester, polyester, polyurethane and PP.

The most common example of a "composite" in a broad sense is concrete. In this use, structural steel rebar provides the strength and stiffness to the concrete, while the cured cement holds the rebar stationary. Rebar alone would flex too much and cement alone would crack easily. However, when combined to form a composite, an extremely rigid material is created.

The composite material most commonly associated with the term "composite" is Fiber Reinforced Plastics. This type of composite is used extensively throughout our daily lives. Common everyday uses of fiber reinforced plastic composites include, aircraft, boats and marine, sporting equipment, automotive equipment, wind turbine blade, body armor, building materials, water pipes, bridges, tool handles and ladder rails.

In comparison to common materials used today such as metal and wood, composites can provide a distinct advantage. The primary driver and advantage in the adoption of composites is the lightweight properties. In transportation, less weight equates to more fuel savings and improved acceleration. In sporting equipment, lightweight composites allow for longer drives in golf, faster swings in tennis, and straighter shots in archery. While in wind energy, the less a blade weighs the more power the turbine can produce. Besides weight savings, the most important benefits of composites include, non-corrosive, non-conductive, low maintenance, long life and also design flexibility. (http://composite.about.com)

1.1.1 Type Of Composites

There are several types of composites and it can be grouped into categories based on the nature of the matrix each type possesses. Method of fabrication also varies according to physical and chemical properties of the matrix and reinforcing fibers

1.1.1.1 Polymer Matrix Composite (PMC)

The most common advanced composites are polymer matrix composites. These composites consist of a polymer thermoplastic or thermosetting reinforced by fiber. These materials can be fashioned into a variety of shapes and sizes. They provide great strength and stiffness along with resistance to corrosion. The reason for these being most common is their low cost, high strength and simple manufacturing principles. (http://www.slideshare.net)

1.1.1.2 Metal Matrix Composite (MMC)

Metal matrix composites, as the name implies, have a metal matrix. Examples of matrix in such composites include aluminum, magnesium and titanium. The typical fiber includes carbon and silicon carbide. Metals are mainly reinforced to suit the needs of design. For example, the elastic stiffness and strength of metals can be increased, while large coefficient of thermal expansion and thermal and electrical conductivities of metals can be reduced by addition of fibers such as silicon carbide. (http://www.hsctut.materials.unsw.edu)

1.1.1.3 Ceramic Matrix Composite (CMC)

Ceramic matrix composites have ceramic matrix such as alumina, calcium, aluminosilicate reinforced by silicon carbide. The advantages of CMC include high strength, hardness, high service temperature limits for ceramics, chemical inertness and low density. Naturally resistant to high temperature, ceramic materials have a tendency to become brittle and to fracture. Composites successfully made with ceramic matrix are reinforced with silicon carbide fibers. These composite offer the same high temperature tolerance of super alloys but without such a high density. The brittle nature of ceramics makes composite fabrication difficult. Usually most CMC production procedure involves starting materials in powder form. There are four classes of ceramics matrix, glass, conventional ceramics, cement and concreted carbon component. (http://www.hsctut.materials.unsw.edu)

1.1.2 Reinforcement

The primary function of fibers or reinforcements is to carry load along the length of the fiber to provide strength and stiffness in one direction. Reinforcements can be oriented to provide tailored properties in the direction of the loads imparted on the end product. Reinforcements can be both natural and man-made. (http://www.mdacomposites.org)

Many materials are capable of reinforcing polymers. Some materials, such as the cellulose in wood, are naturally occurring products. Most commercial reinforcements, however, are man-made. Of these, by far the largest volume reinforcement measured either in quantity consumed or in product sales, is glass fiber. Other composite reinforcing materials include carbon, aramid, UHMW (ultra high molecular weight) polyethylene, PE, polyester and nylon. Carbon fiber is sometimes referred to as graphite fiber. The distinction is not important in an introductory text, but the difference has to do with the raw material and temperature at which the fiber is formed. More specialized reinforcements for high strength and high temperature use include metals and metal oxides such as those used in aircraft or aerospace applications. (http://www.mdacomposites.org)

Early in the development of composites, the only reinforcements available were derived from traditional textiles and fabrics. Particularly in the case of glass fibers, experience showed that the chemical surface treatments or "sizings" required processing these materials into fabrics and other sheet goods were detrimental to the adhesion of composite polymers to the fiber surface. Techniques to remove these materials were developed, primarily by continuous or batch heat cleaning. It was then necessary to apply new "coupling agents" (also known as finishes or surface treatments), an important ingredient in sizing systems, to facilitate adhesion of polymers to fibers, particularly under wet conditions and fiber processing. (http://www.mdacomposites.org)

Most reinforcements for either thermosetting or thermoplastic resins receive some form of surface treatments, either during fiber manufacture or as a subsequent treatment. Other materials applied to fibers as they are produced include resinous binders to hold fibers together in bundles and lubricants to protect fibers from degradation caused by process abrasion. (http://www.mdacomposites.org)

There are several type of reinforcement or fiber such as glass fiber, carbon fiber, aramid fiber and natural fiber. All this fiber can be classified into synthetic type and natural type fiber.

1.1.2.1 Glass Fiber

Based on an alumina-lime-borosilicate composition, "E" glass produced fibers are considered the predominant reinforcement for polymer matrix composites due to their high electrical insulating properties, low susceptibility to moisture and high mechanical properties. Other commercial compositions include "S" glass, with higher strength, heat resistance and modulus, as well as some specialized glass reinforcements with improved chemical resistance, such as AR glass (alkali resistant). (http://www.mdacomposites.org)

Glass fibers used for reinforcing composites generally range in diameter from 0.00035" to 0.00090" (9 to 23 microns). Fibers are drawn at high speeds, approaching 200 miles per hour, through small holes in electrically heated bushings. These bushings form the individual filaments. The filaments are gathered into groups or bundles called "strands." The filaments are attenuated from the bushing, water and air cooled, and then coated with a proprietary chemical binder or sizing to protect the filaments and enhance the composite laminate properties. The sizing also determines the processing characteristics of the glass fiber and the conditions at the fiber-matrix interface in the composite (http://www.mdacomposites.org). Figure 1.1 shows the glass fiber illustration.

Figure 1.1: Glass fiber (http://sdsx-trading.en.made-in-china.com)

Glass is generally a good impact resistant fiber but weighs more than carbon or aramid. Glass fibers have excellent characteristics, equal to or better than steel in certain forms. The lower modulus requires special design treatment where stiffness is critical. Composites made from this material exhibit very good electrical and thermal insulation properties. Glass fibers are also transparent to radio frequency radiation and are used in radar antenna applications. (http://www.mdacomposites.org)

1.1.2.2 Carbon Fiber

Carbon fiber is created using polyacrylonitrile (PAN), pitch or rayon fiber precursors. PAN based fibers offer good strength and modulus values up to 85-90 Msi. They also offer excellent compression strength for structural applications up to 1000 ksi. Pitch fibers are made from petroleum or coal tar pitch. Pitch fibers extremely high modulus values (up to 140 Msi) and favorable coefficient of thermal expansion make them the material used in space/satellite applications. Carbon fibers are more expensive than glass fiber; however carbon fibers offer an excellent combination of strength, low weight and high modulus. The tensile strength of carbon fiber is equal to glass while its modulus is about three to four times higher than glass. (http://www.mdacomposites.org)

Carbon fibers are supplied in a number of different forms, from continuous filament tows to chopped fibers and mats. The highest strength and modulus are obtained by using unidirectional continuous reinforcement. Twist-free tows of continuous filament carbon contain 1,000 to 75,000 individual filaments, which can be woven or knitted into woven roving and hybrid fabrics with glass fibers and aramid fibers (http://www.mdacomposites.org). Figure 1.2 shows the carbon fiber.

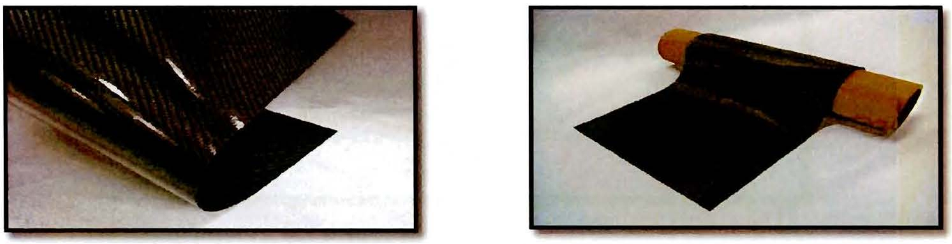

Figure 1.2: Carbon fiber (http://www.velocite-bikes.com)

Carbon fiber composites are more brittle (less strain at break) than glass or aramid. Carbon fibers can cause galvanic corrosion when used next to metals. A barrier material such as glass and resin is used to prevent this occurrence. (http://www.mdacomposites.org)

1.1.2.3 Aramid Fiber

Aramid fiber is an aromatic polyimid that is a man-made organic fiber for composite reinforcement. Aramid fibers offer good mechanical properties at a low density with the added advantage of toughness or damage/impact resistance. Aramid is very tough allowing significant energy absorption but, compared to carbon, it is lower in compressive strength and has poorer adhesion to the matrix. It is also susceptible to moisture absorption. They are characterized as having reasonably high tensile strength, a medium modulus, and a very low density as compared to glass and carbon. The tensile strength of aramid fibers is higher than glass fibers and the modulus is about fifty percent higher than glass. These fibers increase the impact resistance of composites and provide products with higher tensile strengths. (http://www.mdacomposites.org)

Aramid fibers are insulators of both electricity and heat. They are resistant to organic solvents, fuels and lubricants. Aramid composites are not as good in compressive strength as glass or carbon composites. Aramid fibre properties depend on the structure used and can be tailored for high toughness or high modulus Dry aramid fibers are tough and have been used as cables or ropes, and frequently used in ballistic applications (http://www.mdacomposites.org). Figure 1.3 shows the aramid fiber illustration.

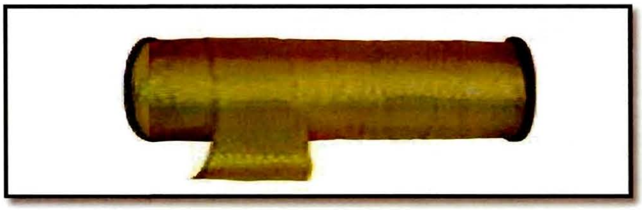

Figure 1.3: Aramid fiber illustration (http://www.aircraftspruce.ca)

1.2 OBJECTIVE

There are two main objectives of this project that have been set as a project goal in order to accomplice this project which is to study the effect of BF length on the properties of BF/PP and to determine the effect of bamboo loading on the properties of BF/PP.

1.3 PROBLEM STATEMENT

Natural fiber composites have become a popular as anew material because of their high strength and stiffness, natural availability, and environmental friendless. Additionally, they are also recyclable, renewable, and have a very low raw material cost. Natural fiber may play an important role in developing biodegradable composites to resolve the current ecological and environmental problems. However, in this study a BF is used as a material to reinforce a polymer matrix in PP composite. Therefore the mechanical properties of BF/PP composite such as tensile test, flexure test, density and macrostructure analysis will be performed to determine their properties.

1.4 SCOPE

This research will study the effects of BF length (4, 3, and 2 cm) on the mechanical properties of BF/PP composite. The various ratio of BF/PP composite needs to be determined. The ratio of composite will be fixed at, 70:30, 60:40 and 50:50. Alkaline treatment will conduct to extract thin BF bundles from raw bamboo. The mechanical properties of BF/PP composite such as tensile test, flexure test, hardness, density and macrostructure analysis will be performed to determine their properties.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this literature review with respect to BF composite it was found, the length of the fiber, matrix and fiber extraction methods are different, which they have used PP and epoxy as matrix and the fiber length were used 0.2, 0.3, 0.4, and 0.5 cm only. Three methods have been used for fiber extraction namely, mechanical extraction, alkaline treatment and steam explosion.

2.2 MATRIX (BINDER OR RESIN)

In previous studies two types of matrix were used in the production of BF composites, namely PP and epoxy. PP is a thermoplastic polymer types while epoxy is a thermosetting polymer types. Each of this has their own advantages and disadvantages. Function of the matrix is to hold the reinforcements in an orderly pattern. Because the reinforcements are usually discontinuous, the matrix also helps to transfer load among the reinforcements.

2.2.1 Polypropylene (PP)

PP is a thermoplastic material. Its have linear structure based on the monomer C3H6. It is manufactured from propylene gas in presence of a catalyst such as titanium chloride. Beside that, PP is a by-product of oil refining processes. Most PP used is highly crystalline and geometrically regular (isotactic) opposite to amorphous thermoplastics, such as polystyrene, PVC, polyamide, etc, which radicals are placed randomly (atactic). It is said that PP has an intermediate level of crystallinity between low density polyethylene (LDPE) and high density polyethylene (HDPE); On the other hand PP has higher working temperatures and tensile strength than polyethylene (http://www.lenntech.com). Figure 2.1 show the PP structure.

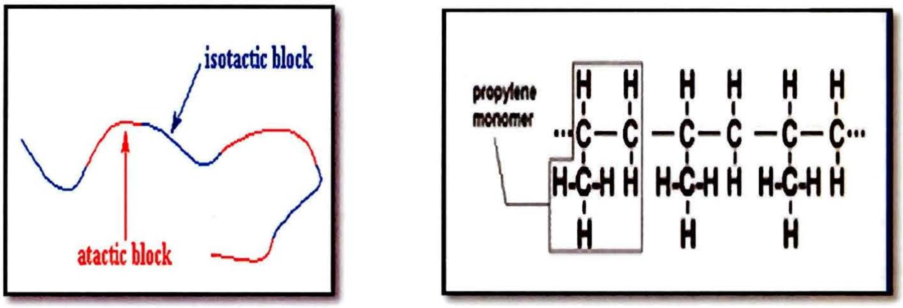

Figure 2.1: PP structure.

The first PP resin was produced by Giulio Natta in Spain, although commercial production began in 1957 [http://www.lenntech.com]. PP offers many different advantages. These advantages allow it to be used for a wide variety of different products and uses, from high heat to cold weather and more. PP is an economical material that offers a combination of outstanding physical, chemical, mechanical, thermal and electrical properties not found in any other thermoplastic. Compared to low or high density polyethylene (PE), it has a lower impact strength, but superior working temperature and tensile strength.

PP provides excellent resistance to organic solvents, degreasing agents and electrolytic attack. It has lower impact strength, but its working temperature and tensile strength are superior to low or high density polyethylene (PE). It is light in weight, resistant to staining, and has a low moisture absorption rate. This is a tough, heat-resistant, semi rigid material, ideal for the transfer of hot liquids or gases. It is recommended for vacuum systems and where higher heats and pressure are encountered. It has excellent resistant to acids and alkaline, but poor resistance to aromatic, aliphatic and chlorinated solvents.