EFFECT OF BUILD ORIENTATION ON MECHANICAL PROPERTIES OF EPOXY RESIN REINFORCED COCONUT FIBER

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Composite materials and layered structures based on natural plant fibers are increasingly regarded as an alternative to glass fiber reinforced parts. One of their major fields of application can be found in structural components for the automotive industry. Product examples are door trim panels or instrument panels. For such applications utmost impact strength is required in order to implement a maximum of passenger safety by a good crash behavior. This study is carried out to investigate the mechanical properties of epoxy resin reinforced coconut fiber and describes the effect of build orientation or arrangement parameters based on tensile testing of the process conditions on this important composite characteristic. From the experiment, it was found that the addition of the coconut fiber into polymer matrix had increased the tensile strength of the composite. But, the tensile strains of the composites are decreasing when the fiber is added into the polymer matrix. However, the modulus of elasticity of the reinforced epoxy is increased compared to unreinforced epoxy.

ABSTRAK

Bahan komposit dan struktur berlapis berdasarkan fiber dari tumbuhan semakin meningkat keperluan sebagai bahan alternatif untuk bahagian-bahagian gentian kaca. Salah satu bidang yang utama penggunaannya boleh didapati dalam komponen berstruktur untuk industri permotoran. Contoh produk yang dihasilkan adalah panel pemekut pintu ataupun panel barangan. Kajian ini adalah untuk mengkaji ciri-ciri mekanikal dari epoxy resin komposit gentian fiber kelapa dan mengulas kesan-kesan daripada orientasi binaan ataupun parameter susunan berdasarkan ujikaji terikan keatas kepentingan ciri-ciri komposit. Eksperimen ini menunjukkan bahawa penambahan fiber kelapa kedalam matrik polimer meningkat kekuatan terikan keatas komposit. Tetapi, kekuatan regangan oleh polimer tersebut menurun apabila fiber ditambah kedalam matrik polimer. Walau bagaimanapun, elastik modulus epoxy resin bergentian menaik berbanding epoxy tanpa gentian.

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LIST OF SYMBOLS

σ	Tensile Stress
□	Tensile Strain
E	Modulus of Elasticity
%	Percentage
°	Degree

LIST OF ABBREVIATIONS

ASTM	America Standard Testing Material
PMC	Polymer Matrix Composite
GFRP	Glass Fiber Reinforced Polymer
CFRP	Carbon Fiber Reinforced Polymer
FRP	Fiber Reinforced Polymer
RC	Reinforced Concrete
MMC	Metal Matrix Composite
TPs	Thermoplastics
TSs	Thermosets
SEM	Scanning Electron Microscopy

CHAPTER 1

INTRODUCTION

1.1 General

The depletion of petroleum resources together with increasing environmental concern around the world are acting synergistically to provide the impetus for new products and materials that are compatible with the environment and dependent on fossil fuel (A.K Mohanty,2005). Composites material, especially “green composite” fit well in replacing the petroleum resources. Green composites are known for their bio degradable properties, easily recycled and strength properties. Economy also plays a major roles in reviving the application of natural fiber which are cheaper, readily available, environmental friendly and easy to process. It is the major task for scientist and engineer to develop new biobased product to fulfill the world demand. Biopolymers are now starting to migrate into the mainstream and biobased polymers may soon be competing with commodity plastic (A.K Mohanty,2005).

Most plastic themselves are not suitable for load bearing application as they have low strength, stiffness and dimensional stability. Thermoplastic for example Polypropylene, Polyethelylene and Polystryrene have limited strength and resistance to weather, flame and ozonation. With the industrial used of plastic, combinations of plastic with natural fiber or wood flour were introduced years ago (A.K Bledzki, 2002). The introduction of natural fiber helps to adjust the mechanical properties and modify composition of the polymeric material.

1.2 Objectives

The objectives of this study are:

1. To study the effect of different build orientation to the composite.
2. To determine the mechanical strength of the epoxy resin reinforced coconut fiber composite.

1.3 Project Scope:

In this project, epoxy and coconut fiber will be used as the material to build a composite. Since the composite is to be built, the parameter in this project is build orientation of the composite. Then analysis is done based on the result from the composite by tensile test. The tensile properties will be obtained based on the tensile test conducted. Ten specimens are prepared for each case but only five of the best result is carried out for further analysis.

1.4 Problem Statement

The term composite could mean almost anything if taken at face value, since all materials are composed of dissimilar subunits if examined at close enough detail. But in modern materials engineering, the term usually refers to a “matrix" material that is reinforced with fibers.

Many composites used today are at the leading edge of materials technology, with performance and costs appropriate to ultra demanding applications such as spacecraft. Metal and glass are available as matrix materials, but these are currently very expensive and largely restricted to Research & Development laboratories.

Coconut plant is the common plant in all around the world. There are many useful of parts of coconut tree. Usually, many parts of coconut will be wasted by industry especially in handicraft industry. So, by manipulate the waste from coconut tree for example coconut husk, it can contribute in engineering field which is used as composite. By eliminate or recycle the waste of coconut husk, cost of production can be reduced. Besides that, a good performance of the application can also be achieved.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, all information regarding this study are briefly discussed and supported with article review extracted from reference books, journal and internet articles. Among the topics discussed in this chapter are glass fiber, epoxy, plastics which is focus for thermoplastic and composites.

2.2 Composites

Composite materials are those that are formed by the combination of two or more materials to achieve properties that are superior to those of its constituents. Thus, composite materials are as diverse as porcelain enamel products (glass coated metal), plastic or metal laminated corrugated paper, fiberglass strengthened cement, stainless steel clad carbon steel, fiber reinforced plastics, and steel or glass reinforced rubber (tires).

Composite materials date from the dawn of earliest recorded history. The first known application of composite materials occurred several thousand years ago when the Egyptians started using straw strengthened sun dried clay bricks in construction (R. Naslaln, 2005). Since that time great strides have been made in the development of composite materials. They now offer the promise of new products with extraordinary strength, stiffness, and chemical and temperature resistance.

Composite now generally classify into four categories:

(i) Polymer matrix composites.
(ii) Metal matrix composites.
(iii) Ceramic matrix composites.
(iv) Carbon matrix composites.

2.2.1 Polymer Matrix Composites

Polymer matrix composites (PMC) are formed by embedding continuous fibers in a resin matrix which binds the fibers together (R. Naslaln, 2005). Common fibers include carbon, glass, and aramid fibers while common resins are epoxy, polyester abd vinyl ester resins. The most widely used PMC composites are glass fiber reinforced polymer (GFRP) composites and carbon fiber reinforced polymer (CFRP) composites (R. Naslaln, 2005). PMC composites are a new generation of structural materials for civil engineering structures. They are light, strong and corrosion-resistant. Due to these advantages, they offer great opportunities for the retrofit of existing structure and for constructing high performance structures. Major research interests and technological services include:

(i) Use of FRP as externally bonded reinforcement for the strengthening or retrofitting of existing reinforced concrete (RC) structures such as beams, slabs and columns.
(ii) Use of FRP prefabricated tubes or shapes in hybrid FRP-concrete structures and as all FRP structural components in bridges and other structures for new construction.

(iii) Integration of smart sensors such as optical fibre sensors into FRP to develop smart FRP structures.

2.2.2 Metal Matrix Composites

Metal matrix composite (MMC) materials have been so intensely researched over the past year that many 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.

2.2.3 Ceramic Matrix Composites

Ceramic matrix composite (CMC) have been developed recently with improved mechanical properties such as strength and toughness over the unreinforced ceramic matrix. CMC are believed to be toughened by three main mechanisms, all of which result from the reinforcing fibers interfering with crack propagation in the ceramic. These mechanisms are (Houston R&D, 1994):

(i) Crack deflection. Upon encountering the reinforcement, the crack is deflected making its propagating path more meandering. Thus higher stresses are required to propagate the crack.

(ii) Crack bridging. Fibers can bridge the crack and help keep the material together, thus increasing the stress level needed to cause further cracking.

(iii) Fiber pullout. The friction caused by fiber being pulled out of the cracking matrix absorbs energy and thus higher stresses must be applied to produce further cracking.

2.3 Polymer

Polymer is a molecule made up of smaller molecules that are joined together by chemical bond (A. Brent Strong, 2006). However, a simple understanding of polymers can be gained by imagining them to be like a chain, or perhaps, a string of pearls, where the individual pearls represent small molecules that are chemically bonded together.

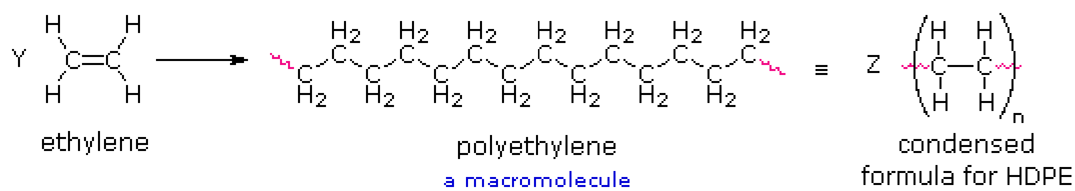

Figure 2.1: Polymer Structure.

2.3.1 Thermoplastics

Thermoplastics have the simplest molecular structure with chemically independent macromolecules. By heating, they are softened or melted, then shaped, formed, welded and solidified when cooled. Multiple cycles of heating and cooling can be repeated without severe damage, allowing reprocessing and recycling.

Often some additives or fillers are added to the thermoplastic to improve specific properties such as thermal resistance, wear resistance and chemical stability. Some thermoplastics are crosslinkable and are used industrially in their two forms, thermoplastics and thermosets. The link created between the chains of the thermoplastics limits their mobility and possibilities of relative displacement that bring certain advantages and disadvantages (A. Brent Strong, 2006).

The advantages of using thermoplastics are:

(i) The softening or melting by heating allows welding and thermoforming.
(ii) The processing cycles are very short because of the absence of the chemical reaction of crosslinking.
(iii) Processing is easier to monitor, because there is only a physical transformation.
(iv) The wastes are partially reusable as virgin matter because of the reversibility of the physical softening or melting.

Beside of the advantages of the thermoplastics, there are also their disadvantages. The disadvantages of the thermoplastics are as follow:

(i) When the temperature rises, the modulus retention decreases, due to the absence of chemical links between macromolecules.
(ii) For the same reason, the creep and relaxation behaviors are not as good as for the thermosets.
(iii) There are few materials workable in the liquid state.

2.3.2 Thermosets

Thermosets before hardening, like thermoplastics, are independent macromolecules. But in their final state, after solidified, they have a three-dimensional (3D) structure obtained by chemical crosslinking produced after the molding or during the processing.

The link created between the chains of the thermoplastics limits their mobility and possibilities of relative displacement that bring certain advantages and disadvantages (A. Brent Strong, 2006).

There are many advantages of thermosets. The advantages of thermosets are:

(i) Infusibility: Thermosets are degraded by heat without passing through the liquid state. This can improved some aspect of fire behavior. Except for particular cases, they do not drip during a fire and a certain residual physical cohesion involves a barrier effect.

(ii) When the temperature increases the modulus retention is better due to the 3D structure.

(iii) Better general creep behavior, the links between the chains restricting the relative displacements of the macromolecules.

(iv) Simplicity of the tools and processing for some materials worked or processed manually in the liquid state.

Beside of the advantages of the thermosets, there are also their disadvantages. The disadvantages of the thermosets are as follow:

(i) The chemical reaction of crosslinking takes a considerable time that lengthens the production cycles and often requires heating that is an additional expenditure.

(ii) The processing is often more difficult to monitor because it is necessary to take care to obtain a precise balance between the advances of the crosslinking reaction and the shaping.

(iii) Certain polymer release gases in particular water vapour during hardening.

(iv) The wastes are not reuseable as virgin matter because of the irreversibility of the hardening reaction. At best, they can be used like fillers after grinding.

(v) The infusibility prevents assembly by welding.

2.3.3 Thermoplastics vs Thermosets

Polymers can be classified into thermoplastics (TPs) and thermosets (TSs) depending on their mechanical behavior on heating and cooling. TPs comprise long-chain molecules held together by weak bonds (Figure 2.2a). When heat is applied, the molecules “slide past” one another and the polymer softens. On cooling, the molecules cannot slide past each other easily and the polymer hardens. TS longchain molecules, however, are linked together by small molecules via strong chemical bonds, a process sometimes referred to as vulcanization (Figure 2.2b). This three-dimensional network is so rigid that the molecules cannot move very much even when the polymer is heated. Thus, TSs do not soften when heated (Ralph M. Paroli, Institute for Research and Constructions).

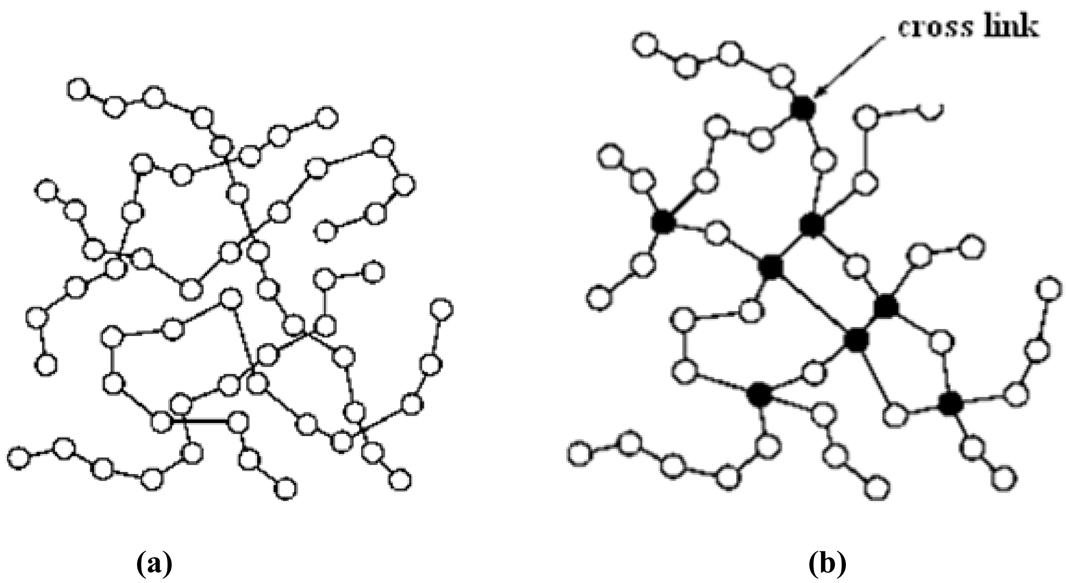

Figure 2.2: Thermoplastic and Thermoset Structure.

Because of these differences, TP and TS membranes are bonded differently when applied. TPs can be bonded using heat welding: the hot air melts the polymer at the seam and the two strips of membrane become fused. TS membranes are usually bonded using adhesives or tapes (Ralph M. Paroli, Institute for Research and Constructions).

2.3.4 Thermoplastics and Thermosets Processing.

There are many types of processing the thermoplastics. The most common process are injection molding and blow molding,. In injection molding, the softened or melted thermoplastics are forced into a mould cavity. Then there are cooled to solidify to acquire its final performances. Apart from a coefficient of shrinkage and possibly warpage, the part has the shape of the cavity.

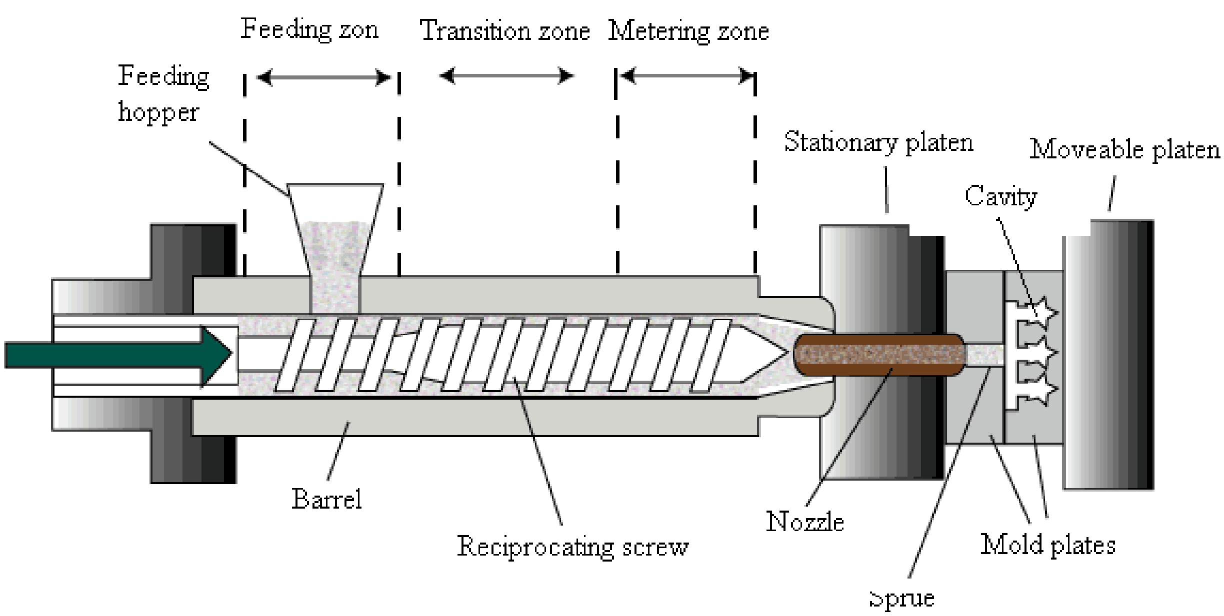

Figure 2.3: Injection Molding Machine

An injection molding machine (Figure 2.3) comprises three main parts:

1. An extruder with a heating device for resin plasticizing or melting. The screw design and the temperatures depend on the injected material.

2. A ram system allowing introduction under high pressure of the dosed material into the mould. On some types of injection machine, the screw also acts as the ram.

3. A mould with the cooling device to allow cooling of the thermoplastic which will give part solidification and allow its release from the mould. The mould can be mono- or multi-cavity.

Blow molding is a manufacturing process by which hollow plastic parts are formed. It is a process used to produce hollow objects from thermoplastic. In general, there are three main types of blow molding: extrusion blow molding, injection blow molding, and stretch blow molding. The blow molding process begins with melting down the plastic and forming it into a parison or preform. The parison is a tube-like piece of plastic with a hole in one end in which compressed air can pass through. The basic process has two fundamental phases. First, a parison of hot plastic resin in a somewhat tubular shape is created. Second, a pressurized gas, usually air, is used to expand the hot parison and press it against a female mold cavity. The pressure is held until the plastic cools. This action identifies another common feature of blow molded articles. Part dimensional detail is better controlled on the outside than on the inside, where material wall thickness can alter the internal shape. Once the plastic has cooled and hardened the mold opens up and the part is ejected. The principle of blow molding is shown as Figure 2.4 below.

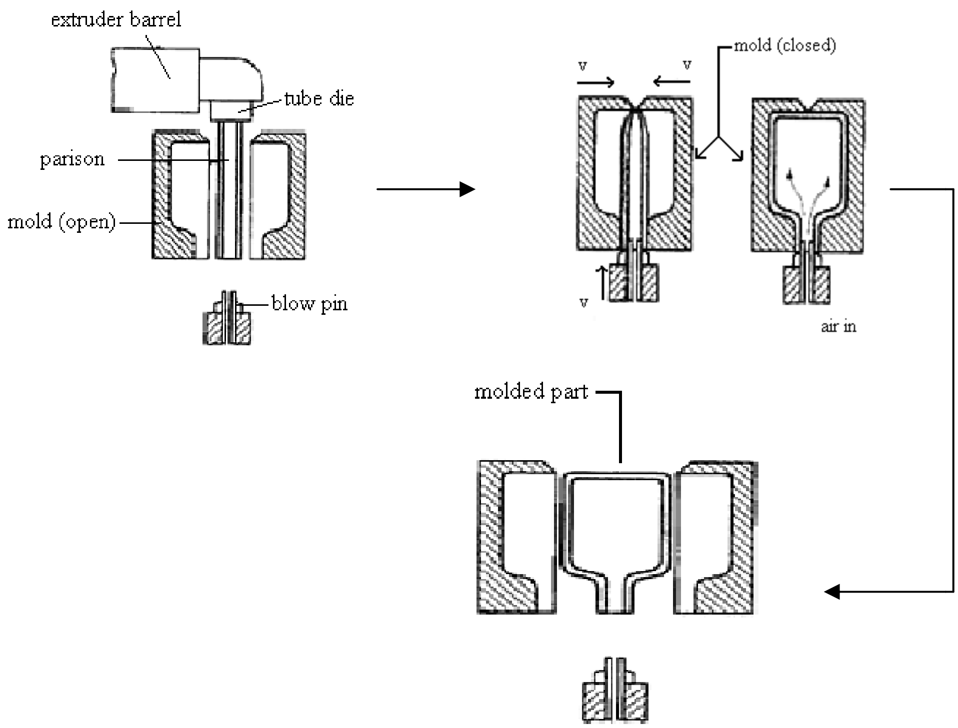

Figure 2.4: Principle of Blow Molding.

2.4 Epoxy Resin

Epoxy resins based on bisphenol A are about 85% of the world‘s epoxy resins production. More than 60% of the global production is used in the coatings industry (J. George, I. Van De Weyenberg, 1999). They have appropriate properties like high chemical and thermal resistance, very good adhesion to various substrates, hardness and elasticity. Epoxy resins are produced according to two different methods:

(i) Polycondensation of bisphenol A and epichlorohydrin carried out in the solution in the presence of sodium hydroxide (Bryan E.,1994) where purification of the product is needed.

(ii) Polyaddition of bisphenol A lower-molecularweight epoxy resins (Bryan E.,1994) in the presence of a catalyst where pure product is obtained so all the costly procedures of purification are avoided.

In the industry, these two reactions are generally provided under conventional heating and epoxy resins are manufactured by the melting process where in liquid epoxy resins and bisphenol A are heated in a batch reactor for a couple of hour. The reaction is carried out at the temperature range 140—180°C with nitrogen "blanket" to minimize oxidative degradation reactions (Bryan E.,1994). In the reaction, the known catalysts such as tertiary amines or phosphines, quaternary ammonium or phosphonium salts, and imidazole derivatives are applied. The reaction mixture needs an excess of epoxy groups in relation to active hydrogen atoms in bisphenol A (Bryan E.,1994).

Important product areas for epoxy resin are marine, automotive, electric and electronic, building, construction, sport and leisure, domestic and sanitary appliances, furniture as well as military applications. Epoxy resins are very versatile as the processing into a composite product can be done using several techniques; hand lay-up and spray lay-up lamination, casting, compression molding, pultrusion, resin transfer moulding (RTM), vacuum infusion and filament winding (Astrom, B.T, 1997).

2.5 Natural Fiber

Natural fiber can best be describes as fiber that derived from vegetable matter. There is growing interest in the possible use of natural fibers in RPs, not only in the developing countries that produce them, but also in the industrial countries, where some believe they might help in solving recycling problems.

Natural material usually sensitive to temperature and they also tend to absorb water and often exhibit extreme variation in quality that is not good for an automobile manufacturer (Donald V Rasato & Dominick V Rosato, 2004). The advantages of natural fibers include low density and cost, better damage tolerance in RPs, and high specific strength to stiffness. However, there are still have disadvantages of natural fibers because they continues to be basic problems of degradation by moisture, poor surface adhesion to hydrophobic resins and susceptibility to fungal and insect attack. As review properties can be improved by treatment of the fibers, one obvious route being to reduce the water absorption which has a direct effect on physical performance such as tensile properties (Donald V Rasato & Dominick V Rosato, 2004).

2.5.1 Coconut Fibers

Coconut fiber is obtained from the fibrous husk of the coconut from the coconut palm, which belongs to the palm family (Palmae). Coconut fiber has high lignin content and thus low cellulose content, as a result of which it is resilient, strong and highly durable. The remarkable lightness of the fibers is due to the cavities arising from the dried out sieve cells. Coconut fiber is the only fruit fiber usable in the textile industry. Coir is obtained by retting for up to 10 months in water followed by sun-drying. Once dry, the fiber is graded into "bristle" fiber (combed, approx. 20 - 40 cm long) and "mattress" fiber (random fibers, approx. 2 - 10 cm long) (Transport Information Services (TIS), 2002). It is used to produce hawsers, ropes, cords, runners, mats, brooms, brushes, paint brushes and as stuffing for mattresses and upholstered furniture.

2.5.2 Jute Fibers

Jute fiber is the most important natural fibers. It contains 56 - 64 wt% cellulose, 25 – 29% hemicelluloses, 11 – 14% lignin, and a small proportion of fats, pectin, ash and waxes. These low- cost natural fibers consists mainly cellulose and hemicelluloses chains running parallel to the fiber direction and lignin. The properties of jute fibers are high performance, average unidirectional- oriented tensile strength (Ts) is 500 MPa, elastic modulus (E) is 40 GPa and elongation is 1.7% (Donald V Rasato & Dominick V Rosato, 2004).

2.5.3 Soya Bean/Cellulose Fiber

Soya bean fiber is one of the kinds of organic or natural fiber. It is also claimed to be a variable alternative to glass fiber in reinforced plastics. The basis is waste cellulosic fibers bound with soy protein/ phenolic binder systems (Donald V Rasato & Dominick V Rosato, 2004). This fiber can be formed into extruded shapes and compression molded sheets and can be nailed, sawed and machined.

2.6 Application of Natural Fibers

The consumption of raw materials such as coal, petroleum and natural gas fossil resource has increased steadily since the early of industrialization. In addition to energy and heat production, fossil resources have been and still used as basic materials for chemical industry, for eaxample the products of which have replaced many of the renewable raw materials such as natural fiber and lamp that have been used.

Natural fibers can be applied in many kinds of engineering field such as aerospace, construction, electrical component and others. It is because their behavior is same like the E-glass fiber. The surface of natural fibers is rough and uneven and provides good adhesion to the matrix in a composites structure. In a comparison the tenacity and elongation at failure of both natural fibers and synthetic fibers shows that the natural fibers can compete with E-glass fibers (N. J. Marston, 2008)

Chapter 3

Methodology

3.1 Introduction

In this chapter, the detail process of the project will be discussed. This method is related on how the project will be carried out step by step. Methodology of a project can be defined as a sort of management and project planning from the beginning until the final stage of the project. Thus, a well planned methodology can avoid delay of works and clash activities. It can also accomplish the procedures which will satisfy the project objectives on time when it being followed perfectly. Generally, this chapter described the approaches and major stages of the project undertaken.

3.2 Flow Chart

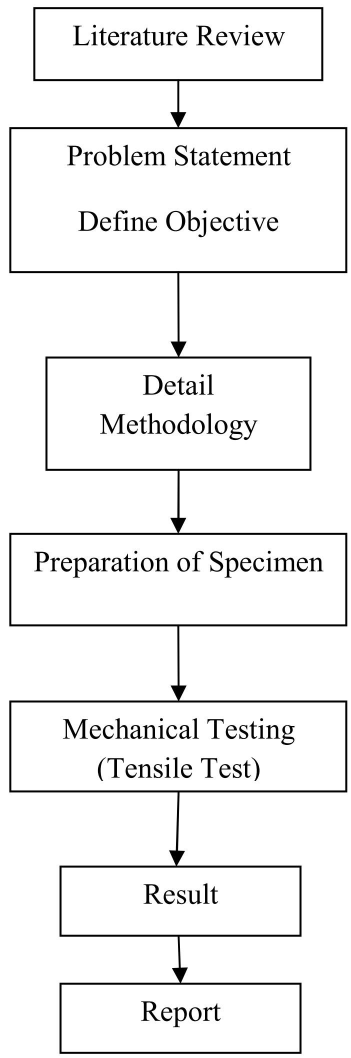

Figure 3.1: Flow Chart of the Project.

Flow chart is the rough planning on how the study is done from the idea of the study until the output based on the experiment. Flow chart is important to make sure the project or study becomes smooth without any problem.

3.3 Experiment Method

This research was conducted based on method testing of the material testing which is tensile test. Tensile test is the test to determine the ultimate strength and the yield strength of the material before the material undergoes plastic deformation. In this case the material is the composite which is made from epoxy and natural fiber (coconut husk). The fiber used is long type fiber which means that the coconut husks not be cut into small pieces. In this test the material will be pulled/stretched to failure in a relatively short time at a constant rate.

3.4 Cleaning

Cleaning is the process of clearing the fiber content in the coconut husk. Coconut husk need to be cleaned to remove the water in the fiber of the coconut husk. The existence of water in the fiber can affect the result obtained during tensile testing under constant load.

3.4.1 Drying

When the retting process is done, the drying process is applied. The coconut husk is put into the furnace in the temperature of 50˚C for about 6 hours. This process is to dry the water in the natural fiber. To produce a good fiber, the moisture must be clean out to ensure the testing could be done without any external effect from the fiber.

3.5 Hand Lay-up

Hand lay-up is a process in which coconut fibers and resin are simultaneously deposited in an open mold. The step of lay-up process is really simple. The epoxy is fed through into an open mold. The mold size is 320mm in length, 200mm in width and 80mm in high as shown in Figure 3.2 (a). Coconut fiber that had been rolled is arranged in the open mold and epoxy is fed through into the open mold as shown in Figure 3.2 (b). The mixture of resin and the fiber is rolled by a roller to compact the fiber and the matrix together. The part is cut into pieces after it is fully cure in room temperature. The dimension of the specimen is 200mm in length, 5mm in thickness and 20mm in width as shown in the Figure 3.2 (d).

(a)

(b)

(c)

(d)

Figure 3.2: Hand Lay-up Process.

3.6 Fiber Orientation

In this study, the mix proportion (length, volume and combination way of fibers) and the fiber orientation of 0°, 90° and random were chosen as parameters. And in each mix proportion, three types of fiber orientation were prepared; 0˚, 90˚ and random orientation. The specimen in which the flow direction was parallel to the tensile loading direction where the fiber orientation is 90 degree is categorized as Case A. The specimen with the angle of 0 degree between the flow direction and loading direction where the fiber orientation is 0 degree is categorized as Case B. And the last one is the random orientation of fiber which is categorized as Case C.

Figure 3.3: Blank Epoxy

Figure 3.4: 90° Fiber Orientation

Figure 3.5: 0° Fiber Orientation

Figure 3.6: Random Orientation

3.7 Tensile Test

A tensile test also known as tension test. It is the most fundamental type of mechanical test that is usually performed on material. Tensile tests are simple, relatively inexpensive, and fully standardized.

The test is done by using a standard computerized tensile test machined name Universal Tensile Machine DTU-900 MH Series which shown in Figure 3.7. The test will be carried out according to ASTM D638 standard. The speed of the crosshead is set to 2.5mm/min for every test specimen. Ten test specimens were tested for each composite material but only five of the best result will be selected for the data analysis. The elongation of the specimen was continued until the entire specimen broken. The load versus elongation graph will be recorded for each specimen. From the graph that has been plotted, the tensile strength, percentage of elongation and Young's Modulus of the composite can be determined.

Figure 3.7: Universal Tensile Machine DTU-900 MH Series

3.7.1 Machine and Software Set up.

Setting up the machine is rather easy. Basically the lower jaw of the machine is fixed and the upper jaw of the machine will moved upward as the applied force direction. The plate is clamped between the upper and lower jaw as shown in Figure 3.8.

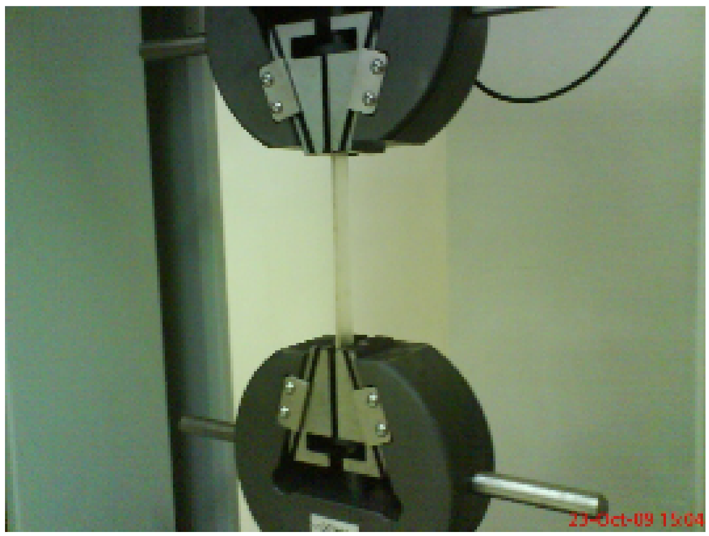

Figure 3.8: Clamping Position of the Plate

After clamping the plate, open the software of Tensile Machine DTU-900 MH Series as shown in Figure 3.9. Code editor icon is selected to choose the specimen type and the type of test for the experiment. For this test, polymer specimen was chosen and the type of test used for this test is plate tensile test. The figure of the software as is shown in Figure 3.10.

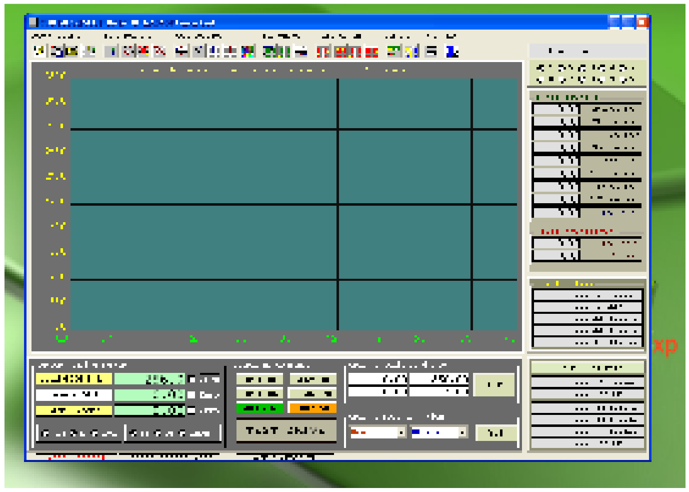

Figure 3.9: The software of Universal Tensile Machine DTU-900 MH Series

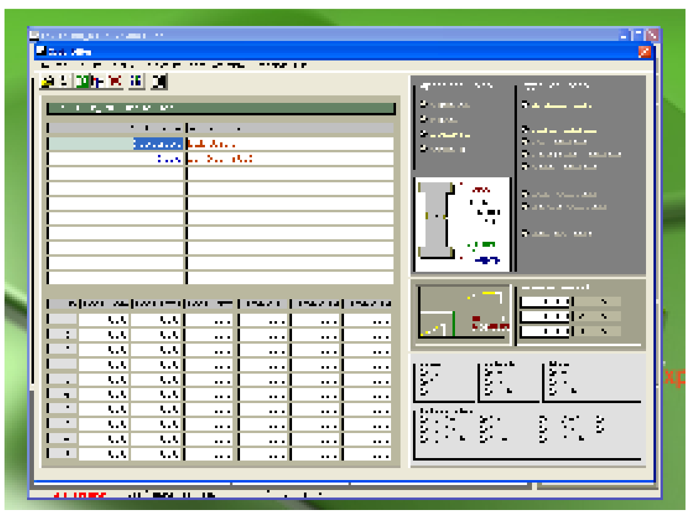

Figure 3.10: Code Editor Specifications.

Before running the test, the plate must be clamped tightly at the lower jaw and after zero the distance of elongation stroke at the software, the lower jaw is clamped tightly. Test drive icon is clicked at the bottom centre of the window and the test is stared. The pre-testing set up window will appear. Finally check the test specifications is checked and start now icon is clicked to begin the tensile test as shown in Figure 3.11.

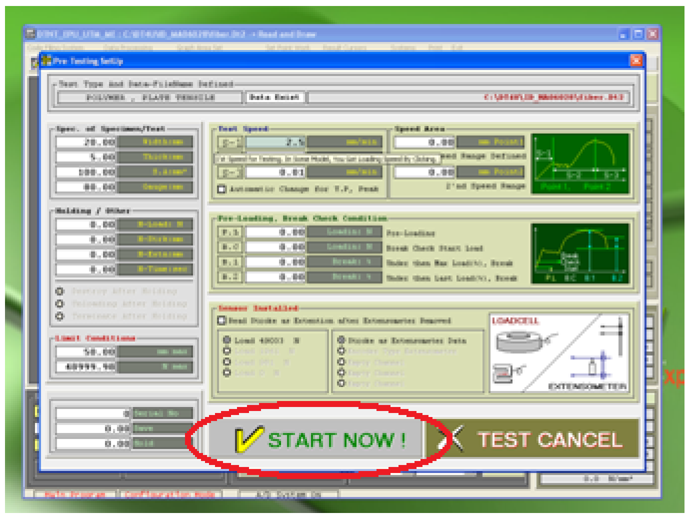

Figure 3.11: Pre-Testing Set up Window

The plate will be in tension mode as the applied loads keep increasing until reach the maximum load of the machine or the specimen is broken. The graph will be plotted based on the applied load and the stroke of plate as shown in Figure 3.12.

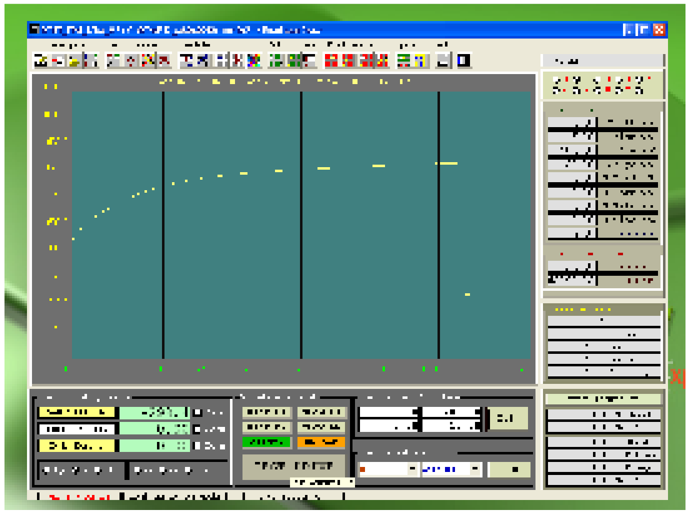

Figure 3.12: The Graph Plotted by the Software

The test will be stopped automatically, the plotted graph is displayed and the data of the graph will be printed out by clicking the print work icon at top of the window. The same steps were used to run the test for the other plates.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Tensile Properties

The tensile properties of blank epoxy and combined with coconut husk fiber orientation are shown in Table 4.1.

Samples	Strength, σ (MPa)	Young's Modulus, E (MPa)	Strain, □ (%)
Blank epoxy	10.80	68.44	15.78
0^0 orientation	11.80	541.28	2.18
90^0 orientation	15.82	520.39	3.04
Random orientation	12.24	478.13	2.56

Table 4.1: Tensile properties of blank epoxy and combined with coconut fiber orientation.

4.1.1 Tensile Strength

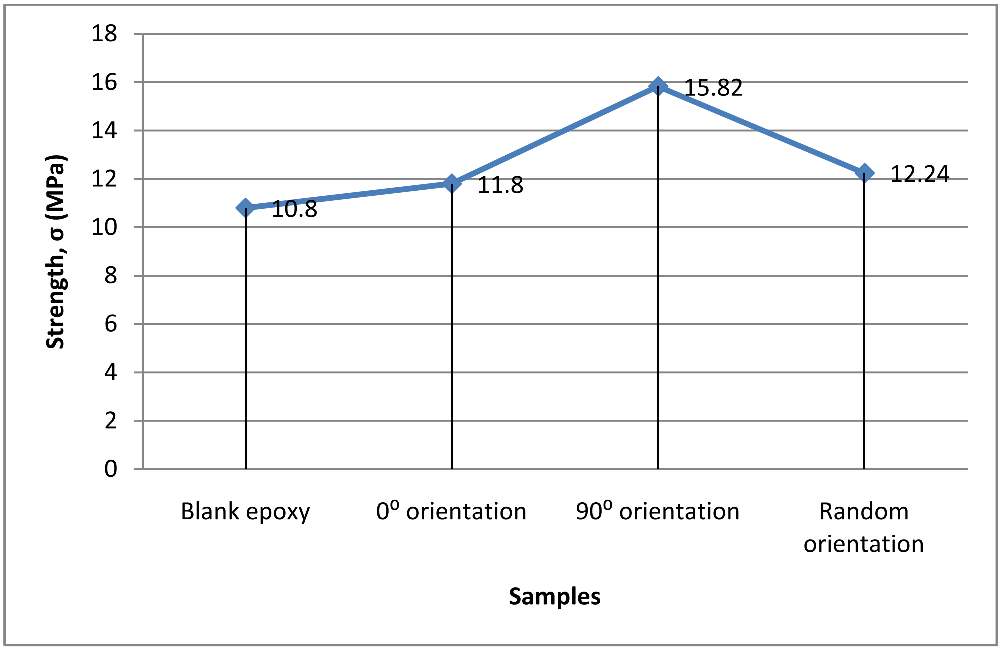

Figure 4.1 : Tensile strength of pure epoxy and combine with coconut fiber orientation.

The result from Figure 4.1 above clearly shows that the strength of 90^0 orientation of coconut fiber sample is the highest from other composites. The presence of the fiber orientation gives high degree of rigidity and toughness to the composite, so high amount of stress is needed to break the samples. Better wetting of fiber and matrix resin results in the increase in tensile stress. This is due to the fact that coconut fiber particles strengthen the interface of the composite. The epoxy matrix transmits and distributes the applied stress to the coconut fiber resulting in higher strength. Therefore, the composite can sustain higher load before failure compared to the unreinforced epoxy (Bruce Davis, 2003).

The tensile strength of random orientation coconut fiber is much lower than the 90^0 orientation samples. It is because random fiber orientation in the composites has both 90^0

and 0^0 orientation. The strength of this composite will be high or lower according to the orientation. If the sample breaks at the 0^0 orientation the strength value will be lower.

The orientation in 0^0 making the reinforcement becomes weaker than the 90^0. This orientation cannot hold the structures of the composite as well as 90^0 and random orientations do. So, the composite tends to break easily and lower amount of stress is needed to break the samples. However, if the orientation is 90^0, higher stress is needed to break the structure of the composites. It is because the arrangement of the fiber that hold the structure is parallel to the applied force (Paul Gramann, 2003). So, when the sample broke, the fibers still hold the structure of the composites. That is why the tensile strength of 90^0 orientations is greater than 0^0 orientations.

From the experiment, we can see that the lowest strength of the composite is epoxy combine with 0^0 coconut fiber orientation. As discussed earlier, the fiber cannot hold the structure longer compared to random and 90^0 orientation because the applied force is tangential with the fiber orientation. Under equal static loading, failure occurred around a localized through thickness shear fracture plane (J. George, 2000). This may be attributed to the woven nature of the composite which tends to result in through-thickness shear failure initiation across a longitudinal fiber bundle. The equal static failure mechanisms generally included matrix cracking, localized warp fiber fracture, weft fiber pull-out, and delamination along the middle plies.

4.1.2 Young's Modulus

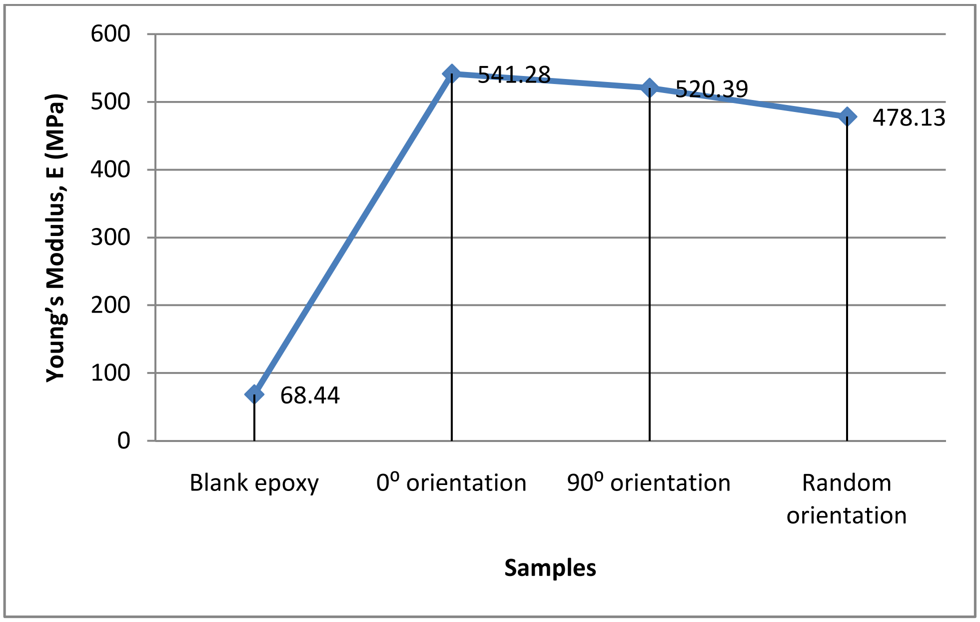

Figure 4.2 : Young's modulus of pure epoxy and combine with coconut husk fiber orientation.

Young's Modulus is a measure of a stiffness of the material before it fails. Greater value of Young's Modulus refers to a tougher material. Epoxy resin contains single molecules (monomers) of the epoxy resin chemical and the curing agent combine to form long chains of molecules (polymers). As the mixture cures, it becomes a hard polymer (Sergio Neves Monteiro, 2007). The addition of coconut fiber orientation in polymer matrix should increase the Young's Modulus of the composites.

From the experiment, it shows that the Young's modulus of the composites vary from one sample to another. The 0° orientation sample shows the highest Young's modulus compare to others samples. The existents of the fiber in the sample make the composite becomes tough. Combination of epoxy and coconut fiber based on 0° orientation make them hold the structure before the molecules of epoxy slip pass one another. Besides that the covalent bonding in the composite help the sample from getting slip easily when the tensile force is applied (Ailton Silva Ferreira, 2007). High stress is needed to break the fiber that holds the original material from breaking.

The existence of 0° fiber orientation in the composite affected the strain rate of the samples. The strain rate of the 0° fiber orientation becomes lower thus resulting in high value of Young's Modulus. The behavior of the fiber itself which is woven and hairy has made the matrix hard to move/slip pass one another. Compared to 90° orientation, the applied load is parallel to the fiber arrangement thus making the strain of the composite higher than 0° orientation. This situation has change the modulus of elasticity in term of the strain rate of the composite.

One of the coconut fiber properties which is has high cellulose contain has cause the high crystalline to the epoxy molecules thus resulting in low elongation. The characteristic of the cellulose which is hydrophilic (attract water) has create air bubble in the composite. Existence of the air bubble in the composite is not good for the structure because it can cause delamination of the matrix and fiber contact. This situation caused the stress and the strain rate become lower compared to unreinforced epoxy.

4.1.3 Tensile Strain

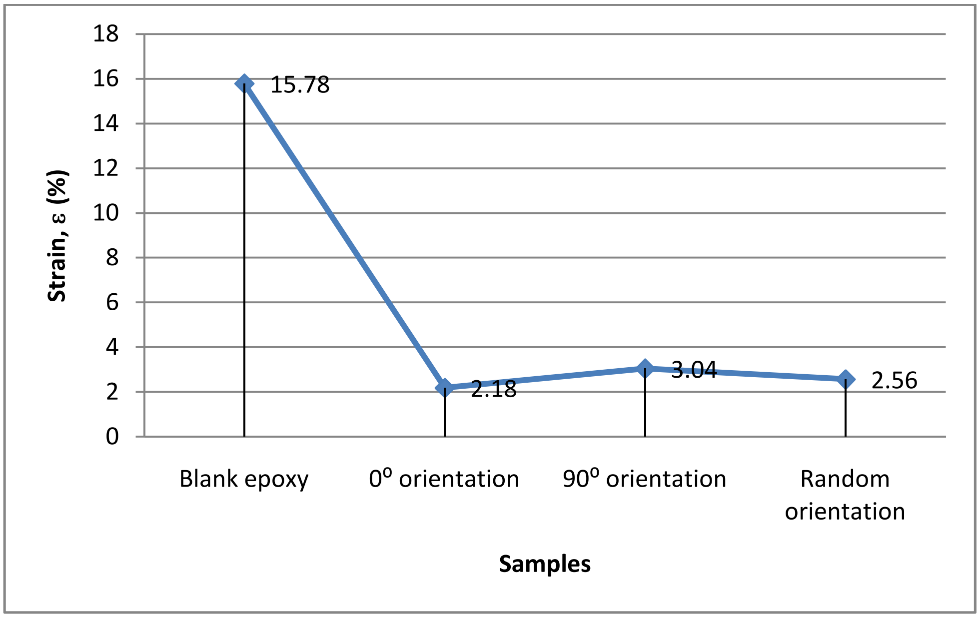

Figure 4.3 : Tensile strain of pure epoxy and combined with coconut husk fiber orientation.

The tensile strain of all samples differs from each other. Blank samples have the highest tensile strain. The addition of the fiber in the composite restricts the mobility of polymer molecules to flow freely past one another. This situation has caused premature failure for the material. For the others three results obtained, it shows that the tensile strains are lower than the blank epoxy which is lower than 5% of the elongation. It is because the fibers in the composite act as the strengthening mechanism to the material and do not allow the slip of the covalent bonding molecules to take place (Kevin A. Brown, 2007). The effect of strain rate on the modulus and strength may also be attributed to the woven structure and geometry of the composite.

90° orientation of fiber shows higher strain-rate sensitivity than 0° and random orientation composites because of the higher interaction between the matrix and fibers

(Richard Brooks, 2007). Furthermore, the rate sensitivity of the tensile strength can also be attributed to the rate dependence of the coconut fibers. This is supported by the fact that the tensile strength of the composite laminate is primarily governed by the fiber strength. It can be conclude that coconut fiber can elongate upon applied stress before the material fail.

0° fiber orientation has the lowest tensile strain because of the fiber orientation in the composite. The fiber is arranged horizontally with the applied force based on y-axis. So, the fiber in the composite will easily slip when force is applied to them. The 0° orientation fiber could not withstand the force longer and cause the breaking in short time. This behavior makes the 0° orientation have the lowest tensile strength among those three samples that have been added with the fiber inside the original material.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The purpose of this study is to determine the properties of epoxy reinforced coconut fiber composite. The experiment shows that the fiber orientations in the composite give the effect to the strength of the original material. It can be concluded that adding various types of fiber orientation into the original material have made the material become stronger with high strength and high modulus of elasticity of the material.

By conducting the tensile test, the strength and properties of the material can be determined. The tensile properties of epoxy reinforced coconut fiber composites are greater than the original/blank epoxy. It shows that 90° fiber orientation has the highest tensile strength compared to the 0° and random orientation. The presence of the fiber orientation gives high degree of rigidity and toughness to the composite, thus high amount of stress is needed to break the samples. The increase of the fiber contact, results in the increase of tensile stress. This is due to the fact that coconut fiber particles strengthen the interface of the composite. The epoxy matrix transmits and distributes the applied stress to the coconut fiber resulting in higher strength. Therefore, the composite can sustain higher load before it fail compared to the unreinforced epoxy.

The highest strength of composites occur at 90° fiber orientation. High amount of stress is needed to break the material with that kind of fiber orientation. This property is good in engineering field for example in automotive and construction field where high strength of material is needed. By using the natural fiber, the cost of production can be decrease because there are growing interests of natural fiber nowadays. Besides that, natural fiber is easy to set either from plants or animals matter. The advantages of natural fibers include low density and cost, better damage tolerance in reinforced plastics, and high specific strength to stiffness. However, there are still disadvantages as natural fibers continue to be basic problems of degradation by moisture, poor surface adhesion to hydrophobic resins and susceptibility to fungal and insect attack. As review, properties of epoxy resin reinforced coconut fiber can be improved by treatment of the fibers, one obvious route being to reduce the water absorption which has a direct effect on physical performance such as tensile properties.

Modulus of elasticity of the coconut fiber also high compare to unreinforced epoxy. The modulus of elasticity is the measures of the stiffness of the material before it fail. Higher amount of modulus of elasticity refers to tougher material. The 0° fiber orientations give the highest amount of modulus of elasticity which means that, the type of this orientation is very tough and produces brittle material.

From this study, some key observations can be made about the effect of strain rate on the tensile mechanical properties of epoxy reinforced coconut fiber composites. At high strain rates, the tensile stiffness, maximum strength, and strain to failure tend to significantly increase with increase in strain rate. However, further detailed study is required to elucidate the relationship between failure mechanisms and the strain-rate sensitivity of the mechanical properties.

5.2 Recommendation

Some recommendations have been identified for further work as this study only focuson the effect of fiber orientation to the composite. The following aspects should be taken into consideration in order to set better result:

(i) Check the compatibility of the microstructure using Scanning Electron Microscopy (SEM).

(ii) Make comparison between two different material and fiber used in the composite for example man- made fiber such as glass fiber or carbon fiber to know which is better and reduce cost of production.

(iii) Make pre-treatment of the fiber before the lay-up process is done by adding adhesion promoter or use chemical binder. This is because in this project, the resulting in poor result/analysis.

(iv) Add other testing method for example hardness or impact testing to examine their compatibility of the matrix and fibers.

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APENDIXES