MECHANICAL PROPERTIES OF COCONUT SHELL IN REINFORCED POLYMER COMPOSITE

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This report is submitted

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DECLARATION

I declare that this thesis entitled “The Mechanical Properties of Coconut Shell in Reinforced Polymer Composite” 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

Signature :..................................

Name :..................................

Date :..................................

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 Bachelor in Mechanical Engineering (Hons)

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Signature	:…………………….
Supervisor Name	:…………………….
Date	:…………………….

DEDICATION

I would like to dedicate my Bachelor Degree to my late father, Tar Singh Tiwana A/L Gurdial Singh, the person that encourages me to pursue mechanical engineering field. My father, who taught me that the best knowledge in life which is to look at the positive side in every negative things. Next, it also dedicates to my beloved mother, Sarzi Kaur who worked hard to give me moral and financial support to finish my studies.

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ABSTRACT

Nowadays, the utilization of natural fibers in composites has been increasing and developed to save the environment by using biodegradable materials. The aim of this project is to study the mechanical properties of polymer composite reinforced with coconut shell. Previous studies show that synthetic fiber has more disadvantages than natural fiber such as lower mechanical properties, high cost and higher environmental risk. Powders are produced from coconut shell by using crusher machine, will be the reinforcing material of composite meanwhile unsaturated polyester resin will be the matrix of composite. The optimum ratio of filler content must be obtained to analyze the performance and effects of increasing filler content to tensile properties of composite. In this project, powder particle size 500 µm and below which is randomly distributed, and filler concentration varies by 10%, 15%, 20%, 25% and 30% into polyester matrix. The composites will be produced by using open-mould method and by mixing the powder with resin using stirrer machine. The characterization of particles will be determined by collecting data from the tensile, hardness test, density test and microstructure analysis. ASTM standards were obliged for every specimens that will be fabricated for each test. Polyester Resin and hardener will be mixed to form a solid. Methyl Ethyl Ketone Peroxide (MEKP) are hardeners that referred to as catalyst. MEKP used in this project is Butanox-M60. The main finding of this project is sample with 15% filler content shows maximum tensile properties while hardness increases gradually as filler content increase from 10% to 30%. The Tensile Stress and extension at break increased 15.91% and 6.11% respectively and filler content increased from 10% to 15% then reduce as filler content further increased. Meanwhile, the hardness and Young's Modulus shows increase 21.5% and 33.26% respectively for sample from 10% to 30% filler content. The density decreases by 0.58% as filler content increase from 10% to 30%.

ABSTRAK

Dewasa ini, penggunaan gentian semulajadi dalam komposit telah meningkat dan dibangunkan untuk menyelamatkan alam sekitar dengan menggunakan bahan biodegradable. Tujuan projek ini adalah untuk mengkaji sifat mekanik komposit polimer yang diperkuat dengan kulit kelapa. Kajian terdahulu menunjukkan bahawa gentian sintetik mempunyai lebih banyak kelemahan berbanding gentian semulajadi seperti sifat mekanikal yang rendah, kos yang tinggi dan risiko alam sekitar yang lebih tinggi. Serbuk yang dihasilkan daripada kelapa dengan menggunakan mesin penghancur, akan menjadi bahan pengukuhan komposit manakala resin poliester tidak tepu akan menjadi matriks komposit. Nisbah optimum kandungan pengisi mesti diperolehi untuk menganalisis prestasi dan kesan peningkatan kandungan pengisi terhadap sifat mekanikal komposit tersebut. Dalam projek ini, saiz partikel serbuk 500 µm dan ke bawah yang diedarkan secara rawak, dan kepekatan pengisi berbeza sebanyak 10%, 15%, 20%, 25% dan 30% ke dalam matriks poliester. Komposit akan dihasilkan dengan menggunakan kaedah acuan terbuka dan dengan mencampurkan serbuk dengan resin menggunakan mesin pengaduk. Pencirian zarah akan ditentukan dengan mengumpul data dari tegangan, ujian kekerasan, ujian ketumpatan dan analisis mikro. Piawaian ASTM adalah wajib bagi setiap spesimen yang akan direka untuk setiap ujian. Resin poliester dan pengeras akan dicampur untuk membentuk pepejal. Metil Etil Ketone Peroksida (MEKP) adalah pengental yang disebut sebagai pemangkin. MEKP yang digunakan dalam projek ini ialah Butanox-M60. Temuan utama projek ini adalah sampel dengan kandungan pengisi 15% menunjukkan sifat tegangan maksimum manakala kekerasan meningkat secara beransur-ansur sebagai kandungan pengisi meningkat dari 10% hingga 30%. Tekanan tegangan dan sambungan pada rehat meningkat masing-masing 15.91% dan 6.11% dan kandungan pengisi meningkat daripada 10% kepada 15% kemudian menurun jika kandungan pengisi yang semakin meningkat. Sementara itu, kekerasan dan Modulus Young menunjukkan peningkatan sebanyak 21.5% dan 33.26% untuk sampel dari 10% hingga 30% kandungan pengisi. Ketumpatan berkurangan sebanyak 0.58% apabila kandungan pengisi meningkat dari 10% hingga 30%.

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LIST OF ABBREVIATIONS

PMC	Polymer Matrix Composite
CCS	Crushed coconut shell
CS	Coconut Shell
PR	Polyester Resin
MMC	Metal Matrix Composites
CMC	Ceramic Matrix Composites
ACM	Advanced Composite Materials
FRP	Fiber Reinforced Polymer
PRP	Particle Reinforced Polymer\
USP	Unsaturated Polyester
AC	Activated Carbon
ER	Epoxy Resin
UTeM	Universiti Teknikal Malaysia Melaka

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CHAPTER 1

INTRODUCTION

1.1 Background

The development of studies in natural fibers has increased insignificantly around the globe. Coconut shell is an organic natural plant fiber that is widely found nowadays in many industries such as building structure, furniture, packaging, agriculture, medicine and sportswear (Vasu et al, 2017). Natural fiber is also renewable source which can be extracted from leaf, seeds and grass. Coconut also have unlimited availability in many countries, it can be found abundantly in many countries such as India, Thailand, Indonesia, Malaysia, Sri Lanka and also Bangladesh. Lately, there has been escalation of interest and demand for natural fibers in many industries. The renewability of the biodegradable bio-composite makes it a highly interested attribute. It is also known that natural fibers show better mechanical properties compared to conventional synthetic fibres (Dayo, A. Q, 2017).

Other natural fibres are additionally frequently utilized as reinforcements. For example, jute, hemp and flax are commonly utilized as reinforcing material in composites. The composite can be relegated as thermosetting or thermoplastic polymer to compose a composite that has propitious properties like low energy engenderment, biodegradable and low manufacturing hazard (Bambach M.R, 2017). However, composite with natural fibre consist of intrinsic vigor that this potential can be enforced in many sector and industry as long as we understand to analyse the mechanical deportment.

Composite consist of discontinuous phase, which is additionally kenned as reinforcing material, and perpetual phase, which are kenned as matrix. The parameter of composite such as shape, size and size distribution of reinforcement are consequential in determining the mechanical properties of the composite (Bhaskar and Singh, 2013). Anteriorly, ceramics, metals and plastics and controls the composite industry. The high ebullience to supersede metals in industry is due to attribute that is light, vigorous and corrosion resistant. Cull of matrix and reinforcing material of a composite must be opportune cumulation to engender efficient composite. Nowadays, many nations are competing their technology to engender rialto for the benefits of human life and composites with low cost and best quality are engendered as customer demand. Figure 1.1 shows material development is consequential in the composite industry especially material cull that plays major role in demonstrating mechanical properties of the composite. Furthermore, material culls withal portray the advancement and development of human life (Sapuan M.S, 2014).

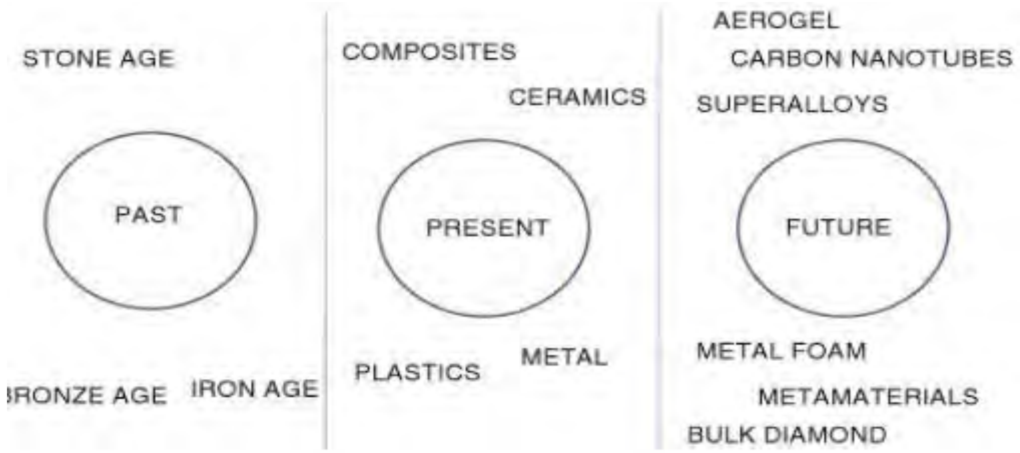

Figure 1.1: Past, Present and Future Development of Composite

(Sapuan M.S, 2014)

1.2 Problem Statement

Conventional synthetic fibers that are utilized these days such has more disadvantages than lignocellulosic natural fiber. As an alternative to conventional reinforcing fiber, lignocellulosic natural fiber is utilized since it is cost efficacious and environmental cordial through utilization of natural fillers or reinforcement in polymer composite (Salmah. H et al, 2013). Past studies show that the utilization of natural fiber composite as reinforcing material has better mechanical properties, reduced implement wear, illimitable availability, low price, and quandary free disposal due to less abrasive nature of the lignocellulose fibers.

Utilizing lignocellulose fibers provides a more salubrious working environment than the synthetic fibers. The glass fiber dust from the trimming and mounting of glass fiber components causes skin vexation and respiratory diseases among workers. For examples, there was some evidence of an 'asbestos type' condition arising from handling fiber (Cheremisinoff, N.P, 1990).

Coconut fiber is additionally incrementing in agro waste. This designates that coconut shell will be discarded after it was utilized in agriculture. Hence, it is important to fabricate sample set of composites is consequential to analyze the mechanical properties using coconut shell as an agro waste, which is to ensure healthy environment by using agro waste in composite in the future. This is indispensable for the future development of composites that will be utilized in the future in many fields such as building materials, marine cordage, fishnets, furniture, and other household appliances (Karthikeyan and Udhayasankar, 2015).

1.3 Objective

Lignocellulosic fibres are low cost raw material, which are abundant in nature, and renewability makes more interest. Natural fibres are cheaper than man-made fibres such as carbon glass and aramid. The project is cognate to engendering specimen with high mechanical properties at low cost which is rigorously environmental amicable. The engenderment of synthetic fibre depends mainly on fossil fuels and needs more energy as compared to natural fibre. The objectives of this project are as follows;

1. To fabricate coconut shell polymer composite.
2. To determine the mechanical properties of coconut shell polymer composite.
3. To study the effect of filler concentration on mechanical properties of coconut shell reinforced polymer.

1.4 Scope of Project

The flaw of composites is conventionally the cost which the raw material is often sumptuous. Consequently, the material cull for this project is circumscribed due to budget constraint.

The scopes of this project are:

1. Type of matrix used is only polyester resin as thermosetting polymer. Polyester resin is known for its low cost and high properties.
2. Type of reinforcing material used is organic plant fibre which is coconut shell. The availability of coconut shell is abundant in Melaka, Malaysia. This will help to reduce cost project.
3. Filler concentration of composite varies from 10%,15%,20%,25% and 30% only. Previous studies show that the mechanical properties are poor if the filler is too concentrated in the composite.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to Composite

In this project, we will focus on Polymer Matrix Composites (PMC) as it is the type of composite that will be produce and analyzed in this project. Widely, classification of matrix can be made based on the matrix material composite. They are:

- Metal Matrix Composites (MMC)
- Ceramic Matrix Composites (CMC)
- Polymer Matrix Composites (PMC)

MMC are widely utilized as housings, tubing, cables, heat exchangers, structural member due to high transverse vigor, greater erosion resistance and higher categorical modulus good attributes over monolithic metals. The high density is the disadvantage of metal matrix composites and consequently results in low categorical mechanical properties compared to polymer matrix composites. Furthermore, it requires high energy for fabrication.

CMC are kenned for its fiber attribute to resist temperature. Ceramic fibers can be found abundant as alumina and silicon carbide. They are salutary in very high temperature applications, and where environment assailment is an issue. Poor properties of ceramic fibers results in tension and shear, and due to these attributes, most applications of ceramic fibers as reinforcement are mostly particulate form. Ceramic Matrix Composites (CMCs) are use in environments with high temperature since it is able to resist temperature, the matrix is reinforced with short fibers, or whiskers made from silicon carbide and boron nitride.

Polymer Matrix Composite (PMC) can be relegated into according its matrix, either thermosets or thermoplastic polymer. The material utilized as matrix are polymer that will determine the properties PMC. In PMC, vigor and stiffness of PMC are lower if in comparison to MMC and CMC. In order to surmount this quandary, reinforcing other materials to the polymer can elucidate the matter. In integration, fabrication of PMC does not require high temperature and pressure and involute equipment. PMC can be divided into two relegation classes, that are Fiber Reinforced Polymer (FRP) and Particle Reinforced Polymer (PRP). These composites show higher overall properties to individual components of polymer and ceramic.

Particles utilized in PRP include ceramics, glasses, metal particles such as aluminum and amorphous materials. Particles are utilized as matrix of the composite to elevate the modules of the matrix. This results in the decrease ductility of the matrix. Another reason to utilize particles are to reduce the cost of the composites.

FRP materials is very consequential since it has high value of modulus and tensile vigor when reinforced with fibers. Furthermore, FRP shows better vigor and modulus compared to metallic materials due to its low concrete gravities, the vigor-to-weight ratios and modulus-to-weight ratios (Shackelford and Alexander, 2000).

Nowadays, materials such as steel and concrete are competing with FRP in many engineering industries such as in automobiles, boats, aircrafts industry as well as construction materials. These industries are usually found abundant with FRP.

Fiber reinforced plastics are attentive composite in many industries. It is because of its estimable categorical mechanical properties, high strength to weight ratio and corrosion resistance (Courtney T.H, 1990). Relegations of composite materials were according to its own matrix material. It can be divided into particulate reinforced composites, fiber reinforced composites and structural composites.

2.1.1 Definition of a Composite

Composites should not be regarded simple as a coalescence of two materials. In the broader consequentiality, the coalescence has its own distinctive properties. In terms of vigor or some other desirable quality, it is better than either of the components alone or radically different from either of them. They are compound materials, which is different from alloys which, the individual components keep their original attribute but are so incorporated into the composite as to take advantage only of their attributes and not of their shortcomings, in order to obtain an improved material (Prakash T, 2009).

Composite materials as homogenous materials consisting of two or more solid phases, which are in intimate contact with each other on a microscopic scale. They can be additionally considered as homogeneous materials on a microscopic scale in the sense that any portion of it will have the same physical property. It also provides characteristics not available from any discrete material. They are cohesive structures made by physically coalescing two or more compatible materials, different in composition and characteristics and sometimes in form (Verma et al, 2013).

2.1.2 Characteristics of Composite

Properties of composites are vigorously dependent on the properties of constituent materials and the interaction among them. The shape, size and size distribution of the reinforcement influences the properties of the composite.

The shape of the discontinuous phase, the size and size distribution and volume fraction determine the interfacial area of composite. This is paramount since it determines the extent of the interaction between the reinforcement and the matrix.

Concentration of composite can be controlled during fabrication. Concentration of parameter plays role in influencing the properties of composite. The concentration can be quantified as volume or weight fraction.

2.1.3 Application of Composite

In 1940s, Americans first developed glass fiber polymer matrix composites and kenned as the first developed and applied materials. It is then developed to be utilized in military. After that, glass fiber has been developed and utilized in many other fields. In the 1960s, people commenced to develop that the properties of glass fiber do not genuinely meet the requisites. Then, lightweight carbon fiber and carbon fiber composite with high specific modulus and high specific vigor were developed between the1960s and the 1970s. The development of composites then was followed by aramid fiber and other high-performance fibers. Thus, incipient composite materials starting from carbon fiber composite material was kenned as the advanced composite materials (ACM).

Now, the utilization of ACM has incremented ecumenically and utilized in many industries. In aerospace industry, a minutely minuscular number of ACM are utilized. However, a highly advanced composite material will be utilized, as it will be utilized in highly advanced technology. The conception to utilize composites in this field is to reduce cost and weight. ACMs are additionally widely utilized in conveyance, furniture, building and construction, conveyances.

Natural fiber composites were then introduced much akin to glass fibers and synthetic and are called bio composite which contains natural fiber in the polymeric matrix. These composites are mostly biodegradable and renewable which avails to contravene world pollution then has incremented recently. Polymer Matrix Composites (PMC) is an example of natural fiber composite that is developed which as gain ecumenical interest.

2.1.4 Polymer Matrix Composites (PMC)

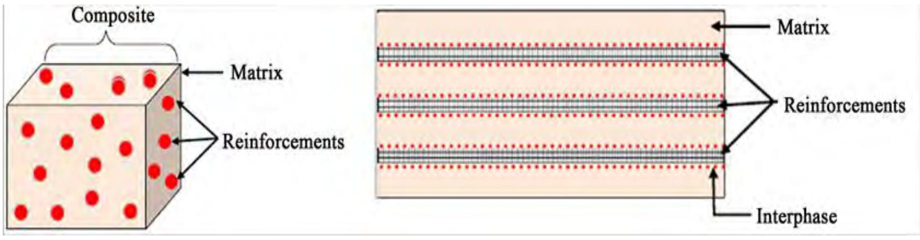

Figure 2.1: Components of Composite

(Source: http://file.scirp.org/Html/7-2710345_59743.html)

Figure 2.1 shows two main composition of a composite that is matrix and reinforcements. FRP consist of one or more discontinuous phase which is withal kenned as reinforcing material that is embedded to perpetual phase which is kenned as matrix (Bhaskar and Singh, 2013). In this research, composite consist of two component that is coconut shell as reinforcement and unsaturated polyester resin as matrix.

The role of reinforcing material is to sustain high tensile loads, while the matrix is in charge in rigidity to the composite. Loads are transfer by matrix, which is transfer from one to another fibre. However, FRP can be classified into two classes, that is thermosets and thermoplastic polymer. Thermosets are cured by a chemical reaction that is irreversible. The molecules in the polymer undergoes “cross-link” that is usually ionic or covalent bond (Karthikeyan and Udhayasankar, 2015).

2.2 Matrix of Composite

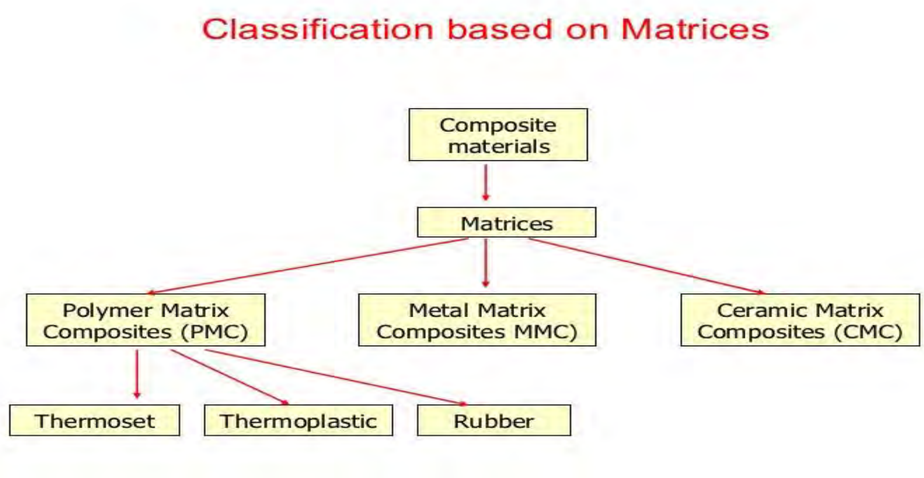

Figure 2.2: Classification of Matrices

(Source: https://www.slideshare.net/BKLR/polymer-matrix-composites)

Figure 2.2 shows the classification based on Matrices. Matrices is divided into three that is polymer, metal and ceramic. In a composite, the matrix functions as to transfer load to and between fibers by holding or "glues" the fibers together by cohesive and adhesive characteristics. Other than that, the matrix also protects fibers from environmental effect and abrasion (Karthikeyan and Udhayasankar, 2015). The matrix in composite binds the fibre together by its cohesive and adhesive characteristics. Since lignocellulosic fibre shows poor mechanical properties, hence alkaline treatment was implemented to increase interfacial adhesion between reinforcement and matrix. Moreover, the matrix contributes in resistance crack propagation and damage tolerance owing to the plastic flow at crack tips (Schwartz M.M, 1992). The type of matrix is major importance since the matrix determines the characteristic of the composite.

The type of matrix is divided into polymeric, metallic, carbon and ceramic. Polymer resin is classified into thermosetting and thermoplastics which is identified by the type