IMPACT BEHAVIOUR OF COCONUT SHELL REINFORCED POLYMER COMPOSITES

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DECLARATION

I declare that this project entitled "Impact Behaviour of Coconut Shell Reinforced Polymer Composite" is the result of my own research except as cited in the references. The project has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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

Name : Nurul Sakinah binti Azizan

Date : 25th June 2019

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 the degree of Bachelor of Mechanical Engineering (Hons).

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

Name of Supervisor : Dr. Kamarul Ariffin bin Zakaria

Date : 25th June 2019

DEDICATION

To my beloved family

ABSTRACT

To date, there is a large body of knowledge in the literature on the development of natural composites. Nonetheless, some of the main limitation is the brittleness of the natural composites when using Polyester resin as a matrix can lead to poor mechanical performance of natural composites. Thus, the main objectives of this project are i) to fabricated Coconut Shell Reinforced Polymer Composite and ii) to study the impact behavior of Coconut Shell Reinforced Polymer Composite. In this project, the coconut shells were started by reinforcing coconut shell particle using a blender. The size of coconut shell was sieved at 500µm size using vibratory sieve shaker. The coconut shell composites were prepared from 0 wt% Coconut Shell Powder (CSP) following 10 wt% of CSP and 25 wt% of CSP. Open moulding method was used in this project by mixing the Unsaturated Polyester (USP) Resin and CSP using a stirrer machine. This project following Standard Test Method for Measuring the Damage Resistance of Fiber Reinforced Polymer Matrix Composite to a drop Weight Impact Loading (ASTM D7136). The impact behavior of the Coconut Shell Polymer Composites were investigated under drop weight impact test. The experimental began with 0 wt% CSP following 10 wt% and 25 wt% CSP at 1 m/s, 2 m/s and 3 m/s velocities. The result obtained was determined by collecting data from energy absorbed, force and displacement. This project shows as increase the impact velocity, the energy absorbed by the specimen also increase. 0 wt% CSP gives the highest energy absorbed which is 6.071 J. This test suggests 25 wt% specimen for material application due to lowest energy absorbed which is 0.684 J. The presence of 10 wt% CSP gives larger damage area compared to 25 wt% CSP. It shown the 25 wt% CSP gives better impact performance than 0 wt% CSP and 10 wt% CSP at 1 m/s low velocity impact or impact energy.

ABSTRAK

Sehingga kini, terdapat banyak pengetahuan dalam kesusasteraan mengenai perkembangan komposit semulajadi. Walau bagaimanapun, beberapa batasan utama adalah keruntuhan komposit semulajadi apabila menggunakan resin poliester sebagai matriks boleh menyebabkan prestasi mekanikal komposit semulajadi yang tidak baik. Oleh itu, matlamat utama projek ini adalah i) untuk fabrikasi Komposit Polimer Bertetulang Tempurung Kelapa dan ii) untuk mengkaji tingkah laku kesan Komposit Polimer Diperbuat daripada Tempurung Kelapa. Dalam projek ini, cangkang kelapa dimulakan dengan menguatkan zarah kelapa menggunakan pengisar. Saiz tempurung kelapa dipancarkan pada saiz 500µm menggunakan ayak penggetar. Kompos komposit kelapa telah disediakan dari 0 wt% Powder Shell Coconut (CSP) berikut 10% berat CSP dan 25% berat CSP. Kaedah pembukaan terbuka digunakan dalam projek ini dengan mencampurkan Resin Poliester Tidak Teratur (USP) dan CSP menggunakan mesin pengaduk. Projek ini mengikuti Kaedah Ujian Piawaian untuk Mengukur Rintangan Kerosakan Komposit Matriks Polimer Diperkuat Gentian ke penurunan Pengaruh Berat Berat (ASTM D7136). Tingkah laku kesan Polimer Komposit Polimer Kelapa telah disiasat di bawah ujian kesan penurunan berat badan. Eksperimen bermula dengan 0% berat CSP berikut 10% berat dan 25% berat CSP pada 1 m / s, 2 m / s dan 3 m / s halaju. Hasil yang diperoleh ditentukan dengan mengumpulkan data dari tenaga yang diserap, daya dan perpindahan. Projek ini menunjukkan sebagai meningkatkan kelajuan impak, tenaga yang diserap oleh spesimen juga meningkat. 0 wt% CSP memberikan tenaga tertinggi yang diserap iaitu 6.071 J. Ujian ini mencadangkan spesimen 25 wt% untuk aplikasi material kerana tenaga terendah yang diserap iaitu 0.684 J. Kehadiran 10 wt% CSP memberikan kawasan kerosakan yang lebih besar berbanding dengan 25% CSP. Ia menunjukkan bahawa 25% berat CSP memberikan prestasi impak yang lebih baik daripada 0% berat CSP dan 10% berat CSP pada kesan kelajuan rendah atau kesan impak rendah 1 m / s.

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CS	Coconut Shell
CCS	Crushed Coconut Shell
USP	Unsaturated Polyester
FRC	Fiber Reinforcing Composite
PMC	Polymer Matrix Composite
MMC	Metal Matrix Composites
CMC	Ceramic Matrix Composites
CSP	Coconut Shell Powder

CHAPTER 1

INTRODUCTION

1.1 Background

The interest in utilizing natural fibre as reinforcement has incremented dramatically during the last few years. Natural fibres can be divided into three subgroups, plant, animal and mineral fibres. Plant fibres such as flax, cotton and hemp are short or at least discontinuous and based generally on cellulose. Mineral fibres such as asbestos are also short, being rarely longer than a few centimetres and their fully crystalline structure places them apart from the others. Animal fibres which are based on animal protein can be discontinuous as in the case of wool or they can be virtually continuous as with silk. Coconut shell is one of the most important natural fillers engendered in tropical countries like Malaysia, Thailand, Indonesia, India and Sri Lanka. Fibre reinforced polymer matrix got considerable attention in numerous applications because of the good properties and superior advantages. The advantages of natural fillers are their low cost, high toughness, corrosion resistance, low density, good specific strength properties, low cellulose content, recyclable and biodegrable. (Kim, 2010)

A composite material is a cumulating of two or more distinct constituents all of which are present in plausible proportions and have different properties so that the composite property is conspicuous different from that of each other of the constituents. Composites are widely used in both military and civilian industries. They are used in the manufacture of a variety of products ranging from aircraft, spacecraft, satellites, missiles and rockets, marine equipment's and automobile components. Composite can be designed and fabricated to obtain various properties that suit specific applications. The polymer used as matrix materials can be divided in two primary families, the natures of which depend on their molecular structures. These are thermoplastic and thermosetting resins.

When resins are reinforced the composite which is formed has properties which depend on both the resin properties and those of the fibres and their arrangements. Polyester resins are most widely used in general purpose composites but epoxy resins represent the most important group of resin systems used in high performance composites. (Renard and Bunsell, 2005)

1.2 Problem Statement

The application of natural fibre reinforced polymer composite is increasing rapidly. This is especially related to certain problems concerning the utilization of synthetic fibre reinforced composites. As far as synthetic polymer composites ae concerned, waste disposal and recycling are major issues. Landfill disposal being increasingly excluded around the world due to growing environmentally sensitivity. It need to cover factors such as efficient cost effective and environmentally friendly recovery of raw materials, carbon dioxide thermal utilization or bio degradation in certain circumstances. Consequently, the fibres are usually strong polar materials and exhibit significant hydrophilicity. Most polymer matrices tend to be a polar and hydrophobic. As a result, there are significant problems of compatibility between fibre and matrix, leading to poor dispersion, a weak interface and ultimately inferior quality composites. Such compatibility problems have to be tackled with use appropriate methods to improve adhesion between fibre and matrix. This has possible general strategy to achieve this goal which is modify the matrix properties. The addition of natural fibres can influence processing thus some negative effects such as corrosion or abrasion of screw, barrel and mould can appear. It is important to consider that in some cases selected processing parameters need to be changed. A single drop weight test can produce several different damage modes simultaneously. In fibre reinforced polymer composite the damages can marginally detect so it is important to identify the factor that contributes to the damages and characteristics of impact test for fibre reinforced polymer composites.

1.3 Objective

The objectives of projects are:

1. To fabricate coconut shell reinforced polymer composite.
2. To investigate the impact behaviour of coconut shell reinforced polymer composite under impact loading.

1.4 Scope of Project

The scopes of projects are:

1. Type of fibre reinforced material used in natural fibre plant which is coconut shell.
2. Use of unsaturated polyester resin as a thermosetting polymer. Variation in the basic components of the polyester chain an in the ratio of the saturated and unsaturated components allows a wide range of resins to be produced to meet different performance requirements. It is also low cost other than resin.
3. Type of process used for coconut shell fibre reinforced polymer is open moulding.
4. Types of experiment which is drop weight test that include ratio of coconut shell powder and velocity parameters.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Composites

Composite material is a combination of two or more different materials to create unique and superior materials. There are several composite of classifications. The most common is Polymer Matrix Composite (PMC) or Fibre Reinforced Polymers (FRP). For this classification, polymer is used as the matrix and natural fibre as reinforcement. The fibres are usually glass, carbon and natural fibre. For the polymers that commonly used are polypropylene, polyethylene (thermoplastics) and epoxy, polyester (thermosets). Classification of matrix can be made based on the matrix material composite. They are Polymer Matrix Composites, Metal Matrix Composites and Ceramic Metal Composites. Figure 2.1 below shows the classification of matrix.

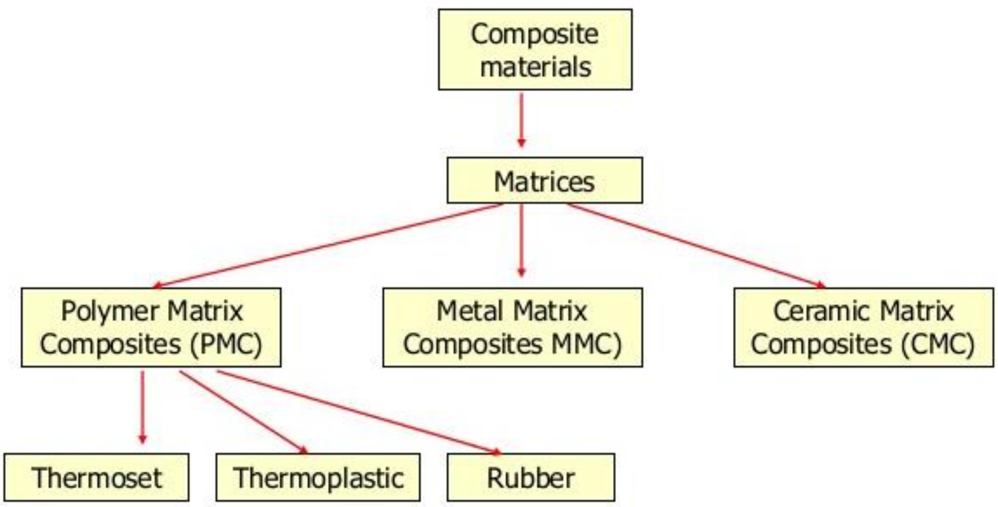

Figure 2.1: Classification of matrices (Nagappa, 2015)

Polymer Matrix Composites (PMCs) are advanced materials used in a variety of engineering applications because of their desirable-specific properties such as high strength and weight ratios that are not fully exploited yet (Anthony Waas, 2008). Most of the polymer matrix composites are filled with different inorganic fillers such as silicon carbide, aluminium oxide, silica, magnesium hydroxide, zinc oxide to achieve the desired mechanical properties. (Kiran, 2017). High-temperature polymer matrix composites comprising high temperature thermosetting polyimide resins reinforced with carbon fibres have emerged as an important class of aerospace materials that offer light weight combined with damage tolerance. Polymer matrix composites (PMCs) with advanced polyimide matrices that offer improved high-temperature capability are currently being considered for applications at temperatures previously limited to metals. (Ruggles-Wrenn and Noomen, 2018)

(Krishan Chawla, 2013) presented that Metal Matrix Composites consist of a metal or an alloy as the continuous matrix and a reinforcement that can be particle, short fibre or continuous fibre. They are three kinds of MMCs:

- Particle reinforced MMCs
- Short fibre reinforced MMCs
- Continuous fibre reinforced MMCs

Ceramic Matrix Composites(CMCs) have a very attractive package of properties which is high strength and high stiffness at very high temperatures. They are also having flaw properties because they are prone to catastrophic failures easily at surface or internal. They are extremely susceptible to thermal shock and easily damaged during fabrication. (Krishnan Chawla, 2013)

Based on the studies by (Lopresto et al, 2016) has mentioned that composite materials are made of two or more different materials to create properties that cannot be obtained from any one material component alone. In the composite, one of the materials is performed as matrix while the other one is performed as reinforcement. The properties of composite material are depending on the nature reinforcement and matrix. However, the composite can be telling they are combination between two materials but they do not dissolve or blend into each other easily, the materials need to undergoes several process before it become a new composite material.

2.1.1 Definition of Composites

Polymer composites are multi-phase materials produced by combining polymer matrix with fillers and reinforcing fibre to produce a bulk material with properties better than those of the individual base materials. The matrix can be thermoplastics, polyvinyl chloride or thermosetting. Fibres are used to reinforce the polymer and improve mechanical properties such as elasticity, strength, hardness and ductility. High strength fibres of glass, aramid and carbon are used as the primary means of carrying load, while the polymer matrix protects the surface of fibre and binds them into a cohesive structural unit. These are commonly called fibre-reinforced polymer composite materials. (Subrata Chandra Das, 2014)

2.1.2 Characteristic of Composites

Fibre and reinforcements generally increase the load carrying capacity and strength and reduce the extent of interaction of the polymer with the counter face. Fibres are wear resistant and wear preferentially to the matrix. The performance of fibre reinforced polymers depends on the type of fibre and matrix, concentration, distribution, aspect ratio, alignment and its adhesion to the matrix. (Fahim, 2008)

Natural fibre reinforced composites there is a lack of good interfacial adhesion between cellulose fibres and the hydrophobic resins due to their inherent incompatibility. The presence of waxy substances on the fibre surface contributes immensely to ineffective fibre to resin bonding and poor surface wetting. Similarly, the presence of free water and hydroxyl groups, especially in the amorphous regions, worsens the ability of plant fibres to develop adhesive characteristic with most binder materials. High water and moisture absorption of the cellulose fibres causes swelling and a plasticizing effect resulting in dimensional instability and poor mechanical properties. Fibres with high cellulose content have also been found to contain a high crystalline content. These are the aggregates pf cellulose blocks held together closely by the strong intermolecular hydrogen bonds which large molecules. (Fahim and Chand, 2008)

2.1.3 Applications of Composites

The main application of the natural fibre reinforced composites is in the automotive industry area, which has developed various new components based on natural-fibre composites. Natural fibre reinforcement in blended thermoplastics or resonated thermoset compression mouldings is now generally accepted for applications as door liners, parcel shelves and boot liners. The automotive components with natural fibre reinforced composites can be expected to increase steadily with increased model penetration. But the new invention is that, nowadays, natural fibre composites are used also in the exterior components of an automotive.

Recent research and development (Aková, 2013) shown that composite materials are increasingly used in the automotive and construction industries. The composite materials are chemically treated to highly cross linked or three dimensional network structure which is highly solvent resistant, tough and creep resistant. Thermoplastics are more advantageous than thermoset because it has low processing cost, ease of moulding complex parts, flexible, tough and show good mechanical properties.

Natural fibre composites are commonly used for manufacturing many components in the automotive sector. This is because the characteristic of natural composite fibre composites are highly ultimate breaking force and higher impact strength. Plant fibres are mainly used in this manufacture because of its reduction in weight about 10%, energy production of 80% and 5% cost reduction. (Aková, 2013). For example, the recent appliances using natural fibres over the world as presented in Figure 2.2.

Figure 2.2: Fibre Reinforced Polymer Composites Applications (Daniel Gay, 2014)

2.1.4 Polymer Matrix Composites

(Udhayasankar, 2015) represented that polymer matrix composites can be classified according to whether the matrix is a thermosets or a thermoplastic polymer. Thermosets are solidified by irreversible chemical reactions, in which the molecules in the polymer form connected chains. The most thermosetting matrix materials for high performance composites used in the aerospace industry are the epoxies.

Thermoplastic matrix composites are currently the focus of rapid development and even though the manufacturing technologies for thermoplastic are normally not as well developed as those for thermoset. The thermoplastic provides several advantages, such as low manufacturing cost, high toughness, good hot and wet properties, high environmental tolerance and good corrosion resistance. The main disadvantages of thermoplastic-matrix are high processing temperature, high viscosities, high coefficient of thermal expansion and they generally do not resist heat as well as thermosets.

However, improvements are being made in developing thermoplastics with a higher melting temperature. Fibrous polymer matrix composites can be classified according to whether the fibrous are short or continuous. The continuous fibres are more efficient at resisting loads than short ones, but it is more difficult to fabricate complex shapes from materials containing continuous fibres than from short fibre or particle reinforced material. This is because of the relatively low processing temperature required to fabricate polymer-matrix composites. For thermosets such as epoxy, phenolic polyester, vinyl ester, cyanate ester and polyamides, the processing temperature typically ranges from room temperature to about 2000°C. Thermoplastic polymer such as polypropylene, poly vinyl chloride, poly sulfone, poly ether either ketone, polyamide, nylon, polycarbonate and polyphenylene sulfide, the processing temperature typically ranges from 3000°C to 4000°C. The moulding methods are those conventionally used for polymer by themselves.

For thermoplastic methods include injection moulding, extrusion, calendaring and thermoforming. For thermosets methods include compression moulding or matched die moulding. Depending on the application and on the type of load to be applied to the