UNIVERSITI PUTRA MALAYSIA

PERFORMANCE OF SUGAR PALM FIBRE-REINFORCED VINYL ESTER COMPOSITES AT DIFFERENT FIBRE ARRANGEMENTS

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By

MUHAMMAD AMMAR BIN ISHAK

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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DEDICATION

Thanks to my mother, father, wife and individuals who support me in spiritual and motivation during the long effort to complete this thesis

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman : Mohd Sapuan Salit, PhD, PEng
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Natural fibre reinforced composites have gained their significance in engineering because of green material. Plus, it have tolerable strength and stiffness, ease to access, lightweight, ease of detach, support energy recovery, good toughness, low density, low price and biodegradable. Although sugar palm fibre has been studied by many scholars for more than a decade as reinforcement in composites, there is no work reported in the literature on using the vinyl ester (VE) as matrix in the sugar palm fibre composites. Hence, a study on performance of sugar palm fibre reinforced VE composites is discussed in this thesis. The goal of this study is to determine the effect of different fibre arrangements on mechanical, water absorption and morphological properties of long sugar palm fibre reinforced VE composites. Hand lay-up method was used while preparing the composites. VE was mixed with untreated long sugar palm fibres in a mould at three types of arrangements which were unidirectional, 0°/90° woven, and ±45° woven; and left for curing. Test samples were cut from the composites and were tested for mechanical properties (tensile, flexural and impact test) and water absorption. Some fractured specimens from the impact test were investigated under scanning electron microscope (SEM) to study the interface between fibre and matrix. Results showed unidirectional gained excellent performance in tensile modulus, flexural strength, flexural modulus, impact strength, and water absorption with value of 2501 MPa, 93.08 MPa, 3328 MPa, 33.66 kJ/m^2, and 0.32 %, respectively. Only tensile strength was led by ±45° woven (15.67 MPa). Therefore, unidirectional is the best fibre arrangement for sugar palm fibre reinforced VE composites compared with arrangement of 0°/90° woven, and ±45° woven due to have consistent results through all tests, and can be proposed as material in useful application such as automotive applications.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PRESTASI KOMPOSIT VINIL ESTER DIPERKUAT GENTIAN ENAU PADA SUSUNAN YANG BERBEZA

Oleh

MUHAMMAD AMMAR ISHAK

November 2017

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Gentian semulajadi penguat komposit telah mendapat kepentingan dalam kejuruteraan kerana bahan hijaunya. Tambahan pula ia mempunyai kekuatan dan kekukuhan yang boleh diterima, juga mudah diakses, ringan, mudah diasingkan, menyokong pemulihan tenaga, ketahanan yang baik, ketumpatan yang rendah, harga rendah dan biodegradasi. Walaupun gentian enau telah dikaji oleh ramai penyelidik lebih daripada sedekad sebagai bahan penguat dalam komposit, namun tidak ada kerja yang dilaporkan dalam kepustakaan menggunakan vinil ester (VE) sebagai matriks dalam komposit. Oleh itu, kajian mengenai prestasi komposit VE diperkuat gentian enau dibincangkan dalam tesis ini. Matlamat kajian ini adalah untuk menentukan kesan susunan gentian yang berbeza terhadap sifat mekanikal, sifat penyerapan air dan sifat morfologi komposit VE diperkuat gentian enau panjang. Kaedah layangan tangan digunakan semasa menyediakan komposit. VE telah dicampurkan bersama gentian enau panjang yang tidak dirawat di dalam acuan pada tiga jenis susunan iaitu satu arah, tenunan 0°/90° dan tenunan ±45°; dan dibiarkan untuk pemulihan. Sampel ujian dipotong dari komposit dan diuji secara sifat mekanikal (tegangan, lenturan dan hentakan) dan penyerapan air. Sesetengah spesimen yang pecah dari ujian hentakan diperiksa di bawah pemeriksaan mikroskop elektron (SEM) untuk mengkaji permukaan gentian dan matriks. Keputusan menunjukkan susunan gentian satu arah memperoleh prestasi cemerlang dalam modulus tegangan, kekuatan lenturan, modulus lentur, kekuatan hentakan, dan penyerapan air dengan nilai 2501 MPa, 93.08 MPa, 3328 MPa, 33.66 kJ / m2 dan 0.32%. Hanya kekuatan tegangan sahaja yang dikuasai oleh tenunan ±45° (15.67 MPa). Oleh itu, susunan gentian satu arah adalah susunan yang terbaik untuk komposit VE diperkuat gentian enau kerana mempunyai keputusan yang konsisten melalui semua ujian, dan boleh dicadangkan sebagai bahan dalam aplikasi yang berguna seperti aplikasi automotif.

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I certify that a Thesis Examination Committee has met on 23 November 2017 to conduct the final examination of Muhammad Ammar bin Ishak on his thesis entitled "Performance of Sugar Palm Fibre-Reinforced Vinyl Ester Composites at Different Fibre Arrangements" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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Name of Member of Supervisory Committee: Dr. Mohamad Ridzwan Ishak

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LIST OF ABBREVIATIONS

MEKP	Methyl Ethyl Ketone Peroxide
VE	Vinyl ester
SEM	Scanning Electron Microscope
ASTM	American Society for Testing and Materials

CHAPTER 1

INTRODUCTION

1.1 Background

Composite materials are combination of two or more materials to obtain properties that are fantastic to those of its components. For fibrous composite, the primary parts of composite materials are fibre and matrix. Fibre itself gives great of the stiffness and strength. For matrix, it holds fibres together which provide the load transfer between fibres and composites, and the external load and supports. Other substance, such as fillers are used to minimize the cost and enhance processability and dimensional stability (Katz and Mileski, 1987).

There are many fabrication processes in industries including prepeg lay-up process, traditional lay-up and autoclave cure, filament winding, wet lay-up process, spray-up process, pultrusion, compression moulding, resin transfer moulding, and injection moulding. Each process had been chosen according to the products to be made. For prototype and pre-production product, the suitable fabrication process is hand lay-up as sandwich constructions and structural reinforcements are possible.

Use of natural fibre as reinforcement is alternative that researchers choose for enhancing strength and ductility of brittle materials including introduce the green products. Besides, natural fibres are easy accessibility, lightweight, ease of detach, support energy recovery, good toughness, non-corrosive nature, low density, low price, great thermal properties, minimum tool wear, minimum dermal respiratory annoyance, less erosion to operate equipment, renewability and biodegradability (Singha and Thakur, 2008).

The combination of natural fibre and synthetic polymer as composite material were discussed from previous studies. Many findings had been made showing good and bad results. However, researchers committed to carry on the effort continuously to explore the benefit of natural fibre and what it can offer to communities.

Study about sugar palm fibres as composite-based natural fibre was started around last decade (Sapuan and Maleque, 2005). Sugar palm fibres have superior specific properties that are affable to human health and nature. It is also biodegradable during disposed (Sastra et al., 2006; Maleque et al., 2007; Bachtiar et al., 2008; Zuhri et al., 2010; Sahari et al., 2011).

Picture of sugar palm fibre on the tree is depicted as in Figure 1.1. Sugar palm fibre wrap around the tree trunk. Ladders are required to facilitate the process of fibre harvesting as the height of the mature tree is over 2 metres. Figure 1.2 shows sugar palm fibres have been harvested and collected. The collected fibres can be used to fabricate some products such as rope, broom, brush, and roof.

Figure 1.1 : Fibre on sugar palm tree

Figure 1.2 : Sugar palm fibres after harvested

1.2 Problem Statements

Natural fibre composites have been utilized in various applications such as aerospace, automotive, marine, building construction, and furniture productions. Numerous natural fibres have been benefited as reinforcements in polymer composites including banana stem, oil palm, sugar palm, coconut coir, pineapple leave, and sugarcane bagasse. Natural fibres are chosen in composite materials due to comparable specific tensile properties, reduce health hazards, tolerable insulating properties, less density and low energy use while being operated (Satyanarayana, 2009).

In the past, many studies have been conducted on the application of sugar palm fibres as reinforcement in polymer composites. Various studies about determine the properties of sugar palm fibre composites have been worked out such as by Siregar (2005), Bachtiar et al. (2008), Leman et al. (2005), Leman et al. (2008), Leman (2009), Suriani et al. (2007), Misri et al. (2008), and Ali et al. (2010). Study about the arrangement of sugar palm fibres in composites was done by Leman et al. (2005), Siregar (2005), and Suriani et al. (2007) by using epoxy as matrix. Yield of those studies can be concluded as long fibre composites possess higher impact strength than short fibre composites (Leman et al., 2005), woven fibre composites have higher tensile and flexural properties than long and short random fibre composite, and woven fibre composites have great interlock between fibre and matrix compared to long and chopped random reinforced epoxy composites (Siregar, 2005).

As continuity on what researchers have done before, vinyl ester is proposed in this study to suggest a new polymer that being reinforced by sugar palm fibres. Several arrangements of fibres also proposed to find out the better arrangement. The study is important to evaluate the chance of using it as new polymer composites in engineering applications. Besides, the study is pertinent to give information to researchers about its potential for being used in their studies in future. Therefore, the study is aiming to find out the performance of sugar palm fibre reinforced vinyl ester composites at different fibre arrangements.

1.3 The Aim and Objectives of Study

The goal of this study is to investigate the performance of sugar palm fibre reinforced VE composites at different fibre arrangements. To meet this aim, the subsequent objectives are proposed:

- To fabricate the sugar palm fibres reinforced vinyl ester composites at different fibre arrangements
- To determine the effect of different fibre arrangements on mechanical properties of sugar palm fibres reinforced VE composites

- To determine the effect of different fibre arrangements on water absorption and morphological properties of sugar palm fibres reinforced VE composites

1.4 Significance of Study

The availability of information about long sugar palm fibres reinforced VE at different fibre arrangements is limitedly mentioned in the past. This research is pertinent to determine the properties of composites to generate idea of researchers in future. Besides that, the significance of study is to explore the various modifications on composites in order to fabricate the composite material as purposed to be in. Different fibre arrangements are the modification to be proposed for investigating the effect of long sugar palm fibres reinforced VE on mechanical, water absorption, and morphological properties.

1.5 Scope and Limitation

The scope of research is focusing on the mechanical, physical, water absorption, and morphological properties of long sugar palm fibres reinforced VE composites at different fibre arrangements. The research will be limited to use sugar palm fibres from Kg. Kuala Jempol, Negeri Sembilan, Malaysia. Also, the study will be limited to use only 1 wt% of cobalt and 15 wt% of fibre in each composite. The arrangements of fibres were chosen are three including unidirectional (0°), 0°/90° woven and ±45° woven. Tensile test, flexural test and impact test were worked out by following the standard of ASTM D638, ASTM D790 and ASTM D256 respectively. Specimens were repeated for 5 times for every test. Specimens of impact test were observed under scanning electron microscope to describe the relationship between matrix and fibre at event of impact.

1.6 Organization of Thesis

This thesis consists of five chapters. Chapter one describes the overview of study. Chapter one is including background of study, problem statements, objectives of study, significance of study, and scope and limitations. Chapter two is a part of chapter one, but it is separated to another section. In chapter two, the previous research that related to study was reviewed. Information and knowledge from past studies were learned to carry out the investigation on this study. Chapter three is about the methodology to work on in order to obtain the results. Techniques and procedures being used will be explained further in this section. After results were obtained, data will be put in chapter four. Results were tabulated to give easy understanding about the response of the results. In this chapter also results will be analysed and discussed in details. Chapter five is about conclusion of the whole study. Conclusion is stated about the outcome of the study whether achieve the objectives or not. In this chapter, recommendation is also reviewed for improvements in future study.

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