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EFFECT OF IMMERSION TREATMENT OF FIBRE ON MECHANICAL PROPERTIES OF PUTRUDED KENAF VINYL ESTER COMPOSITES

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By

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

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NUR MARLIANA BINTI MOHAMAD

November 2016

Chairman : Professor Mohd Sapuan Salit, PhD, P.Eng
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Recently, a traditional materials such as metal, ceramic, plastic and wood which have served in engineering applications for a long time are being substituted by the natural composite materials. The natural composite materials seem to be advantages over the traditional material in their recyclability, sustainability, easy to obtain and cheap, easy and low cost of production and environmental friendly. Despite the natural fibre composite have many advantages but it also have the limitation high moisture absorption compare to syntetic composites. The purpose of this research is to compare the mechanical properties of kenaf and glass pultruded vinyl ester composites and to determine the effect of immersion in sea water, distilled water and acidic solutions on mechanical properties of kenaf pultruded vinyl ester composites. The specimens of the kenaf composites were produced using pultrusion machine and immersed in various solution such as sea water, distilled water and acidic solution. The specimen tested using mechanical testing such as tensile, flexural and impact test. These studies have been done in order to evaluate the strength, stiffness, and toughness behaviour of kenaf reinforced vinyl ester composites as which is can be used as replacement of raw materials for the reinforcement of polymer matrix composites The mechanical properties of the kenaf and glass pultruded composites has been carried out to compare the performance of the kenaf pultruded over the glass pultruded which is shown a largely used in commercials. The results of tensile strength of the glass and kenaf pultruded 248.1 and 148.5 MPa, tensile modulus 14.1 and 12.3 GPa, flexural strength 322.2 and 185.5 MPa, flexural modulus 5.3 and 2.03 GPa and impact energy 274.73 and 59.71kJ/m2 respectively. The results on the effect of immersion in acidic, sea water and distilled water on mechanical properties of kenaf pultruded reinforced vinyl ester composites shows that sea water has the smallest reduction of tensile strength, flexural strength and impact strength, were decreased from 1st, 2nd and 3rd weeks. Acidic solution shows the highest reduction of the properties of tensile strength, flexural strength and impact strength due to the highest degradation on the pultruded composites.

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

KESAN RAWATAN RENDAMAN TERHADAP SIFAT MEKANIKAL GENTIAN KOMPOSIT VINIL ESTER KENAF BERPULTRUSI

Oleh

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Pengerusi : Professor Mohd Sapuan Salit, PhD, P.Eng
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Kebelakangan ini, bahan tradisional seperti logam, seramik, plastik dan kayu dimana digunakan dalam aplikasi kejuruteraan untuk jangkaan yang lama telah ditukarkan kepada penggunaan komposit gentian semula jadi. Komposit gentian semula jadi dilihat mempunyai kelebihan melibihi bahan tradisional seperti kebolehan kitar semula, kemampanan, mudah didapati dan murah, mudah dan murah kos pengeluaran dan mesra alam. Walaupun komposit gentian semula jadi mempunyai banyak kelebihan tetapi ia juga mempunyai kadar penyerapan kelembapan yang tinggi berbanding dengan komposit sintetik. Tujuan kajian ini adalah untuk membandingkan sifat-sifat mekanik kenaf dan kaca vinil ester kenaf komposit berpultrusi dan menentukan kesan rendaman dalam air laut, air suling dan larutan berasid pada sifat mekanik vinil ester kenaf komposit berpultrusi. Spesimen bagi vinil ester kenaf komposit berpultrusi telah dihasilkan menggunakan mesin pultrusion dan direndam dalam pelbagai larutan seperti air laut, air suling dan larutan berasid. Spesimen yang diuji menggunakan ujian mekanikal seperti tensil, lenturan dan ujian hentaman. Tujuan penyelidikan ini adalah untuk mengkaji kesan rendaman didalam cecair yang berbeza seperti asid, air laut dan air suling terhadap sifat mekanikal komposit kenaf terpultrusi diperkuat dengan vinil ester. Kajian ini dilakukan bagi menilai sifat tegangan, keliatan and kekuatan komposit kenaf terpultrusi diperkuat dengan vinil ester dimana ia boleh digunakan sebagai gantian bahan mentah dalam memperkuatkan komposit matrik polimer. Sifat mekanikal kenaf dan kaca terpultrusi telah dilakukan bagi membandingkan prestasi kenaf terpultrusi terhadap kaca terpultrusi dimana ia digunakan dengan meluas didalam pasaran. Keputusan sifat mekanikal kaca dan kenaf terpultrusi seperti kekuatan tegangan ialah 248.1 MPa dan 148.5 MPa, modulus tegangan 14.1 GPa dan 12.3 GPa, kekuatan lenturan 322.2 MPa dan 185.5 MPa, modulus lenturan 5.3 dan 2.03 GPa, dan kekuatan tumbukan 274.73 kJ/m2 dan 59.71 kJ/m2 telah dibentangkan. Hasilnya, kesan rendaman dalam air laut, air suling dan larutan berasid pada sifat mekanik komposit vinil ester kenaf berpultrusi menunjukkan bahawa air laut mempunyai pengurangan sifat mekanik yang paling kecil daripada kekuatan tensil, kekuatan lenturan dan kekuatan hentaman, telah berkurangan daripada 1, 2 dan minggu ke-3. Larutan berasid menunjukkan penurunan tertinggi terhadap sifat-sifat kekuatan tensil,

kekuatan lenturan dan kekuatan hentaman disebabkan oleh kemerosotan paling terhadap degradasi komposit.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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CHAPTER 1

INTRODUCTION

1.1 Background

Recently, many traditional materials such as metal, plastic, wood and ceramic which have served in engineering applications for a long time are being replaced by the composite materials, in order to meet the demand of weight reduction and performance enhancement. The rapid development and usage of synthetic fibres in the composite industries become issues to environmental and their hazardous during composites fabrication.

Pultrusion is one of composite fabrication processes where it operates by the combination of two techniques; pulling and extrusion processes which can produce hard and solid composite profiles. It is reported by Nosbi et al., (2010) that fabrication of high stiffness composite products using a pultrusion process can utilize fibres with the fibre contents exceed 70%. The availability of natural fibre in yarn form allowed the fibre such as kenaf, jute, flax etc. as the reinforcement in the pultruded composites industries. There is a number of passed researchers worked on the pultrusion process using natural fibre as a reinforcement in the various study area (Tsang et al., 2000: Liang et al., 2005; Angelove et al., 2007; Akil et al, 2009; Zamri et al., 2011; and Fairuz et al., 2014).

The availability of the kenaf fibre due to their fast grown (161 day to harvest) brings them as the popular choice among the researcher to do a study on them (Yousuf Ali Gumaan El--Shekeil (Yameni) 2012). The study on mechanical, thermal and physical properties of the kenaf pultruded composites were carried out by Universiti Sains Malaysia using polyester as the matrix. Akil et al., (2010) studied acoustic behavior of the hybridization of kenaf and glass by pultrusion process. The study was continued by Omar et al., (2010) with the study on the compressive behavior of kenaf pultruded composites. The effect of the immersion in the various solutions on the mechanical properties of kenaf pultruded composites by Nosbi et al., (2010) and Marzuki et al., (2011). Malek et al., (2014) investigated the effect of the homogeny additive on the kenaf pultruded phenolic composites.

Despite the advantages of natural fibres listed above, their limitations include absorption when compared with synthetic fibres such as causes the fibres to swell, decreases their mechanical properties, provides the necessary conditions for

biodegradation, and changes their dimensions (Zamri et al., 2011). Akil et al (2009) and Zamri et al (2011) investigated the effect of water absorption on pultruded jute fibre reinforced unsaturated polyester composites. Law and Ishak (2011) also Haniffah et al (2015) studied the effect of water absorption on kenaf fibre reinforced polypropylene composites.

The current research is concerned on the comparison between mechanical properties of kenaf and glass pultruded vinyl ester composites and the effect of immersion in the various solutions on the mechanical properties of kenaf pultruded vinyl ester composites.

1.2 Problem statements

Natural fibres has become a great attention to most researcher. As far as mechanical properties are concerned, the main target is to strike a balance of stiffness, strength and toughness. Despite the natural fibre composite have many advantages but it also have the limitation high moisture absorption compare to syntetic composites. There are limited studies in the comparison between mechanical properties of glass and kenaf pultruded vinyl ester composites and effect of immersion with various solutions on mechanical properties kenaf pultruded vinyl ester composites studies. It is important to study the behaviour of the properties of pultruded kenaf composites under different conditions of environment because natural fibre composites entered the commercial industries. Expected outcomes the study will reveal the weaknesses and the advantages of the pultruded kenaf composites that can be use in the designing commercial pultruded products.

1.3 Research aim and objectives

Generally, the aim of this study is to achieve better measurement on mechanical behaviour of kenaf and glass pultruded vinyl ester composites. The specific objectives are:

1. To investigate and compare the mechanical properties of kenaf and glass pultruded vinyl ester composites.
2. To determine the effect of immersion in sea water, distilled water and acidic solutions on mechanical properties of kenaf pultruded vinyl ester composites.

1.4 Scope and limitation of work

This study focuses on the measurement of tensile, flexural and impact properties of pultruded kenaf and glass reinforced vinyl ester composites. Then the study was carried out on effect on mechanical properties of pultruded kenaf reinforced vinyl ester composites with different immersion treatment such as sea water, distilled water and

acidic solution. The tensile properties of pultruded kenaf reinforced vinyl ester composites were conducted using the ASTM D3916-02 standard, flexural properties ASTM D4475-96 standard, and impact test was performed according to Hufenbach et al., (2008).

1.5 Structure of the thesis

A literature review of research work in various areas relevant to this research is presented in Chapter 2. Various topics have been addressed in this chapter, including polymers, vinyl ester, mechanical properties of vinyl ester composites, pultruded composites, and water absorption behavior of the composites. The reviews also cover existing studies reveals the importance of natural fibre composites for development and design for sustainability of engineering products. The methodology of this research is described in Chapter 3. This research has been divided into two stages, which are pultruded profile fabrication and experimental. The results of mechanical behaviour of kenaf and glass pultruded vinyl ester composites and discussion are presented in chapter 4. Conclusions and recommendations are presented in Chapter 5.

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