STUDY THE MECHANICAL PROPERTIES AND MORPHOLOGY OF GLASS-CARBON FIBER REINFORCEMENT/POLYETHYLENE (PE) HYBRID COMPOSITE

SHARIFAH NOORASHIQAH BT SYED MOHD ZAINOL

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Study of the Mechanical Properties and Morphology of Glass-Carbon Fiber Reinforcement /Polyethylene (PE) Hybrid Composite

This report submitted in accordance with requirementof the Universiti Teknikal; Malaysia Melaka (UteM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) with Honours

by

Sharifah Noorashiqah Bt Syed Mohd Zainol

FACULTY OF MANUFACTURING ENGINEERING
2009

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PSM

JUDUL: Study of the Mechanical Properties and Morphology of Glass-Carbon Fiber Reinforcement /Polyethylene (PE) Hybrid Composite

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Alamat Tetap:
No2 Jln lintang maju5,Taman Serai Maju,34300 Bagan Serai, Perak

Cop Rasmi:
INTAN SHARHIDA BINTI OTHMAN
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

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Email : fkp@kutkm.edu.my

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UTeM, No 1, Jalan TU 43,
Taman Tasik Utama, Hang Tuah Jaya,
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DECLARATION

I hereby declare that this report entitled "Study of the Mechanical Properties and Morphology of Glass-Carbon Fiber Reinforcement /Polyethylene (PE) Hybrid Composite" is the result of my own research except as cited in the references.

Signature	:	
Author's Name	:	Sharifah Noorashiqah Bt Syed Mohd Zainol
Date	:	18th Mei 2009

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Materials) with Honours. The members of the supervisory committee are as follow:

Puan Intan Sharhida BT Othman

(Main Supervisor)

"Insert the date and official stamp here"

INTAN SHARHIDA BINTI OTHMAN
Pensyarah
Fakulti Kejuruteraan Pembuatan
Universiti Teknikal Malaysia Melaka
Karung Berkunci 1200, Ayer Keroh
75450 Melaka

21 May 2009

ABSTRACT

This report presents study of the mechanical properties and morphology of glass-carbon fiber reinforcement /Polyethylene (PE) hybrid composite. The objectives of this study are to investigate the effect of various fibers loading to the mechanical and physical properties of PE hybrid composite. This study is also carried out o to determine the morphology of glass-carbon fiber reinforced PE hybrid composite at different fiber loading and interfacial adhesion between each other. The glass-carbon fiber was a blend of polyethylene, with the precise ratio which was compounded using an internal mixer. Then, fabricate composite through the processes of crushing the compound and hot press the particle. The composite is cut into desired dimensions of specimen for tensile test ASTM D638, flexural test ASTM D 790, impact test ASTM 256 and water absorption test ASTM D570. Through the findings, it was found that the greater mechanical strength for tensile test was 25wt%, for flexural test was 20wt% and for impact test was 25wt%.In addition, water absorption test has shown that the increase of fiber loading will reduce the amount of water absorbed. As conclusion it has been found that Glass-Carbon fiber with certain percentage fiber loading is suitable as fiber material in hybrid composite significantly in attain greater mechanical properties.

ABSTRAK

Projek sarjana muda ini menerangkan tentang kajian mekanikal ke atas campuran kaca-karbon pengukuh gentian dan polietilena untuk menghasilkan hibrid komposit. Objektif kajian ini adalah untuk melihat kesan pengisian yang berlainan bagi ciri-ciri mekanikal dan fizikal untuk Polietilena hibrid komposit. Selain itu, ia juga mengkaji morfologi tetulang gentian kaca dan karbon / polietilena hibrid komposit pada perbezaan pengisi dan ikatan permukaan antara satu sama lain Gentian kaca dan karbon dicampur dengan polietilena dengan nisbah yang betul menggunakan mesin pengadun dalaman. Seterusnya pembentukan komposit melalui proses penghancuran dan mesin pemampat hidraulik. Komposit dipotong mengikut dimensi yang betul berdasarkan kod Standat Nasional Amerika bagi ujian regangan ialah ASTM D638, ujian pembengkokan ASTM D790 , ujian impak ASTM 256 dan ujian penyerapan air ASTM D570. Melalui kajian morfologi terhadap sampel menggunakan mesin pengimbas mikroskop elektron menujukkan ikatan antara gentian kaca dan karbon serta polietilena. Melalui kajian yang telah diperolehi, kekuatan mekanikal terbaik bagi ujian regangan ialah 25wt%, ujian pembengkokan ialah 20wt% % dan bagi ujian impak ialah 25wt%. Seterusnya bagi ujian penyerapan air menunjukkan makin tinggi gentian semakin kurang penyerapan air. Kesimpulannya gentian kaca-karbon dengan peratusan gentian yang sesuai sebagai gentian di dalam hibrid komposit penting untuk memperolehi sifat mekanik yang terbaik.

DEDICATION

To my beloved mother and family.

ACKNOWLEDGEMENTS

In the name of ALLAH, the beneficent, the merciful. It is with the deepest sense of gratitude of the Almighty ALLAH who gives strength and ability to complete this project and thesis as it is today.

Firstly, I would like to express my sincere appreciation to my project supervisor Mrs. Intan Sharhida Bt Othman for her support, advice and guidance of this project. I would like also to thank my parents Syed Mohd Zainol Bin Syed Salim and Saripah Rokiah BT Syed Ishak for giving me the support and courage that I needed to complete this research.

To the technician and also to the other lecturer of Faculty Manufacturing Engineering who give commitment during the research had been made. Their advice and assistance in various ways have been extremely helpful and I would also like to say thank you to my friends and other people that are not listed here directly or indirectly in fulfilling this research. Thank You.

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CF	-	Carbon Fiber
CFRP	-	Carbon fiber reinforced polymer
FRP	-	Fiber reinforced polymer
GF	-	Glass fiber
GFRP	-	Glass fiber reinforced polymer
PE	-	Polyethylene
PP	-	Polypropylene
PAN	-	Polyacrylonitrile
PET	-	Polyethylene Terephthalate
PMC	-	Plastic Matrix Composite
Rb	-	Biaxial ratio
RC	-	Reinforced Concrete
RPM	-	Rotational per minute
SEM	-	Scanning electron Microscope
UTM	-	Universal testing machine

CHAPTER 1

INTRODUCTION

1.1 Background of Study

A major problem in the construction industry is building a structure that can withstand cyclic axial and cyclic lateral loads during an earthquake. Reinforced concrete (RC) columns, which carry the largest load in many RC structures, are particularly vulnerable to failure during seismic activity. One solution to protect these columns from earthquakes is to retrofit the RC columns using fiber-reinforced plastic (FRP) composites. FRP composites offer many advantages to help earthquake-proof RC columns, including low life cycle costs due to zero maintenance and easy installation

Since the earthquake in San Fernando, CA, in 1971, designs of RC columns to support bridges have changed to address inherent reinforcement weaknesses, such as weak transverse reinforcement as well as insufficient seismic detailing (Poveromo, 2003).

However, many RC bridge columns were built before 1971 thus, do not pass the new design codes. In 1994 the Northridge earthquake damaged 40,000 structures including collapsing 7 major freeway bridges. All seven of the destroyed bridges were built to the old design codes and could possibly have been saved if they had been properly seismic retrofitted. Current substandard RC columns must be retrofitted in the near future in order to avoid potential catastrophic destruction during an earthquake. Typically, steel retrofits are used to improve flexural and shear strength of a RC column because steel has established structural design allowable and properties. However, steel reinforcements corrode over time and require periodic maintenance. Although the material cost for purchasing the steel to be used in these retrofits is low, installation and regular maintenance is laborious and costly (Antonio, 1998).

A better solution to protect these columns from earthquakes is to retrofit the RC columns using fiber-reinforced plastic composites. FRP composites typically are at least twice as strong as steel and weigh 20 percent less. Also, the ability to tailor FRP composites, by changing the orientation of the fibers, allows the user to strengthen a structure in preferential directions to meet performance requirements. The disadvantage of using FRP composites is that the material cost is usually high. However, prices for fibers have been decreasing rapidly and material cost is a small portion of the total cost of a FRP composite retrofit. Since steel corrodes and is heavier than a typical FRP composite, a steel retrofit will have a much 2 higher installation and maintenance cost than a FRP composite retrofit. In many designs, FRP composites provide the most cost-effective solution when repairing a RC column (Poveromo, 2003).

Selecting the right composite or given application entails consideration of several parameters such as strength, ductility, stiffness and also corrosion resistance. Fiber-Reinforced Polymer (FRP) composites are nowadays beginning to be introduced in buildings, bridges and other civil construction, where their desirable properties can enhance performance. Acceptance of FRP composites wills require new paradigm for the composites industry. Besides this, standards for composites would facilitate their use in civil infrastructure, creating a market for new FRP building materials by providing a basis for structural design that is comparable with existing standards for other common construction materials.

1.2 Problem Statement

This research is about the mechanical properties of glass - carbon fiber blends with the polyethylene matrix to produce hybrid composite. Shock, impact, or repeated cyclic stresses can cause the laminate composite to separate at the interface between two layers, a condition known as delamination. Following that individual fiber can separate from the matrix.

Composites can fail on the microscopic or macroscopic scale. Compression failures can occur at both the macro scale or at each individual reinforcing fiber in compression buckling. Tension failures can be net section failures of the part or degradation of the composite at a microscopic scale where one or more of the layers in the composite fail in tension of the matrix or failure the bond between the matrix and fibers.

Some composites are brittle and have little reserve strength beyond the initial onset of failure while others may have large deformations and have reserve energy absorbing capacity past the onset of damage. The variations in fibers and matrices that are available and the mixtures that can be made with blends leave a very broad range of properties that can be designed into a composite structure.

For instance should the matrix be susceptible to solvent attack, the composite would be inappropriate for use an environment where that solvent would be present even though the reinforcement is not solvent sensitive. The same argument would hold for other types of chemical attack temperature effect and for weathering. The greatest disadvantages of composites are however the cost of material the lack of well defined and easy to employ designs rules and the lack of high productivity manufacturing methods. The cost of the materials seems the easiest to solve as volume usage will likely bring the cost down.

The disadvantages of utilizing composites in infrastructure applications such as bridges are considerable but not overwhelming. The first, but not necessarily the most significant, disadvantage of composites is their relatively high initial costs. Although graphite and other advanced fibers will probably reduce in cost with increased volume of consumption, it is very doubtful that the cost of glass fibers can be significantly reduced with increasing volume of consumption it is very doubtful that the cost of glass fibers can be significantly reduced with increasing volume of consumption. The cost of matrices such as polymer based resins will also not be reduced significantly with increased consumption. The second disadvantage of composite structural system is the lack of highly efficient mechanical connections. The mechanical bolted connections in composite applications are not as efficient or are easily designed as in the case of steel pipe welded and bolted connections used in steel structures to reduce mechanical type connections, adhesive type joust are required. However the adhesion of one part to another requires detailed knowledge of the adhesive and the bond surface, as well as quality control. All of these factors generally result in relatively low allowable adhesive stresses. Furthermore, many engineers tend to dislike adhesive type connections in the presence of fatigue and vibration type loads (Wai and Lan ,1999).

Hybrid has a better all around combination of properties than composites containing only a single fiber type. The advantage offered by hybrid composites materials are often considered in terms of the improvement in a particular mechanical property resulting from the addition of a second reinforcement type. A variety of fiber combination and matrix materials are used but in the most common system both carbon and glass fibers are incorporated into a polymeric resin. The carbon fibers are strong and relatively stiff and provide a low density reinforcement; however the are expensive. Glass fibers are inexpensive and lack the stiffness of carbon. The glass-carbon hybrid is stronger and tougher, has a higher impact resistance, and may be produced at a lower cost than either of the comparable all carbon or glass reinforced plastics. When hybrid composites are stressed in tension failure is usually does not occur suddenly. The carbon fibers are first to fail at which time the load is transferred to the glass fibers. Upon failure of the glass fiber, the matrix phase must sustain the applied load. Eventual composite failure concurs with that of the matrix phases.

Hybrids have unique features that can be used diverse design requirements in a more cost effectively way than either advanced or conventional composites. Some of the advantages of hybrid over conventional composites are balanced strength and stiffness, optimum mechanical properties, thermal distortion stability reduced weight and cost, improved fatigue resistance, reduced weight and cost improved fatigue resistance, most of all , optimum cost as related to performance reduced notch sensitivity , improved fracture toughness, improved impact resistance (Cubberly and Ramon B. ,1989).

1.3 Objective

The objectives of this project are:

a) To find the effect of how many percent of glass and carbon fiber to the mechanical and physical properties of polyethylene hybrid composite
b) To investigate the effect of various fiber loading to the mechanical and physical properties of polyethylene hybrid composite
c) To study the morphology of glass-carbon fiber reinforced polyethylene hybrid composite at different fiber loading and interfacial adhesion.

1.4 Scope of study

The scope of this project to study the mechanical properties and analyzes the structure of hybrid composite. The specimen used is made of hybrid composite where it mixes up of glass-carbon/polyethylene as raw materials. Following that, the fiber loading of hybrid composite is different. The hybrid composite specimen make use of tensile test, flexural test, impact test and swelling test to make the observation which one of the fiber loading will get the greater mechanical properties. The microstructure analysis of the specimen is observe by using Scanning Electron Microscopy (SEM) to study where is the fibers are agglomerate between each other and axis of the orientation of the fibers is parallel or random to the loading direction. This research also responsible to make recommendations for increasing the mechanical properties and suggests possible improvements of the hybrid composite.