UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Characterization of Mechanical Properties on Polystyrene/E-glass in the Absence and Presence of Charcoal Particles

Report submitted in accordance with partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Engineering Materials)

By

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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"BERKHIDMAT UNTUK NEGARA KERANA ALLAH"

Yang benar,

…………………………………………………..
Pn. Zurina bt Shamsuddin
Pensyarah,
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DECLARATION

I hereby declare that this report entitled **"Characterization of Mechanical Properties on Polystyrene/E-glass in the Absence and Presence of Charcoal Particles"** is the result of my own research except as cited in the references.

Signature	:	
Author's Name	:	**Lee Beng Choon**
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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*). The members of the supervisory committee are as follow:

<u>Pn. Zurina bt Shamsuddin</u>
(Main Supervisor)

ABSTRACT

This research presents the characterization of the mechanical properties on the Polystyrene/E-glass composite in the absence and presence of the charcoal particles. The purposes of doing this research are to determine the value of mechanical properties of the polystyrene/E-glass/charcoal hybrid composite upon the different charcoal loadings and to analyze the morphology behavior of the hybrid composite in relation to their mechanical properties. In this project, the charcoal particles, E-glass fiber with the length of 4mm and polystyrene pellet are used to form composite with the weight ratio 10:0:0, 7:3:0, 7:2:1, 7:1.5:1.5 and 7:1:2. The size of charcoal particles was characterized by using SEM. The specimens were fabricated by using the internal mixer, crusher and compression-moulding machine to form the composite sheet. The composite sheets were then cut into the dimension as required by ASTM 638 and ASTM 790. The specimens were divided into two categories; one was subjected to mechanical testing and another one was subjected to water absorption testing prior to mechanical testing. The effect of the charcoal loadings and water absorption on the tensile properties and flexural properties of the specimen were observed. The dry specimens were then further analyzed with the morphology analysis on the fracture surface of the specimen by using the SEM. The results showed that the charcoal filled composite had increased the tensile strength and tensile modulus as the charcoal loading increased. The optimal flexural properties of the PS/E-glass/charcoal hybrid composite were found at the weight ratio of 7:1.5:1.5 and leveled off at charcoal loading of 20wt%. The morphology behaviors showed were observed conformed to the obtained mechanical properties. The hydrophilic character of charcoal attributed the charcoal filled PS/E-glass specimens present improved of tensile stress and flexural modulus after of the water absorption. Additionally, the addition of charcoal into PS/E-glass was found reducing the density of the hybrid composite.

ABSTRAK

Kertas kerja ini menerangkan projek bertajuk "Characterization of the mechanical properties on the PS/E-glass in the absence and presence of the charcoal particles". Tujuan menjalankan kajian ini adalah untuk menentukan perbezaan sifat mekanikal pada PS/kaca-E komposit jika serbuk arang ditambah dengan peratus pengisian yang berbeza dan mengkaji sifat morfologi pada PS/kaca-E/arang berhubung dengan sifat mekanikalnya. Dalam projek ini, serbuk arang digunakan sebagai pengisi manakala kaca-E dengan panjang 4mm digunakan sebagai penetulang untuk menghasilkan PS/kaca-E/arang komposit hibrid pada nisbah berat 10:0:0, 7:3:0, 7:2:1, 7:1.5:1.5 and 7:1:2. Saiz pada serbuk arang ditentukan melalui analisis mikroskop. Komposit hybrid dibentukkan ke dalam kepingan dengan mengunakan mesin pencampur dalaman, penghancur and pemampat. Kepingan komposit yang dihasilkan seterusnya dipotong berdasarkan dimensi yang ditetapkan dalam ASTM 638 and ASTM 790. Sampel-sampel yang dihasilkan dibahagikan kepada dua kumpulan, satu untuk ujian mekanikal dan satu lagi untuk ujian penyerapan air sebelum menjalani ujian mekanikal. Kesan-kesan setiap pengisian arang pada sifat mekanikal seperti sifat ketegangan dan sifat kelenturannya sampel ditentukan melalui ujian ketegangan dan ujian kelenturan. Kemudiannya, sifat morfologinya pada permukaan yang telah retak dikaji dengen mengunakan SEM. Hasil ujian mekanikal menunjukkan penambahan pengisian serbuk arang ke dalam komposit meningkatkan sifat ketegangannya. Sifat kelenturan pada komposit hibrid didapati paling optima pada nisbah berat 7:1.5:1.5 dan menurun pada pengisian arang sebanyak 20 wt%. Sifat morfologinya didapati akur dengan sifat mekanikalnya. Kesan ujian penyerapan air, penambahan arang yang berciri hidrofilik ke dalam PS/kaca-E komposit menunjukkan peningkatan pada kekuatan ketegangan dan modulus kelenturannya. Selain itu, penambahan serbuk arang juga didapati mengurangkan ketumpatan komposit hybrid.

DEDICATION

For my beloved mother and father.

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

°C	-	Celcius
ASTM	-	American Society of Testing Materials
A-W	-	Apatite-Wollastonite
eg.	-	Example
F_2	-	Gas Fluorin
Fig	-	Figure
FM	-	Flexural Modulus
FRP	-	Fiber Reinforced Polymer
FS	-	Flexural Strength
GF	-	Glass Fiber
GFN6,6	-	Glass Fiber/Nylon 6,6
GFPP	-	Glass Fiber/Polypropylene
LF	-	Long Fiber
min	-	Minutes
mm	-	Milimeter
MPa	-	Mega Pascal
OCL	-	Organo Bentonite Clay
OH	-	Hydroxyl
PA	-	Polyamide
PBT	-	Polybutylene terephthalate
PC	-	Personal Computer
PEKK	-	Polyetheretherketone
phr	-	Parts Per Hundred Resin
PMC	-	Polymer Matrix Composite
PP	-	Polypropylene
PS	-	Polystyrene

PS/E-glass	-	E-glass Reinforced Polystyrene Composite
PS/E-glass/Charcoal	-	Charcoal Filled E-glass Reinforced Polystyrene Hybrid Composite
PVA	-	Polyvinyl Acetate
SEM	-	Scanning Electron Microscope
SFRP	-	Short Fiber Reinforced Polymer
TEM	-	Transmission Electron Microscope
TM	-	Tensile Modulus
TS	-	Tensile Strength
UTM	-	Universal Testing Machine
UTS	-	Ultimate Tensile Strength
vol %	-	Volume Percentages
W	-	Weight Fraction
wt%	-	Weight Percentages
ρ	-	Density

CHAPTER 1
INTRODUCTION

1.1 Background

The use of the hybrid composite has become popular in recent years. Hybrid composite is a composite material in which two or more high-performance reinforcements are combined to make the enhanced the composite properties. Its behavior which bringing together different properties of the reinforcement appears more favorable compared to others since it improved performance with a balance in cost. The goals of the design of hybrid composites mainly include high strength and stiffness on a weight basis.

Throughout the past, E-glass fibers have being used as the reinforcement for thermoplastic matrices in order to improve the mechanical properties of the composite. The E-glass fiber reinforced composite was confirmed to have greater performance of the composite as the glass fibers content loading increases. However, the increasing of the glass fibers content loading are tend to bring up the cost of the composite as well. Owing to that, the replacement of glass fibers with less expensive fillers was advisable if the performance levels are accessible.

Fillers very versatile because of their two distinct advantages comprise improved performance or cost ratio and access to properties not attainable from unfilled polymers. Traditionally, the common filler material used for composites comprised of glass, black carbon, silica and others. However, presently, more attentions have been paid to utilization of economical fillers such as charcoal, fly ash, wood flour, limestone and mineral instead of conventional fillers for the search of reducing cost of composites as well as to impart some desirable properties.

Domestic charcoal is the blackish porous residue consisting of impure carbon produced by heating wood in the absence of oxygen. In recent decades, the utilization of low cost charcoal as a replacement for synthetic fibers in advanced materials has gained interest among researchers throughout the world due to its pronounce effect and advantages such as low density, unlimited availability, low cost, and reduced energy consumption over traditional glass fibers (Byrne *et al.*, 1997; Qiao *et al.*, 2001). However, there was little quantitative study regarding the knowledge of competence of charcoal, particularly regarding the effect of charcoal loading on morphology and mechanical properties.

There are several considerations have to make taken into account in the design of charcoal filled hybrid composite. One of the most important issues is the degradation behavior of the hybrid composites exposed to environmental conditions such as humidity, sunlight or microorganisms. Generally, all polymer composites absorb moisture in humid atmosphere and when immersed in water. Thus, the poor resistance of the filler to water absorption can attribute undesirable effects on the mechanical properties of the polymer composites such as leads to the degradation of fiber-matrix interface creating a poor stress transfer efficiencies resulting in reduction of mechanical properties.