UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF BENTONITE AND SPENT BLEACH EARTH (SBE) ADDITION ON THE SINTERED PROPERTIES OF GLASS WASTE COMPOSITE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Materials) (Hons.)

by

AHMAD SYUKRY BIN ISMAIL

B051010047

910220035129

FACULTY OF MANUFACTURING ENGINEERING

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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) (Hons.). The member of the supervisory is as follows:

……

(Dr Zurina Binti Shamsudin)

ABSTRAK

Projek ini bertujuan untuk mengkaji kesan bentonit dan lebihan peluntur bumi (SBE) ke atas ciri-ciri mekanikal gelas komposit yang tersinter. Botol kaca digunakan sebagai bahan mentah yang utama dan lebihan peluntur bumi (SBE) dan bentonit sebagai pengisi. Botol tersebut dipecahkan menggunakan tukul sehingga mencapai saiz 2-3 mm. Kemudian, serpihan kaca itu dihancurkan lagi dengan menggunakan pengisar bebola planet. Serbuk gelas yang terhasil ditapis menggunakan penapis yang bersaiz 75 μm. Serbuk kaca tersebut kemudiannya dicampur dengan SBE dan bentonit dengan peratusan berat komposisi 65:30:5, 65:25:10, 65:20:15 dan 65:15:20. Serbuk kaca yamg dicampur dimampatkan dengan menggunakan penekan manual. Selepas itu, sampel-sampel tersebut disinter di dalam relau pada suhu 850^0C selama 15 minit dengan kadar pemanasan dan penyejukan sebanyak 2^0C/min. Mikrostruktur sampel-sampel diimbas dengan menggunakan imbasan mikroskop electron (SEM), fasa-fasa yang terbentuk diperiksa dengan menggunakan pembelauan sinar-X, kekerasan diuji dengan mesin kekuatan Vickers dan kepadatan sampel-sampel tersebut diuji dengan menggunakan mesin densimeter. Daripada hasil XRD, komposisi 65:25:10 mempunyai kristal carneigeit sahaja dan menunjukkan bacaan kekerasan yang paling tinggi. Manakala, komposisi 65:15:20 dan 65:20:15 menunjukkan sedikit perbezaan dengan nilai 2.5Hv. Di sisi yang lain pula, komposisi 65:15:20 menunjukkan keliangan yang paling kurang berdasarkan gambar SEM dan ketumpatan paling tinggi dengan nilai 2.33 g/cm^3. Keputusan menunjukkan bahawa komposisi 65:15:20 lebih sesuai untuk digunakan dalam industri terutama dalam penghasilan jubin berdasarkan keputusan kekerasan.

ABSTRACT

This project aims to investigate the effect of bentonite and spent bleaching earth (SBE) addition on the sintered mechanical properties of glass waste composite. The bottle glass waste was used as main raw and spent bleaching earth and borate are used as fillers. The bottles were crushed using a hammer to get pieces of glass with a size of 2-3 mm. The glass pieces were grounded using the planetary ball grinding machine. Powder glass that formed was sieved using 75 μm siever. The glass powder was mixed with SBE and bentonite at compositions of 65:30:5, 65:25:10, 65:20:15 and 65:15:20 weight percentage. The mixed powder was compacted using a manual uniaxial hand press. After that, the samples were sintered in the furnace for 15 minutes at 850^0C with heating and cooling rate 2^oC/min. The microstructure of the samples were scanned using scanning electron microscope (SEM), the phases were examined using X-ray diffraction (XRD), hardness of the samples were tested using Vickers hardness and density of the samples were analyzed using densimeter. From XRD results, 65:25:10 composition shows carneigeit only and gave highest hardness reading. However, hardness of 65:15:20 and 65:20:15 compositions show only slight differences with only 2.5Hv. On the other hand, 65:15:20 composition shows lowest porosity based on SEM pictures and highest density with 2.33 g/cm^3. The results suggest that the 65:15:20 composition is more suitable to be used in industrial application especially in tiles production based on hardness test's result.

DEDICATION

To my beloved family, friends and UTeM.

ACKNOWLEDGEMENTS

First of all, I would like to thank to ALLAH for HIS blessing that provide me a good health and rational thinking within period given to finish this project. Secondly, peace and blessing be upon Prophet Muhammad because of his efforts today we can feel the blessing of Islam and faith.

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Al_2O_3	-	Aluminium Trioxide
APFE	-	European Glass Fiber Producer Association
ASTM	-	American Standard of Testing Material
B_2O_3	-	Boric Trioxide
CaCO	-	Limestone
CaO	-	Lime
$CaSiO_3$	-	Wollastonite
$Ca_4Si_2O_7F_2$	-	Cusdipine
CMC	-	Ceramic Matrix Composite
Cu	-	Cuprum
E-glass	-	Low electric conductivity of glass
EURIMA	-	European Insulation Manufacturers Association
g/cm^3	-	Gram per centimeter cube
g/mL	-	Gram per milliliter
g	-	gram
H_V	-	Vickers Hardness
kg	-	Kilogram
kV	-	Kilovolt
m	-	Mass
MgO	-	Magnesium Oxide
µ m	-	micrometer
mA	-	Milliampere
mm	-	Millimeter
MMC	-	Metal Matrix Composite
MPa	-	Mega Pascal
MSW	-	Municipal Solid Waste

$NaAlSiO_4$	-	Carneigeite
Na_2CO_3	-	Soda Ash/ Sodium Carbonate
Na_2O	-	Sodium Oxide
Na.27 Li.1 Mg 1.32 Fe.59 Be.17	-	Coerderite
NDT	-	Non-destructive Test
nm	-	Nanometer
N/mm^2	-	Newton per millimeter square
ρ	-	Density
PbO	-	Lead Oxide
PMC	-	Polymer Matrix Composite
PVB	-	Polyvinyl Butyral
rpm	-	Rotation per minute
SBE	-	Spent Bleaching Earth
SEM	-	Scanning Electron Microscopy
SiC	-	Silicon Carbide
SiO_2	-	Coesite
SiO_2	-	Silica/ Silicon Oxide
SLG	-	Soda lime glass
SLSG	-	Soda lime silicate glass
V	-	Volume
XRD	-	X-Ray Diffraction
^0C	-	Degree Celcius
θ	-	Angle
^{0}	-	Theta
%	-	Percent

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF STUDY

The quantity of waste glasses has been increased significantly without being recycled. This phenomenon contributes to the increasing of the risk to public health. For years, glass has been used as a container for liquids such as wine, olive oil, perfumes, soft drink and others. Mogensan (2008) reported that in some European countries, about 85% of glass packaging is processed to make new bottles and jars. Glass does not degrade or precisely undergo slow degradation rate through the recycling process, so it can be recycled repeatedly. Recycling glass is one of the initiatives to protect and conserve the natural resources and the environment. Nowadays, glass recycling has become a trend and its increasing year by year as more attention paid to efficient and sustainable use of natural resources.

High demand of recycled glass from industries increased due to the potential of recycled glass converting into a new product. Recycled glasses were becoming more preferable material due to public awareness about environmental sustainability. Recycling has given a big impact on the manufacturing industry. Melting down old glasses requires less energy than processing the new raw materials (Mogensen, 2008). The emission of greenhouse gases can be reduced by 200 kilograms for each to of recycled glass (Mogensen, 2008).

In this study, Spent Bleach Earth (SBE) and bentonite will be added in mixture of glass waste composite powder. SBE is generated from pre-treatment of crude palm oil in a refinery. The second material that will be used is bentonite. Bentonite is a geological term for soil materials with a high content of a swelling mineral, usually montmorillonite. The montmorillonite mineral belongs to the smectic group which all members have swelling properties. Bentonite acts as a rheology modifier, binding agent and filler.

1.2 PROBLEM STATEMENT

The quantity of municipal solid waste (MSW) generation has increased significantly from 16, 200 tons in 2001 per day to 19, 100 tonnes per day in 2005 (Zamali, M. Lazim, and Abu Osman, 2009). 3% of the MSW are glass (Malaysia Economic Planning Unit, 2006). However, glass in landfill will consume space because it does not easily degrade. In regard of this matter, this project will be focused on the usage of glass waste as matrices. Malaysia is rich with natural resources. One of the resources that has attracted researcher is spent bleaching earth (SBE). SBE is the extraction of residual oil from palm oil refining industry. One of the examples of the usage of SBE is in the construction of buildings in order to improve wastage in produced in Malaysia. Very little works have been done concerning the study of glass waste reinforced with SBE.

As for this study, additional material which is bentonite will be added as filler to improve glass mechanical properties such as hardness of the glass. It is expected that the addition of bentonite as the filler will increase the composite properties. Thus, there is a gap of knowledge regarding the material properties with the addition of bentonite in a composite application. It is known that the properties of composite materials have better properties than pure materials. The potential usage of SBE and bentonite as reinforcement and filler in this composite could be achieved by tailoring the material

properties with formulation batch. This paper reports on the effect of the addition of bentonite and SBE on the properties of sintered glass waste.

1.3 OBJECTIVES

The main aim of this research is to study the development of glass strength. Towards achieving the mentioned aim, the related objectives associated were identified as follows:

a) To formulate the composition of percentage of bentonite and SBE on batch glass waste composite towards to sintering profiles.
b) To characterize the effect of bentonite and SBE on microstructure and phases of glass waste composite
c) To investigate and analyze the physical and mechanical properties of glass waste composite.

1.4 SCOPE OF WORK

The scope of this project is to investigate the effect of bentonite and spent bleaching earth (SBE) addition on the sintered properties of glass waste composite. The study starts by collecting the waste glass bottles as raw materials to be used in preparation of glass composite samples. The glass bottles will be cleaned to remove dirt and unwanted materials. The bottles will be crushed using hammer and planetary ball milling to obtain a glass powder. The glass will be crushed until passed through a sieve of less than 75 μ − m. Then, the process is followed by mixing the glass powder with SBE and bentonite with a composition of 65:30:5, 65:25:10, 65:20:15, 65:15:20 % relatively.

The next process is compacting the mixed powder glass. Compaction will be done using a hand press with a pressure of 3 tonnes. The pressure will be applied uniaxially. The circle sample with a diameter of 13 mm is now called green sample. Green sample referred to unfired sample. After that, the sample, in the form of pallet will be sintered in furnace for approximately 14 hours with heating and cooling rate at 2^0C/min. The maximum temperature is 850^0C. The samples will be soaked at 850^0C for 15 minutes. Lastly, the sample will be subjected to sample characterization. This includes testing the mechanical strength, physical analyses and characterization analyses. The mechanical strength of the sintered sample will be tested using the Vickers hardness test. The physical analyses will be done by investigating the sample density. The microstructure analysis of the surface of producing glass composite samples will be conducted using scanning electron microscopy (SEM). The phases present in the sample will be investigated by using X-ray diffraction (XRD). In summary, this study will be focused on the effect of addition of SBE and bentonite on sintered properties of glass waste composite.

1.5 STUDY OUTLINE

Following this introduction, Chapter 2 presents a general literature review for studying of the properties of waste glass materials with the addition of bentonite and Spent Bleach Earth (SBE). These studies focused on the properties of the waste glass and the difference of the properties after mixes with different portions of bentonite and SBE. The characterization of material also reviewed.

Chapter 3 demonstrates the employed descriptive variables in the experimental study considering the properties of waste glass. These descriptive variables start with the preparation of raw material, followed by preparing the sample, and the characterization of the sample.

Chapter 4 presents the results and discussion for the characterization of the material properties of glass waste composite. Finally, a comprehensive summary of this study, its major conclusions and recommendations for future areas of study are presented in Chapter 5.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is intended to give an overview of glass recycling components involved, such as glass waste, SBE and bentonite with their properties. In addition, this chapter provides a comprehensive review on the history of glass waste reinforced with emphasis on the material properties. Finally, there is a review of characterization methodologies that encompasses of X-Ray diffraction (XRD), scanning electron microscopy (SEM), Vickers Hardness and density test using Archimedes test.