UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EFFECT OF SINTERING RATE ON 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 Material) (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirement of Bachelor of Manufacturing Engineering (Engineering Material) (Hons). The member of the supervisory is as follow:

…….

(Dr. Zurina Binti Shamsudin)

ABSTRAK

Projek ini bertujuan untuk mengkaji kesan kadar pemanasan dalam pembakaran ke atas komposit sisa gelas. Bahan mentah yang digunakan untuk komposit adalah sisa gelas SLG dan lebihan peluntur bumi (SBE). Sisa gelas dihancurkan untuk mendapatkan serpihan sampel gelas dengan ukuran saiz 2 ke 3 mm. Serpihan gelas itu akan dihancurkan menggunakan mesin pengisar bebola. Serbuk gelas yang dihasilkan akan ditapis menggunakan penapis bersaiz 75µm. Serbuk gelas akan dicampur dengan SBE dengan peratusan komposisi 70:30. Komposit hijau akan dimampat menggunakan penekan manual. Sampel itu akan dibakar di dalam relau selama 15 minit pada suhu 750°C pada kadar penyejukan 2°C/min dan 3 kadar pemanasan berbeza; 2°C/min, 4°C/min dan 6°C/min. Sampel 2°C/min menunjukkan kehadiran kristaliniti yang paling tinggi dalam XRD dan ketumpatan paling tinggi. Gambar sampel 6°C/min pula menunjukkan rongga yang paling banyak dalam SEM dan kekerasan Vickers yang paling rendah. Dalam ujian pengembangan haba 6°C/min juga menunjukkan pengembangan yang paling rendah. Kadar pemanasan yang rendah sesuai digunakan untuk memperbaiki sifat mekanikal komposit manakala kadar pemanasan tinggi sesuai pula sesuai untuk kegunaan pengembangan haba dan rendah ketumpatan.

ABSTRACT

This project aims to investigate the effect of heating rate of sintering on glass waste composite. The raw material used for the composite is glass waste and spent bleaching earth. The glass waste is crushed to get pieces of glass sample with size of 2 to 3 mm. The glass pieces are ground using planetary ball grinding machine. Powder glass formed will be sieved using 75 μm siever. The glass powder is mixed with SBE with composition 70:30 respectively. The mixed powder is then compacted using a uniaxially manual hand press. The sample is sintered in a furnace for 15 minutes at 750°C with cooling rate of 2°C/min and 3 different heating rate; 2°C/min, 4°C/min and 6°C/min. 2°C/min sample shows high crystallinity in XRD and highest density. 6°C/min sample figure shows highest porosity in SEM and lowest Vickers hardness. In thermal expansion test 6°C/min also showing lowest expansion. Low heating rate is suitable to improve mechanical properties while high heating rate is suitable for thermal expansion and low density application.

DEDICATION

To my beloved family, friends and UTeM

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First of all, I thank God for the blessing He gave, giving me a chance to going through this life and for giving me rational mind in making decision.

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LIST OF ABBREVIATION, SYMBOLS AND NOMENCLATURE

SBE - Spent bleaching earth

XRD - X-ray diffraction

SEM - scanning electron microscope

Na2O - sodium oxide

CaO - calcium oxide

SiO2 - silicon oxide

NaCl - sodium chloride

CMC - ceramic matrix composite

MMC - metal matrix composite

μm - micrometer

MPa - Mega Pascal

Mm - millimeter

SiC - silicon carbide

V - volume

°C - Degree Celcius

Θ - angle

% - percent

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Glass usage is widely applied in many field of industry. According to Millers (2012), it has been reported that in 2010, approximately 25 billion glass containers were made in the United States. About 80 percent were beverage containers, almost three-quarters of which were beer bottles. The rest were mostly food containers. Another 5 billion bottles are imported. Most of these are green or brown wine and beer bottles. Properties of glass is cannot be degraded and hard to sustain. The wastes from the glass have given negative impact on the environment. Researches had been made and waste is identified to have large potential in industry. Glass was discovered to a certain unique function due to its properties. The usage is widely applied worldwide and waste had increased in surprise way through. Glass is hardly degraded and it takes time to fully degrade the composition. That is the reason many alternatives had been searched and one of them is recycling it. Recycle means reproduce glass material into a new material or reuse the glasses. Based on report by United State Environmental Protection Agency(2012) stated that 90 percent of recycled glass is used to make new containers.

Recycled glass meets high demand from the industries as it contains high potential on thermal behavior to be reproduce into new improved product (Mungwena and Rashama,

2013). The requirement needed in the industry is satisfied by the characteristic of the new form of glass waste. Through several researches it is proven that material from the improved material could meet the requirement of advanced technology (Yang *et at*,2013). By defining the right composition and methods could meet the expected character. Mogensen (2008) stated that melting down old glasses requires less energy than processing new raw materials because of the characters on waste product is already obtained . This shows that recycling method is better than reproduce the glass using conventional method of forming. Recycling is highly potential to reduce pollution around us. According to Alexander et al (2012), glass is highly possible to cause pollution if not managed in a right procedure. The dissolution of glass matrix can occur during disposal. Recycling of glass also resolve the problem of resources that have highly demand on it. Dyer (2014) stated that manufacturing of a new glass from glass waste needs higher cost compared to reuse it into a new material because of the raw material obtaining process.

In the study glass will be composited with natural resources. According to Behera (2014), natural waste could be sustain by producing new material to reduce environmental impact in term of consumption. Natural resources is usually disposed after usage and the potential of this resources is hardly defined as the researches is limited on this kind of resource.

Spent Bleaching Earth (SBE) is used in the composite along with glass waste. SBE is a solid waste from the edible oil industry can be converted to a clay-carbon adsorbent for potential reuse in the adsorptive cleansing of vegetable oils. Commercial and laboratory-prepared adsorbents were screened for their ability to remove coloured pigments, impurities and trace contaminants from rapeseed and crude coconut oils. Yi (2010) stated that Spent Bleach Earth (SBE) is highly potential to be used in a composite material because of high physical strength and less concrete effect. As dealing with composites material, the composition percentage of each material is concerned. Glass is

added with Spent Bleach Earth (SBE) in the specific volume of 70% glass and 30% SBE. The properties has not yet be defined and research on this composite will be focused on the thermal behavior and the correlation of phases produced to physical and morphological behavior.

1.2 PROBLEM STATEMENT

The composite produced in the experiment are consist of glass waste and SBE. The waste products are used in the experiment to obtain sustainability aspect that can be achieved from the composite. The effect of heating rate on glass waste reinforced by SBE is still unknown as the composite is using natural resources that are not widely used until present condition. Karamanov (2003) proved that addition of material to glass ceramic could improve the mechanical character of the composition. Elbatala et al (2013) stated that different heating rate produces different polycrystalline volume in a glass ceramic. Low heating rate means that the temperature applied is in low range. The material are slowly heated by increasing of heat in low range. The material produced from sintering process of different heating range possess different character.

Piva et al(2013) prove that lower heating rate reduce porosity on the surface region. The increase of heating rate is linearly propotional to the amount of porosity. Meanwhile, Nagendra et al (2000) stated that amorphous phase contribute on porosity present in the microstructure. More amorphous phase showing increasing of porosity in the structure. This condition can be correlated to the heating rate effect on porosity. Gunnewieka (2014) also stated that higher heating rates will cause higher final density of a sample that shows low hardness. The relation of all condition obtained from the heating rate effect must be exactly defined to correlate to each other in a scientific manner.

1.3 OBJECTIVES

The fundamental objective of the investigation is to study the recycle glass development. The side related objective is defined as:

a. To characterize the effect of sintering rate on physical properties of glass waste composite.

b. To analysis the morphological of glass waste composite produced from selected samples.

1.4 SCOPE OF WORK

In this study, glass waste composite is prepared from glass waste and SBE. This work will be initiated by preparing the raw materials needed in order to resume on sample preparation. The material must be on intended condition to ensure that the expected result is precisely meet. The glass waste is cleaned to avoid dirt and impurities exist beneath it. The glass waste composite will be prepared first by crushing the glass waste using crusher. Crushed glass obtained is then applied in planetary ball milling to finer the size to approximately 75 μm. SBE will be cleaned using sonication process. Ethanol will added and the mixture will be placed in ultrasonic bath. This process have to be done 6 times before dried from any excess liquid existence from it. The raw material is then mixed in ball grinding machine with the volume of 70% glass and 30% SBE in the composition of each samples.

The mixture is compacted using hand press with reach of 3 MPa. The pressure applied uniaxially on the samples. Sample shaped at diameter of 13 mm called as green body before sintered. Using temperature and cooling rate are fixed at 750^{o}C and 2^{o}C/minute. Sintering will be varied at 3 different heating rate; 2^{o}C/minute, 4^{o}C/minute and 6^{o}C/minute. After sintered in resulted time according to heating rate, the samples will be ready for characterization. X-ray diffraction (XRD) test will be conducted to ensure that the sample is in glass ceramic character from the phases. Density test will determine the physical property of the composite. Mechanical properties will be tested using Vickers hardness and thermal expansion test. Scanning electron microscope (SEM) is used to analyze on the microstructure behavior of the samples from different heating rate. The results from the tests will be correlated to each other.

1.5 STUDY OUTLINE

Chapter 2 present relevant literature review on the related research on the study of heat stability and morphology of glass waste composite produced by sintering method. The chapter focused on the effect of heating rate parameter on physical properties and morphological behavior from previous study.

In chapter 3, methodology of the research conducted is justified. All the related variables on waste glass properties are presented in details. Methodology encompasses of the preparation of raw materials, compounding of samples, sintering process and characterization technique.

Chapter 4 presents the result and discussion for characterization of morphology and properties of glass waste composite. It consist of results from material characterization, physical and mechanical test with discussion the result obtained. Chapter 5 present the conclusion and recommendation deduced from this study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter gives overview on components involves in the experiment. The materials used in the experiment is viewed on their properties that give expectations on result. The review gives guideline on conducting the study on glass waste and SBE for composite material. The review on characterization methods emphasizes on X-ray diffraction (XRD), scanning electron microscope (SEM),thermal expansion, Vickers hardness and density test.

2.2 GLASS

2.2.1 INTRODUCTION

Glass is a unique material that are made from fusion of sand with other material such as soda and lime. In traditional practice, it is only involve cooling from a melt (Shelby, 2005). The mixture of silica and intended material are heated before quickly cooled down to prevent regular crystalline structure. Time passes and many discovery have been found on the character and potential of glass. The materials are melted together at a very high temperature to obtain wide range of usage. It is a combination of crystalline and amorphous phases with more crystalline phases in the structure (Calvez, 2014). As glass cools, atom is locked in a random position before it solidifies into perfect crystal arrangement. Crystallization must be bypassed to produce more stable state (Turnbull, 2006).

2.2.2 Soda Lime Glass

Soda lime glass is a ceramic with composition of Na_2O, CaO and SiO_2 with a specific ratio. The ratio usually used to form such glass is 12.9% Na_2O, 11.6% CaO and 75.5% Si_2O (Wiberg, 2001). This glass is produced from melting of the raw material at temperature of 1675°C or higher with fining agent such as NaCl (Jong, 1989). It is suitable to be recycled because it is capable to be resoftened (Low, 1980).