STUDY ON WASTE GLASS MILLING FOR FELDSPAR REPLACEMENT IN CERAMIC TILE

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering

by

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2018

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

Tajuk: **STUDY ON WASTE GLASS MILLING FOR FELDSPAR REPLACEMENT IN CERAMIC TILE**

Sesi Pengajian: **2017/2018 Semester 2**

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee are as follow:

…….....

(Profesor Madya Dr Jariah Binti Mohamad Juoi)

ABSTRAK

Projek ini bertujuan untuk mengkaji dan menganalisis kesan saiz zarah SLSG terhadap sifat-sifat seramik kaca hijau. Kaca kitar semula digunakan sebagai bahan mentah utama dan botol kaca yang digunakan adalah jenis soda telus silikon kaca (SLSG) untuk menggantikan feldspar dalam pembuatan jubin seramik. Proses ini bermula dengan menghancurkan botol kaca dengan menggunakan tukul untuk mendapatkan saiz yang lebih kecil. Kemudian, kaca dihancurkan dengan menggunakan proses menggiling iaitu dengan mesin kilang bola planet. Untuk menguji saiz zarah bahan yang berbeza, kaca serbuk dibahagikan kepada tiga jenis saiz yang berbeza iaitu <75µm, <45µm dan <32µm. Serbuk SLSG dicampur dengan tanah liat dan kuarza dengan 30: 40: 30 wt%, dicampur dengan tanah liat, kuarza dan feldspar dengan 10: 40: 30: 20 wt% dan sampel terakhir sebagai tanda aras tanpa serbuk SLSG dengan komposisi tanah liat, kuarza dan feldspar dengan 40: 30: 30 wt%. Daya kekuatan penekanan yang dikenakan adalah 200MPa. Dalam kajian ini, suhu sintering adalah 1150ºC. Ujian analisis yang dijalankan semasa eksperimen adalah penyerapan air, ketumpatan pukal dan keliangan manakala ujian mekanikal ditentukan melalui ujian mikrokekerasan. Berdasarkan analisis dan ujian mekanikal, didapati bahawa gabungan SLSG dan feldspar menurunkan nilai penyerapan air daripada badan jubin standard. Kaca sisa boleh digunakan sebagai pengganti dengan feldspar dalam jubin seramik kerana ia mempunyai fungsi yang sama iaitu sebagai agen fluks.

ABSTRACT

This project aims to study and analyze the effect of particle size of soda lime silicate glass on the properties of green glass ceramics. Recycled glass are used as the main raw material and the glass bottles used is a type of transparent soda lime silicate glass (SLSG) to replace feldspar in manufacturing of ceramic tiles. The process starts by crushing the glass bottles by using a hammer to make it into a smaller size. Then, the crush glass were grind by using planetary ball mill machine. To test the different particle size of materials, the powder glass were sieved through three different types of size which were <75μm, <45 μm and <32 μm. SLSG powder then mixed with clay and quartz with 30 : 40 : 30 wt.%, mixed with clay, quartz and feldspar with 10 : 40 : 30 : 20 wt.% and last sample as a benchmark is without SLSG powder with composition of only clay, quartz and feldspar with 40 : 30 : 30 wt.%. The pressing pressure is 200MPa. In this study, the sintering temperature is 1150ºC. The analyses testing that were carried out during the experiment were water absorption, bulk density and porosity while the mechanical testing was determined by microhardness testing. Based on the physical testing, it was found that the combination of SLSG and feldspar has the lowest water absorption value which is 1.01% with particle size <45μm of SLSG. The waste glass can be used as a replacement with feldspar in ceramic tiles as it carry the same purpose which is as a fluxing agent.

DEDICATION

I would like to show my gratitude to my supervisor, Associate Prof. Dr. Jariah binti Muhamad Juoi from University Technical Malaysia Malacca (UTeM) for giving much and guideline for this Final Year Project throughout numerous consultations. Most important, I would like to show my highest gratitude to my family who always support me and always continuously keeping up my spirit. Once again sincerely thank you all for supporting me to complete this project successfully. I would also like to expand my deepest gratitude to all those friends who have directly or indirectly guide in completing this project.

ACKNOWLEDGEMENT

First of all, I would like to take an opportunity to express my gratitude to those who contributed and showed their kindness in helping and assisting me to complete this project. First and foremost, I would like to thank my supervisor, Associate Prof. Dr. Jariah binti Muhamad Juoi and my panels, Dr. Syahriza binti Ismail and Dr. Mohd Edeerozey bin Abd Manaf for all the guidance and encouragement. I am in debt for the patient, support and motivation from the beginning to the end of my project. Thank you also for instructing and teaching me in developing the understanding of the project and eventually me enable to grasp the essence of this project. Most important, I am thankful to my family whom continuously keeping up my spirit and supporting me in term of financial and moral. They keep on encouraging me whenever I faced any difficulties throughout my study period. Lastly, I would like to thank all my classmates and friends for their cooperation and also those who had supported me in any aspects throughout the project. Once again sincerely thank you all for supporting me to complete this project successfully.

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LIST OF ABBREVIATIONS

ASTM	-	American Standard Testing Method
CRT	-	Cathode Ray Tube
LCD	-	Liquid Crystal Display
MPa	-	Mega Pascal
SEM	-	Scanning Electron Microscope
SLSG	-	Soda Lime Silicate Glass
SPWG	-	Solar Panel Waste Glass
XRD	-	X-Ray Diffraction

LIST OF SYMBOLS

%	-	Percent
℃	-	Degree Celsius
°C/min	-	Degree Celsius Per Minute
μm	-	Micron Meter
G	-	Gram
G/cm³	-	Grams Per Centimeter Cube
H	-	Hour
mg	-	Milligrams
Wt%	-	Weight Percentage

CHAPTER 1

INTRODUCTION

1.1 Background of Study

In the course of the most recent decades, mechanical improvement has produced expansive measure of waste. Because of fast change, wastes source is increasing all over the state. The disposal of the wastes is one of the issues that have gotten a great deal of consideration and high demand towards the safety of the environment. One procedure used to lessen such wastes is by reusing and recycling into another products which it is give advantages to both nature and economy (Raimondo et al., 2007). The recycling of waste glass has turned into a major natural concern because of the expanding interest for landfill space and natural assets (Mohajerani et al., 2017).

In Malaysia, there are consists of three different glass bottle makers and they create 600 tons of new bottles day by day. However, just 10% of these containers will in the end send to the manufacturing plants and be reused to make new ones. Regardless of from being waste, utilized jugs are profoundly esteemed raw materials in glass generation neither as jugs or sheets and cleared. The presence of cullet in the heater diminishes the softening point temperature and henceforth, saves money on fuel. The general rule is, for each 5% cullet utilized, it can spare 1% on fuel utilization. So it shows well to reuse glass bottles (Raimondo et al., 2007) .

The Kuala Lumpur Glass plant utilizes almost a million liter of medium fuel oil every month when the production is at 230 tons per day. Of this, 69 tons or 30% is cullet, half of which is privately gathered waste bottles and the rest from rejects in the manufacturing plant (Hillary Chiew, 2005). In comparison, glass bottles in Thailand have a recycled content of as much as 80% while those in Europe, between 60 to 70%. Waste glass is a huge segment of family and industry, such as in the group of beverage and food. One of the critical waste glasses is soda lime silica (SLS) waste glass. Since the significant synthetic organizations of SLS waste glass are essentially SiO_2 (73.9%) and CaO (11.2wt %). SLS waste glasses have been utilized as a part of different fields of study and it give great mechanical properties. According to Tucci and his colleagues, they have concluded that compressive quality of their ceramic tile expanded by including SLS glass.

1.2 Problem Statement

In the most recent years, the reuse of various waste glass had turned into a business other option to conventional raw materials that majority for feldspar and quartz-feldspathic sands in ceramic formulation (Raimondo et al., 2007). Not long ago, some previous research papers considered the raw materials in ceramic tiles is by introduction of soda lime waste glasses. In ceramic formulation, which is soda lime silicate glass is replace by feldspathic fluxes for example with additions of up to 5 wt.% will not bring any significant change in the technological behavior of the product and also can make a reduction of the sintering temperature.

The utilization of waste glasses in the generation of building materials has been effectively found after since it can decrease both the utilization of normal assets and the cost of waste disposal. Many authors have thought about this as the most reasonable field for the potential reusing of waste glasses. Truth be told, because of both the substantial measure of fluid stage (50– 65%) developed during firing and the adaptability of the tile making procedure, smooth

materials might be brought into ceramic bodies without adjusting the traditional manufacturing cycle (Raimondo et al., 2007).

The use of feldspar in the ceramic tile production has a higher investment capital and it is gain from natural resources which is feldspar is made from minerals in the earth's crust. Meaning to say, the usage of feldspar can lead to expensive cost because the raw materials itself is hard to gain compared to waste glass resource. SLS waste glass does not require higher cost because it is composed from abandoned bottles and can easily find out at many places. On the other hand, the SLSG also carry the same purpose as feldspar in manufacturing of ceramic tiles which is it can acts as fluxing agent. By using SLSG in the composition, it can help to reduce the sintering temperature of the materials without changing the features of the end products. Specifically, the use of SLSG with feldspar because the SLSG has slightly similar composition and function that can be done same as feldspar. Furthermore, by substituting the feldspar with SLSG can help to reduce waste that made up from community. In addition, it is apparently very good if the waste can be recycle to make something useful in industry.

The problem statement in this present study is to investigate the effect of different particle size of SLSG react to ceramic tiles formulation. Also the different composition of mixture can lead to different properties of green glass ceramics.

1.3 Objectives

There are several objectives of this project which are:

i. To analyze the effect of different weight percentage of SLSG in replacing feldspar towards physical and mechanical properties of green ceramic tiles.
ii. To investigate the effect of particle size of SLSG on the properties of green glass ceramics.

iii. To assess the mechanical properties and microstructure of optimize sample green ceramic.

1.4 Scope of study

The scope is to analyze the effect of different weight percentage is by using 0 wt.%, 10 wt.% and 30 wt.% of SLSG to be mix with clay, quartz and feldspar. The scope of this study also to investigate the effect of particle size of SLSG on the physical and mechanical properties of green ceramic tiles. This study starts by preparing the ceramic tiles by using traditional composition of the materials that involved. The fabrication process of common ceramic process is carry out which is by using uniaxial pressing method. The SLS glass powder is prepared by crushing and sieving to get a particle size of <75μm, <45μm and <30μm.

The physical properties were analyzed using water absorption, porosity and bulk density analysis that determined based on American Standard Testing Machine (ASTM) C373-88 Standard test method. The mechanical properties that analyzed was microhardness testing. The microhardness testing was examined by using standard test ASTM C 1327-99.

Then, the material characterization that investigate are X-Ray Diffraction (XRD) and Scanning Electron Microscopy (SEM).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The content in this chapter is elaborating about the traditional ceramic tiles formulation in details. Each materials that involved in the formulation was discussed such as their composition and properties. In this chapter also briefly explain about the replacement of feldspar in ceramic tiles with waste glass. Furthermore, the particle size of the materials also being explained on how it can change its result if the size of the particles are different.

2.2 Ceramic Tiles Formulation

Ceramic products are manufactured by using large amount of fluxing agents such as sodium and potassium feldspar, nefeline, talc and ceramic frits (Genraro et al., 2003). Ceramic tile is composed from sand, natural products, and clays and once it has been molded into shape they are then fired in a kiln. When making ceramic tiles they can either be glazed or unglazed. To produce ceramic tile, the materials needed are clay, quartz, feldspar, talc, and silica.

Ceramic tile flooring comprises of clay, and other ceramic materials, which is prepared in a kiln to a changeless hardness. To enhance ecological execution, reused windshield glass is frequently added to the ceramic blend. The figure 2.1 below shows the flow diagram major elements of the production of general ceramic tile manufacturing.

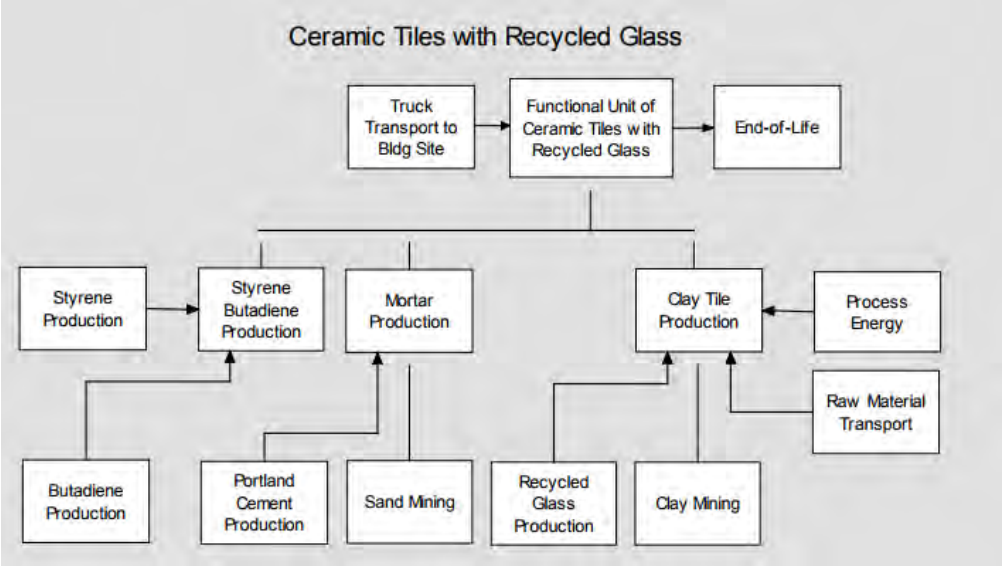

Figure 2.1 : Ceramic Tile System Boundaries (Genraro et al. 2003)

2.2.1 Clay

Clay is a fine-grained natural rock or soil material that combines one or more clay minerals with traces of metal oxides and organic matter. Clay also is basically a sedimentary rock deriving from alternation of primary rocks that majority contain clayey minerals of micronic dimension and characterized by high plasticity. The clay can be classify on the basis of the prevalent clayey minerals and hence distinguish the ingredients that contain in the clay itself. Typical common components that may presence in clays are feldspar, quartz, iron oxides and hydroxides, titanium oxides, calcite, dolomite, and organic substances.

In formation of ceramic bodies, clay based minerals are the main constituent that generally ranges from 40 to 60 wt % (Manfredini & Hanuskova, 2012).

2.2.2 Feldspar

Feldspar is a fundamental and essential fluxing material for ceramic bodies and also coatings and one of the three fundamental unrefined materials for the triaxial body. Feldspar gives the gleaming stage to the ceramic bodies and they are added to lessen the capital investment. Feldspars are found in pegmatite shakes when in doubt of the stone sort which can be considered as a mix of feldspar minerals together with quartz and mica (Tucci et al., 2004).

There are three sorts of feldspar minerals to be particular Na-Feldspar or albite, the K-Feldspar or orthoclase and Ca-feldspar or anorthite. Unmatured feldspar does not occur in nature yet rather are widely appealing in creation. As needs be sodium feldspar moreover contains orthoclase and anorthite. Additional minerals are accessible for instance, quartz, squeeze compound and magnesia. In the artistic tile body especially the fired tile, feldspars accept a crucial part in achieving the vitreous thought of the body and the high mechanical security of the thing toward the complete of the ending stage. Other than going about as a flux, feldspars similarly energize drying and landing of gas in the midst of ending like other non-plastics (Tucci et al., 2004).

The partial and fully replacement of K-feldspar with waste glass powder in a ceramic tile mix changes the amounts of the different alkalis in the mixture (Tucci et al. 2004 and Malleucci et al. 2002).

2.2.3 Silica

Silica is the most abundant oxide on the world's hull. A lot of silica happens as free silica that is generally as quartz albeit its vast majority is joined with different components in the silicate minerals (Rimola et al., 2013).

There are 3 sorts of silica found in nature that are shake, granular and powdered. The first type is rock type. This sort is otherwise called quartz stone. Because of its polluting influences content, this sort of silica does not regularly utilized as a part of the artistic business. The next type is granular type. This type of silica is known as silica sand and is the most regularly found. This sort of silica is broadly utilized as a part of earthenware production since it is somewhat unadulterated even without beneficial. The last type is powder type. This nebulous kind of silica is known as diatomaceous earth and contains a lot of pollutions. The utilization does not in pottery however for the most part in warm protection (Rimola et al., 2013).

Silica exists in an extraordinary assortment of structures. The three key crystalline structures are quartz, tridymite and cristobalite (Rimola et al., 2013).

Quartz when stood out from the other unrefined materials in the fired bodies is decently poor. Silica sand or stone is used as a piece of the body as a wellspring of silica. Development of silica sand decreases its unfired quality and flexibility however help to empower escape of gasses in the midst of drying and ending. It furthermore lessens drying shrinkage and grows the whiteness of the let go body (Rimola et al., 2013).