FORMULATION OF GLASS CERAMIC FOAM FROM WASTE FOR LOW THERMAL CONDUCTIVITY APPLICATION

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

by

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DECLARATION

I hereby, declared this report entitled "Formulation of Glass Ceramic Foam from Waste for Low Thermal Conductivity Application" is the result of my own research except as cited in references

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfilment of the requirement for the degree of Bachelor of Manufacturing Engineering (Hons). The members of the supervisory committee are as follow:

……..……

(Professor.Madya Dr Jariah Binti Mohamad Juoi)

ABSTRAK

Objektif projek ini adalah untuk menentukan kesan peratusan berat karbon hitam dan sisa soda limau silika kaca pada sifat fizikal, mekanikal, haba dan fasa dan mikro struktur busa seramik kaca yang dihasilkan. Berdasarkan kajian terdahulu, pengaruh keliangan terhadap kekonduksian terma telah dikaji dan dari sini kualiti busa seramik kaca yang dihasilkan dapat ditingkatkan. Sampel telah dihasilkan dengan peratusan berat yang berbeza dari karbon hitam, bola tanah liat dan sisa soda limau silika kaca yang merupakan kumpulan 1 dengan 89% SLSG, 1% CB, 10% bola tanah liat, kelompok 2 dengan 85% SLSG, 5% CB , Tanah liat 10% dan kumpulan 3 dengan 80% SLSG, 10% CB, 10% tanah liat bola. Selepas sampel dicampur dengan baik, mesin die uniaxial digunakan dengan 3.5 tan untuk membentuk sampel dalam bentuk silinder dengan diameter 25mm dan ketinggian 5mm. Selepas itu, sampel itu menjalani proses sintering di relau pada 850^0 C dan kadar pemanasan 2^0 C / minit dan kemudian biarkan ia menyejuk secara semula jadi. Lima ujian telah dijalankan untuk menganalisis dari segi fizikal dan mikrostruktur Ujian yang telah dilakukan adalah ujian pengembangan haba, ujian kekerasan mikro, SEM, XRD, dan ujian fizikal. Dari hasil ujian, kita dapat melihat bahawa apabila jumlah peningkatan karbon hitam, keliangan sampel juga akan meningkat. Ini boleh dibuktikan dengan hasil ujian keliangan yang jelas di mana sampel dari kumpulan 1 mempunyai 12.06% keliangan, kumpulan 2 mempunyai 13.69% dan kumpulan 3 mempunyai jumlah keliangan tertinggi iaitu 14.51%. Selain itu, ujian pengembangan haba juga membuktikan bahawa sampel dengan porositas tertinggi akan mempunyai CTE terendah. Kesimpulannya, rumusan terbaik untuk menghasilkan buih seramik kaca ialah peratusan berat badan kumpulan 3 (80% SLSG, 10% CB dan 10% bola tanah liat). Peningkatan selanjutnya harus dilakukan dengan terus meningkatkan sifat penebat haba buih seramik kaca dengan meningkatkan jumlah penambahan karbon hitam

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ABSTRACT

The objective of this project is to determine the effect of weight percentage of carbon black and waste soda lime silica glass on the physical, mechanical, thermal properties and phase and microstructure of glass ceramic foam produced. Based on previous research, influence of porosity on thermal conductivity had been studied and from here the quality of the glass ceramic foam produced can be improved. Sample had been produced with different weight percentage of carbon black, ball clay and waste soda lime silica glass which is group 1 with 89% of SLSG, 1 % CB, 10% ball clay, group 2 with 85% of SLSG, 5 % CB, 10% ball clay and group 3 with 80% of SLSG,10 % CB, 10% ball clay. After the samples is well mixed, a uniaxial die machine is used with 3.5 tons to form the samples in a cylindrical shape with diameter of 25mm and height of 5mm. After that, the sample is undergo sintering process in furnace at 850°C and a heating rate of 2°C/minute and then let it cool down naturally. Five testing had been carried out to analyse in term of physical and microstructure The testing that had been done is thermal expansion testing, micro hardness testing, SEM, XRD, and physical testing. From the result of the testing, we can see that when the amount of carbon black increase, the porosity of the sample will also increase. This can be proved by the result of apparent porosity testing where sample from group 1 had 12.06% of porosity, group 2 had 13.69% and group 3 had the highest amount of porosity which is 14.51%. Furthermore, the thermal expansion testing also proven that the sample with highest porosity will have the lowest CTE. In conclusion, the best formulation to produce glass ceramic foam is weight percentage of group 3 (80% SLSG, 10% CB and 10% ball clay). Further enhancement should be carry out on continue improving the thermal insulation properties of glass ceramic foam by increase the amount of carbon black addition

DEDICATION

Dedication to my beloved parents and family for giving me moral support, money, cooperation, encouragement and also understanding

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LIST OF ABBREVIATIONS

Al_2O_3	-	Aluminium Oxide
CaO	-	Calcium Oxide
CB	-	Carbon Black
CTE	-	Coefficient of Thermal Expansion
K_2O	-	Potassium Oxide
MgO	-	Magnesium Oxide
MPa	-	Mega Pascal
Na_2O_3	-	Disodium Trioxide
SEM	-	Scanning Electron Microscope
SiO_2	-	Silicon Dioxide
SLSG	-	Soda Lime Silicate Glass
WT	-	Weight Percentage
XRD	-	X-Ray Diffraction

Chapter 1

Introduction

1.1 Background

Glass ceramic foam is a very common material that we can found in our daily life. Many objects arounds us are made of glass ceramic foam or part of them are made of glass ceramic foam. For example like filter for car engine and insulation layer for machine.

Glass ceramic foam is a type of tough foam made by ceramic and glass. Various manufacturing process like direct foaming method, replica and sacrificial template can be used to produce this material. It had excellent characteristic such as low thermal, low electrical conductivity incombustibility and low density. The characteristic and wide application field of glass ceramic foam had lead to a continuous increase demand of this material. Glass ceramic foam can be applied on lots of field for example like insulation, pollution control, building and electronic device. Due to this, many research had been carried out on glass ceramic foam from different aspect.

This project is intended to find out the most suitable formulation of glass ceramic foam that made from waste material and the effect of weight percentage of carbon black and waste soda lime silica glass to it properties. Compression strength and thermal conductivity test carried out to check whether the product of this project reached standard.

1.2 Problem Statement

Various research had been carried out on glass ceramic foam from different aspect. For example, some of the research focus on how to made high quality glass ceramic foam from waste, some of them try to determine the effect of temperature during foaming process on the structure of glass ceramic foam and part of the research aim to determine the relationship between proportion of waste material and the structure of glass ceramic.

One of the way to reduce production cost is re-use waste material as raw material of a product. But this method had its own risk too because adding a wrong proportion of waste materials as raw material may lower down the quality of the final product.. Therefore this project is needed to solve this problem. This project is intended to determine the effect of weight percentage of carbon black particle and waste glass on the mechanical, physical and thermal properties. Furthermore, effect of weight percentage of carbon black and waste glass on the phase and microstructure of glass ceramic foam produced is also one of the objective of this project.

There are some similar research which also focus on produce glass ceramic foam from waste material (Linfeng Ding, 2015). Different with this project, this research focus on the preparation of glass ceramic foam from waste glass and blast furnace slag while this project is intended to prepared glass ceramic foam from carbon black and waste glass. From this project, the different in term of the properties and microstructure of glass ceramic foam produce from this two types of waste can be known

In the others hands, various studies had been done on glass ceramic foam and each of them focus on different aspect. For example, some of the research focus on the relationship between sintering temperature, types of raw material and the properties of glass ceramic foam made. But there is not much research focus on the effect of carbon

black weight percentage on the properties and microstructure of the glass ceramic foam. Therefore, this study is needed to provide more information on this field.

1.3 Objectives

I. To determine the effect of carbon black weight percentage and waste soda lime silica glass on the physical, mechanical and thermal properties.
II. To analyse the effect of carbon black weight percentage and waste soda lime silica glass on the phase and microstructure of glass ceramic foam produced.

1.4 Scope

i. Produce glass ceramic foam from waste material with standard physical and mechanical properties
ii. Waste substance use in this project is limited to black carbon and waste soda lime silicate glass

1.5 Benefits of Study

By carry out this project, we are able to determine the most suitable weight percentage of waste material to be use as raw material which can produce the best quality glass ceramic foam. From the result of this project, the cost of production of glass ceramic foam also can be reduced if this project proved that waste material can be use as raw material of glass ceramic foam. Furthermore the quality of glass ceramic foam can be improved since the most suitable proportion for waste material to be added in was found. Other than this, this research also intended to determine the relationship between carbon black and the structure of glass ceramic foam. The result of this project may provide some useful information for further research on related topic.

CHAPTER 2
LITERATURE REVIEW

2.1 Background

This chapter contains on all the information gathered from different source that are related to the project. The properties of black carbon and waste glass (soda lime silica glass, SLSG) are also clearly defined. Other than this, the properties of glass ceramic foam and it processing method are discussed. Lastly, the properties of glass ceramic produced by different type of waste are discussed.

2.2 Waste

According to the United Nations Statistics Division (UNSD) Glossary of Environment Statistics, waste is described as "material that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose. Wastes may be generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, and other human activities. Residuals recycled or reused at the place of generation are excluded.

Waste can be categorized into three different group which is hazardous waste, medical waste and disposal-solid waste. Based on a study conducted by Ministry of Urban Wellbeing, Housing and Local Government (MHLG) which covered 5 states in Malaysia (Kelantan, Terengganu, Kuala Lumpur, Selangor and Pahang). Waste produced in this 5 states represent 70% of the total amount of waste in the country and Figure 2.1 show that domestic waste stand a 64%, 25% of the waste is industrial waste and then 8% of commercial waste and 3% of construction and institution waste (Omran et al., 2008).

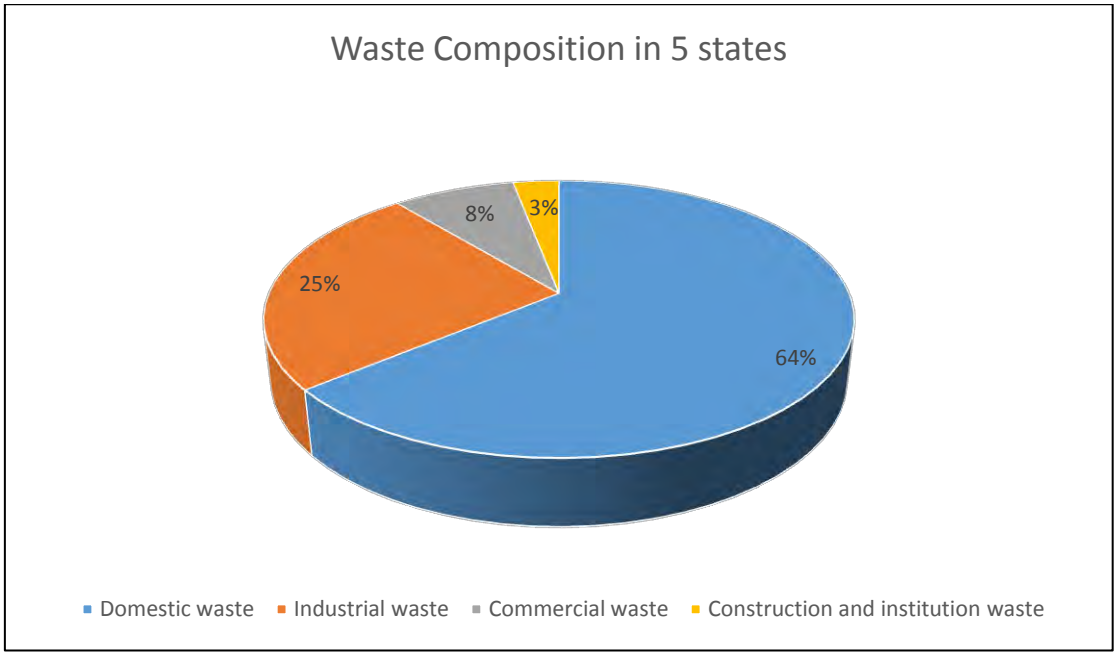

Figure 2.1: Waste composition (Kelantan, Terengganu, Kuala Lumpur, Selangor and Pahang) (Omran et al., 2008)

2.2.1 Waste Glass

Glass is generally produced from silica sand (SiO_2), soda ash (Na_2O) and limestone (CaO) as main raw material. Glass is a non-crystalline amorphous solid that have short range atomic arrangement. It have properties like transparency, brittle, high corrosion resistance and don't not react with foods.

The demand of glasses had increased steadily over this few years due to the growing of industries and human population. Glass can be applied on many field for example food packaging, windows, tableware or even housing and building.

In U.S., 41 billion glass container are produced annually. In others words, almost 150 for every children, man and woman. Food container are around 33% of it, 31% are beer bottles, 9% are wine and liquor bottles, beverages bottles are about 22% and the remaining 5% are container for cosmetics, pharmaceuticals, and other materials. If we categorized in term of colour, over 65% of the glass waste are clear, 25% are brown or amber and the remaining 10% come in different shades of green and occasional blue and other colour. Furthermore, 2 to 4 billion containers are imported into U.S. annually where most of them are beer, wine and liquor bottles (Ravindra K Dhir, 1997)

2.2.1.1 Recycling of glass

Initially, the application of glasses were limited to jars, bead and bowls, but as technology getting more and more advanced, the application field of glasses had expand to field like windows, shelves, lighting, appliances, fibre optic cable and solar panels. This is because of the invention of different type of glass with varying properties.

The high demand of glasses had lead to a problem the amount of waste glasses produced each year is getting higher and higher. One of the solution to this problem is recycle. Glass can be recycled without changing its composition or quality. Normally glass container is recycled into new glass container and no further development done on this material.

The European Union recycled up to 73% of glass packaging with Sweden, Belgium, Luxembourg and Germany being the best performers (Container Recycling Institute, n.d.).This might seem like a high number but actually there is still many limitation in glass recycling. Only a fraction of this amount may be remanufactured due to the strict limitation of glass manufacturing. Initially, glass need to be collected and categorized into different colour. The glasses that cannot be categorized is broken or mixed during the collection phase along whit glass that contain composite material or contaminants that are not economical or technical impossible to remanufactured. This type of waste glass cannot be recycled due to chemical incompatibility. Other than this, problem may rise during the manufacturing process because of the different of melting points of each type of glasses as only 5g of non-recyclable glass is enough to contaminate a tonne of recyclable glass.

Figure 2.2 had shown the recycling process of glass container. First, waste glasses if being collected from the centre and sorted by colour. After that, glasses if crushed into small pieces called cullet and soda ash, sand, lime stone and silica is mixed with the glass cullet. Next, the mixture is melted in furnace and the molten glass is slowly poured into moulds. The formed shape glass container is cooled slowly and finally a new glass container is produced and ready to be use.