CHARACTERIZATION AND MECHANICAL PROPERTIES OF POROUS CERAMICS WITH DIFFERENT MIXTURE OF CARBON BLACK (CB) AND POLYMETHYL METACRYLATE (PMMA) CONTENTS

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2023

Faculty of Mechanical and Manufacturing Engineering Technology

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A thesis submitted in fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Refrigeration and Air Conditioning System) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2023

DECLARATION

I declare that this Choose an item. entitled "Characterization and Mechanical Properties of Porous Ceramics with Different Mixed of CB and PMMA Contents" is the result of my own research except as cited in the references. Choosing an item has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : MOHAMAD IZZAT BIN SALLEH

Date : 11TH JANUARY 2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Refrigeration and Air Conditioning Systems) with Honours.

Signature :

Supervisor Name : ASSOC. PROF. TS. DR. UMAR AL-AMANI BIN HAJI AZLAN

Date : 11TH JANUARY 2023

DEDICATION

In the name of Allah, the Entirely Merciful and The Bestower of Mercy and with deep appreciation to the Prophet Muhammad S.A.W. I did the task successfully without any complications faced. I finished this project within the allotted time and to the best of my ability.

To express my gratitude and appreciation to both of my parents, Habibah binti Dahlan, my mother and my father Salleh bin Mut, for their endless support throughout this process.

ABSTRACT

Ceramic materials are superior to both metals and polymers. High performance mechanical strengths include hardness, wear, stiffness, density, fracture toughness, and other application-specific mechanical requirements that surpass those of steel, alloys, and polymers. Consequently, the objective of this study is to improve the porosity of ceramic while preserving its strength, as well as to analyze other ceramic qualities and make ceramic samples with varied proportions of carbon black and polymethyl methacrylate. Material selection is the initial step of the procedure. Clay, feldspar, and silica are the primary components used to manufacture these samples. 0%, 3%, 5%, and 10% weight percentages of carbon black and polymethyl methacrylate are combined inside the mixture. The mixture is subsequently weighed before being ball-milled for three hours. The final product will be a fine powder that will be sieved. The powder is subsequently compacted via a pressing operation. Before the samples are reduced during the sintering process, the fine powder is applied to a mould. The testing phase begins with the following stages. It consists of X-ray Diffraction analysis, density, and porosity testing, bending testing, thermal conductivity testing, and scanning electron microscope examination (SEM).

ABSTRAK

Bahan seramik lebih unggul daripada logam dan polimer. Kekuatan mekanikal prestasi tinggi termasuk kekerasan, haus, kekakuan, ketumpatan, keliatan patah dan keperluan mekanikal khusus aplikasi lain yang mengatasi keperluan keluli, aloi dan polimer. Oleh itu, objektif kajian ini adalah untuk meningkatkan keliangan seramik sambil mengekalkan kekuatannya, serta menganalisis kualiti seramik lain dan membuat sampel seramik dengan pelbagai bahagian karbon hitam dan polimetil metakrilat. Pemilihan bahan adalah langkah awal prosedur. Tanah liat, feldspar dan silika adalah komponen utama yang digunakan untuk mengeluarkan sampel ini. 0%, 3%, 5%, dan 10% peratusan berat karbon hitam dan polimetil metakrilat digabungkan di dalam campuran. Campuran kemudiannya ditimbang sebelum dikisar bola selama tiga jam. Hasil akhir akan menjadi serbuk halus yang akan diayak. Serbuk kemudiannya dipadatkan melalui operasi menekan. Sebelum sampel dikurangkan semasa proses pensinteran, serbuk halus disapu pada acuan. Fasa ujian bermula dengan peringkat berikut. Ia terdiri daripada analisis Difraksi sinar-X, ujian ketumpatan dan keliangan, ujian lenturan, ujian kekonduksian terma, dan pemeriksaan mikroskop elektron imbasan (SEM).

ACKNOWLEDGEMENT

In the name of Allah, the Most Merciful and Gracious

I would like to begin by expressing my gratitude and thanks to Allah, the All-Mighty, who is both my Creator and Sustainer, for everything that has been bestowed upon me since the beginning of my life. I do like to take this opportunity to thank the Universiti Teknikal Malaysia Melaka (UTeM) for the research. In addition, I would like to thank the Malaysian Ministry of Higher Education (MOHE) for the financial assistance.

Associate Professor Ts. Dr. Umar Al-Amani Bin Haji Azlan, my primary advisor, deserves the highest level of gratitude from me for all the assistance, counsel, and inspiration he has provided. His unfailing patience in directing, as well as the invaluable insights he provided, will be remembered for all time. I'd like to express my heartfelt gratitude to Mr. Ammar Baqir and Mr. Syazwan Zulhilmi for all their help and support.

Finally, I do like to express my heartfelt appreciation to my cherished parents for their unending love, support, and prayers. Finally, I'd like to express my gratitude to everyone who has offered me assistance, support, or inspiration throughout my academic career.

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LIST OF SYMBOLS AND ABBREVIATIONS

°C	-	Degree Celsius
µ	-	Micrometers
Mm	-	Millimeters
CB	-	Carbon Black
PMMA	-	Polymethyl methacrylate
PFA	-	Pore-forming agent
%	-	Percentage
CMC	-	Ceramic Metrix Composites
NSA	-	Total surface area
STSA	-	External value
Wt%	-	Weightage
Mpa	-	Mega Pascal
Wa	-	Dry Mass
Wb	-	Mass suspended in water
Wc	-	Saturated mass
FRP	-	Fibre-Reinforced Plastic
XRD	-	X-ray Diffraction
SEM	-	Scanning Electron Microscope
CIP	-	Cold Isostatic Pressing
HIP	-	Hot Isostatic Pressing

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CHAPTER 1

INTRODUCTION

1.1 Background

Mechanical properties of ceramic tiles are crucial nowadays. The reason why it is crucial is tiles are commonly used in any industry. Not only on its mechanical but also on its thermal properties. Ceramic tiles mechanical properties will determine its strength, hardness, rigidity, density, and others.

Ceramic materials properties are determined by the types of atoms present, the types of bonds between the atoms, and the way the atoms are packed. This is referred to as atomic scale structure. Most ceramics are composed of two or more elements. The term for this is compound. Alumina (Al2O3), for instance, is a compound composed of aluminum and oxygen atoms.

Basically, this research is focused on the microstructural, strength, peak formation of ceramic, density, and porosity of the ceramic tiles samples by using a mixture of Pore Forming Agent (PFA). The mechanical properties like the strength will be determined by the amount of porosity in the ceramic sample.

Porous ceramics can be made in several different methods. Organic chemicals were incorporated into the ceramic body and then removed during the firing stage, which was an early technology that is still commonly used today. Other methods have considerable benefits and could be employed in the future. Controlling processing and, as a result, final material qualities is a major issue.

1.2 Problem Statement

Several mechanical qualities, including strength, density, porosity, and others, impact ceramic samples. The primary concern is how to preserve the strength of the ceramic while increasing its porosity. The preliminary conclusion of this study is that the greater the number of porosities, the lower the strength.

Ceramic tiles include pores, which also determines their mechanical strength. As the number of pores on a ceramic tile grows, its mechanical strength will decrease. As the number of pores rises, this will also affect the strength. To improve the outcome, the pore-forming agent is added at a level that does not compromise the ceramic tile's strength.

Pore-forming chemicals have shown the ability to reach high porosity levels. During the heating process to the firing temperature, organic particles are burnt away, leaving gaps in the ceramic body. These voids will have a specific shape. The amount of pore-forming agent needed is dictated by the pore-forming agent employed, and so maybe controlled by using the right pore-forming agent. content of incorporation and particle size distribution.

There are a few options of pore-forming agents that can be used in ceramic tiles which are polypropylene, polymethyl methacrylate, and black carbon. The one that will be used for this research is a mixture of Carbon Black (CB) and Polymethyl Methacrylate (PMMA). CB and PMMA and was chosen because of its large scale of manufacture and inexpensive price, making it economically attractive for industrial applications. The previous study concerning the thermal degradation of CB and PMMA had shown that both decompose into many aliphatic compounds, in a fast way and without lasting residue. The other reason is there are no hazardous gases emissions during ceramic tile making.

This research will focus on measuring the performance of ceramics with different parameters by using a mixture of CB and PMMA as pore-forming agent.

1.3 Research Objective

a) To fabricate the ceramic samples with various contents of mix PFA (Carbon Black and Polymethyl Methacrylate)

b) To characterize the mechanical properties of ceramic samples.

1.4 Scope of Research

This study will be accomplished to analyze the preparation of powder, ceramic tile production, characteristics of the powder, pore-forming agent, and ceramic and study of ceramics. This analysis will be done to achieve the optimal condition of ceramic tile with similar mechanical strength for the application of the buildings.

To make ceramics, there are many types of powder used. In the preparation of powder, a study for the type of powder needs to be done. This preparation is crucial because this research is to determine the amount of powder that will increase the porosity of the ceramic tiles that will be produced.

Scanning Electron Microscope (SEM), three-point bending strength, density, and porosity will be examined. Each analysis and test determine the best parameter. Analysis and tests will inform any improvements and fixes. A performance test will be accomplished as a crucial step for this research. After completing each test, a few studies will be done on the ceramic tiles to acknowledge its characterization and mechanical properties.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the next section of this chapter, we will discuss the historical research that has been conducted on this topic, structured ceramics. The literature review will encompass a variety of research papers, which will all be analyzed alongside the current project and compared to one another. This chapter provides a general overview of the history of ceramics and their constituent elements. In addition to the chapter being read, numerous other periodicals, books, newspapers, and other publications serve as guides. This chapter emphasizes the significance of analyzing prior research and, by extension, the problem's evolution over time. The investigation of previous works provides not only a strategy but also a foundation for the success of this endeavor. To have any chance of successful fortifying ceramic, it is essential to exert the effort required to do so.

2.2 History of Ceramics

Even though technological advancements in tiles have made it possible to use it on walls, floors, ceilings, fireplaces, murals, and even as an external cladding material, ceramic tile is still extremely popular today. This is even though it has been in use ever since the invention of clay roof coverings, which occurred many years ago.

The word "ceramic" comes from the Greek word "keramos," which translates to "pottery," but its origin in Sanskrit means "to burn." Our English word "ceramic" comes from this Greek word. This is because the tiles were baked in a high-temperature oven to ensure that they were sufficiently dry to withstand the natural elements. Consequently, this result was achieved. Kilns were used in later times instead of the sun to harden the tile body and create a beautiful surface finish on tile. Earlier tiles were baked in the sun.

Ceramics made by humans have been found in sites that are at least 24,000 years old, according to archaeologists. Figurines of humans and animals, slabs, and balls made of ceramic were among the artefacts that were found in Czechoslovakia at the time. These ceramics were made by combining animal fat and bone with bone ash and a fine material that resembled clay. This process resulted in the creation of ceramics. After being shaped, the ceramics went through a process called firing, during which they were subjected to temperatures that ranged from 500 to 800 degrees Celsius. The firing took place in horseshoe and dome-shaped kilns that were partially dug into the ground and lined with loess walls. It is unknown what these ceramics were used for in the past, but it is highly unlikely that they served any practical purpose. Around 9,000 BC, it is believed that people started using pottery vessels for their intended purposes for the first time. These containers certainly served the purpose of holding and storing several types of food, including grain.

Figure 2.1 Ancient ceramics

It is accepted that the production of ancient glass was closely related to the production of pottery, which flourished in Upper Egypt around 8,000 BC. The application of a colored glaze to the ceramic pot while it was being fired may have been the result of the presence of sand containing calcium oxide (CaO), combined with the use of soda, as well as the overheating of the pottery kiln. According to the opinions of various experts, glass was not independently produced from ceramics and fashioned into separate items until the year 1500 BC.

Since these epochs, the technology behind ceramics, including glass, as well as the applications of ceramics, have steadily increased. Ceramics have made a significant contribution to human advancement, but humans frequently ignore or downplay the importance of this fact.

Figure 2.2 Ceramics used in modem days.

Ceramics and glass have been important to the development of many modem industries, such as electronics, optoelectronics, medicine, energy, automobiles, aerospace, and space exploration. Ceramics and glass have also been used in space exploration. The processing of ceramics and the ability to characterize their properties have both advanced, which has made it possible to create materials with properties that can be tailored. The development of translucent ceramics, ductile ceramics, hyper elastic bones, and microscopic capacitors have all been made possible thanks to nanotechnology.

2.2.1 Material of Ceramics

There are two distinct categories of ceramic materials that are utilized in the engineering industry. There are two types of ceramics: the traditional ones and the advanced ones. Feldspar, silica (also known as flint), and clay are the three most common components of traditional ceramics. Bricks, tiles, and porcelain figurines are a few examples of this type of material. On the other hand, compounds made of Al203, silicon carbide (SiC), and silicon nitride are what constitute advanced ceramic materials (Si3N4)

2.2.2 Properties of Ceramics

The characteristics of ceramic materials, like the characteristics of any other material, are determined by the types of atoms pre t, the types of bonding that exist between the atoms, and the way the atoms are packed together on an atomic scale is the name we give to it. Most ceramics are made up of at least two distinct components. A compound is another name for this structure. For instance, the chemical compound known as alumina (Al203) is formed by combining atoms of aluminum and oxygen.

Ceramic materials are held together by a chemical bond between their constituents. The most common types of chemical bonding found in ceramic materials are the covalent and ionic types. The term "metallic bond" refers to the chemical connection that exists between metals. The covalent and ionic bonds that exist between atoms are significantly stronger than the metallic bonds that exist between them. Because of this, metals tend to be more ductile, while ceramics tend to be more brittle.

Ceramics have high melting temperatures, which contributes to their ability to withstand high temperatures. Additionally, ceramics have high levels of hardness, strength, resilience, and low electrical and thermal conductivity. Ceramics possess significant levels of hardness, strength, and resilience, as well as significant levels of hardness, strength, and resilience. Ceramics are excellent insulators because they do not react in any way with other compounds. Upon chemical testing, they do not react with anything.

It is possible for the porosity of a ceramic to affect its properties, such as its ability to transfer heat and its resistance to breaking. This result can be explained by the fact that the gas that fills the ceramic's pores has a low thermal conductivity. Because of this, we see it. Consequently, the impact of thermal insulators within ceramics has been amplified. In contrast, when porosity is increased, both strength and durability are diminished. Because porosity affects the amount of air that can pass through a material, this is the case. To find a solution to the problem, it is necessary to exercise control over the porosity of the ceramic.

2.2.3 General Applications

Even when subjected to extremely high loads, most other materials, including ceramics, show little sign of wear when brought into contact with ceramics. Ceramic materials have a lower specific gravity and therefore weigh less than iron-based alloys and steel. Traditional ceramics are extremely brittle, and they can crack from even the smallest scratches, even when they are loaded with force and subjected to impact. This material is not easily worn down and is resistant to corrosion. Ceramics are known for being more expensive