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BORANG PENGESAHAN STATUS TESIS*

JUDUL: The Fabrication of Porous Ceramic

SESI PENGAJIAN : 2007/2008

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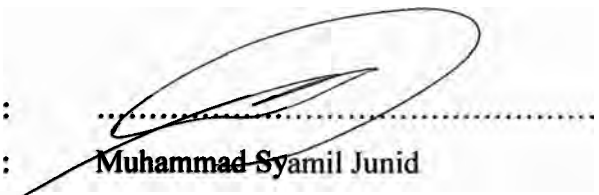

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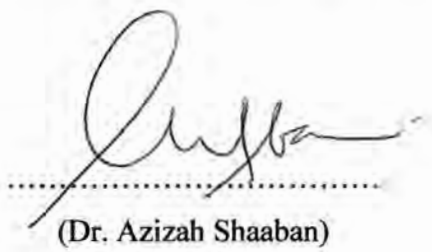
APPROVAL

This PSM submitted to the senate of UTeM and has been as partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Engineering Materials). The members of the supervisory committee are as follow:



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ABSTRACT

Porous ceramics are desirable for certain application like filters, humidity and gas sensors. Porosity can be found in almost every types of materials science like metals, ceramics, polymers, composites, semiconductors and biomaterials.The best well known porous materials is ceramics. In order to produce porous ceramic some special technique will be implemented during the process. Some amount of charcoal will be mix up in the mixture prior sintering and will be burned out to leave the pores at sintering temperature of 1250°C. There are 8 different sample produces which have charcoal wt% as these, 0 wt%, 1 wt%, 2 wt%, 3 wt%, 4 wt%, 5 wt%, 6 wt%, and 7 wt% respectively. It was found that it was proved the more weight percentage (wt %) charcoal was added the porosity distribution also would increase. The SEM microstructure could describe briefly the distribution of the porosity inside those pallets and the average size of pores. There were also several standard testing procedures successfully conducted for porous ceramic to determine characteristics, properties and behaviors. The diameters, weight distribution, relative density after sintering (gmm^{-3}), and the Vickers Hardness value after sintering were directly proportional to the charcoal wt% composition added. The relative volume and porosity volume were calculated to determine exact porosity.

ABSTRAK

Seramik berongga amat banyak kegunaannya di sesetengah aplikasi seperti penapis, penguji kelembapan serta sensor gas. Keliangan atau keronggaan boleh dijumpai di mana-man sahaja jenis bahan saintifik seperti logam, seramik, polimer, komposit, bahan semikonduktor dan bio-bahan. Untuk menghasilkan seramik berongga teknik-teknik khas akan dilakukan semasa proses pembuatan. Arang dalam kuantiti tertentu akan dicampurkan sebelum process pembakaran dan akhirnya ia akan terbakar bersama-sama serta meninggalkan ruang kosong iaitu rongga. Terdapat 8 sampel berlainan disediakan mengikut kandungan arang yang berlainan iaitu 0 %jisim, 2%jisim, 3%jisim, 4%jisim, 5%jisim, 6%jisim, 7%jisim dan 8%jisim masing-masing. Kajian mendapati is terbukti menunjukkan peratusan jisim (%jisim) arang yang meningkat akan meningkatkan taburan keliangan tersebut. Gambarajah SEM dapat menceritakan secara jelas tentang taburan liang dan rongga dan purata diameter masing-masing. Beberapa ujikaji yang moden telah berjaya untuk mengenalpasti ciri-ciri serta sifat-sifat liang berongga. Diameter, taburan jisim, ketumpatan relatif selepas pembakaran (gmm^{-3}), dan ujikaji kekerasan Vickers selepas pembakaran adalah berkadar langsung dengan peratusan jisim (%jisim) arang yang ditambah. Isipadu relatif juga isipadu liang berongga dikira untuk mendapatkan hasil sebenar liang berongga.

DEDICATION

For My Mom, Dad and Friends

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LIST OF ABBREVIATIONS, SYMBOLS, SPECIALIZED NOMENCLATURE

ANOVA	-	Analysis of Variance
AT	-	Annual Turnover
ASTM	-	America Society for testing and Materials
A	-	Ampere
AWD	-	Analytical Working Distance
Cl^-	-	Chloride
C_3H_8	-	Propane
C_4H_{10}	-	Butane
CH_4	-	Methane
C_2H_6	-	Ethane
CO_2	-	Carbon Dioxide
cm	-	Centimeter
Cu	-	Copper
C	-	Carbon
CE	-	Counter electrode
daN	-	force display (Newton)
E	-	Electron
Et al	-	et alli (and others)
Ec	-	Current electrochemical parameter
Eq	-	Equation
Ep	-	Editional photographers
EW	-	Equivalent Weight
FKM	-	Fakulti Kejuruteraan Mekanikal
FKP	-	Fakulti Kejuruteraan Pembuatan

Fe	-	Iron
GPP	-	Gas Processing Plants
g/l	-	gram per liter
H_2S	-	Hydrogen Sulphide
He	-	Helium
Hz	-	Hertz
HT	-	High tension generator
KM	-	Kilometer
K	-	Kelvin
Kw	-	Kilowatts
Kg	-	kilograms
L	-	Liter
M	-	Metal
m/s	-	meter per second
max	-	Maximum
Mpa	-	MegaPascal
Mn	-	Manganese
mm	-	Millimeters
m/min	-	meter per minute
MHz	-	Megahertz
NaCl	-	Sodium Chloride
N_2	-	Nitrogen
NS_4	-	Synthetic electrolytic solution
NG	-	Not Good
N	-	Newton
pH	-	Potential of hydrogen
PSL 1	-	Products Specification Level 1

Psi	-	Pounds Per Square Inch
P	-	Phosphorus
Rpm	-	Rotation per minute
SEM	-	Scanning Electron Microscope
Sdn. Bhd	-	Sendirian Berhad
S	-	Sulfur
SAXS	-	Small Angle X-ray Scattering
Tcf	-	Trillion cubic feet
UTeM	-	Universiti Teknikal Malaysia Melaka
V	-	volt
Wt %	-	Weight Percentages
WE	-	Working Electrode
XRD	-	X-ray diffraction
XVGA	-	Extended Vieo Graphes Array
XVP	-	X-View Package
Zn	-	Zinc
^{o}C	-	Degree Celsius
%	-	Percentage
^{o}F	-	Degrees Fahrenheit
µm	-	micron meter
pA	-	picoAmpere (10^{-12})
aA	-	attoAmpere (10^{-18})
ρ	-	Density
nm	-	nanometer

CHAPTER 1
INTRODUCTION

There is no doubt that, porous ceramics have become increasingly important in industry recently due to their multiple applications and utilizations. In fact porous characteristic can be found in almost every types of materials science like metals, ceramics, polymers, composites, semiconductors and biomaterials. The expression of porosity can be traced back especially in implementing in various sectors of geology, hydrogeology, soil science, and building science. Porous materials particularly ceramics are a medium or matter that contains porosity manners. Porosity is a measure of the void spaces in a material, and is measured as a fraction, between 0–1, or as a percentage between 0–100 percent, Answer.Com, (2007). The term *porosity* is used in multiple fields including manufacturing, earth sciences and construction.

Porosity can give a big impact on materials performance, properties, strength, and density. Therefore, it is obligatory to gain knowledge on controlling the porosity and permeability, factors that influence porosity and measuring technique for porosity determination. It is also essential to discern the fundamentals of porosity and permeability themselves. Synthesizing porosity and permeability can be traced back to their theoretical themselves. This project is trying to reveal the secrets behind the fabrication of the porous ceramic and also term of porosity and permeability. As a token of knowledge, some special techniques and method implemented yet investigated in the fabrication of the porous ceramics will be disclosed as well.

1.1 Project Background

Before initiating several tasks, preamble of the project is essential for the comprehension of the entire particular developments. Thus, in this preliminary chapter of the following sections elucidate about the project background, problem statements, objective, scope, project significance, contributions and lastly the conclusion of the chapter. As for the identity to the project that will be developed, the system is entitled *'The Fabrication of Porous Ceramics'*.

With the project background as the initial elaboration of the system, the mentioned section best describe the project in a briefly summarized paragraph for the entire sections as a whole. Following to the next sub-chapter is problem statements; perceptibly it depicts the problems that encountered to the current porous ceramics processing and fabricating in industry. As for the objective is tally with the contents from the problem statements, resolutions for the predicaments are solved within the scope of the objectives listed. On the other hand, synchronized with the problem statements and objective for the system the scope plays an imperative role for the both sections as to evade any possible deviation from the foremost aspects for to-be porosity and permeability. Which ever beneficial from the anticipated from the project is recorded in the project significance section, in addition with the related section of the expected output, the character and outline of the project can be predicted. For the finale of this chapter, brief summary of the sub-chapters and the hints next activities are written.

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1.2 Objectives and Aims

Based from the numerous internal and external factors, the objectives below are the solution to the problem statements existed in the fabrication of porous materials. The problem statements will be mentioned in the next subdivision. The main objectives of the experiment plus the project are:

1) To study the method of fabrication process for porous ceramics especially ceramic based porcelain.
2) To produce porous ceramics components according to the conventional process of fabrication of ceramic materials.
3) To produce the ceramic components with specific properties as well as required shape and size within specific dimensional tolerances.
4) To investigate the correlation between the weight percentage of charcoal powder and porosity in sintering temperature of 1250°C.
5) To inspect factors influence porosity and permeability in porous ceramic.
6) To generate several standard testing procedures for porous ceramic to determine porosity and permeability.
7) To conduct several standard testing procedures for porous ceramic to determine characteristics, properties and behaviors.

1.3 Problem Statements

Controlling the pore size in fabrication of porous materials is always a challenge for materials scientists. Factors like particle size of the starting materials, processing technique, type of binder and distribution of binder will determine the pore size and shape. Sintering temperature also can contribute into the distribution of pores and the pores size themselves.

The cost of fabrication is also the main issue to be investigated and run along with implementation of latest method of fabrication of porous materials. Nowadays, the cost is considered the critical issue in fabrication of porous materials especially in industrial. In order to survive and win in the fierce competition each other, much company has to adopt the latest method of fabrication technique in the lowest cost.

Adjusting the variables in processing and fabrication of porous materials are quite disputed and needed the deep studies and researches. During processing and fabricating, there must be some improvement implemented. Right technique or variable installation can give big impact upon the quality of the final product.

Dimensional, measurements and tolerances is required in high precision and accuracy in the fabrication of porous ceramic. Metrology science can be applied in order to create the good measurements system. Precision and accuracy can be deteriorated if mishandling occurs in the process. Proper technique is highly required in order to maintain the quality of overall product.

1.4 Scope of Project

Several scope and criteria has been studied and determined to make the project realistic and relevant to the topic discussed. They can fall into some categories. The scope in this project can be divided into 4 which are material usage, fabrication and process function, investigation purpose, and setting variables.

1) Materials Usage: The study in this project is limited to porcelain based ceramic product and excluding polymer, plastic, composite or metallic material. In order to control and product the porosity characteristics the usage of graphite is likened compared to other materials.
2) Fabrication and Process Functions: Porcelain powder and graphite powder will be mixed together by using tumbling process and be compressed into cylindrical shape. The sintering process will take on next and during sintering, the graphite will completely burned and leaves pores inside the ceramic.
3) Tools Utilization: Hereby, it is decided to use several tools that can facilitate to accomplish this project. In the project it is decided to use sieving machine, furnace or oven, and uniaxial compaction machine. Other machines used especially in determine the characteristics are SEM, and Vickers Hardness Test.
4) Investigation Purposes: The research is also only limited to investigate the correlation between the weight percentage of charcoal binder and the porosity behavior. It is also planned to investigate the properties, characterization and strength (hardness) of final product.
5) Setting Variables: It is also decided to facilitate the temperature variable to be constant at 1250°C when sintering. Numerous variables are also planned to be settled especially during experiment.

1.5 Project Significant

This project is very important since it show the methodology of the conventional fabrication of the porous ceramics. It also studies about porosity and permeability in ceramic materials especially porcelain based ceramic. During the project implementation a lot of knowledge and experience students can gain by either theoretical or practical activities.

1.6 Expected Result

Regarding to the objective, the expected outcome will be 8 sample of the porcelain ceramic pallet compacted in cylindrical shape by using uniaxial compaction technique. Each sample contains different characteristic of the porosity as the aim of the study is to control the porosity in ceramics. The first sample will be used as an indication which no charcoal will be added or 100% of composition will be pure porcelain powder (100wt% of porcelain). The nest 7 sample will be add charcoal as weight percentage in 1wt%, 2wt%, 3wt%, 4wt%, 5wt%, 6wt% and 7wt% in order. The size of porcelain pellet is approximately 40 mm in diameter and 5 mm in height.