

**UNIVERSITI TEKNOLOGI MARA**

**PERFORMANCE AND ANALYSIS OF  
CERAMIC SLIP ROTARY  
MOULDING FOR FINE BONE  
CHINA PRODUCT**

**NORAZNE BINTI NASIR**

Thesis submitted in fulfillment  
of the requirements for the degree of  
**Master of Science**  
**(Mechanical Engineering)**

**Faculty of Mechanical Engineering**

**May 2019**

## ABSTRACT

One of the methods to produce ceramic products is by using slip casting processes. However, the process produces waste from the excess slip and takes a long time to complete the process. Alternatively, a new process is being established by combining the traditional slip casting technique and existing polymer rotary moulding concept called Ceramic Slip Rotary Moulding (CSRM). The CSRM machine was developed to control the parameters such as temperature (heating and cooling), time and speed. The CSRM machine is suitable in producing hollow ceramic products especially for ceramic materials such as fine bone china (FBC). FBC is a soft material used for tableware and art ware products due to its brightness and high strength. This research focuses on formulation of ceramic slip for CSRM and preparation of five different particle sizes of FBC measurements (106  $\mu\text{m}$ , 125  $\mu\text{m}$ , 212  $\mu\text{m}$ , 250  $\mu\text{m}$  and 300  $\mu\text{m}$ ) to produce FBC product by using CSRM machine. Different particle sizes of the FBC materials were tested and analysed to produce FBC product by controlling the temperature, speed, time and also the weight of the slip to get the best quality of product. The parameters obtained will become the guideline for the overall process and test to produce the best hollow FBC product. Overall process analyses have been established where the temperature was controlled at 90°C and the speed at 14 rpm. The formulation was successfully produced for the CSRM with solid content of 80% and sufficient green strength achieved was at 1.63 N/mm<sup>2</sup>; was able to hold the green body during demoulding and ready for sintering process. Using the new slip formulation of FBC for CSRM process and established process parameters, good quality of FBC hollow product was produced with an average wall thickness of 4mm.

## ACKNOWLEDGEMENT

Firstly, I would like to acknowledge and thank my supervisor Assoc. Prof. Dr. Nor Hayati Saad for all her support throughout my MSc studies. I have been honoured to work under such a dedicated and excellent supervisor who always appreciated and provided positive feedback for improvement of my thesis. Thank you very much for all her guidance, discussions, words of encouragement and the time she spent editing and commenting on the draft copies. Thank you also for all her quick replies even with busy schedule. The time she spent with me is very much appreciated.

Sincere thanks to Assoc. Prof. Ir. Dr. Bulan Abdullah my second supervisor who always gave me excellent support, guiding me to find the right direction in both my studies and career. Thank you also to En. Abdul Rahim Mahamad Sahab from SIRIM BERHAD for helping me throughout my studies. All his help is very much appreciated.

I specially thank Norrul Hafizan Ab Wahab for helping me in the lab. I thank all the technicians and staff Fakulti Kejuruteraan Mekanikal for their support throughout my studies.

Last but not least thank you to all my family and lovely parent Nasir Bin Jusoh [REDACTED] [REDACTED] for the prayer and determination to educate me.

Finally, I thank my husband Mohammad Faezeen Bin Mad Nordin for his support, love and never-ending encouragement throughout my studies. Thank you for giving me this wonderful opportunity to study at UiTM SHAH ALAM - without him it would not have been possible for me to reach up to current achievement.

# TABLE OF CONTENTS

	<b>Page</b>
<b>CONFIRMATION BY PANEL OF EXAMINERS</b>	<b>ii</b>
<b>AUTHOR'S DECLARATION</b>	<b>iii</b>
<b>ABSTRACT</b>	<b>iv</b>
<b>ACKNOWLEDGEMENT</b>	<b>v</b>
<b>TABLE OF CONTENTS</b>	<b>vi</b>
<b>LIST OF TABLES</b>	<b>xi</b>
<b>LIST OF FIGURES</b>	<b>xiii</b>
<b>LIST OF PLATES</b>	<b>xv</b>
<b>LIST OF SYMBOLS</b>	<b>xvii</b>
<b>LIST OF ABBREVIATIONS</b>	<b>xviii</b>
<b>LIST OF NOMENCLATURE</b>	<b>xix</b>
<b>CHAPTER ONE: INTRODUCTION</b>	<b>1</b>
1.1 Background of Study	1
1.2 Problem Statement	2
1.3 Objectives	2
1.4 Scope of Research	3
1.4.1 Material parameter	3
1.4.2 Coagulant, dispersant and binder	3
1.4.3 Process parameter	3
1.5 Significance of Study	4
1.6 Outlines of the Research	4

<b>CHAPTER TWO: LITERATURE REVIEW</b>	<b>5</b>
2.1 Overview of Ceramics	5
2.2 Introduction of Ceramics	6
2.2.1 Processing of Ceramics	7
2.2.2 Traditional Ceramics	7
2.3 Fine Bone China	9
2.3.1 History of fine bone china	9
2.3.2 Comparison between fine bone china and other ceramics	10
2.4 Rotational Moulding	10
2.4.1 Types of rotational moulding machine	10
2.4.1.1 <i>Rock-and-roll Machine</i>	11
2.4.1.2 <i>Clamshell Machine</i>	12
2.4.1.3 <i>Vertical Machine</i>	12
2.4.1.4 <i>Shuttle Machine</i>	13
2.4.1.5 <i>Fixed-Arm Carousel Machine</i>	14
2.4.1.6 <i>Electrically Heated Machine</i>	14
2.5 Advantages and Disadvantages of Plastic Rotational Moulding	15
2.6 Applications	16
2.6.1 Rotational moulding process of plastic	16
2.6.2 Ceramic Slip Rotational Moulding (CSRM) process of ceramic	17
2.7 Ceramic Slip Rotary Moulding (CSRM) Process	17
2.8 Glazing and decorating process	19
2.8.1 Glazing	19
2.8.2 Decoration Process	20
<b>CHAPTER THREE: METHODOLOGY</b>	<b>22</b>
3.1 Flow chart of overall process for FBC product using CSRM machine	23
3.2 Powder Preparation of FBC	25
3.2.1 Process of fine bone china	25
3.2.2 Raw Material of Fine Bone China	26
3.2.3 Drying process	27
3.2.4 Crushing process	27
3.2.5 Sieving process	28