COMPARISON BETWEEN TRADITIONAL AND SLIP CASTING MAMBONG POTTERY

by

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DECLARATION

I declare that this thesis entitled "Comparison Between Traditional and Slip Casting Mambong Pottery"is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

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Date : _____

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PERBANDINGAN ANTARA TEMBIKAR MAMBONG TRADISIONAL DAN TEMBIKAR MAMBONG TUANGAN SLIP

ABSTRAK

Terdapat pelbagai jenis tembikar Melayu tradisional antaranya Labu Sayong, Buyung dan Terenang. Salah satu dari tembikar itu ialah tembikar daripada Kelantan iaitu tembikar Mambong. Tembikar ini kurang dikenali terutama bagi penduduk di luar negeri Kelantan. Kajian ini sangat penting untuk dijalankan supaya tembikar Mambong tidak hilang dan kekal untuk generasi seterusnya. Objektif kajian ini ada untuk membandingkan produk tempatan iaitu tembikar Mambong tradisional dan produk teknologi iaitu tembikar Mambong tuangan slip. Seterusnya, mencirikan ketumpatan, kekuatan, ciri fizikal, pengecutan dan fasa bagi setiap sampel. Tembikar Mambong tradisional dibeli dari pembuat tembikar daripada Kampung Mambong dan tembikar Mambong tuangan slip dibuat daripada teknik tuangan slip. XRD digunakan untuk mengenal pasti perbezaan fasa antara tanah liat Mambong mental dan tanah liat Mambong yang dibakar juga antara tembikar Mambong tradisional dan tembikar Mambong tuangan slip. Ketumpatan sampel di ukur menggunakan Prinsip Archimedes. MOR digunakan untuk mengukur kekuatan sample sebelum retak. Dalam kajian ini, fasa tanah liat Mambong mentah dan yang telah dibakar menunjukkan sedikit perubahan tetapi untuk tembikar Mambong tradisional dan tembikar Mambong tuangan slip menunjukkan perubahan yang sangat besr dalam corak XRD. Ketumpatan tinggi untuk tembikar Mambong tradisional berbanding tembikar Mambong tuangan slip. Warna tembikar Mambong berubah dari coklat ke merah-coklat selepas proses pembakaran kerana kehadiran zat besi. Pengecutan kering dan pengecutan pembakaran tembikar Mambong tradisional adalah lebih tinggi daripada tembikar Mambong tuangan slip. Tembikar Mambong tuangan slip mempunyai kekuatan yang lebih tinggi berbanding tembikar Mambong tradisional. Kesimpulannya, dengan menggunakan kaedah tuangan slip, ketumpatan, kekuatan, ciri fizikal, pengecutan dan fasa untuk tembikar Mambong dapat ditingkatkan.

COMPARISON BETWEEN TRADITIONAL AND SLIP CASTING MAMBONG POTTERY

ABSTRACT

There are various examples off traditional Malay pottery such as Labu Sayong, Buyung and Terenang. Other than those potteries, there are one more pottery which is Kelantan traditional pottery that is Mambong. This pottery is less popular by other people especially outside Kelantan. It is important to carry on this research so that the Mambong pottery will not disappear and to ensure that it is sustained for nest generation. The objectives of this research is to compare between local product which is traditional Mambong pottery and technology product which is slip casted Mambong pottery. Then to characterize their density, strength, physical appearance, shrinkage and phase. Traditional Mambong pottery has been brought from the potter at Mambnog village and slip casted Mambong pottery is made by using slip casting method. X-ray diffraction (XRD) is used to identify the difference phase between raw Mambong clay and fired Mambong clay also for traditional Mambong pottery and slip casted Mambong pottery. Density of sample is measured by using Archimedes Principle. Modulus of rupture (MOR) is used to measure a specimen's strength before it ruptures. In this review, phases of the raw and fired Mambong clay shows a bit changes but for traditional Mambong pottery and slip casted Mambong pottery shows a very huge changes in XRD pattern. Due to the presence of iron in clay, the colour of Mambong pottery changes from brown to reddish-brown after firing process. The dry shrinkage and fired shrinkage for traditional Mambong pottery is higher than the slip casted Mambong pottery. Slip casted Mambong pottery has higher strength compared to traditional Mambong pottery. In conclusion, by using slip casting technique, density, strength, physical appearance, shrinkage and phase of Mambong pottery can be improved.

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVATION

MOR – Modulus of Rupture
XRD – X-ray Diffraction
XRF – X-ray Florescence
POP – *Plaster of Paris*

LIST OF SYMBOL

Al_2O_3 - Aluminium oxide
SiO_2 - Silicon oxide
SiC - Silicon carbide
Si_3N_4 - Silicon nitride
K_2O -Kalium oxide
P_2O_5 - Phosphorus oxide
Fe_2O_3 - Iron oxide
TiO_2 - Titanium oxide
MgO - Magnesium oxide
CaO - Calcium oxide
Si - Silicon
Al - Aluminium
Fe - Iron
Ti - Titanium
Ca - Calcium
% - Percentage
° - Degree

CHAPTER 1

INTRODUCTION

1.1 Background of study

Labu Sayong, Belanga, Buyung and Terenang are the examples of traditional Malay pottery. The most popular pottery in Kuala Kangsar, Perak is Labu Sayong. The shape of Labu Sayong is inspired by gourd and pumpkin used for store water. Water that been stored in the gourd will cooling naturally. Belanga is normally used to cook curries and it has round base and wide rim shape. Buyung can be identified by a bulbous body and straight neck. Buyung functions as a water container. Round base of Buyung is believed to allow heat to be transferred more evenly. Terenang is popular in the state of Pahang and Terengganu. It has a concave neck and a convex-shape body that will help in carrying water. Most of the function of Malay pottery is to store water.

Other than four potteries that have been mention, there is one more pottery which is Mambong. This pottery is less known by other people especially outside Kelantan. Mambong is the Kelantan's traditional pottery. Mambong is the name of village that is located in Kampung Ulu Sungai Kelantan. Name of Mambong derived from the local Kelantan dialect word mambo (ng) (Said *et al*, 2011). Mambong pottery is handicraft based out of clay. Smoke container, round bottom water jar, squat water vessel, vessel with handles, earthenware pot and steam pot are the examples of the Mambong pottery pieces (Said *et al*, 2011). Mambong pieces are reddish brown because of high content of iron in the clay. Aluminium oxide, iron oxide, silica, calcium oxide, sodium oxide,

potassium oxide, phosphorus oxide and magnesium are the mineral materials present in the clay composition used by Kelantan potters (Said *et al*, 2011).

Mambong pottery is not fragile and can withstand high temperature that suitable for use as cooking container (Said *et al*, 2011). Clay will be 'porous' when low temperature of firing is implement on Mambong pottery. Porosity in Mambong pottery will make it ideal for cooling water. Production of Mambong pottery needs very high hand skills. Wooden stick, bamboo stick, paddle and anvil stones are the simple devices that implement into Mambong. Mambong potters combined two methods which are prewheel method and wheel method. To finish the product, Mambong potters use manual wheel.

Design and decoration of Mambong pottery is related to the nature such as mountain picture motifs, flowers, animals (birds and fish) and also include natural cosmos such as stars, sun and moon. Mambong pottery is unique and need to be preserved and recognized to ensure that this traditional handicraft is sustained for the next generation.

1.2 Problem statement

The focus of study for this research is Mambong pottery because there is no comprehensive studies and survey on the Mambong pottery. It is important to carry on this research so that the Mambong pottery will not disappear and to ensure that it is sustained for next generation.

There is limitation on the method that has been used by Mambong potters. There are many Mambong potters that still use traditional technique compared to modern technique. The reason why they still use traditional technique maybe because of they want to maintain the originality of the Mambong pottery. The amount of the pottery that can be produced was quite small. It is difficult to fulfill the customers demand.

The purpose of this research is to compare the traditional technique used by Mambong potters with the Mambong pottery that has been fabricated by using the modern approach (slip casting). The work will determine if there are any differences in term of density, phase, shrinkage, physical appearance and strength for both Mambong pottery.

1.3 Objectives

1) To compare between traditional and slip casting Mambong pottery.
2) To characterize their density, strength, physical appearance, shrinkage and phase.

1.4 Expected outcome

Through this study, there should be a varies of density, phase physical appearance, shrinkage and strength between traditional Mambong pottery with Mambong pottery that has been fabricated by using slip casting. By comparing this pottery, the researcher can know the advantages and limitation for traditional and slip casting technique to the Mambong pottery product.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, there are several topics that will be discussed for further understanding about the final year project. The first topic will explain about ceramic followed by traditional ceramic then clay. Next topic gives an overview about pottery. Then, another topic is about Mambong pottery. Overview about pottery forming process is mentioned in topic six. The last topic is about slip casting.

2.2 Ceramic

Ceramic are compounds between metallic and non-metallic elements (Callister & Rethwisch, 2011). Common ceramic materials include oxide (or alumina, Al_2O_3), silicon dioxide (or silica, SiO_2), silicon carbide (SiC), silicon nitride (Si_3N_4) and for traditional ceramic composed of clay minerals as well as cement and glass (Callister & Rethwisch, 2011). The term 'ceramic' derived from the Greek word *keramikos*, which means "burnt stuff" indicating that desirable properties of these materials are normally achieved through the high-temperature heat treatment process called firing (Callister & Rethwisch, 2011).

Ceramic artefacts contribute in historical understanding of the technology and culture of the people who lived long time ago. Ceramic obtained by firing clay was the first synthesis materials made by human hands with a certain ingenuity (Sciau & Goudeau, 2015).

Generally ceramic materials are divided into conventional ceramic and advanced ceramics. The conventional ceramics are growing at slow rate. The example for this ceramic is refractory materials. The market for advanced ceramic can be divided into three categories which are structural, electronic and coating (Rak, 2000). Fiberglass insulation, TV screens, coffee mugs, dinner place setting and decoration knickknacks are the examples of ceramic that can be found at home (Elizabeth, 2012).

Ceramics have exhibited extreme brittleness which is lack of ductility and are highly susceptible to fracture. The engineer has done some improvement to ceramic through resistance to fracture that suitable used for cookware, cutlery and also automobile engine part (Callister & Rethwisch, 2011).

2.3 Traditional Ceramic

Ceramic materials that are originated from common, naturally occurring raw materials such as clay minerals and quartz sand. Traditional ceramic object is nearly as old as the humankind (Mason, 2016). Abrasive, cement, glass and clay are the examples of traditional ceramic.

2.4 Clay

Raw materials that been used to produced pottery is clay. Element such as Si, Al, Fe, Ti, K and Ca are found in clays (Gani *et al*, 2015). Clay refers to a naturally occurring material composed primarily of fine-grained minerals, which is normally plastic at appropriate water contents and if it applied with high temperature which dried or fired it will be harden (Guggenheim & Martin, 1995).

The clay minerals play an important role in ceramic bodies where when water is added, they could become hydroplasticity. In addition, clays fuse or melts over a range temperature. A dense and strong ceramic piece may be produced during firing without complete melting such that the desired shape is maintained (Callister & Rethwisch, 2011).

The clay characteristics is not only determining by the percentages of elements in clays, but also effect the physical, mechanical and chemical properties of pottery. If the element like silica increases, it will arise the melting point, lower the fluidity and enhances the hardness and tensile strength. The green body can withstand to the sintering temperature and also increasing the hardness of the pottery if content of alumina is increase (Gani *et al*, 2015).

'Clays' is the name usually given to all or more or less compacted deposition rocks deriving from alterations of primary rocks, mostly contain clay mineral of micronic dimension and characterized by high plasticity (Hanuskova, 2012). Examples of clay product are brick, pipe, tile and craft which is pottery.

2.5 Pottery

Pottery is made by forming a clay into objects of a required shape and then will be heated at high temperature in a kiln to remove water inside the clay (Shuaib & Enoch, 2013). Pottery have been popular as an object related to community life. The discovery of artifacts of prehistoric pottery in the burial place can be proven that pottery as an object related to community life (Said *et al*, 2011).

Pottery is used as tool for Malay daily needs in the kitchen for cooking and storage of food and beverages. Water that been stored in the container pottery will become more cold and food is cooked in earthenware more delicious and distinctive flavor (Nor, 2015).

Labu Sayong, Belanga, Buyung and Terenang are some of the examples for traditional Malay pottery as shown in figure 2.1. Labu Sayung (earthen ware or gourd pitcher) is the pottery heritage from the Sayung area of Kuala Kangsar, Perak. This heritage has been keep alive and still being practiced traditionally by Malays in Kuala Kangsar over the year. The cradle of Labu Sayong start with the use of the labu or gourd as utensil function for collect and store water (Arifin, 2015). Sayong pottery was inspired by a gourd or pumpkin (Gani *et al*, 2015).

Figure 2.1: The Malay traditional pottery (Haron & Mutalib, 2013).

Labu sayong production are in Sayong and Pulau Tiga, Perak (Gani et al,2015). The most popular Labu Sayong is black colored pottery and make it more unique. The

black surface of Labu Sayong cause by the oxidation reaction of the paddy husks during firing process or reduction (Haron & Mutalib, 2013).

The largest state in Peninsular Malaysia is Pahang. Pahang is divided into nine districts. Among nine districts in Pahang, Jerantut is the only districts that produce pottery. Since the end of Mesolithic age, pottery has been existed in Pahang. The main production of clay forms is Terenang, clay pot (Belanga Tembeling), censer (bekas perasap) and large jar (tempayan) (Haron & Mutalib, 2013). Terenang has angular-shape with concave neck and a convex body that will helps to carry water.

Normally, belanga can be found in most of rural Malaysian homes. The belanga can be characterized by a round base and wide rim. Usually it been used to cook curries because the round base of belanga is believed will allows heat to be distributed more evenly.

Mambong pottery is the pottery handicraft known in Kelantan. Kelantan pottery is not as popular and great as other pottery but still has its own specialty (Haron & Mutalib, 2013).

2.6 Mambong Pottery

Kelantan is divided into ten provinces known as Tumpat, Pasir Mas, Kota Bahru, Bachok, Tanah Merah, Pasir Puteh, Machang, Kuala Krai, Gua Musang and Jeli. Kuala Krai is the location of Kelantan traditional pottery (Said *et al*, 2011). Mambong pottery is the pottery handicraft known in Kelantan. Around 1980's, the late Mohammad Ghazali Yusoff was pioneered and the person who introduce the pottery handicraft. He was the headman of Mukim Mambong, Batu Mengkebeng, Kuala Krai, Kelantan (Haron & Mutalib, 2013).

The location of Mambong village is in Kampung Ulu Sungai Kelantan. Figure 2.2 shows the map of Mambong village. Mambong pottery are handicraft based on clay. The name of Mambong is descended from the local Kelantan dialect word mambo (ng) (Said *et al*, 2011).

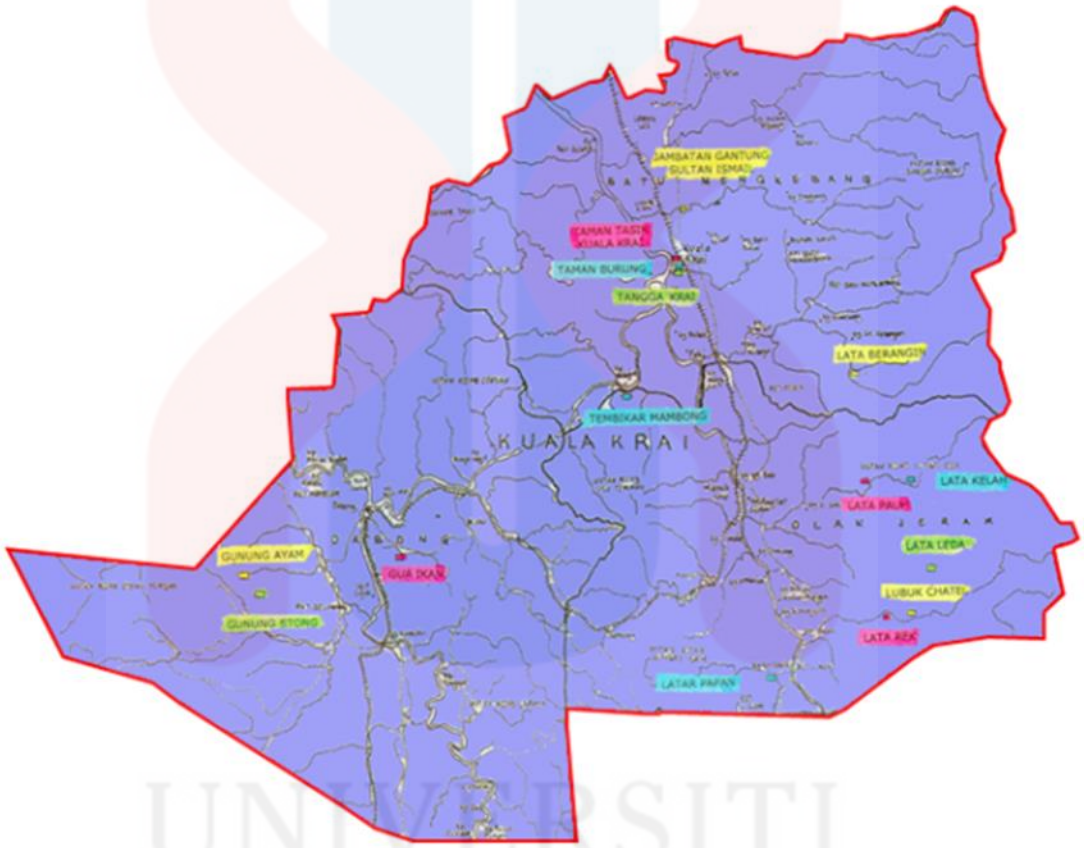

Figure 2.2: Map of Mambong village (Kelab pencinta sejarah Kelantan, 2012).

Figure 2.3 shows the example of Mambong pottery pieces which are a) water container, b) pot, c) smoke container and d) steam pot. Generally, the pot used for cooking is called periuk due to smaller size. Most of Mambong product are reddish brown because of the high content of iron in the clay. Aluminium oxide, iron oxide, silica, calcium oxide, sodium oxide, potassium oxide, phosphorus oxide and magnesium are the mineral materials that can be found in the clay composition used by Kelantan potters (Said et al, 2011).

a)  b) 

c)  d) 

Figure 2.3: Mambong pottery pieces (Said *et al*, 2011).

Appearance of Mambong pottery production has strong connection with natural environment such as mountain picture motifs, flowers, animal (bird and fish) and natural cosmos such as star, moon and sun (Said *et al*, 2011).

2.7 Pottery Forming Process

Traditional technique used by potters is coiling and pinching. It is the best method to produce the pottery such as Labu Sayong, Terenang and Mambong.

Other technique that can be used are Jolly-Jigger Machine and throwing machine. Throwing machine same function as plate used in traditional technique which is coiling and pitching. This machine is difficult to handle because it spins faster (Gani *et al*, 2015). One of traditional craft is the art of carving. The potteries that applied carving technique are Labu Sayong, Terenang and Mambong (Hamdzun, 2014).

Figure 2.4 show the molding process which are a) model of jolly jigger machine, b) model separate from mold pieces, c) slip poured inside the plaster of paris mold and d) semi-dried clay body inside the mold. The main item for production of traditional pottery is by using mold. This process is referring to production of Labu Sayong. The shape of Labu Sayong clay is produced using trimming method. During this process, several types of blade ware be used. Before mold making process started, the model will be left for a while to dry (Haron and Mutalib, 2013).

a)  b) 

c)  d) 

Figure 2.4: The molding process (Haron & Mutalib, 2013).

According to the Haron and Mutalib, clay preparation for Labu Sayong, Terenang and Mambong is nearly the same. Figure 2.5 shows the clay forming process that are a) thick clay coil placed inside a plate for pinching process, b) the outer surface made firmer using wooden spatula, c) the internal part is stretched out to form a convex belly for the clay pitcher, d) the head of the clay pitcher is formed and it was smoothed using wooden spatula, e) burnishing using river pebble and f) smoothing the internal part of Mambong using metal tool. The clay from river bed will be dried out after being taken. For production of clay for Labu Sayong, the grinded clay is sieved into a big pot. The sieving process is important in order to separate impurities such as sand and stone from clay.

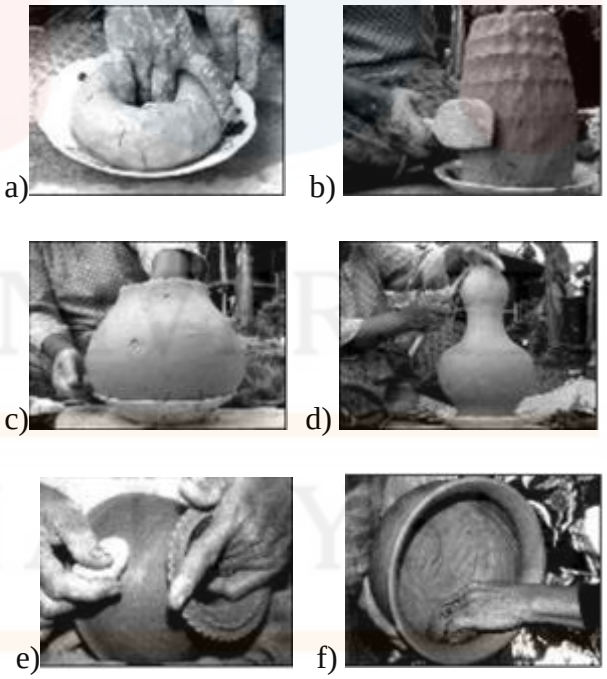

Figure 2.5: The clay forming process (Haron & Mutalib, 2013).

The figure 2.6 show the preparation of clay process starting with a) Clay is poured using traditional wooden mortar and pestle, b) pounding the clay using wooden hand pestle, c) ‘Melepa’ process and d) blending the slip using a plunger. Terenang production start with ‘melepa’. The clay slip will be poured onto a porous bat called ‘lepa’ because it easier for absorption of water from the clay. For Mmabong production, the fine sand taken from the river is added to the grinded clay before being pounded again in order to make it even finer.

Figure 2.6: The preparation of clay process (Haron & Mutalib, 2013).

Firing is important process for production of pottery. The figure 2.7 shows the firing technique process that are a) Firing in open trenches and b) gas kiln. Pottery body can be hardening through firing process. This firing of earthenware can be in open firing with no permanent structure such as bonfire and firing in a closed and permanent structure such as a kiln. Labu Sayong, Terenang and Mambong through the firing process in open trenches which a hole is made on the ground and lined with coconut tree leaves. Gas kiln is the best firing technique which are safer, cleaner and time saving (Gani et al, 2015).

a)  b) 

Figure 2.7: The firing technique process (Haron and Mutalib, 2013).

According to Haron and Mutalib, a process to decorate the pottery surface with motifs which creates pattern is one of important process for pottery production. The figure 2.8 shows the decorating process technique applied for pottery production which are a) pattern produce using wood stamp and b) cut out technique. Labu Sayong, Terenang and Mambong use stamping technique, incising and carving technique for decoration. Stamping technique is the technique where a small wooden block is used to stamp the leather-hard clay surface.

a)  b) 

Figure 2.8: The decorating technique process (Haron & Mutalib, 2013).

Other technique is incising. The motifs such as ‘tulang ikan’, pucuk rebung’ and ‘potong wajik’ can be produced by incising the clay surface by using sharp tool carving technique is not popular as stamping technique and incising. During the leather-hard stage and free-hand drawing technique, carving is done to produce flora motifs. The figure 2.9 shows the example of floral motif that can be used.

Figure 2.9: Example of floral motif (Said et al, 2011).

The aspect of design and pattern of the earliest pottery is starting thrived time to time. Striped line, zig-zag pattern, messy lines, round line and point are several examples for ancient pottery. The pattern of ancient pottery has similarity with the current Malay traditional pottery (Gani et al, 2015).

2.8 Slip Casting

Slip casting is the process of making pottery by using mold and slip (Gani N.A, 2015). Slip can be defined as a suspension of clay in water while casting is pouring lip into porous molds to form pottery.

The Chinese used biscuited clay molds before *plaster of Paris* (POP) been discovered for use in molding. '*Plaster of Paris'* name derived due to discovery of gypsum deposited as Montmartre in Paris (Wardell, 2007). The name of *plaster of Paris* is derived from a large sediment at Montmartre in Paris. Slip casting is very simple and inexpensive technique (Elizabeth, 2012).

The most common materials used for the production of porous molds for slip casting are gypsum, plaster or *plaster of Paris*. The figure 2.10 shows the picture of gypsum in powder form. These materials are used because it has characteristic of absorbing water into the porous plaster. Art, hardware and hobby stores are the places that can be found *plaster of Paris*. Gypsum can be re-forming when the *plaster of Paris* powder is being mixed with water (Elizabeth, 2012).

Figure 2.10: Gypsum in powder form (Elizabeth, 2012).

The mold will be fill by slip. Then it was leave it for about few minutes. The plaster wall is able to absorb the liquid to form the thickness of the clay pitcher body cause the slip to sink (Gani *et al*, 2015). 60% clay and 40% water is the ratio for producing slip (Haron & Mutalib, 2013). Figure 2.11 shows *plaster of Paris* when it been mix with the water.

Figure 2.11 Mixture of plaster and water (Elizabeth, 2012).

Compared to other conventional methods, this technique is inexpensive and time-efficient for casting complex parts. This technique is inexpensive since it can be found all over the earth and quite abundant in supply (Elizabeth, 2012).

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

Mambong pottery that has been brought from Mambong village and Mambong pottery that has been fabricated by using slip casting.

3.2 Methods

The raw material of Mambong pottery that has been brought from the potter at Mambong village and also fabricated Mambong pottery by using slip casting was crush into a small piece. The reason for crushing the sample in small pieces was to make further sample characterization easier.

3.2.1 Slip Casting

The figure 3.1 shows the steps of slip casting process starting from pouring clay in form of liquid into a mold. Water and sodium silicate were mixed together within 15 minutes. After that, added clay little by little in the mixture of water and sodium silicate to avoid the formation of clots. Mixed the mixture within two hours or until the clay homogeneous with water and produce slip. Leave the slip a day before being used. Mold was prepared by mixing water and plaster of paris with appropriate amount into desirable shape. The mold was filled with the slip or also known as liquid clay.

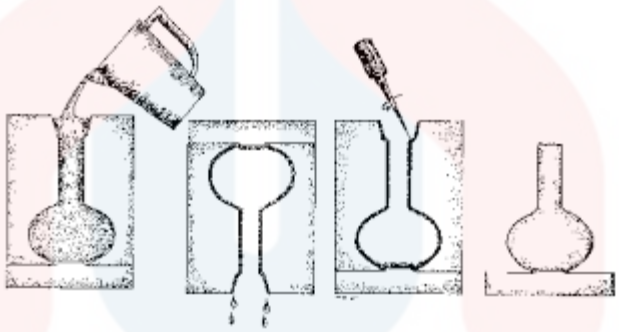

Figure 3.1: Slip Casting.

The composition of slip was 25% to 40% water and the rest amount was for clay. Mold absorbed the water from the slip because the mold has porous structure. The green body were dried and then removed it from the mold. The green body were undergoing further drying process before firing.

3.2.2 X-ray diffraction (XRD)

X-ray powder diffraction (XRD) is an analytical technique used for phase identification of a crystalline materials. The technique is based on Bragg's Law, which gives the position of possible peaks in the X-ray diffractogram after the x-rays have scattered against a crystalline material.

The X-ray diffraction angle is directed starting from 10° until 90°. The main purpose for conducting XRD analysis is to identify the elements/compounds present in the Mambong sample. In addition, the element and compound of each peak shown on the diffraction patterns were searched and verified by the analytical software.

3.2.3 Archimedes Principle

Archimedes' principle is a low of physic fundamental that relate to fluid mechanics. In Archimedes' principle, the buoyant force on a submerged object is equal to weight of the fluid that is displaced by the object.

The dry sample was weight and recorded as $M_{D.}$ Then the sample was place in the beaker that contain water in order to remove air bubble inside the sample by using vacuum pump. After all the air bubble be removed, sample was weight and recorded as $M_{W.}$ The sample was place inside the beaker that contain water and the weight was recorded as $M_{S.}$ The equation 3.1 shows the formula of Archimedes principle. This formula will be used in order to find the density of the ceramic sample. The equation 3.2 shows the formula for porosity.

$$\text{Bulk density (g/cm}^3\text{)} = \frac{M_D}{M_W - M_S} \times \text{density of water} \quad (3.1)$$

$$\text{Porosity} = \frac{M_W - M_D}{M_W - M_S} \times 100\% \quad (3.2)$$

M_D = mass of sample in dry before vacuum

M_S = mass of sample in water

M_W = mass of sample after vacuum

3.2.4 Modulus of Rupture

The maximum stress a rectangular test pieces of specific dimensions can be withstanding in a three point bending it breaks is the definition of Modulus of Rupture (MOR). Modulus of rupture is a measure of a specimen's strength before it ruptures. The modulus of rupture can be expressed in N/mm^2 or MPa.

The ceramic sample will be prepared according to;

Ceramic test piece dimensions:150 mm × 25 mm × 10 mm.

Modulus of rupture (MOR) are calculated according the equation 3.2;

$$MOR = \frac{3}{2} \times \frac{SL}{WR^2}, [kg/cm^2, N/mm^2 (MPa)] \quad (3.3)$$

S = stress at which the sample is broken.

L = sample length.

W = sample width.

R = sample thickness.

3.3 Research Flow Chart

The figure 3.2 shows the summarization of research that been written in a flow chart. Based on the flow chart, raw materials which is Mambong pottery are divide into two sample. First sample is traditional Mambong pottery that buy from Mambong village. The other sample is Mambong pottery that been fabricated by using slip casting. These two sample will be crush in small pieces. After that, cleaning process will be done by sung ultra-sonic. These two materials will be characterize based on their density, microstructure, phase and strength.

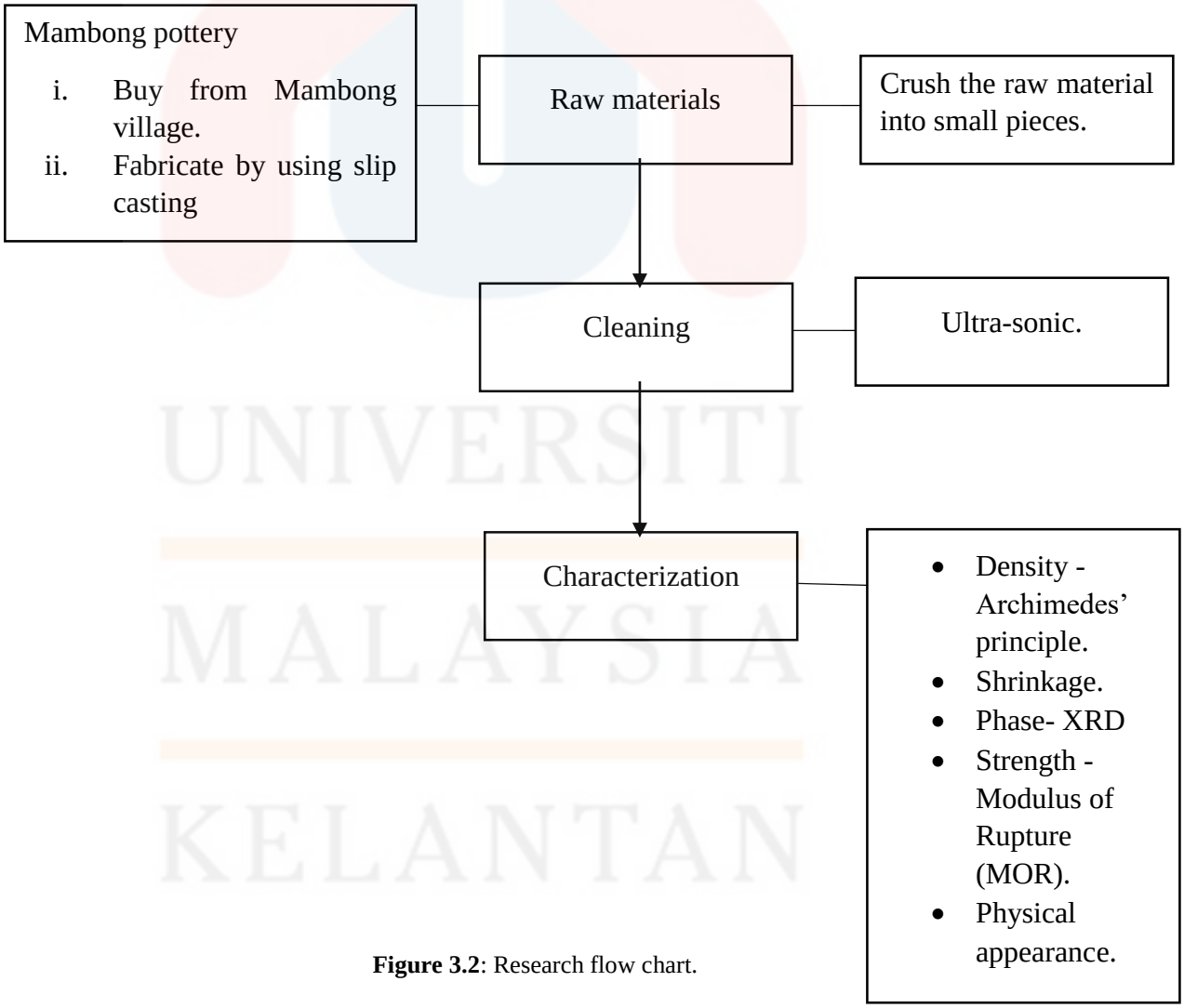

Figure 3.2: Research flow chart.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter consist of result analysis that was gained from the experimental work. This chapter will elaborate the difference of the traditional Mambong pottery with the Mambong pottery that was fabricated via slip casting. The result focus on phase identification by XRD, density by Archimedes principle, strength by Modulus of rupture (MOR), shrinkage and physical appearance for Mambong pottery.

4.2 XRD analysis

There were several study that have been done to identify the composition of clay in Malaysia. Usually XRD and XRF was used to identify the elemental composition of clay. Si, Al, Fe, Ti, K and Ca were the most element found in the clay. Several studied reported that they exist in form of oxide compound which were SiO_2, Al_2O_3, Fe_2O_3, TiO_2, MgO, CaO, K_2O and P_2O_5 (Gani *et al*, 2015).

Figure 4.1 show the XRD pattern of traditional Mambong pottery that was obtained from XRD analysis. The highest intensity peak of the sample for raw and fired Mambong clay powder show the quite similar value but the weaker peak shows a bit changes. A further analysis need to be carried out to observe what reaction has been occurred when the Mambong clay was fired. The sample shows that the peak that closely matched with standard pattern. Miller Indices of the peak were $(0\bar{1}0)$.

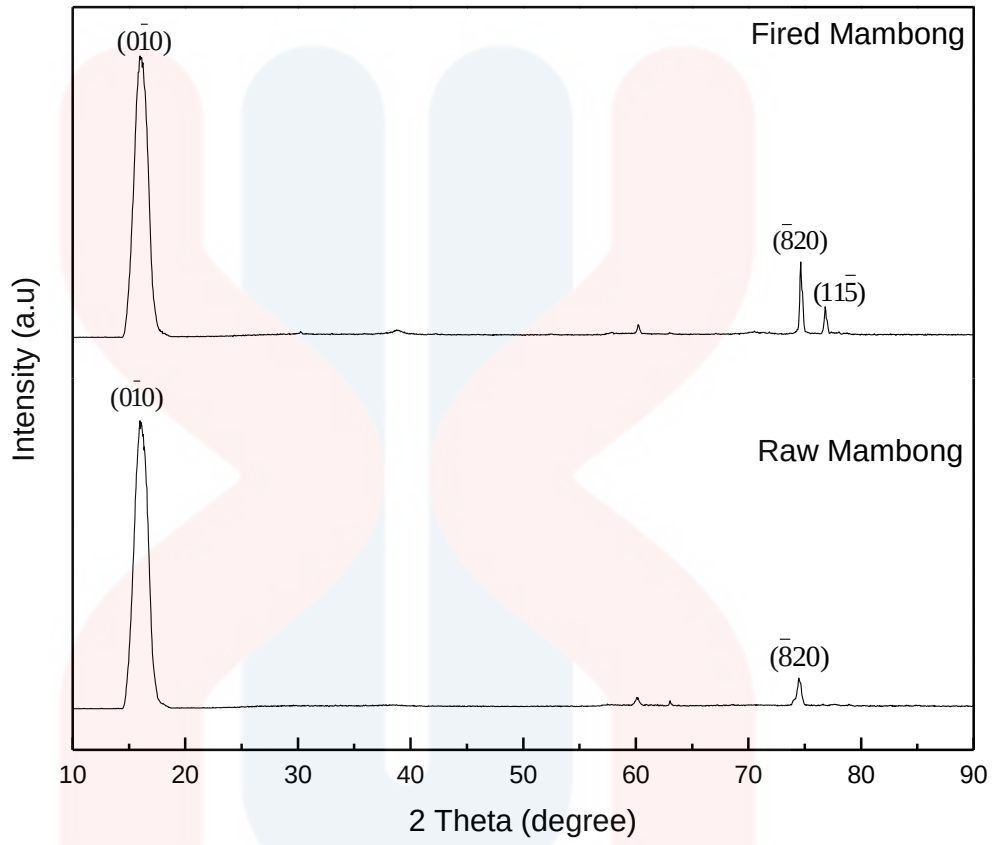

Figure 4.1: XRD phase for raw Mambong clay and fired Mambong clay.

Figure 4.2 shows the XRD pattern for traditional Mambong pottery and Mambong pottery that was fabricated via slip casting after firing process. The fired traditional Mambong and slip casted Mambong pottery shows dissimilar pattern. A very huge changes has been detected, but it need further analysis on XRD to conclude what was real happened to both of the sample. Both of them should show the same XRD trend, but the peak was totally different.

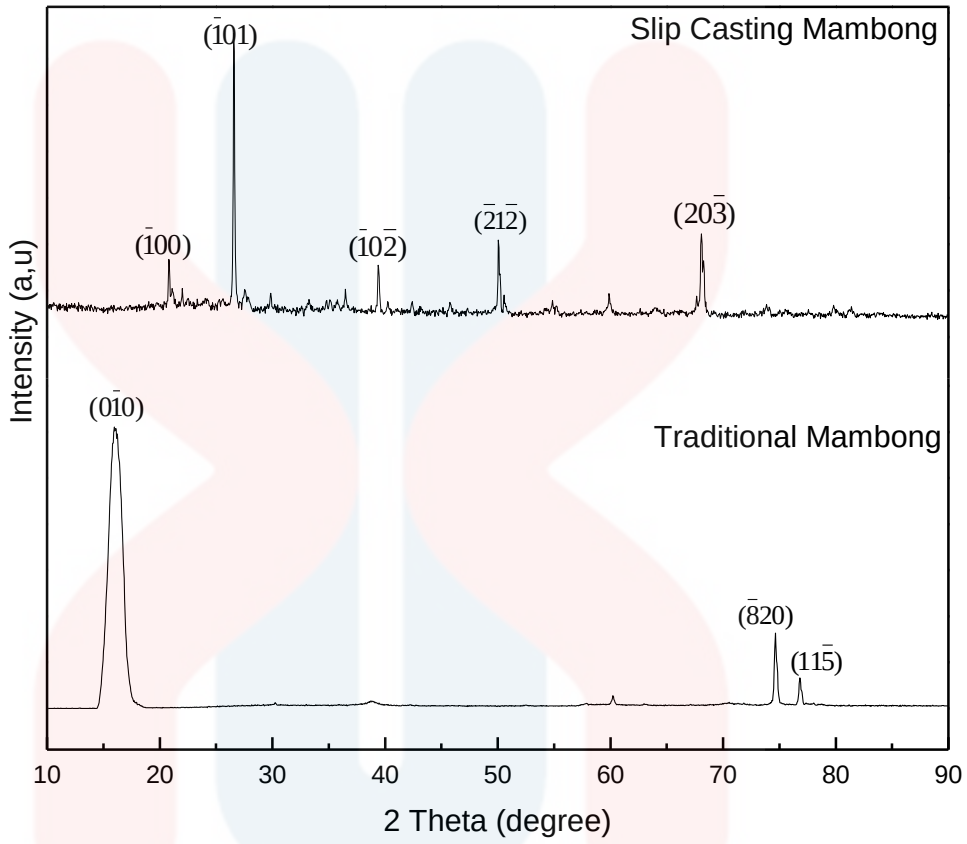

Figure 4.2: XRD phase for traditional Mambong pottery and Mambong pottery that was fabricated via slip casting.

4.3 Density

Figure 4.1 shows the comparison of density between traditional Mambong pottery and the Mambong pottery that was fabricated via slip casting. There were three samples for each traditional Mambong pottery and the Mambong pottery that was fabricated via slip casting for density measurement.

Density was calculated by using this equation, density (g/cm^3) = $\frac{M_D}{M_W - M_S}$ × density of water.

Based on the figure, traditional Mambong pottery show the higher value of density compared to slip casting Mambong pottery. The average value of density for traditional Mambong pottery was 1.763 g/cm^3, while the average value of density for Mambong pottery that was fabricated via slip casting was 1.461 g/cm^3.

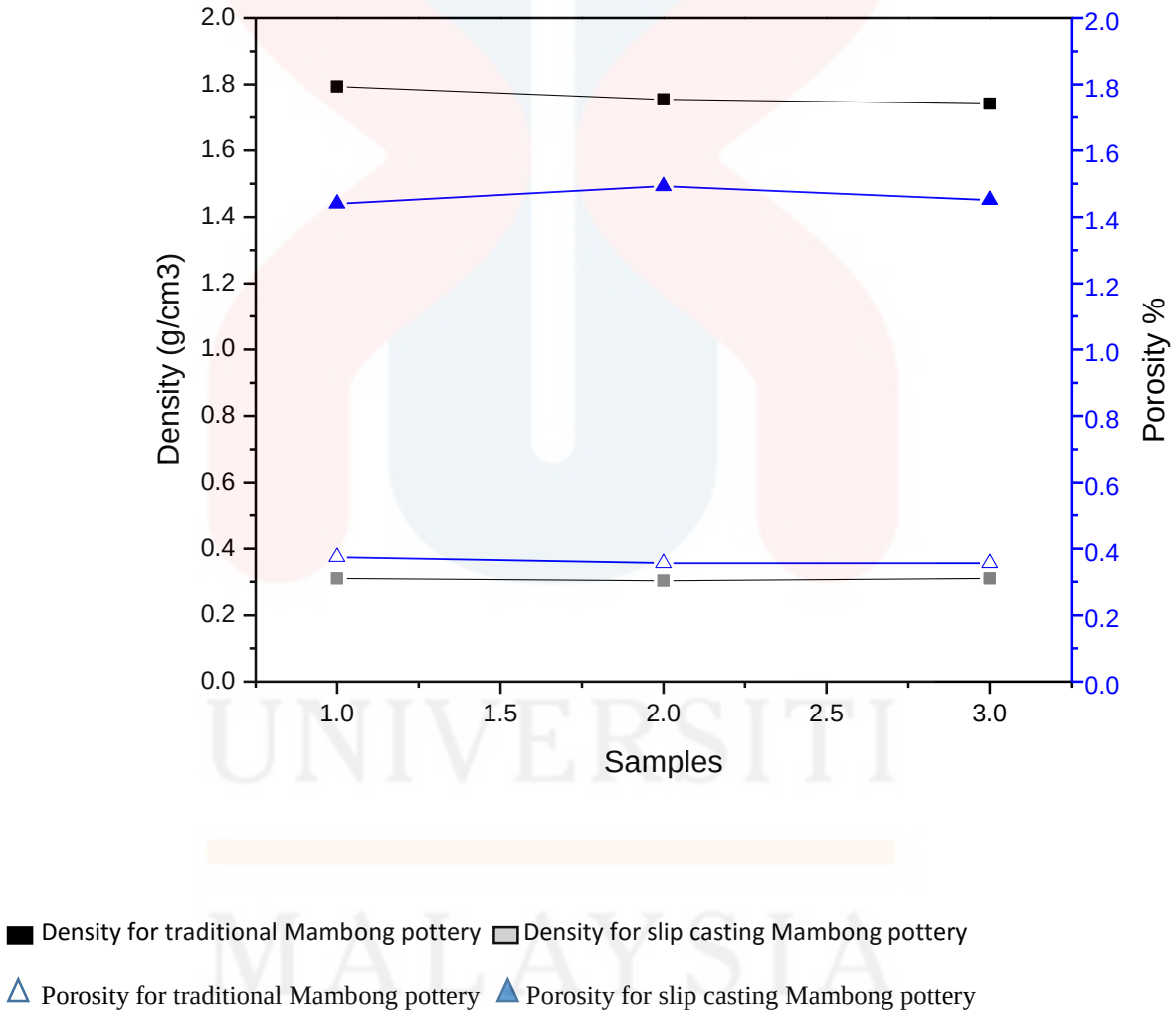

Figure 4.3: The density and porosity result for traditional and slip casted Mambong pottery.

The particle size of traditional Mambong pottery was not controlled by Mambong potter. Raw clay was grinded by using traditional mortar and pestle after drying process. The grinded clay then was sieved to remove impurities and become clay powder (Gani *et al*, 2015).

Meanwhile, particle size for Mambong pottery that was fabricated via slip casting were controlled. Dry raw clay was grind by using grinder machine in order to gain fine grain clay powder. Then the clay powder be sieved with 450 micronmeter siever. Particle distribution for traditional Mambong pottery were not homogeneous compared to Mambong pottery that was fabricated via slip casting.

Theoretically, the density for slip casted pottery should be higher than the traditional casted pottery. It was due to better distribution and more homogenous grain particle size for the slip casted pottery. But in this research, the opposite result was obtained. It might due to the errors while handling the experiment.

Porosity was calculated by using this equation, Porosity = $\frac{M_W - M_D}{M_W - M_S} \times 100\%$.

Porosity for traditional Mambong pottery were lower than Mambong pottery that was fabricated via slip casting with 30.8% and 36.2% respectively. Mambong pottery showed close average porosity with the prehistoric pottery samples found from Bukit Tengku Lembu, Gua Batu Tukang, Gua Cha and Gua Kecil that average between 30% and 35% (Stephen, 1997).

4.3 Physical appearance

Figure 4.4 (a-c) shows the colour of Mambong clay before and after firing process. The colour of Mambong clay before firing process was brown. After firing process, the colour of Mambong clay change from brown to reddish-brown for both traditional Mambong clay and fabricated Mambong clay via slip casting. Most of Mambong product were reddish-brown colour because of the content of iron in the clay (Said *et al*,2011). But, the colour does not reflect the amount of iron present besides being the colouring agent of the clay (Gani *et al*,2015).

(a) (b)

(c)

Figure 4.4: Colour of Mambong clay powder. a) before firing process, b) after firing process for traditional Mambong pottery and c) after firing process for Mambong pottery that was fabricated via slip casting.

Figure 4.5 shows the sample for traditional Mambong pottery and figure 4.6 shows the sample for Mambong pottery that was fabricated via slip casting. Both sample shows the difference in shape. Based on the figure, surface of sample for traditional Mambong pottery was more rough compare to sample for Mambong pottery that was fabricated via slip casting which was smooth. The appearance shape for slip casted Mambong pottery was more beauty compare to sample for traditional Mambong pottery. It might due to the making process for the samples. Traditional Mambong pottery was make by hand using coiling and pinching technique while sample for slip casted Mambong pottery was make using mold.

Figure 4.5: Sample for traditional Mambong pottery.

Figure 4.6: Sample for Mambong pottery that was fabricated via slip casting.

4.3 Shrinkage

Table 4.1 shows the dry shrinkage and fired shrinkage result for traditional Mambong pottery and Mambong pottery that was fabricated via slip casting. Based on the table, traditional Mambong pottery shows the higher percentage of dry shrinkage which was 9.76 % compared to Mambong pottery that was fabricated via slip casting which was 5.72 %. Based on the table too, traditional Mambong pottery also shows the higher percentage of fired shrinkage which was 1 % compared to Mambong pottery that was fabricated via slip casting which was 0.58 %.

The shrinkage was calculated by using this equation, % shrinkage = $\frac{L_0 - L_1}{L_0} \times 100$

Previous research show that drying shrinkage for Labu Sayong was 6 % lower than traditional Mambong pottery but higher then Mambong pottery that was fabricated via slip casting (Oskar *et al,* 2015). Firing shrinkage for Labu Sayong was 10 % higher than traditional Mambong pottery and Mambong pottery that was fabricated via slip casting.

Table 4.1 Dry and fired shrinkage for traditional Mambong pottery and Mambong pottery that was fabricated via slip casting.

Samples	Dry shrinkage (%)	Fired shrinkage (%)
Traditional Mambong pottery	9.76	1
Slip casted Mambong pottery	5.72	0.58

4.4 Modulus of rupture (MOR)

Figure 4.7 show the comparison of modulus of rupture (MOR) for traditional Mambong pottery with Mambong pottery that was fabricated via slip casting. Based on the figure, slip casted Mambong pottery show higher modulus of rupture value which was 76.234 N/mm² while for traditional Mambong pottery was 43.776 N/mm². Mambong pottery that was fabricated via slip casting has higher value of strength because it can withstand longer until maximum stress before it breaks or rupture compare to the traditional Mambong pottery. Particle distribution for Mambong pottery that was fabricated via slip casting was homogenous compared to traditional Mambong pottery.

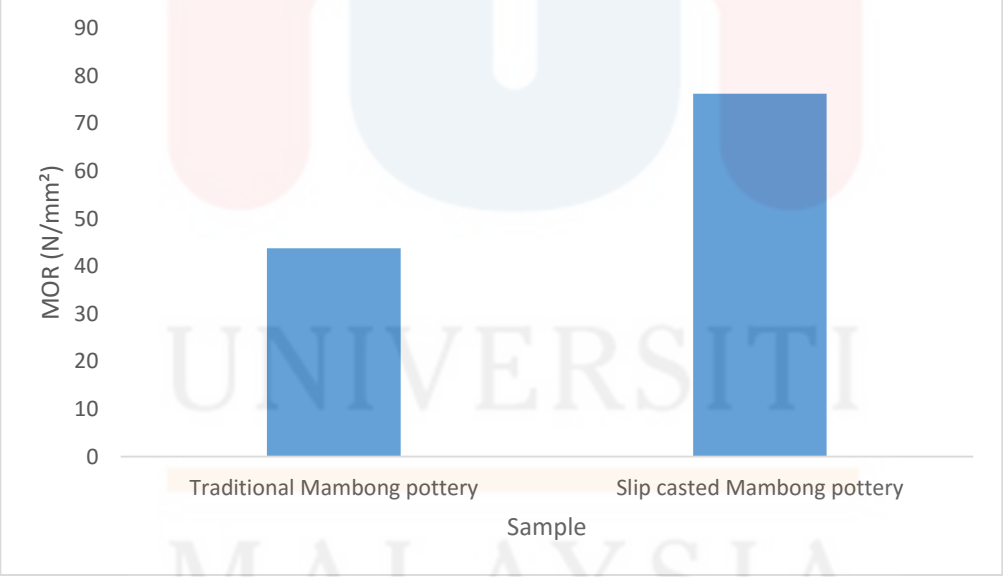

Figure 4.7: Modulus of rupture (MOR) for traditional Mambong pottery and Mambong pottery that was fabricated via slip casting.

CHAPTER 5

CONCLUSION AND SUGGESTIONS

5.1 Conclusion

Mambong pottery is one of the traditional pottery that can be found in Malaysia. It is comparable with other potteries. In the presence of slip casting techniques, it can help Mambong potter to increase the production of pottery manufacturing in the future compare with traditional method. No expensive equipment is required for slip casting technique. A wide variety of complex shapes can be produced by using slip casting methods and finish product have excellent properties because fine powder is most suited to sintering that could not be produced using traditional technique. Density, phase, physical appearance, strength and shrinkage of the Mambong pottery can be improved by using slip casting technique.

5.2 Suggestions

1) Based on the findings from this research, further research need to be done in order to prove the thesis in the future.
2) Improve the laboratory facilities that relate to the title of thesis so that students can use it to run the experiment.

REFERENCES

Ariffin, K. S. (2004). Silica. 1-7.

Arifin, A. (2015). Pottery-production Heritage of Kuala Kangsar. *Traditonal Malay Pottery of Kuala Kangsar : It History and Development*, 113-133.

Callister, W. D., & Rethwisch, D. G. (2011). Materials Science and Engineering. In W. D. Rethwisch, *Materials Science and Engineering* (pp. 6-7 ; 518-519). US: John Wiley & Son (Asia) Pte Ltd.

Doremus, J. F. (2008). structure, properties and processing. In J. F. Doremus, *ceramic and glass materials* (pp. 1-2). new york: springer.

Elizabeth. (2012). Ceramic Slip Casting.

Gani N.A, S. M. (2015). Chemical Composition of Clays for Pottery in Malaysia : A Review. *Journal of Tropical Resources and Sustainable Science*, 144-153.

Guggenheim, S., & Martin, R. T. (1995). Report Definition of Clay and Clay Mineral : Joint Report Of The Aipea Nomenclature Commities . 255-256.

Hamdzun Haron, N. A. (2014). Cut out Carving : An Innovation of Malay Heritage Design Pattern (Labu Sayong). 936-944.

Hanuskova, T. M. (2012). Natural Raw Materials in 'Traditional' Ceramic Manufacturing. *Journal of the University of Chemical Technology and Metallurgy*, 465-470.

Haron, H., & Mutalib, N. A. (2013). Technology and Production Process of Malay Traditional Heritage Pottery in Malaysia.

Mason, T. O. (2016). traditional Ceramic. 1-5.

Mazlan, M. A. (2014). Mambong pottery attracts tourists to Kuala Krai. *The Brunei Times*, 1-3.

Nor, S. M. (2015). Reka Bentuk dan Ragam Hias Tembikar Mambong : Satu Perbandingan Lama dan Baharu.

Said, T. S., Ramli, H., & Sedon, M. F. (2011). Local Genius of Mambong Pottery in Kelantan , Malaysia. *International Journal of Humanities and Social Science*, 147-155.

Sciau, P., & Goudeau, P. (2015). Ceramics in art and archaeology : a review of the materials science aspects.

Shuaib, A. A., & Enoch, O. F. (2013). The Art of Kelantan Traditional Pottery : The Limitations and Way The Art of Mass Production. *The proceedings of the 4th Social, Development and Environmental Studies International Conference 2013, UKM Bangi, Malaysia. 19 March 2013. ISBN 978-983-2795-25-4*, 1-10.

Wardell, S. (2007). *Slip Casting.* USA: University of Pennsylvania Press 3905Spruce Street Philadelphia, Pennsylvania 19104-4-4112.

Zak.S, R. (2000). Advanced Forming Techniques in Ceramics.

Zahar, I. (n.d.). Proposed Local Art Criticism's Model for traditional ceramic ; Mmabong pottery as case study.

APPENDICES

1) DENSITY

Bulk density (g/cm^3) = $\frac{M_D}{M_W - M_S}$ × density of water

M_D = mass of sample in before vacuum

M_S = mass of sample in water

M_W = mass of sample after vacuum

Traditional Mambong pottery.

Sample 1 = $\frac{0.638}{0.748-0.393}$ × 0.9982

=1.794 g/cm^3

Sample 2 = $\frac{0.979}{1.148-0.591}$ × 0.9982

=1.754 g/cm^3

Sample 3 = $\frac{0.940}{1.107-0.568}$ × 0.9982

= 1.741 g/cm^3

Sample	M_D (g)	M_W (g)	M_S (g)	Density (g/cm^3)
1	0.638	0.748	0.393	1.794
2	0.979	1.148	0.591	1.754
3	0.940	1.107	0.568	1.741

Slip casting Mambong pottery.

Sample 1 = $\frac{1.310}{1.650-0.742} \times 0.9982$

= 1.440 g/cm^3

Sample 2 = $\frac{0.927}{1.148-0.528} \times 0.9982$

= 1.492 g/cm^3

Sample 3 = $\frac{0.458}{0.570-0.255} \times 0.9982$

= 0.451 g/cm^3

Sample	M_D (g)	M_W (g)	M_S (g)	Density (g/cm^3)
1	1.310	1.650	0.742	1.440
2	0.927	1.148	0.528	1.492
3	0.458	0.570	0.255	1.451

2) Porosity

Porosity = $\frac{M_W - M_D}{M_W - M_S}$

Traditional Mambong pottery

Sample 1 = $\frac{0.748 - 0.638}{0.748 - 0.393}$

= $\frac{0.11}{0.355}$

= 0.310

Sample 2 = $\frac{1.148 - 0.979}{1.148 - 0.591}$

= $\frac{0.169}{0.557}$

= 0.303

Sample 3 = $\frac{1.107 - 0.940}{1.107 - 0.568}$

= $\frac{0.167}{0.539}$

= 0.310

Average porosity = $\frac{0.310 + 0.303 + 0.310}{3}$

= 0.308

Slip casting Mambong pottery

Sample 1= $\frac{1.650-1.310}{1.650-0.742}$

= $\frac{0.34}{0.908}$

= 0.374

Sample 2 = $\frac{1.148-0.927}{1.148-0.528}$

= $\frac{0.221}{0.62}$

= 0.356

Sample 3 = $\frac{0.570-0.458}{0.570-0.255}$

= $\frac{0.112}{0.315}$

= 0.356

Average porosity = $\frac{0.374+0.356+0.356}{3}$

= 0.362

3) Shrinkage

Traditional Mambong pottery

Sample	Before firing	After firing
1	135.67 mm	133.94 mm
2	135.63 mm	134.04 mm
Average	135.35 mm	133.99 mm

Slip casting Mambong pottery

Sample	Before firing	After firing
1	141.44 mm	140.86 mm
2	141.41 mm	140.36 mm
Average	141.425 mm	140.61 mm