# THE UTILIZATION OF LOCAL RAW MATERIALS FOR THE PRODUCTION OF MARBLED WARES USING THE JIGGER-JOLLEY TECHNIQUES.

BY

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## DECLARATION

I solemnly declare that this thesis is an original work of mine and that it has not been submitted anywhere else for the award of any degree. All references are duely acknowledged in "References."

Umar A.A. Sullayman.

CERTIFICATION

This Thesis entitled THE UTILIZATION OF LOCAL RAW MATERIALS FOR THE PRODUCTION OF MARBLED WARES USING THE JIGGER-JOLLEY TECHNIQUES, by Sullayman, Umar Adeika Adeiza, meets the regulations governing the award of the degree of Masters of Arts (Industrial Design) of Ahmadu Bello University, Zaria. It has this day, been approved for its contribution to knowledge and literary presentation.

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## DEDICATION

This thesis is dedicated to my father - Late Alhaji Sullayman A. Adeiza whose inspiration and commitment formed the bedrock of my sound education;but never lived long to see the fruits of his labour.

# ABSTRACT

Sulayman Umar Adeika Adeiza, The Utilization of Local Raw Materials for the production of Marbled weres using the Jigger-Jolley Techniques pagers 107 Tables: 13, Figures: 13, plates: 8 and Rerences: 26.

The problems of this study were centred on identification, beneficiation and utilization of local raw materials and colouring Oxides for the production of marbled wares using the digger-jolley techniques. It also focused attention on the design and production of models, templates and plaster moulds; as well as formulation of suitable bodies and colouring engobes.

The growing demand for ceramic Tablewares necessitates the use of machines for mass production and reproducibility of identical wares beyond the limits of throwing and slip casting. Moreso is man's continued quest for creative colour applications to evolve uniqueness in ceramic products.

Raw materials like kaolin, secondary clays Quartz, Wood Ash, etc were processed and used for

making stoneware and porclain bodies engobes and glazes. Also, models were made from which the templates were fabricated using mahogany wood. Oxides like Iron Oxide, Manganese, Cobalt and Chrome were used to colour a base slip for marbling effects. Also used were variously coloured clay bodies and plastic slip for body agate. Samples were fired to 1280°C in Oxidized Kerosene and Electric Kiln atmospheres.

The test samples provided successful results in terms of structural design and garbling tests conducted under transparent glazes. Sparkling colour effects were recorded from wares coated with water clear transparent glaze while mottled effects were recorded from wares bearing glaze II (partly transparent glaze)

On the basis of analysing data collected, the following findings were made:

plaster to water ratio of 130: 100 is ideal for making jigger-jolley moulds while such moulds made in parts can be joined together with 140:100 ratio respectively.

plaster turning on a Throwing Wheel has been found to produce suitable moulds for successful jigger-jolley production.

Buff-firing slip can be produced entirely from locally sourced raw materials without adding any imported material.

Seasoned Mahogany wood proved very suitable for taking cross-sectional impressions of clay models.

It is believed that this study will not only contribute to the body of knowledge in Industrial Ceramics but will serve the needs of Nigerian ceramic investors.

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## DEFINITION OF SPECIAL TERMS

1. Agate Ware - Earthenwares intended to imitate the agate stone by wedging tinted clays together so that the colours extend through the body (Hughes, 1977).

2. Automatic Spreader- A machine used in the prepation of clay slug into a flat circular bat before transfering it onto the mould for jiggering.

3. Ball-mill - A porcelain jar filled with flint pebbles and rotated with either a wet or dry charge of chemicals. It is used to blend and to grind glaze and body ingredients. (Grebanier, 1975).

4. Bat - A pancake of clay. (French, 1972).

5. Bentonite - A general term for a montmorillonite clay often added to body to improve its plasticity. (Pottery Crafts Catalogue, 1989).

DEFINITION OF SPECIAL TERMS (CONTINUED...)

| | | | |
|---|---|---|---|
| 6. | Bloating | - | Blistering effect of over-firing a clay body. (Hamilton, 1978). |
| 7. | Body | - | A combination of two or more different clays or often minerals to form the structure of Ceramic wares. (Hamilton,1978). |
| 8. | Calcining | - | Changing the physical properties of a material by heating it to red heat and allowing it to cool down before use. (Hamilton, 1978). |
| 9. | Case-mould (Master mould) | - | Positive mould made from block mould and from which working moulds can be produced. (French, 1972). |
| 10. | Chuck | - | Lathe attachment for holding pots during turning processes. (French, 1972). |
| 11. | Chum | - | See Chuck |
| 12. | Cottle | - | Retention wall, usually made of clay, cardboard or plastics for holding molten plaster in place |

DEFINITION OF TERMS (CONTINUED ...)

- until it is set enough to stand on its own.

13. Earthen Ware - Porous ceramic usually made from refined clays. Must be glazed to hold liquid. (Hamilton, 1978).

14. Engobe - A liquid clay or clays, sometimes with the addition of fluxes and non-plastics like feldspar, whiting flint. Besides its use in mould casting, it is most frequently employed as a thin coating over all or part of a ceramic body, either to provide a different coloured surface under a glaze, to cover up surface defects, to provide a suitable background for under glaze brushwork decoration, or to serve as a layer through which designs may be cut to the body. (Grebanier, 1975).

15. Felt Machine - Machine used for fettling the top rims of jiggered or jolleyed wares especially plates and flat wares. (Okwor, 1990).

DEFINITION OF TERMS (CONTINUED...)

16. Filter Cakes - Plastic and hard sheets of clay obtained by compressing slip clay in the Filter press, thereby driving out about 75-80% of water in the slip.(Okwor,1990).

17. Filter Press - A machine that forces water out of slip clay to produce plastic clay from the slip within a period of at most 24 hours. (Okwor, 1990).

18. Jiggering - A machine for shapping pottery or industrial method of producing pottery, by means of profiled tool at a fixed distance from the rotating surface of the plaster mould, shapping the convex side of the ware. It is mainly for flat wares. (Pottery Crafts Catalogue,1989).

19. Jolleying - A machine for shapping the inside with a profile rotating at a fixed distance with a hollowed plaster suitable for cups (Pottery Crafts Catalogue,1989).

DEFINITION OF TERMS (CONTINUED ...)

20. Lathe Turning - Principal method of plaster mould and model making (French, 1972).

21. Marbling - Surface ornament produced by working together coloured slips or enamels. (Hughes, 1977).

22. Oxidation - The method of firing a kiln with enough oxygen present in the kiln atmosphere to ensure the complete combustion of the fuel gases. Accordingly, the metals present in both the clay and the glaze remain or become oxides, giving the fired result the characteristic colouring of these in combination with the other oxides variously present in the composition. (Grebanier, 1975).

23. Porcelain - Vitreous and transluscent ware emitting a clear ringing note. (Ahuwan, 1990).

24. Profile - Chamfered metal plate of appropriate section used in jiggering and jolleying.(French,1972).

DEFINITION OF TERMS (CONTINUED ...)

25. Pug-mill - Machine used to prepare clay for making processes. It extrudes clay in form of pug-rolls. (French, 1972).

26. Template - See profile.

27. Sizing - Process of separating a mass of plaster from another through the application of liquid soap, greese, oil and slip clay on the surfaces at which separation is required. (Ibe, 1990).

28. Slug - Lump of plastic clay sliced by wire from the pug-roll. (French, 1972).

29. Stoneware - Impervious ceramic with much of the material undissolved but bound by a glassy matrix. (Hamilton, 1978).

30. Storage Ark - An underground tank containing a centrifugal set of blades for storing and mixing slip before it is pumped into the Filter press. (Okwor, 1990).

## DEFINITION OF TERMS (CONTINUED ...)

31. Wedging - Mixing or kneading of clay to produce a homogeneous mass. (Hamilton, 1978).

32. Wirler - A vertical lathe with heavy plaster wheelhead. (French, 1972).

33. Wheel Turning - Making and shapping of Jigger-jolley mould on the throwing wheel head.

## ABBREVIATIONS

| | |
|---|---|
| kg..... | Kilogramme (s) |
| mm ..... | Millimetre (s) |
| cm ..... | Centimetre (s) |
| in. ..... | Inch (es) |
| secs. ..... | Seconds |
| $^{o}C$ ..... | Degree Centigrade |
| r.p.m. ..... | Revolutions per Minute |
| eg. ..... | For Example |
| etc. ..... | Etcetera |

## CONVERSION TABLE

| | | | |
|---|---|---|---|
| 4 | litres | = | 1 gallon |
| 8 | pints | = | 1 gallon |
| 1 | litre | = | ¼ gallon |
| 1 | litre | = | 2 pints |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Introduction

There has been an increasing demand for ceramic wares for use in Nigeria and the West African Sub-region. This ever-growing demand necessitates the use of machineries not only to accelerate production processes but also to evolve mathematical accuracy and similarity in terms of shapes and designs, which might have been humanly impossible given the technology of throwing and slip casting techniques alone.

The use of pottery wares has been as old as man's civilisation. The earliest men used pottery items for cooking, storage of seeds, wine, water, etc. The production techniques look simple, ranging from pinching, coiling, slabbing to building; and the pots were made to serve a relatively few number of people in a more primitive setting.

Okoruwa (1986) observes that in both institutions of learning and local communities, traditional or studio ceramics are being produced appreciably today in Nigeria. While these efforts are commendable, the technique is painfully slow and

lacks the dynamism of current technological growth trends, which would have enhanced quality, self-sufficiency and export potentialities. The growing scope of ceramics in the modern world has extended into architectural, sanitary, electrical and even electronic spheres of application. This not withstanding, pottery has been further enhanced with the introduction of some more complex production and decoration techniques like slip casting, jigger-jolley, pressing, marbling, etc, all to satisfy the changing needs of man and the population trend.
It is then a misnomer for Nigerian ceramists to neglect these important aspects of ceramics only to continue with the traditional techniques which have long been in operation.

Early modern ceramic industries in Nigeria like Modern Ceramic Manufacturers, Umuahia, Richware Ceramic Manufacturers, Lagos and Research Institutes like A.B.U. Zaria and PRODA, Enugu employ Jigger-jolley technique. The number of such organisations are so few compared to those which use throwing. Simple decorative techniques like engraving, sgraffito, sprigging, etc, have been in use rather than the more tasking and creative, decoration like "marbling". Throwing and slip casting however, have their short comings. They are: inability of attaining repetitive designs that are dimensionally equal especially with throwing); too much of apparant porosity and high level of shrinkage in slip

cast wares and problem of linear geometry (thickness) associated with cast wares with varying casting times. These problems, among others which are associated with these techniques are either completely removed or reduced to the bearest minimum in wares made by Jigger-Jolley techniques.

Jigger-Jolley techniques are more suited for flat wares and simple dropping shapes like cylinders and cones. These wares fall within the category of highly consumable table wares like plates, bowls, cups, beakers, etc., whose demands are yet to be satisfied by the present low rate of production, coupled with its attendant high selling price, based especially on throwing technique.

Many willing Nigerians can not use ceramic containers because they do not have the purchasing power. The common man therefore, sees ceramic wares as elitist objects made to satisfy the demand of the well-to-do people. This belief is based on the price placed on the wares. The producer blames this on the hand-crafted labour intensiveness of the production techniques, a situation that Jigger-Jolley techniques stand to reverse. Moreso, marbling methods of decoration have very little recognition among the Nigerian Ceramists. This research tries to bring together and explore the possibilities in these

seemingly obscure or neglected areas of production and decoration. However, where practised at all, marbling has only been known with throwing techniques.

Though some few industries and research institutes give attention to the Jigger-Jolley techniques, it has been very unpopular in Nigeria. Such institutions are the Projects Development Institute (PRODA) Enugu, Modern Ceramic Industry, Umuahia; and Richware Ceramic Manufacturers, Lagos. But the Nigerian Educational Institutions have been appathetic about it.

Thus, the need to research into this area of study is not only timely but quite imperative to the development of ceramics in Nigeria. While the production techniques extols the possibilities of industrial production to specifications in terms of size, weight and volume, the designer's position of creativity and arousing the aesthetic sub-conscious of the viewer is maintained by the "marbling."

## 1.2 Statement of the Problem

The problem of this research is the exploration of Jigger-Jolley techniques in the production of marbled table wares.

The problems of the study that are of specific concern to the researcher are:

1. Devicing a suitable "marbled" body for Jigger-Jolley techniques, using Nigerian raw materials.
2. Making plaster moulds and templates suitable for Jigger-Jolley techniques of industrial ceramic production.
3. Operation of the machine for the actual processes of production thereby solving the problems associated with the production.
4. Making coloured engobes and exploration of their method of application on the bodyto obtain a marbled effect.

## 1.3 Purposes of the Study

The purposes of the study are:

1. To experiment and evolve a suitable body for the production of "marbled" wares using the Jigger-Jolley techniques.
2. To study the processes involved in making moulds and templates for Jiggering and Jolleying.

3. To produce sample marbled table wares using Jigger-Jolley machine.

4. To produce marbled effects on Jiggered or Jolleyed wares using coloured engobes.

## 1.4 Limitations

1. The vertical Jigger-Jolley machines suitable for table ware production have no provision for making horizontal deep grooves, curvatures or flutes necessary in table wares like tea pots, flower vases bottles and electrical porcelains. This is a serious limitation to this study.

2. The orthodox approach to material characterization, preparation and utilization also constituted a limitation to the study.

## 1.5 Delimitations

1. The study was delimited to flat wares like plates and bowls because of the scope of the equipment.

2. For lack of enough time and money, industrial visits were undertaken only to two industries. A greater number of such visits could have provided more information and technical know-how, thereby, providing the differences and similarities between one production unit and another.

3. The design aspect of production was studied rather than an intensive research into the geological explanation of the raw materials, or technical description of the working properties of machineries or equipment.

## 1.6 Basic Assumptions

The following basic assumptions were made:

1. That the raw materials obtained will be suitable for making 'marbled' table wares, using the Jigger-Jolley techniques.
2. That in the absence of all the required facilities or equipment in the Department, research work from the industries will be enough.
3. Prolonged firing may occur due to the malfunctioning of the Electric Kiln at the Department.

## 1.7 Significance of the Study

With man's development needing containers of identical shapes, designs and specific capacity for usage, it becomes imperative for industries involved to take cognisance of these specifications in their production. Okoruwa (1986) says that thirteen million Naira (₦13m) worth of white ware ceramics were imported into the country in 1978 and this was expected to be about one hundred million naira in 1985. However, there was an anticipation for a drop in the 1985 projection because of the Government's drive to cut down importation of goods and services.

Considering the ubiquity and abundance of ceramic raw materials in Nigeria, production maximization requiring less human labour is the altimate in the drive to properly harness these resources. The under utilization of these resources as predicated by the present low level of production through throwing, sculpting, slip casting can not bring about the much desired technological and economic independence or emancipation of the nation.

A number of attributes of Jigger-Jolley techniques are clear pointers to the fact that the future of the technological and economic growth of this nation lies with it. Among such factors that necessitate the use of Jigger-Jolley technique in ceramic production are:

1. Mass production and reproducibility of identical shapes.
2. Reduction in human labour.
3. Achievement of identical wall thickness.
4. Achievement of same (or near same) capacity of similar wares produced from similar moulds, and templates, provided that the templates are set at a specific point; etc.

While slip casting favourably compares with Jigger-Jolley as an industrial method, its short falls like the difficulty in obtaining uniform thickness of the wall, weight and capacity of the ware greatly reduces its reliability and acceptability in the contemporary world of mathematical exactitude. The relative speed of production and durability of plaster for less water absorption in Jigger-Jolley production further enhances its position among all other pottery making techniques - studio or industrial.

"Marbling" which is a creative method of decoration hitherto known with thrown studio pottery is further explored in this study to evolve a fusion of industrial and studio techniques, thereby exposing the potentialities inherent in the fusion of these techniques in Nigeria.

It is believed that an exploration of these techniques will not only add a new leaf to the quest for knowledge in Nigeria but will serve as a spring board for industrial development of ceramics in Nigeria in more technical areas like the high-tension jiggered porcelain insulators. It is also hoped that its technology, along with other productive sectors of the economy will lunch the nation into an industrialised vibrant economy.

It is hoped, too that this study may offer useful information to this university, any other institution of learning and of course, ceramic investors all over the nation on the production of marbled wares using the Jigger-Jolley techniques.

# CHAPTER TWO

## LITERATURE REVIEW

### 2.1 Introduction

Having carefully enumerated the background of Jigger-Jolley technique and "marbled" decoration and their comparative place in industrial ceramics, as well as conditions surrounding them in this study, this chapter deals with earlier research work conducted through the use of the techniques. It touches such areas like the technique of production using the Jigger-Jolley machine, materials, production processes, preparation of materials, composition of materials, moulds, batting, equipment, methods of marbled decoration and Agate ware.

### 2.2 The Technique

According to Singer and Singer (1963) there appears to be some confusion about the use of the words "Jigger", "Jolley", "Jiggering" and "Jolleying". It is proposed here that the two terms are used to differentiate shaping the concave or the convex surface on the mould. Thus, 'Jiggering' is the process of shaping an article on a convex plaster mould, i.e., the inside of a plate, while 'Jolleying' is the process of shaping an article in a concave

mould, i.e., the outside of a cup.

The flat wheel head used in throwing is removed and replaced by a mould holder. It usually has a central conical head known as 'Jigger head' or 'Jolley head'. In this case, the concave and convex surfaces of wares usually made with throwing technique by the pressing and pulling activities of the hand are carried out by both the plaster mould and the jiggering blade or template.

To ensure uniformity in the identity of the wares to be made, Singer and Singer, (Ibid) says that a number of identical moulds have to be made for each spindle.

2.2.1 Jiggering Technique

Kenny (1949) describes 'Jiggering' as a highly mechanical method of making table wares. In this process according to him, a lump of clay is placed on a convex plaster bat and turned while a template is held against it. The bat shapes the inside of a plate and the template cuts the outside. When bowls are jiggered, the bat is concave, forming the outside surface, while the template cuts the inside. He says that Jiggering is the most efficient method of making bowls and plates. Practically, all commercial dinner wares are manufactured this way.

French (1972) describes jiggering as the inside-out version of jolleying. Where in cup making the mould forms the outside of the pot and the profile the inside, in jiggering, the mould forms the top (or inside) and the profile forms the back and foot. Jiggering is principally used for making plates, saucers and shallow bowls.

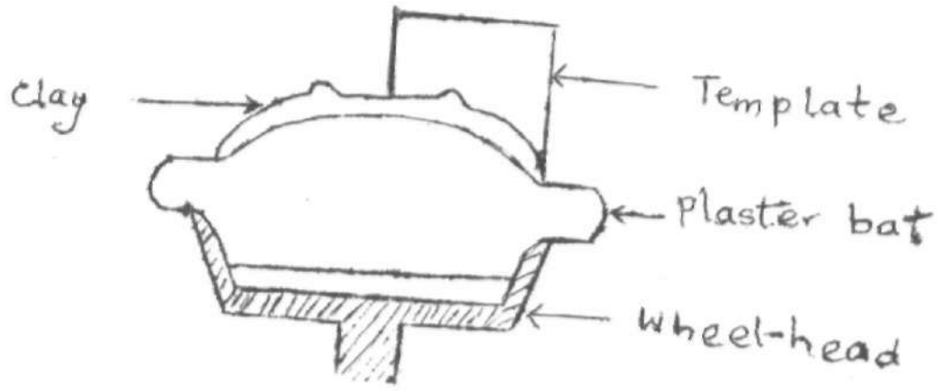
French (Ibid) contends that as with other forms of jolleying, there are two stages of operation. In the first, a slug of clay of the appropriate weight is placed on a revolving spreader and is slapped down on a plate mould. This is then fitted into the other wheel head and revolved. As with cup making, the maker presses the bat down onto the mould with his hand, starting at the centre. The profile is then brought down on the roughly shaped revolving plate to form the foot rim and the back of the plate. Again as in cup making, this profile has been set to give an exact thickness and weight of the plate.

An important weakness in this process is the transfer of the clay bat to the plate mould. If the bat meets the mould off centre the spiral stresses set up in the clay by bat making fight with the further strains induced by the profiling result in a twisted plate. Ideally the spiral stresses set up in producing firstly, the bat, and secondly, the plate, should have a common centre. This is sometimes achieved by introducing into the making

process a third wheel head where the bat is automatically centred on the mould by means of a plunger. One man working with a machine of this type will produce about 72 plates in an hour.

Hamer (1975) opines that Jiggering is a process of forming pots by using a spinning mould, usually of plaster, which gives the inside form. Jiggering is used for plates. The outside of the plate is formed by a metal profile which is fastened to a pivoted arm. This arm is brought down onto the mould and is so adjusted that it leaves the correct clay section.

Figure 2.1 Jiggering a Plate




Source: John Kenny (1949), page 125.

### 2.2.2 Jolleying Technique

Jolleying is done by forming the inner part of a pot with a profile while the outer part is shaped by a moving plaster mould.

Hamer (1975) describes Jolleying as forming a pot by using a spining mould usually of plaster, which shapes the outside of the pot. According to him, the fingers and then a metal profile is on a pivoted arm which brings it into action against the clay but is adjusted so that the correct section of clay is given. Jolleying is normally used for cups, deep bowls and fairly deep lids.

French (Ibid) describes Jolleying as a kind of modified throwing operation where a revolving plaster mould takes the place of the right or outside hand. By this description, the function of shaping a pot by the right hand from outside surface as is the case on throwing wheel, is taken over by the Jolley mould. The function of the left hand is taken over by the two hands in the first place, and secondly by the Jolley profile.

In his explanation on bowl making, Kenny (1949) affirms that bowls may also be jiggered. In this case, a different kind of bat and template are needed. He notes that if the bat makes the inside of the bowl, it would need to be so sharply convex that the

finished form will not lift off as it dried but would crack. For this reason, the jigger bat used in making bowls is 'concave', forming the outside of the bowl, while the template forms the inside of the bowl.

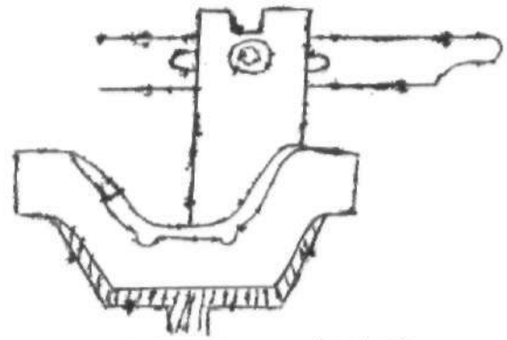
From Kenny's point of view the term jiggering can be used to describe jolleying as long as the template and the mould are suitable for making concave pots.

French (Ibid) states that 'cup making' also known as 'liners' are useful in jolleying process and that this is the straight foreward jolleying method used for small pots such as cups, and small bowls that taper from top to bottom thereby making withdrawal less difficult from one-piece mould. However, the tapering should not be more than that used to make the mould making possible; he cautions.

With this method, the producer or helper first throws on a wheel head a number of 'liners'. A liner is wroughly thrown cylinder of the same height as the finished cup. But it has a little more than half of the diameter of the finished pot. The liner is placed inside a cup mould while the mould is placed into a metal jolley head.

For the making processes, Kenny (Ibid) states that the clay is not flattened into a pancake (like in jiggering) but is rolled into a ball. The clay is pressed into the bottom of the jigger (jolley) but and

Figure 2.2 Jiggering a Bowl



Source: John Kenny (1949) page 126.

worked up the sides of the moulds with the fingers until a wrough bowl is made.

French (Ibid) believes that the use of a ball of clay directly without throwing a liner is more possible and successful when using a plastic clay. In this case, the ball is first pressed onto the bottom of the mould to ensure that the air trapped in the clay is driven out. The clay is now pulled side ways and upwards to make a wrough bowl. The method of throwing liners is important for making cups and bowls in bone China. He further explains that it is inconvenient and unnecessary to throw liners for bowls larger than 4" (10 cm) diameter. Such wares are made by making a flat bat of clay (as for jiggering plates), and then forced into a dome shape on a 'chum'.

Kenny (Ibid) remarks that the wrough bowl shape made from the ball of clay is moistened with the sponge. The jigger arm is lowered. The template now cuts the clay to a smooth inside surface.

Onuora (1990) in his studio at the Projects Development Institute, Enugu does not see the need for making liners. He neither makes a wrough bowl in the mould before jolleying. According to him, those stages are taken care of when he gently applies the profile to open up the clay. He then slightly moistens the clay and presses down the jolley arm to complete the shaping.

French (Ibid) further contends that it is difficult to get a crisp foot ring when using the jolleying method. This is so because the clay resists attempts to force it into sharp corners, especially with cups and bowls made this way. The usual method of making high or precisely shaped foot rings on jolleyed pieces is to place the leather hand pot on a chum of a lathe and turn the foot to shape. With this method, care should be taken to leave enough extra clay at the bottom of the ware to enable this turning. This technique has an advantage of giving foot shapes that could not normally be moulded.

### 2.2.3 Advantages of Jolleying

Jolleying is a relatively cheap way of making pots. According to French (Ibid) it is about half the price of slip casting on cups and similar pieces. It also has other advantages for the ceramic designer:

1. Wares made by this technique are in herently strong and have greater resistance to distortion than cast wares of the same design.
2. Complete control of the section is achieveable by the designer.
3. Strength can be built in where needed to avoid either distortion in firing or damage in use.
4. A perception of lightness can be created in serviceable pots by thinning the section towards the rim.
5. The strain-retaining furrows (hollows) or bad corners found in cast wares are easily avoided in jolleyed pieces. They are avoidable when planning the section for jolleyed pieces.

### 2.2.4 Semi and Automatic Techniques

Jiggering of table ware according to French (Ibid) can be made either by semi or fully automatic methods. It is important to obtain sufficient plasticity of the body. With these techniques,

skilled Jiggers are not needed and the speed of production per person is increased.

According to Singer and Singer (1963), such machines were first developed in the United States of America. He points out that there are three types of these machines:

1. Semi automatic machines,
2. Miller and (3) Fully automatic machines.

There are twin unit jiggers which have two spindles side by side and are operated by one unskilled operator. The two spindles are either used for shaping wares or have separate functions of jiggering and batting. The operator places the mould (already fed with clay) into a spindle. The machine is set into motion. The machine now performs the entire production processes. This includes the lubrication with water and trimming before stopping. The mould with the jiggered ware is removed and the entire operations are repeated.

French (Ibid) refers to all the automatic and semi automatic jiggering techniques as the "Roller methods', pointing out that the method has two important differences:

1. It has a heated revolving profile unlike in the manual jiggers that have stationary bevelled profiles. This revolving profile is some times

called 'bomb' and it forms the inside of the pot.
2. A slug (irregular ball of clay) rather than a thrown liner or bat can be placed in or on the mould and the Roller machine forms the shape conveniently. This cuts away a process, which if included could have elongated the production time on each ware. This advantage therefore, leads to automation, which the manual jiggers can not achieve, he says. Most of the roller machines in operation today are either fully or semi-automatic. Shapes that can be made by the manual jolleying methods are equally suitable for roller making, French, (Ibid) asserts.

Singer and Singer (Ibid) reports that while a batter out and hand jigger man can make some 20 dozens (240 pieces) of 7in. (18.5 cm) diameter plates in an hour, a single operator of a semi-automatic machine can make 23 dozens (276 pieces) of similar plates in an hour. The uniform treatment of wares by this machines also produces more strain-free wares. It can make 34 dozens (408 pieces) of cups per hour.

According to him, the second type of semi-automatic jigger has a slowly revolving table. It has three or more spindles distributed round the circumference. Each spindle has a profile-holder above it which moves round it. At a point in its

journey round with the table, the spindle stops for manual loading of clay and offloading of finished wares. Production, according to him, takes place as the spindle revolves while the profile comes onto it automatically. It sprays water at certain points and trims the ware. There are some machines with eight heads; he asserts, and can produce about 24 plates in a minute; i.e. about 1,440 pieces in an hour. On some of these machines, a different shape can be made on each head.

In the third type unlike in the second one, Singer and Singer, (Ibid) state that the jigger head and the stationary profile are reversed. A revolving table having 6 mould holders is loaded with fresh moulds containing balls of body. It is unloaded manually. It takes each mould to the single shaping head where it is raised gradually and the work is done on the ware by a revolving head holding three profiles in a hood. The head makes a speed of 700 r.p.m. as against the normal 250 r.p.m. of a normal spindle for similar wares. However, the ware makes approximately 2,100 revolutions under the profile per minute. The hood helps to remove excess clay and applies water as required by the production process. A plate is shappened between 4 - 6 seconds. The production rate is 540-600 pieces per hour. The wares tend to lift off the mould because they are subjected to a

centrifugal force. This is because jiggered plates are shaped on the outside of the mould. The three profiles rather than one in the normal situation, provide more pressure and speed on the ware, thereby giving less strain on the ware.

Singer and Singer (Ibid) talking on the Roller Machine report that a plate making machine differing considerably from the jigger has been recently introduced in Great Britain. It rolls the clay unto the mould. The Roller takes the role of the jigger profile. A big advantage with this technique is that a wad of clay can be fed into the mould directly without any batting. While smaller flat wares are easily produceable, larger wares with this technique are less successful. In his explanation on the scope of the Roller Machines, French (Ibid) asserts that they are very quick, very efficient, very sophisticated and are ideal for long runs of a particular item. They are also very expensive and inflexible.

## 2.3 Production

French, (1972) and Singer and Singer (1963) believe that the production technique depends largely on the type of machine being used. While the manual Jigger machines will require thrown liners and clay bats respectively for jiggering and jolleying, the automatic and semi-automatic jiggers do not need this procedure.

The type of wares being made greatly determines the scope or type of machine to use for the production. Singer and Singer (1963) state that undercut vessels have to be made with special tools of the vertical type on which the profile can be moved horizontally when it is down. The profile is applied to the body slowly. A certain amount of kneading has to be performed on it as in throwing. It presses the body down onto the mould and also scrapes and pushes away the surplus.

Speaking on horizontal movement of the tool, Waye (1967) says:

> "Jolleying is widely used in conjunction with turning, for making high tension insulators. The technique is basically the same as that used for domestic ware. Modifications are made for shaping particular types of insulators; for example, provision has to be made for horizontal movement of the tool, for example jolleying deep cavities with undercuts or tapers. Great care has to be taken to avoid introducing strains, which may give rise to local dielectric weakness as in the fired article."

He further states that for this reason stock is removed in small amounts at a time.

With these statements it is clear that jolleying can be employed not only for the making of table wares but for making high voltage insulators. The efficiency and the ability of the profile to move on a horizontal axis is very important in this case. The horizontal movement enables the profile to remove unwanted clay from the sides, rather than the normal process of doing so from the top. This creates grooves at the desired points of the insulators.

Aftershaping in the manual jiggers, the article is removed, first by raising the profile, then the spindle is stopped. The process is entirely different in the automatic and semi automatic methods of production. In this case, all the production procedures are either partially or fully automated. These procedures range from the cutting of slug through placement of mould to the finished stage of production. This method also accounts for extreme mass production of wares that is uncomparable with the manual jiggers. For this very purpose, French (Ibid) refers to this production technique as being "very bad for making small numbers". He further states that using the same mould for production with all these processes or machines is possible, but the

behaviour of the clay on and off the mould can vary considerably.

## 2.4 Operational Behaviour of Clay Body

Singer and Singer (1963) French (1972) and Nelson (1978) contend that there is virtually no clay body that can not be used for jigger-jolley production, except clays with very high or low consistencies. Though jigger-jolleying is said to be an industrial extension of throwing, the composition and preparation of clay for it is different from that of throwing.

Nelson (1971) points out that the composition of the clay used for jiggering is different from that of the throwing clay used by the hand potter. He believes that since the ware is supported by the mould during the initial drying period, it needs not be so plastic. According to him, since plastic clay shrinks more in drying, thus, increasing the likelihood of warpage, it is used in limited amounts. This loss in green and dry strength is compensated for by the addition of various binders such as lignin extract and methocel to the clay body.

Singer and Singer (Ibid) report that automatic jiggers require plastic bodies. They further state that automatic jiggers work slightly less well with vitreous China and probably can not be directly applied to hard porcelain or bone china. This problem is most prominent in the making of flat wares, in which

case, batting is a necessity. Most batting out machines are not suitable for vitreous bodies. Bodies that are less plastic could be improved for the utilization of the automatic jigger by adding organic binders or small quantities of chemicals. For instance, an addition of some quantity of tannic acid could favourably and more easily alter the behaviour of the clay for use by the machine than altering the working properties of the machine itself to suit the bodies.

On semi-automatic Jigger-Jolley machines, Singer and Singer, (Ibid) say that they have been adapted for making bone china ware by using special cams which will allow enough lubrication while the ware is being produced. Though the type of clay body used determines the speed of production, the size of the wares being made has great impact on the production speed. It is faster to produce smaller or lighter wares than producing large or heavy pieces. As a result of the plasticity of earthen ware bodies, plates can be jiggered almost four times as fast as those made of the stiff and much less plastic hard porcelain body. The production of bone china needs to be slow. Large insulators and other wares made of less plastic porcelain bodies need a great deal of skill and time to avoid strain-free pieces. Strained wares are bound to crack or warp.

## 2.4.1 Body Composition

The body composition for jiggering depends on the type of ware or products intended or the use to which the finished products will be put. Jigger Jolley technique can be used to produce a varying range of ceramic products. Among such rage of products are Earthenware, Stone ware, Porcelain, Bone china, etc. The peculiarity of these products in terms of composition of raw materials are considered. The fact that certain existing geologic differences do occur in terms of raw materials, it becomes difficult to state with precision the specification of materials for one body or the other. Other factors to consider include the size of work to be produced in collaboration with the plasticity of the body and the speed of production. Depending on the above variables, a jiggered or jolleyed ceramic ware could be made of either clay alone (e.g. Earthenwares and Stone wares) or clay with other minerals like feldspar, quartz, sand or flint, bentonite, talc, zirconium silicate, bone ash, etc.

However, the composition of body (in terms of quantity and quality of raw materials) for throwing, slip casting, hand building and jigger-jolleying remains the same. The only difference lies in the peculiar needs of each technique. In other words, the chemical composition of a porcelain body (for

instance) for throwing is the same as that for jigger-jolley. The only difference lies in the need to introduce some plasticizer in order to make the body suitable for throwing.

In a particular instance, the Projects Development Institute (PRODA) Enugu, Enugu State of Nigeria, uses a stone ware body of the following composition.

Table 1: Stone Ware Clay Body at Projects Development Institute, Enugu

| Material | Group A | % | Group B | % | Group C | % |
|---|---|---|---|---|---|---|
| Okene Feldspar | 31kg | 8.9% | 15.5kg | 8.9% | 7.75kg | 8.9% |
| Sude Sand (Imo State) | 15Kg | 4.3% | 7.5kg | 4.3% | 3.75kg | 4.3% |
| Fire Clay (Enugu) | 172kg | 49.4% | 86.0kg | 49.4% | 43.00kg | 49.4% |
| Nsu clay | 130kg | 37.4% | 65.0kg | 37.4% | 32.50kg | 37.4% |
| Total | 348kg | 100.0% | 174.0kg | 100.0% | 87.00kg | 100.0% |

Source: Field Work, 1991.

This clay body has dark-ash colour at green stage. It turns to buff when bisque-fired. It is usually coated with a transparent glaze having a satin textural effect.

### 2.4.2 Body Preparation

The body for jigger-jolley technique of production is usually prepared almost in the same manner as casting slips.

Nelson (Ibid) states that the body ingredients are weighed and mixed in a blunger as in the preparation of a casting slip. The resultant slip is screened and pumped into a filter press. The filter press is a machine with perforated metal plates and canvas that squeeze excess water from the slip, leaving a solid plastic clay. The clay which is removed from this machine in slabs is fed into a pugmill. The pugmill removes all or most of the air in the clay through the help of a centrifugal mechanism of using the internal screw blades in the pugmill.

## 2.5 The Moulds

The discovery of plaster of Paris is not only useful in slip casting alone but also serves as a booster to jigger-jolley technique.

Nelson (Ibid) points out that with the use of plaster moulds, the forming process is quite rapid and accurate. In addition, the plaster mould produces a smoother surface than would be possible with bisque mold.

## 2.5. Plaster of Paris

Plaster of Paris, according to Kenny (Ibid) is gypsum rock which has been heated. At the primary stage when mined, it is a hard rock. The material is heated to dry the chemically combined water. This reduces the rock into a soft material that is easily crushed into a fine white powder. Gypsum, very much unlike clay has the property of regaining its crystallization if water is introduced into it. This, however, explains that plaster regains water (when water is introduced to it) despite its loss of the chemically combined water when gypsum was heated to transform it to plaster.

Kenny (Ibid) observes that plaster of Paris is useful to the potter because it will absorb moisture from clay either in liquid or plastic state. He further explains that this is the property which makes plaster of Paris essential to the pottery industry. Clay slip casting and jigger-jolleying might have been probably impossible or unsuccessful if plaster of Paris does not exist, he asserts.

In a separate study, Leach (1976) observes that:

> "Plaster of Paris is to the factory what the wheel is to the potter's workshop. By far the largest proportion of modern pots are made by the use of plaster moulds, whereas in pre-industrial times biscuited clay moulds were employed on a small scale, and it was the wheel which supplied the world with most of its pots. The transition from biscuit to plaster concerns us here, and the relative value of each to the studio or workshop potter. There is no question as to the convenience of this cheap, quick-setting absorbent substance-plaster-in mould-making." He further contends that without it, casting, the most important process in mass production would be impossible."

According to Singer and Singer (Ibid) the plaster of Paris mould used for jiggering and volleying has a porosity of about 30% and has to be carefully controlled for each ware made. According to him, intermittent robbing of oil on the rim of the moulds while working with it is necessary. This is to forestall the incidence of abnormal fast drying of the rims of wares being produced. He further states that every mould lasts for an average of 190 to 200 production cycles. This however, makes plaster of Paris a relatively cheap material for the ceramic industry.

Kenny (Ibid) recommending the kinds and brands of plaster suitable for ceramic production says that the best type for the potter is the U.S. Gypsum Company's Pottery Plaster. He says that if pottery plaster is not available, one can buy the Red Top or Sunflower brands. In another dispensation, Ibe, (1990) of the Projects Development Institute, Enugu, remarks that from his many years of mould making, he found the 'Samia brand' of plaster as being very good for mould making. Samia plaster is however, made in Nouakchott, Mauritania.

### 2.5.1 Making of Jigger-Jolley Plaster Moulds

Mould making for jigger-jolley production, requires a special skill to turn out efficient moulds. Jigger-jolley mould making is largely based on lathe turning. According to French (Ibid) Lathe Turning, whether vertical or horizontal turning or wirling is certainly the most widely used method for producing a model. He further posits that all hollow-ware and flat ware shapes of round section and plain sufaces are modelled in this way. He also asserts that all pieces which will ultimately be produced by jiggering, jolleying or any other automatic making processes are began by lathe turning, whether or not they incorporate flutes and other embellishments.

In this dispensation, French (Ibid) asserts that a plaster lump is prepared in a size larger than the required mould. The lathe is expected to have either tapering spindle attachments or stepped wooden chucks with projecting wooden screws. These are jointly fixed directly into the lathe's shaft. At this point, the plaster lump is produced by making a paper spindle, removing it and setting it up. The wider end rests on a piece of glass. Around this is a cylinderical cottle of the lino which is held in place by the use of plastic clay. The cottle is of the diameter and height of the proposed lump, making sure that the paper cone is central and vertical. The plaster is at this point poured in to fill the cottle. It is left to set and then fitted into the spindle on the lathe.

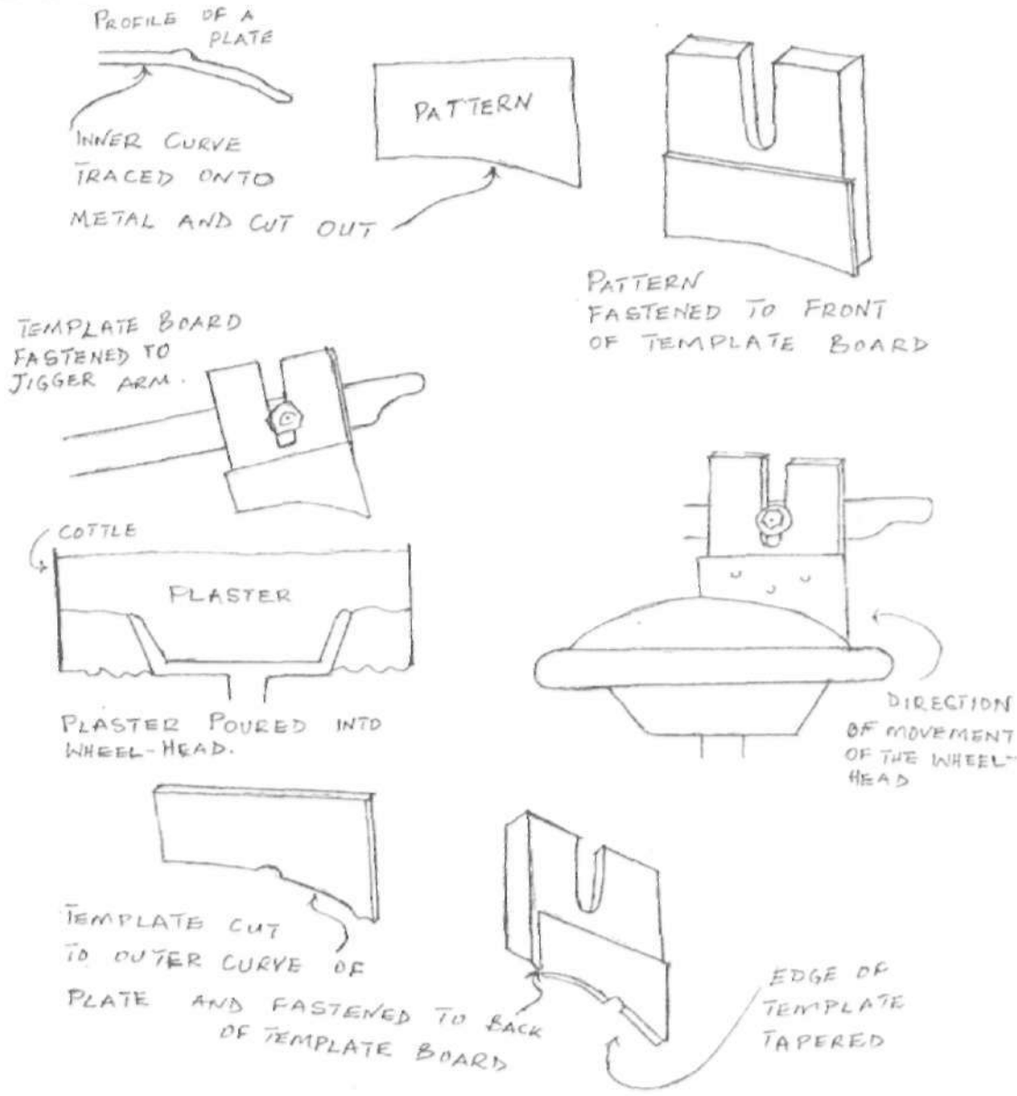
### 2.5.2 The Jigger Bat and Template

In a separate study, Kenny (Ibid) believes that bat making should go along with template making. According to him, the proceedures are carried out by first drawing the cross-section of one-half of the plate and trace the inside curve into a piece of zinc. Then the zinc is cut out with a pair of snips and filled as smooth as possible. (Snips are the scissors used by tinsmiths for cutting sheet metals). According to him, the zinc profile must be screwed to a slotted template board and then fastened to the jigger arm in such a position that it will cut a block of plaster

which is turning in the wheel, into the desired bat. He warns that the inside corner of the zinc profile should be exactly over the centre of the wheel.

He explains that the next stage is casting of the plaster out of which the bat is to be made. All the stages are explained in the following diagrams.

Figure 2.3: Making a Jigger Bat and Template




Source: John Kenny (1949), page 127.

Kenny (Ibid) further states: "If your wheel has a drop head, oil it thoroughly and build a collar of clay 3" wide around the outside of the head. Tie a cottle of building paper around the outside of the clay then mix and pour the plaster." According to him if the wheel does not have a drop head, but has some notches to hold a bat in place, one can cast directly on the head.

As the plaster starts to set (but before hardening) the bat maker removes the cottle and starts the wheel. The template is slowly brought down, cutting the plaster with the profile. The shapening of the bat is completed when the jigger arm is all the way down. At this point, the plaster is allowed to set. The template is held against it once more while the wheel spins. This, he says, is to secure a good finished surface. Turning tools can now be used to trim the outside edge of the bat. The bat or mould is now removed from the wheel head and kept away for drying.

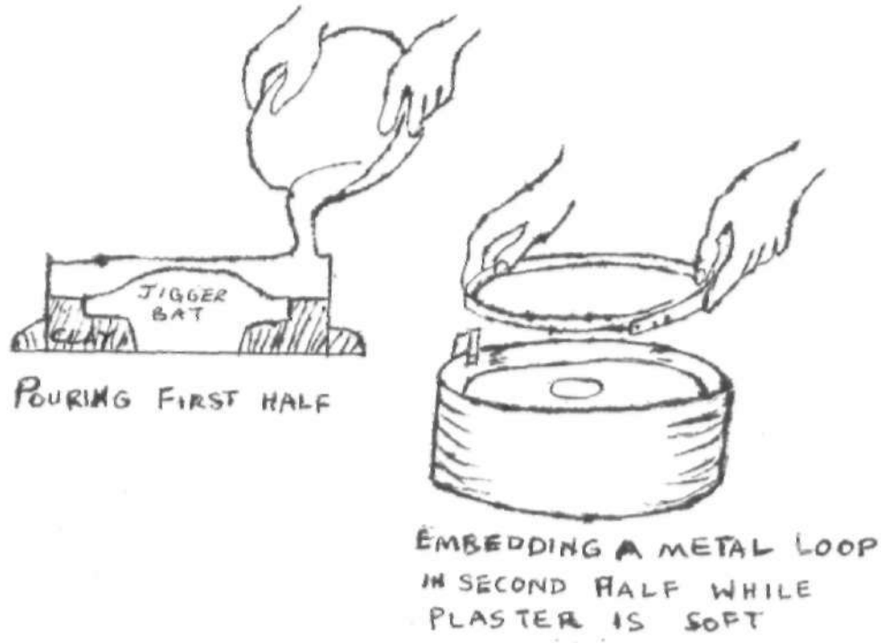
Heavy metals or steel are ideal for making jiggering templates. Templates can however be made solely of wood without metal facing, especially when hard wood is used. The template must be cut to take the shape of the outside curve of the plate and fastened to the back of the template board, which must be tapered. He sees jiggering as more of a pressing process than a cutting one. This he says explains why the surface of the template must slope.

## 2.5.3 Case Mould

When the template and bat of a plate is made, it is almost as easy to make six as making one. This reproduction of identical bats can be achieved by casting the bat to get the case mould. Kenny (Ibid) describes a case mould as one from which other moulds are made.

He points out that this is done by first sizing the jigger bat, setting it in clay as in the following diagram.

Figure 2.4: Making a Case Mould of a Jigger Bat




Source: John Kenny, (1949) page 131).

A cottle is placed around the bat and the clay and plaster is mixed and poured. This forms the bottom piece of the case mould. After setting, he says, it is turned over and the clay is removed, leaving the bat in place. Some notches are cut in the rim. The new piece of mould, just cast along with the bat are sized again. The cottle is set and the second half is casted with a fresh plaster. The second half must not be deeper than the height of the jigger bat. This is because an opening has to be created in the case mould for pouring plaster in the subsequent bat casting.

The top piece of the case mould has to be reinforced. This, according to Kenny (Ibid) is because plaster expands slightly while setting. In this case, a barrel loop is cut to a size that is slightly smaller than the outer circumference of the mould. It is fastened together with short nails. A heavy wire made into a circular loop with the ends firmly twisted together can equally serve. As the plaster starts to set, the circular loop is pressed half way. The plaster should still be in a plastic state at this moment. The loop, according to him should neither touch the bat nor the retaining wall.

The case mould becomes useable as soon as it sets. Casting of bats from the case mould is by sizing it and pouring plaster consequetively. The original bat

which was sized is unfortunately, unuseable again.

## 2.6 Batting

Batting is an important procedure in the jiggering of flat-wares like plates, dishes, etc. According to Singer and Singer (Ibid) the Jiggering of plates, dishes and other flat-wares involves placing the body on the moulds in the form of a flat circular 'bat'. He further states that correct forming of these bats to a uniform thickness and consistency is essential to good jiggering. According to him, a bat may be formed on a plaster base covered with filter cloth for smashing it flat with a plaster maul. This manual method is old. He asserts that a batter out machine can equally do this function. With this machine, there is a plaster wheel head on which a slug of clay is placed for flattening. The plaster disk (wheel head) revolves while a spreader tool is brought down upon the clay: This method is very successful with plastic bodies e.g. the Earthen wares. Even at high speed, Earthen ware batting is still more successful than porcelain batting.

A porcelain bat, according to Singer and Singer (Ibid) will not hold together during manual transfer to the jigger on the cloth. It is therefore, made on a rigid drum, transferred to the jigger and then cut off. He says that the drum method also has a

considerable advantage of ensuring that the centre of the bat comes central on the jigger mould.

There has been an evolution of a batting method for the miller automatic jiggering machine. This has considerable advantages of its own, they say. It has been separately used for a batting out machine. In this case, a thin circular slice of clay is taken off from the pugmill column instead of starting with a slug of clay. Therefore, the need for flattening a ball of clay is eliminated by this process. This slice is then hydraulically raised against a heated die and a high pressure is exerted on the body. For larger pieces of hollow-wares to be made in a jolley, the clay is first spread slightly to make a thicker smaller bat and then pulled over an upright post of plaster covered with a cloth. This can be removed by hand and transfered into the jolley mould and the cloth removed.

## 2.7 Faults in Flat-Wares

Uneven heights of the rim, concave or convex bottoms are common faults found in a good number of flat wares. Some of these faults are due to the preparation of the body, the drying or the firing. These faults are often initiated during the jiggering process. They are much more frequent in vitreous wares, (most particularly in hard porcelain) than in

Earthen wares.

Singer and Singer (Ibid) observs that investigation of such wares during various stages of the firing process show that the densities of various parts are not the same. This arises during the shaping when some parts are more compressed than others. In this case, some parts have higher water content and are subsequently more porous on drying. These parts have a high shrinkage on firing, causing strains. This therefore, leads to the rising or sinking of the centre.

This fault according to Singer and Singer (Ibid) can be corrected by altering the jigger design and angle. He points out that most jigger tools work by compression as well as by cutting. A good combination of these are that more uniform pieces of jiggered wares can be obtained.

They reveal that a round ware, firing to a non-round shape with a wavy edge may be traced to the transfer of the bat to the jigger head. If the centre of the bat does not fall on the centre of the mould, the strains set up during the two operations are not concentric. With the normal hand transfer, the centre rarely coincides. But if the drum-head method of batting is used, this can be achieved.

## 2.8 Equipment

This production technique requires a series of equipment and tools. Pottery Crafts Limited (1989) states that there are a number of industrial equipment and tools needed to operate this technique. Among such equipment are the jigger machine, jolley machine, jigger and jolley machine, vertical jolley machine, horizontal jiggering machine and fully and semi-automatic jiggering machines. Also important is the lathe turning machine. Tools needed include various grades of turning tools as well as jigger-jolley profiles.

Singer and Singer, (1963) report that a batter out and hand jigger man can make some 120 pieces of 18 cm diameter plates in an hour while a single operator of a semi-automatic jigger machine can make 276 pieces of similar plates in an hour. This is a great advantage over throwing and slip casting.

More still, a fully automatic machine, according to him can produce about 1,440 similar pieces of plates in an hour with just three operators. This is not just an advantage over the manual and semi-automatic jiggers but a great advantage over all other making techniques.

Though the automatic and semi-automatic jiggers are not in use in Nigeria at the moment, the manual jiggers are sparingly used in few ceramic industries

and research institutes in Nigeria.

## 2.9 Marbling

Marbling is a form of decoration by which a varigated effect is made on the surface of ceramic ware. In his description of marbling, Bunn (1979) says: "A slab is covered with slip. While this is still wet, contrasting slip is dripped on at random from a brush or a trailer. When this slab is tilted or agitated (still on its board) the slips will 'marble'."

From his own view, Leach (1976) expounds that marbling occurs when one or more slips have been unsuccessfully trailed over a wet background, for which black is the most suitable because of its.(sic) stronger adherence to the board upon which the clay rests. The slips then run into each other and produce most unexpected and occasionally interesting patterns.

Hughes (1977) describes 'marbled ware' as surface ornament produced by working together coloured slips or enamels. He recounts that slip marbling dates from the 17th century and continued until the end of the 18th century, with a revival in the third quarter of the 19th century in recognised 'antique forms'. According to him, it was done in thinly applied lines or splashes of light-coloured slips in two or more

tints, such as red and white, buff and brown, light red and buff, dark red and brown.

He further states that Granite and Porphyry marbling were fashionable in the 18th century. Porphyry is a hard, red kind of rock having white and red crystals. Granite effects, according to him, were achieved by spraying cream ware with grey or bluish mottled flare. As from about 1815 - 1850s, painted marbling flourished. In this case, he says curls, long, thin and irregular lines or patches in yellow, reddish brown and chocolate coloured enamels were applied in the manner of the freer type of paper marbling.

In a separate study, Sullayman (1987) reports that marbling effect can be obtained in polymer ceramic products. Polymer ceramics, otherwise, known as cultured marble is a process of making synthetic ceramic wares using unconventional materials. Ceramics through the ages has been known as products of basic raw materials like clay which is passed through a high range of firing temperature. Cultured marble is neither made of clay nor passed through firing. But the materials have similar chemical composition with clay, e.g. sand, Alumina Trihydrate and Calcium carbonate. Other chemicals like the 'Polyester Resin' and 'Catalyst' carry out the function of plasticity and vitrification respectively. All these are mixed in a

blunger in a specific proportion for production.

Sullayman (Ibid) further states that where marbling design is intended to be obtained from the product, some quantity of powdered artist's water colour is spread on the surface of the batch. The coloured part of the batch is first, carefully removed and spread on the surface of the mould before filling the rest part of the mould to the rim. As soon as the moulds are getting filled the 'Air Compressor Machine' is started. The machine uses air compression method to vibrate, shaken and compress the batch in the mould to a smooth finish.. On de-moulding the wares, a series of colourful and decorative flow of patterns are found on the surface.

This however, reveals the useability of marbling decoration beyond the classroom and studio application on clay products to that of an industrial set up, he states.

Colouration, pigmentation and stain application are major demands of marbling decoration. This attests to the importance of stains, oxides, engobes or slips in marbling. However, some marbling design go beyond a variegated colour application at the outer surfaces of the ware. This accounts for the availability of 'Agate ware'.

Hughes (1977) describes Agate ware as an earthenware intended to imitate agate stone by wedging tinted clays together so that the colours extend through the body. According to Bunn, (Ibid) agate ware is made by partially mixing clays of differing colours. He further states that pots thrown on a wheel with partially wedged clays will usually need to be shaved down with a turning tool at either the throwing or turning stages. This is done to remove the smugged slurry and to reveal the marbled patterns. Agate ware is glazed with a transparent glaze which brings out the colours to great effect.

### 2.9.1 Engobe

Engobe is described by Grebanier (1975) as a liquid clay or clays, sometimes with the addition of fluxes and non-plastics like feldspar, whiting and flint. Besides its use in mould casting, it is most frequently employed as a thin coating over all or part of a ceramic body. This is either to provide a differently coloured surface under a glaze, to cover up surface defects in the body, to provide a suitable background for underglaze brushwork decoration, or to serve as a layer through which designs may be cut to the body. Another name for engobe is slip.

Grebanier (Ibid) further asserts that white slips have best harmonizing effects. According to him, they are best applied to the leatherhard ware when the latter is not too dry and later bisqued. He recommends that the best method of application for a smooth, uniform effect is spraying. The best of the white slips according to him have the following composition.

Table 2.2: White Slip I

| | | |
|---|---|---|
| Flint | - | 34% |
| Cornwall stone | - | 30% |
| Georgia kaolin | - | 25% |
| Ball clay | - | 10% |
| Soda Ash | - | 1% |
| | | 100% |

Source: (Grebanier (1975) page 113

Table 2.3 White Slip II

| | | |
|---|---|---|
| Flint | - | 40.6% |
| Maine feldspar | - | 20.1% |
| Georgia kaolin | - | 28.3% |
| Ball clay | - | 10.0% |
| Soda Ash | - | 1.0% |
| | | 100.00% |

Source: (Grebanier (1975) page 113

Cornwall stone can be substituted with feldspar. This is found to be very successful, according to Grebanier (Ibid), especially for enhancing adhesiveness in the slip.

Barford (1963) observes that a gallon of white- or buff-firing slip is first prepared and used to fill eight pint jars. To prepare coloured slips, standard measuring spoons can be used to add the suggested amounts of oxides, labelling the jars accordingly. Then he provides the following table based on level spoon measurements per pint of liquid base slip:

| | | |
|---|---|---|
| Light blue | - | ¾ teaspoon cobalt (oxide or carbonate) |
| Medium blue | - | 1¼ teaspoons cobalt |
| Dark blue | - | 2 teaspoons cobalt |
| Light Green | - | ¼ teaspoon cobalt and ½ teaspoon chrome |
| Medium Green | - | ½ teaspoon of cobalt and 1 teaspoon chrome |
| Dark Green | - | 1 teaspoon cobalt and 2 teaspoons chrome |
| Pink | - | 3 teaspoon iron oxide |
| Gray | - | ¾ teaspoon cobalt and 2 teaspoons manganese |
| Biege | - | 3 teaspoons manganese |
| Dark Brown | - | 9 teaspoons manganese and 2 cobalt |
| Black | - | 9 teaspoons manganese and 2 cobalt |
| Red-brown | - | 8 teaspoons iron(or use a red-burning clay). |

Colour results obtained from the addition of certain oxides to a base slip depend largely on the type of clay used. To this claim, Barford (Ibid) says: "the amount of oxides given are approximate, as the resulting fired colours will vary according to the type of clay body used in preparing the slips and the types of glazes used over them." A good mixture of the base slip and the colourant (oxides) can be enhanced by stirring, shaking or by grinding in a mortar using a pestle.

In another study, Kenny, (Ibid) asserts that a base slip should be made with the following proceedure: Ball clay and kaolin should be sieved separately, levigated and dried. He suggests a 200 mesh for the sieving.

Table 2.4: White Slip III

| | | |
|---|---|---|
| Kaolin | - | 25% |
| Ball clay | - | 20% |
| Flint | - | 30% |
| Feldspar | - | 17% |
| Whiting | - | 2% |
| Magnesium Carbonate | - | 6% |
| | | 100% |

Source: John Kenny (1949) page 135.

To arrive at various colours, according to him, different colourants are added as follows:

24% of Iron Oxide for Iron red

40% of Pink Oxide for crismon

9% of antimony oxide for yellow

20% of manganese carbonate, 5% of copper oxide and

10% of cobalt oxide for blue.

### 2.9.2 Coloured Clay

The origin of coloured clay can be traced to nature in itself. In this case, certain geologic factors brought about the mixture of kaolinitic minerals with various oxides and carbonaceous matter. This therefore results into a variety in the colours of clay, ranging from white, brown, grey, green, buff, pink to red. As a result of the existence of these colouring oxides, some colouring effects are obtained after firing (instead of the white colour expected of a pure clay). This, however, forms the basis of clay colouration.

Artificial colouration of clay can be achieved through the introduction of colour bearing oxides or stains. Bunn, (Ibid) opines that stains or oxides can be added to soft, fairly sticky clay during wedging or kneading. He further asserts that it is best to experiment with small quantities and have them fired and glazed. This, he says, is because the colour

response is usually only seen to maximum effect after the glaze firing. Too much oxide, according to him, may affect the chemical characteristics of clay, acting as a flux and lowering the maturing temperature of the body. He says that small quantities of coloured slips can be made by drying out coloured slip on a plaster bat. As soon as it becomes plastic, it can be kneaded. The plastic coloured slip can be mixed fully or partially with clay. This however, can be exploited to obtain the effect of 'Agate Ware.'

Bunn however, warns that some oxides are toxic in their raw state and should be handled with care. Cobalt and copper, he says, should be used only for decorative effect and not on the surface of a pot meant to be used for food or drink. This is because certain food acids may attack the glazed surface and release the toxic substance.

These therefore, show that certain variables like the working properties and scope of jigger-jolley machines, the natural colour of clay, colour of slip, firing temperature, firing atmosphere, toxicity of certain oxides, etc., directly or indirectly affect the scope of marbled ware production using the jigger-jolley techniques.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

This chapter encompases the step by step proceedures used in this study. This involves the processes of mould making, template making and the technique behind the improvisation of cup mould jigger-head. It also involves the sources of raw materials used, methods of procurement, processes of beneficiation of the raw materials and the formulation of various bodies and colouring slips.

Also enunciated in this chapter are the proceedures used for production of experimental samples and the firing techniques used for the study.

## 3.2 Mould Making

Moulds were made for three different table ware items such as plates, dishes and beakers and or cups. The models of these items were thrown on the wheels with well kneaded and wedged throwing clay. While the plate and dish moulds were thrown in hollow ware form and neatly trimmed, the beaker or cup model was thrown upside down in a block (solid) form.

## Plate Mould

In making the mould for jiggering plates, the following proceedures were undertaken:

a. The plate was placed on a wad of clay made around a well centred plate on the wheel head, such that the inner (concave) part of it faces up. The placement was so accurate that the side ways extension of the wad (beyond the rim of the plate) was dimensionally equal at all sides of the plate's rim. (See Appendix I Figure 5).

b. A clay cottle was built around the clay wad that housed the plate. The cottle measured 4cm high above the wad. (Ibe 1990). (See Appendix I. Figure 6).

c. At this stage, one and a half measures of plaster weighing a total of 1.950 kg was poured into one and a half measures of water weighing a total of 1.500 kg. This means, however, that the plaster to water ratio used was 130:100 as suggested by Singer and Singer (1963), Pottery Crafts Catalogue (1989) and Kenny (1949). This ratio was used for all the moulds made for this research.

The cottle was removed when the plaster had partially set (10 minutes after pouring the viscous plaster). Partial crystallization of plaster at this state enhanced the possibility of shaping the mould on the wheel-head byturning without sagging, distorting, warping or being too hard for turning.

d. The second part of the mould was made to be of the size of the internal part of the jigger-head. It was done this way to enhance the stability of the mould when placed on the jigger-head. In this case, the bottom part of the jigger-head was filled with a wad of clay. This had two purposes: to reduce the amount of plaster to be used and secondly, to provide a support for standing the metal spindle that was later used to create a hollow through this second piece of the mould.

The spindle and the other parts of the jigger-head retention wall (above the clay wad) were sized with vaseline to ensure easy mould release when the plaster becomes set. An appropriate amount of plaster (1.300 kg) was measured and poured into the required amount of water (1.000 kg) and harmoniously mixed together. The viscous plaster was immediately poured into the jigger-head retention wall. At about 10 minutes after pouring, the tapering spindle was carefully and gently pulled out of the setting plaster.

On setting, the jigger head (with the encased mould) was submerged in water for about 20 minutes to enhance easy mould release. At this point, the jigger-head was removed from water and gently knocked against a concrete slab, thereby, releasing the mould. This mould however, formed the base of the plate mould while the first piece was the actual plate

jiggering mould. (See Appendix I. Figure 7).

e. The two pieces were removed from their moulds: the cottle and the jigger-head, and were joined together using viscous plaster. The tapering spindle used when making the base mould created a tapering vacum running through the whole length of the mould. This vacum provided an opening through which a viscous plaster was poured to join the two pieces together to form one plate jigger-mould. The two pieces were later joined together. (Appendix I Figure 8).

f. The joining process of the actual mould and the base mould was undertaken by first scoring or notching the base of the actual mould. (It is worthy of note that the actual mould (a) bears the inverted or negative shape of the inner or concave part of the real plate). This scoring on mould (a) was done within the centre of it, ensuring that the actual diametre of the top rim of the jigger-head retention wall was not exceeded. This measured 22 cm.

The upper surface of the base mould (b) was scored all over. The purpose of the notching on the surfaces of the two pieces expected to be joined was to ensure permanent adhesion. A ratio of 140.100 of plaster to water was mixed, and was applied in such a highly viscous consistency on the two scored surfaces. The scored surface of mould (b) was

centrally placed on the scored surface of mould (a) and the viscous plaster of 140:100 plaster to water ratio was poured into the spindle vacum already created. This was left for 25 minutes to fully set. The plaster to water ratio as opined by Ibe (1990) was supported by Pottery Crafts (1989), Harmer (1975) and Singer and Singer (1963). The viscous plaster flowed into scored grooves of the two unsized surfaces, thereby, binding the two surfaces together as one. (See Appendix I Figure 9 & Appendix II Plate 1).

The mould was dried for 2 days under the sun after which it was ready for use.

Dish Mould

Mould making for a dish was undertaken by throwing a dish in a hollow-ware form. The dish was turned when it was leather hard. The cross-sectional view of the external part of it was taken at this stage using a soft soldering wire.

Thereafter, the model was centred upside down on the throwing wheel-head. A circular cottle of clay was built around the dish. The wheel-head was sized. 3.5 measures of plaster and water in ratio 130 to 100 respectively was mixed. The viscous mixture was gradually poured unto the inverted exterior part of the dish. This gradual process of pouring was to

avoid the jumping up or change of position by the model and possible breakage of the cottle as a result of forceful pressure, associated with massive pouring.

Ten minutes after the pouring of the last batch of plaster, the cottle was removed. Plaster turning was done on the wheel-head using a pair of calipers to measure the diameter of the entry point of the mould into the mould retention wall of the jolley-head. This was to ensure that the mould could squarely fix into the jolley-head without shaking.

The upper part of the mould extending out beyond the 22 cm diameter of the mould's base was designed to be a balancing device, which provides stability to the mould for good jolleying. The mould was dried for 24 hours before use.

Beaker/Cup Mould

The methods adopted for the making of Beaker or cup mould were the same as those used in making dish jolleying mould. However, the only differences were in the nature of models used, the dimensions for mould-holding or retention cavities and the amount of plaster and water used. The plaster to water ratio used remained the same.

While a hollowed model was used for dish mould making, block model was used for making beaker mould. The mould retention diameter was 13.2 cm while the diameter of the beaker mould base was 8 cm.

1½ measures of plaster to water ratio of 130 to 100 was used.

Plaster Jolley-Head

Due to lack of the conventional jolley-head for making cups and beakers in the Department, an improvisation was made by the researcher. In this case, the cup jolley mould was invertedly centred on a throwing wheel head on which a wad of clay was already smoothly and evenly spread. Another wad of clay was built from the inverted top rim of the mould, up to the end point of the circular and outwardly protruding device, made for mould balancing and stabilization on the jolley-head.

At this point, a conical clay cottle was built around the mould. The inverted plaster mould was then sized, using slip clay so as to enhance mould separation. 1½ measures of plaster to water ratio of 140 to 100 standard measure for case-mould was used thereby, using 2.100 kg of plaster mixed with 1.500 kg of water. This practice was supported by Kenny (1949), Ibe (1990) and Nelson (1978) who believe that case-mould plaster to water ratio must be adopted for a plaster base expected to be subjected to stress and tension.

The jolley-head was turned and some concentric circular lines were made on the surface of the base through the use of a metal modelling tool. These lines were later used as guide in locating the centre at which the metal case joining the jolley-head with the jolley machine was to be placed. (See Appendix II., Plate II,.

Metal Case

It was believed by this study that a direct contact between the metal spindle of the jolley machine and the plaster jolley-head will result into abrassion and subsequent tear and wear of the jolley-head. This resulted into the fabrication of a metal case or bearing, with a flat circular head and a hollowed circular extension, made to the specifications that can house the tapering spindle of the jigger-jolley machine.

The metal case was centred on the inverted base of the already scored surface of the jolley-head. The scoring was done all over the surface to enhance complete adhession. 150:100 ratio of plaster to water was measured in the required proportion ($\frac{1}{2}$ measure) and mixed together. The viscous plaster was carefully poured on to this scored, metal-case bearing surface, thereby, burying the flat head of the metal case inside the plaster. The opening of the

hollowed circular extension of the encased metal case form the point of attachment between the plaster jolley-head and the tapering spindle of the jigger-jolley machine. (See Appendix I , **Figure** 10).

### 3.2.1 Template Making

Three different templates were made, one for each of these items: plate, dish and cup making.

### 3.2.2 Plate Template

For plate making, a wheel thrown and turned plate was turned upside down to take the impression of its back (convex side), including its foot rim. This was done by placing a soft and flexible piece of soldering wire on the plate; gently pressed on it from the centre of the foot rim radius to the edge.

The impression it gave was carefully transferred into a paper using a pencil. The pencil mark was later transferred onto a well seasoned and planed mahogany wood. (Other possible substitutes are metal sheets and ceiling board). This was done by placing a carbon paper between the paper and the wood, pressing a blunt but pointed pen through the lines. The wood was cut out using the hack-saw. The part of the template intended to rest on the clay bat while producing plates was shamfered at the right hand side to an angle of about 45 degrees to enable excess clay

get off the bat while making. All the templates, for plate, dish and beakers in this study were made with mahogany wood. (See Appendix III, Plate 6).

### 3.2.3 Dish and Beakers Templates

The proceedures used for making the plate template were also used for making the dish and beaker or cup templates. The only difference was that the impressions of the first rims already taken along with the entire convex surfaces of the dish and the cup were eliminated from the tracing paper before transfering the impressions onto the wood. This elimination made the templates suitable for jolleying dishes and cups on the concave surfaces without creating furrows at the base. The templates were fixed on the adjustable jigger hand for use.

## 3.3 Sources of Raw Materials

The raw materials used for this study were Kudingi clay, Bomo clay, Tasar Dauda clay, Zaria Feldspar and Ash from Zaria, Kaduna State, Okelele clay from Ilorin, Kwara State, Kankara Kaolin from Katsina State, Okene Lime Stone, Feldspar and Quartz from Kogi State and all other naturally occuring raw materials. Other materials used include plaster of Paris, Mahogany wood, Red-fired clay brick, Iron Oxide,

Cobalt Oxide, Manganese dioxide and mixed wood ash.

The location, procurement and selection of samples were guided by information from practising ceramists, literatures and professionals in related fields.

### 3.3.1 Sampling

Sampling of the population was based on the Random sampling technique . With this method, all the materials in the population were given equal opportunity of being selected on proof upon test of their suitability and reliability.

## 3.4 Processing Selected Raw Materials (Beneficiation)

Except the colouring oxides and plaster of Paris, all other raw materials used in this study were processed by the researcher.

Each of the clays was processed in a separate container. The following was the synopsis of the beneficiation:

a. Ball Clay and Kaolin

i. Soaked for 24 hours

ii. Blunged for 3 hours

iii. Sieved through mesh 80

iv. Dried

v. Stored.

b. Lime Stone

i. Washed

ii. Calcined at 950°C

iii. Jaw crushed

iv. Milled for 24 hours

v. Sieved through 80 mesh

vi. Dried

vii. Stored

c. Feldspar

i. Washed

ii. Calcined at 950°C

iii. Jaw crushed

iv. Milled for 17 hours

v. Sieved through mesh 80

vi. Dried

vii. Stored.

d. Quartz

i. Washed

ii. Calcined at 950°C

iii. Jaw crushed

iv. Milled for 24 hours

v. Sieved through mesh 80

vi. Dried

vii. Stored.

The solid minerals were grounded by wet grinding method. They were later discharged from the ball mill, de-watered, dried, and stored away in plastic containers to avoid possible contamination from the use of metal containers.

e. Mahogany Wood

A well seasoned mahogany wood was smooth-planed, from which the templates were later made.

f. Clay Brick Sherds

Some broken pieces of red-fired clay bricks were collected from within the University Campus and processed as follows:

i. Washed
ii. Jaw crushed
iii. Milled for 18 hours
iv. Sieved through mesh 80
v. Dried
vi. Stored.

## 3.5 Experimenting with Materials

Four different secondary clays were tested for plasticity, shrinkage and colour. They were Kudingi clay, Bomo clay, Tasar Dauda clay and Okelele clay.

### 3.5.1 Plasticity Test

Each of the clays was prepared and rolled into stripes. The stripes were coiled round the finger to

observe if there were crack lines and to examine the extent of such cracks after drying at room temperature.

### 3.5.2 Shrinkage Test

This test was conducted by first preparing the clays into workable consistency. They were pressed into slabs. 10 cm straight lines were made on each of them. They were subjected to bone drying under room temperature. On drying, the lines were measured again.

The dry length was recorded before subjecting the test tiles to bisque firing of 950 $^{o}$C. The percentage of firing shrinkage was also recorded.

### 3.5.3 Colour Test

The fired test slabs in 3.5.2 above provided the basis for fired colour determination. Since clay colour is an important factor in the composition of clay bodies for marbled ware production, this test was very useful to this study because secondary clays are known to be colour bearing materials.

## 3.6 Formulation of Body

The stone ware body composition used in this Department was adopted to be body I. The compositions of the three bodies used were as follows:

Table 3.1: Clay Body I

| | | | |
|---|---|---|---|
| a. | Kankara Kaolin | = | 35% |
| | Kutingi clay | = | 65% |
| | Total | = | 100% |

Source: Studio Test, 1991.

Table 3.2: ClayBody II

| | | | |
|---|---|---|---|
| b. | Kankara Kaolin | = | 65% |
| | Tasar Dauda clay | = | 35% |
| | Total | = | 100% |

Source: Studio Test, 1991.

Based on the assertion of Conrad. (1983) a porcelain body composition was adopted as follows:

Table 3.3: Clay Body III

| | | |
|---|---|---|
| Kankara Kaolin | = | 25% |
| Okelele clay | = | 25% |
| Okene Feldspar | = | 25% |
| Okene Quartz | = | 25% |
| Total | = | 100% |

Source: Studio Test, 1991.

All the percentages were measured by weight. Bodies I and II were used for the production of stone wares while Body III was used for making porcelain.

### 3.6.1 Body Preparation

The conventional method of body preparation by which the required amount of solid materials and water are mixed in a blunger and passed through the storage ark into the dead weight pump to produce the filter cakes, as suggested by Nelson (1975) and Okwor (1990) were not upheld. Rather, the solid materials for each body were placed together into separate containers already containing the required amount of water. The materials were left in water to dissolve naturally within a period of 24 hours.

The materials were hand-mixed into a homogeneous consistency and turned into drying troughs. The bodies dried to the consistency of workable condition. They were wedged, kneaded and cut into the required sizes for the production of experimental samples using the jigger-jolley machine.

## 3.7 Formulation of Colouring Slips

Rather than following the specifications suggested for making white slip by Grebanier (1975), Barford (1963) and Kenny (1949), which demands numerous materials requiring local substitution, a white slip was made with entirely local raw materials. It was named slip I.

Table 3.4: Slip I

| | | |
|---|---|---|
| Kankara Kaolin | = | 45% |
| Okene Quartz | = | 30% |
| Tasar Dauda Clay | = | 20% |
| Wood Ash (mixed) | = | 5% |
| Total | = | 100% |

Source: Ewule (1990).

### 3.7.1 Coloured Slips

The white slip obtained from the composition in 3.7 above provided the basis for the formulation of coloured slips used for the study.

Three litres of white slip was measured out in separate containers for the preparation of each of the coloured slips, except for the purple-dark brown slip. The addition of the constituent colouring oxides was based on level tea-spoonful measurement for eight pint of liquid base slip, as suggested by Barford (Ibid), whose conversion equivalents in metric system (S.I. system) were calculated as follows:

Dark Blue Slip (Slip II)

2 tea-spoonful of cobalt for eight pint of white slip converted to metric system for 3 litres of white slip was (2 x 2 x 3) tea-spoonful = 12 teaspoonful of cobalt.

Black Slip (Slip III)

9 tea-spoonful of manganese and 2 tea-spoonful of cobalt for eight pint of white slip converted to metric system for 3 litres of white slip was (2 x 9 x 3) = 54 tea-spoonful of manganese + (2 x 2 x 3) = 12 tea-spoonful of cobalt = 66 tea-spoonful of manganese and cobalt. In the absence of manganese, manganese dioxide was used as substitute.

Red-brown Slip (Slip IV)

8 tea-spoonful of Red Iron Oxide for eight pint of white slip converted to metric system for 3 litres of white slip was (2 x 8 x 3) = 48 tea-spoonful of Iron Oxide.

Purple-brown Slip (Slip V)

This was entirely composed of different base materials compared to others above.

Table 3.5: Purplish-Brown Slip (Slip V)

| | | |
|---|---|---|
| Bomo Clay | - | 55% |
| Zaria Feldspar | - | 10% |
| Red-fired Brick Grog- | | 20% |
| Iron Oxide | - | 15% |
| Total | = | 100% |

Source: Studio Test, 1991.

## 3.8 Production of Experimental Samples

Two main methods of production were used. The first method was by placing the slug of clay into or onto the mould to form the bat, either inside the jolley mould with the template, or on the jigger mould with the hand. The second method was by throwing liners using the throwing wheel. Thrown liners were shaved using a wooden modelling tool, and then cut out of the wheel head to be completed in the required moulds using the jigger-jolley machine.

Non-coloured clay bodies were experimented with so as to provide the basis for colour comparison. Secondly cobalt oxide was partially applied on clay body surface and used as a slug for jiggering directly on the mould.

Some wet slips were also applied, haphazardly on the surface of clay slugs and placed into or onto the mould, ensuring that the coloured sides faced the mould. They were worked out directly using the machine.

Another test was conducted by using two different clay bodies that naturally have different colours. They were partially wedged together ensuring that there was no harmonious fusion between them. They were tested both as a slug and as thrown liners.

Finally, samples were made using each of the bodies separately. Each of them was coated with a base slip, either white or coloured. Immediately, after this, a splash of slip bearing a different colour was applied and agitated to achieve a variegated surface effect. They were all left to dry gradually and subjected a bisquit firing in electric kiln atmosphere. The samples were fired for eighteen hours to 950°C before glazing them for the gloss firing. (See Basic Assumption).

### 3.8.1 Glazing

Two transparent glazes were applied to the experimental samples. Leach, (1976), Bunn, (Ibid) and Grebanier (Ibid) contended that the real and full colour or marbled effect of slips and stains can only be brought out to the fullest when good transparent glazes are used. The glazes used for this study have different behaviours. While glaze I is a water clear transparent glaze, glaze II is a dull transparent one.

The two glazes which were applied by single and double dipping methods have the following composition:

Table 3.6: Glaze I

| | | |
|---|---|---|
| Okene Feldspar | - | 75.5% |
| Okene Quartz | - | 7.3% |
| Okene Lime stone | - | 8.2% |
| Zinc Oxide | - | 9.0% |
| Total | = | 100.0% |

Source: Studio Test, 1991.

Table 3.7: Glaze II

| | | |
|---|---|---|
| Okene Feldspar | - | 55% |
| Okene Quartz | - | 5% |
| Mixed Wood Ash | - | 20% |
| Tasar Dauda Clay | - | 20% |
| Total | = | 100% |

Source: Studio Test, 1991.

## 3.9 The Firing

The firing was done in stages using both the Electric Kiln and Kerosene buring kiln. An oxidized atmosphere was used in each of the two cases. While the Electric Kiln firing was carried out at the Federal College of Education, Okene, Kogi State, kerosene fuel was used for the second firing at the Department of Industrial Design, Ahmadu Bello University, Zaria.

Carbonaceous matter were burnt off up to about 1000 $^{o}$C before the beginning of vitrification (Waye, 1967), Singer and Singer, (1963) and Uduigwome (1989). In the Electric kiln firing orthon cone 9 bent after 12 hours of firing, and soaking was done for 30 minutes, suggesting a temperature of about 1280 $^{o}$C. In the kerosene fuelled firing, orthon cone 8 melted/flattened, which was also suggestive of a temperature of 1280$^{o}$C. At the end of each firing, the kiln cooled down gradually before the samples were unpacked.

# CHAPTER FOUR

## ANALYSIS OF RESULTS AND FINDINGS

### 4.1 Introduction

As a research into the production of marbled wares using the jigger-jolley techniques, various experiments were carried out on the materials, formulated bodies, slip making and methods of marbled ware production. An analysis of results of various tests conducted are documented in this chapter.

Also contained here are findings on the alternative techniques which have been experimented and found workable by this study.

### 4.2 Result of Mould-Making Test

The plaster to water ratio of 130 to 100 used in the study was found to be very successful. The use of hollowed clay models adopted in the study as against the use of lathe-turned plaster models suggested by French (1972) and Singer and Singer (1963) was also found to be very successful.

Mould turning on the throwing wheel for the purpose of shaping was also successfully applied by the study. This was against the position of Nelson (1978), French (Ibid) and Singer and Singer (Ibid) who believed that lathe turning of moulds for jigger-

Jolley has no other suitable subsitute; or Ibe (1990) who posited that jigger or jolley moulds can only be effectively made by using an industrially pre-fabricated metal case-mould. (Appendix III), Plate IV).

## 4.3 Result of Plaster Jolley-Head Fabrication Test.

It was discovered that the plaster jolley-head improvised for the purpose of this study as a result of non-availability of a metal one in the Department worked effectively like the metal heads. It also proved durable because of the attached metal component to house the jolley spindle.

## 4.4 Result of Template Making Test

Cross sections of clay models carefully taken through the use of soft and flexible soldering wire were found to be successfully transferable onto the template making mahogany wood. The mahogany was found to be very suitable for making templates because of its good seasoning and relative strength. These qualities helped in avoiding the possible problems of water absorption leading to rupture and ocassional dimensional changes.

## 4.5 Results of Secondary Clay Test

The secondary clays used for the study were subjected to various property tests like plasticity, shrinkage and colour tests, providing the following results.

a. Plasticity Result

All the clays (Kudingi clay, Bomo clay, Tasar Dauda clay and Okelele clay) were found to be plastic enough to serve as plasticizer in stone ware body preparation.

b. Shrinkage Results

The clays were tested for dry and firing shrinkage and they produced these results: Clay Test I had 17% shrinkage while Test II had 18% shrinkage. Others are Tests III and IV which had 17% and 15% shrinkage respectively.

Table 4.1: Clay Shrinkage Behaviour

| Clay Test No. | Plastic Length | Dry Length | Dry Shrinkage Percentage | Fired Length | Fired Shrinkage percentage |
|---|---|---|---|---|---|
| 1. | 10 cm | 9.3 | 7.0 | 8.3 | 17 |
| 2. | 10 cm | 9.02 | 9.8 | 8.2 | 18 |
| 3. | 10 cm | 9.3 | 7.0 | 8.3 | 17 |
| 4. | 10 cm | 9.55 | 4.5 | 8.5 | 15 |

Source: Studio Tests, 1991.

c. Colour Test Results

This test showed that Okelele clay and Tasar Dauda clay produce buff and very light pink colours after firing to 950°C respectively, while Bomo clay and Kudingi clay emitted dark pink and light pink colours respectively under the same firing temperature and kiln atmosphere. Table 4.2 gives further details:

Table 4.2: Colour Behaviour of Some Selected Secondary Clays.

| S/No. | Location of Secondary clay | Colour when Raw (Green ware) | Colour when fired to 950°C | Position in terms of Brightness after firing. |
|---|---|---|---|---|
| 1. | Kudingi, Zaria | Brown | Dark pink | 4th |
| 2. | Bomo, Zaria | Dark grey | Light pink | 3rd |
| 3. | Tasar Dauda, Zaria | Brownish grey | Very light pink | 2nd |
| 4. | Okelele, Ilorin | Very Dark grey | Buff | 1st |

Source: Studio Test, 1991.

## 4.6 Results of Clay Body Tests

Several Clay body tests were conducted, which proved suitable for producing jiggered or jolleyed wares. Two of them were picked for production because of their extreme colour differences and stone ware consideration. The extreme colour differences provided a forum for marbling naturally coloured bodies to produce agate marbling. Body I containing 35% of Kankara Kaolin and 65% of Kudingi clay produced a pink colour after firing while Body II which contained 65% Kaolin and 35% of Tasar Dauda clay produced a contrasting colour of 'bright buff' or 'dirty white' after firing.

Body III produced a milky white colour as well as a clear ringing note, indicative of porcelains. It contained 25% of each of Kankara Kaolin, Okelele clay, Okene Feldspar and Okene Quartz.

Marbling of Body I with Body II or III produced clear-cut difference in surface colouration, where Glaze I(water clear transparent glaze) was applied. An obscure or sub-dued effect was obtained where Glaze II (mottled transparent glaze) was applied.

While Bodies I and II could be used for production on the mould as a slug, Body III was only workable when used in the form of 'liners.'

The soaking and hand-mixing of body materials used by this study as against the machine processes advocated by Nelson (1978) and Okwor (1990) did not produce any negative results in the working properties of the bodies.

'Solid slip agate' or 'marbling' has been found to produce blotting in the areas of high oxide presence, when subjected to high stone ware temperature. Conversely, this tendency was absent in wares with liquid slip application.

## 4.7 Results of Slip Tests and Application

The base slip (Slip I) produced a bright buff colour when fired which according to Barford (1963) and Bunn (1978) is a good substitute for white slip. Coloured slips were formulated from addition of specific amounts of oxides to the base slip.

### Result of Dark Blue Slip Test (Slip II)

Twelve tea-spoonful of cobalt for making 3 litres of dark blue slip suggested by Barford (Ibid) could only produce a medium blue effect when marbled with the base slip. The intensity of the slip was high when applied alone on a bright stone ware body (Body I), and highest when applied on a dark stone ware body (Body II). It was believed that an upward review of the number of table spoonful of cobalt is necessary if darker tones of blue are needed, or darker bodies have to be used. **It will also depend on kiln atmosphere.**

Result of Black Slip Test (Slip III)

Fifty-four tea-spoonful of manganese dioxide and twelve tea-spoonful of cobalt for making 3 litres of black slip, suggested by Barford(Ibid) was found to produce dark green effects. It was also believed that an introduction of twelve tea-spoonful of Iron Oxide is necessary to bring about, black colour.

Result of Red-Brown Slip Test (Slip IV)

This slip was made by an introduction of 12 tea-spoonful of Red Iron Oxide to a base-slip. It had red colour at the green and bisque stage. The colour turned reddish-brown after a glaze firing to 1280°C.

Result of Purplish-Brown Slip(Slip V)

This slip composed of Bomo clay, Zaria Feldspar Red-fired Brick grog and Iron Oxide, and it produced a purplish brown colour at green stage. The colour turned to dark brown in most cases and dull black in some few places when fired under transparent glaze to 1280°C.

Results of Slip Application Tests

Generally, colour difussion was observed to have occured slightly in stone ware pieces having wet slip application, while it greatly affected all the porcelain pieces coated with wet slip. The same feature was

observed to have characterised porcelain wares made of partially mixed body and plastic slip.

Blisters were also noticeable with areas of high oxide deposite in porcelain and plastic slip marbling. Stone ware bodies marbled with plastic slip produced a relatively stable colour effect. (Appendix III, Plate V).

## 4.8 Result of Tests on Production Techniques.

Two different techniques were adopted for production and each of the techniques had its own effect on the marbling result. Those techniques were: (1) slug and (2) liners. The direct use of partially mixed plastic slip and clay body on the mould produced sporadic colour patches on the surfaces of the wares borne by the moulds; i.e. concave sides of the plates or the convex sides of the dishes. However, it is important to note that while the colour result is prominent all over the concave surface of the plate, it can only be noticed in the areas around the foot rings of the convex surfaces of the dish.

With the use of 'clay liners' produced from a partial mixture of 'plastic slip' and clay body, colour effects were found in spiral movement from

the areas around the foot rim to the top rim of the convex surfaces of cups and dishes. In plates, the spiral colour effects were noted to have started from the centre and moved to the top rim of the concave surfaces. (Appendix III, Plate VI and VII).

Wet slip application on a clay slug to be used directly to produce wares was found to be very unsuccessful. This was a result of the wares' inability to release from the mould, even after a long period of time. This is very uneconomical, as time is very important in industrial production. Apart from this is a serious disadvantage of having about 70% of works produced through this method cracking out of moulds, requiring some extra time and effort for mould cleaning before any further use. Wares that survived mould release had wrough concave or convex surfaces and were still susceptible to cracks during firing.

## 4.9 Findings

On the basis of the results of experiments carried out in this research, the following observations were made:

1. Plaster to water ratio of 130:100 is ideal for making moulds meant for jigger-jolley production while 140:100 ratio of plaster to water is suitable for joining such moulds made in pieces.

2. Jigger-heads or jolley-heads made with 140:100 ratio of plaster and water, and those made with 150:100 ratio of the same materials can be used as suitable substitutes for metal jigger or jolley heads, provided that suitable metal spindle attachments are embedded at the central points of the base of the heads.

3. Plaster turning and shapping on a throwing wheel has been found to produce suitable moulds for successful jigger-jolley processes.

4. Buff-firing slip can be produced entirely from locally sourced raw materials without an addition of any industrially processed chemical.

5. The production of a dark blue slip requires more than 2 tea-spoonful of cobalt for 8 pints of white slip(12 tea-spoonful for 3 litres) as opined by Barford (1963). This amount of cobalt was only able to produce medium blue effects in 'liquid slip marbling' while it produced light blue in 'solid or plastic slip marbling'. An introduction of 18 tea-spoonful ~~of~~ to white slip will produce the required dark blue effect.

6. The black slip effect which Barford (Ibid) believed could be achieved by an introduction of 9 tea-spoonful of manganese and 2 tea-spoonful of cobalt to 8 pints of white slip (i.e. 54 tea-spoonful

of manganese plus 12 tea-spoonful of cobalt for 3 litres of white slip) ended up as green slip. An addition of 6 tea-spoonful of black iron oxide to this batch will produce the black effect.

7. Light application of the Red-brown slip on the surface of the ware produces the desired reddish effect. It is not advisable, however, to introduce this slip in solid or plastic form to the body because of the property of iron oxide as a strong flux at 950°C and above. Thick application produced colour ranges from deep brown to black under a water clear transparent glaze.

8. The purplish-brown slip was found to produce very dark brown and stable effect under glaze II (mottled transparent glaze) while it produced a range of light brown to blackish and diffused effect under glaze I (water clear transparent glaze).

9. Porcelain bodies with high potash feldspar (Okene Feldspar) are susceptible to warpage because of the high fluxing power ofOkene Feldspar, Umar, (1987). This weakness has to be compensated for by an additional introduction of more Quartz or silica to the body. The feldspar fluxing factor is further accelerated when oxides are introduced into such porcelain bodies in the form of plastic slip and body marbling, Bunn (1978). These have often caused

warpage, blotting and blisters on surfaces of wares made this way. These factors therefore, make surface slip marbling more advisable for porcelain wares than plastic slip and body marbling.

10. Opacifiers like Bauxite and or Zirconium silicate need to be introduced in specific proportion to the slip meant for porcelain marbling in order to improve the refractoriness of the slip.

11. Naturally coloured clays (especially stone ware bodies) produce more stable colour effects under ordinary stone-ware and porcelain condition.

12. Oxide-coloured body marbling or surface slip marbling will produce most reliable colour effects with earthen ware bodies and glazes. This is because of their relatively low maturing temperature, at which point, most of the oxides might have not lost their original colour quality through volatilization normally caused by high temperature firing.

13. True or near to true colour effects were more obtainable from single or light dipping of Glaze I (water clear transparent glaze) than from light dipping of glaze II. Glaze II had brown or dark specks deposits on the surface of the ware, leading to partial opacity which tended to conceal the actual behaviour of the slips, whether thinly or thickly applied.

14. To foster an aeeelerated production of marbled porcelains, organic binders like tannic acid and or bentonite has to be introduced to the body.

15. Flexible soldering wires have been found to be very useful in taking the cross-sectional impression of clay models, thereby, making a template making exercise a simple one.

16. Well seasoned, flat and planed mahogany wood have been found to be very suitable for making functional and durable templates.

17. Local production of colouring oxides in Nigeria will encourage the production of marbled wares and make them affordable to consumers at cheap prices.

18. In confirmation of Singer and Singer (1963) the production of plate with the jigger machine using a porcelain body was completely impossible. It is envisaged that it may be workable if plasticizers are introduced to the body.

19. Slip marbling (at low consistency level) was found to be more successful on the concave than on the convex sides of jiggered or jolleyed wares while plastic (solid slip or slip at high consistency) was found to be more successful on the convex sides of jolleyed wares (dishes and cups) and the concave sides of jiggered wares (plates) respectively.

# CHAPTER FIVE

# SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Introduction

Based on the confines of the limitations of this study, the purposes of this study were centred on the production of marbled wares using the jigger-jolley techniques. This chapter however, encompasses the observations made on the basis of various experiments carried out in the course of the study towards the achievement of the set objectives (purposes) of the study.

## 5.2 Summary

Prior to commencing research into the production of marbled wares using the jigger-jolley techniques, pilot studies were conducted through the use of facilities available in some research institutes in Nigeria, such as the Projects Development Institute, Enugu and Federal Polytechnic Auchi, Edo State. Raw materials for body formulation, slip formulation, mould making and templates were procured, beneficiated and tested to determine their suitability and reliability based on the provisions of the available literatures and the pilot studies conducted. Production techniques were also tested, based on the

utilization of bodies and slips under various application conditions. These were necessary to determine the level of suitability or otherwise of various materials and techniques put to test, with a view of making resolute recommendations, predictions or adjustments where necessary.

Some of the raw materials used such as kankara kaolin, Okene feldspar , Okene Quartz and Okelele secondary clay proved suitable for porcelain production with on-the-ware slip coating rather than with plastic slip marbling through partial wedging before jolleying. Jiggering was however, found impracticable (whether with slug or liners) when porcelain body was used. Conversely, the two techniques were practicable for jiggering and jolleying with stone ware bodies under 'slug' and 'liner' conditions. Plastic marbling of slip and body were also very successful with stone ware bodies.

Clear and mottled transparency were obtained from oxidized firing using electric and kerosene fuels for firing the wares separately coated with the two different transparent glazes used.

Plaster to water ratios of 130:100, 140:100 and 150:100 were used in mould making and in the improvisation of jolley-head; and they were found to be very effective for the various purposes they were

adapted. Seasoned mahogany wood was used for making templates which provided fruitful results.

## 5.3 Conclusions:

On the basis of results obtained from various tests carried out in the study, the following conclusions were drawn:

1. The materials used in formulating each of the bodies and slips, if beneficiated and utilized in the manner stated by this study will produce consistent result.

2. Colour stability of slips can be enhanced by introducing in specified limits, some quantity of zirconium silicate or other opacifiers into them.

3. Except in case of specific colour effects that require the formulation of coloured slips, body marbling and high consistency viscous white slips for the purpose of marbling can be made using entirely local raw materials.

4. The porcelain body warpage can be over-comed by reducing the amount of Okene (potash) feldspar in the body and increasing the amount of silica (Okene Quartz) in the same body.

5. A higher amount of plasticizer (that may not introduce colour to the body) will foster the

possibility of jiggering plates and flat dishes with the machine.

6. A mannually mixed clay body (provided that it is thoroughly and homogeniously mixed) can serve as a workable substitute for jigger-jolley production without necessarily passing the body materials through the machine processes upheld by Nelson (1978), Singer and Singer (1963) and Okwor (1990).

7. Rather than using the widely acclaimed plaster turning method of using lathe (French 1972), effective moulds could be made on the potters' throwing wheel.

8. Durable and workable templates could be made after making clay models of designs meant to be jiggered or jolleyed.

## 5.4 General Recommendations:

Table ware production through studio craftsmanship has dominated the Nigerian pottery industry up to the recent times. When industrial techniques were introduced the few organizations involved in this industrial processes are lossing touch with creativity in terms of surface treatment. Where surface decorations were employed at all, they were so repetitive and stereotyped that they lacked the dynamism of individuality, uniqueness or creativity. Studies

into the fussion of studio and industrial techniques are necessary so as to serve as an eye opener to further possibilities in table ware production. Other recommendations made by this study are:

1. The University authority should make more reading materials available in the area of industrial ceramics, as current books and journals in this area are so minimal.

2. The authorities should make provision for equipment and tools that will enhance quantitative and qualitative production of ceramic wares that will meet international standards as well as producing varied range of products. Among such basic equipment are pressure dryers, vertical and horizontal jigger machines, felt machines, humidifiers, viscometer electron magnet, etc.

3. A closer link between ceramics and pure science is advocated by this study. This development should lead to studying geology, chemistry and physics as they relate to ceramics, with a view of improving the bodies and glazes used at the moment. Also, more materials should be made available to researchers in ceramics.

4. Wealthy individuals and corporate bodies as well as professional institutes should be encouraged

to sponsor researches into ceramics and ceramic related fields of study

5. The Federal Government should establish a National Institute for Ceramic Research to explore and exploit ceramic raw materials; process, formulate and produce multi-dimensional ceramic products, ranging from domestic, architectural, technical, technological to nuclear applications. Onaji (1984) stated that various ceramic research institutes abound in America, and that India established a Ceramic Research Institute as far back as 1948. Nigerian steel workers are known to receive training in India on Refractories.

## 5.5 Recommendations for Further Research:

The following areas are recommended for further research in the production of marbled wares using the jigger-jolley techniques and other industrial methods.

1. The need to explore, identify and utilize very plastic bright firing secondary clay as component material in porcelain and white ware production.

2. There is the need to study the chemical properties of Okene Feldspar, Okene Quartz and Okene Limestone because of their strategic importance to ceramic researchers and industrialists in Nigeria.

It is also necessary to undertake comparative studies of these minerals from other geographical locations in Nigeria so as to ascertain the substitutional potentials of the minerals.

3. The design and production of marbled jigger wares that have accessories like knobs, handles sprigged decorations, etc.

4. The utilization of screen printing and photo-sensitized processes in the execution of marbled decoration on jigger-jolley wares.

5. There is the need to study, design and construct horizontal and vertical jigger or jolley machines for the use of manual operators.

6. Investigation into the production of marbled wares using differently coloured slips through the moulded slip casting technique.

7. The possibilities of producing jiggered electric porcelain from suitably formulated bodies using the horizontal jigger machine.

8. Design and utilization of suitable raw materials for the production of special refractories for mass packing of flat wares - plates, saucers and dishes within a limited kiln space.

9. Investigation into case-mould making for the mass production of jigger-jolley moulds.

10. Utilization of low temperature body and glazes for the production of marbled wares using the jigger-jolley techniques.

REFERENCES

Adetoro, S.A. (1986): Research Techniques for Projects Proposals, Reports, Thesis and Desertations. Gaskiya Corporation Limited, Zaria, Nigeria. (pp. 1 - 99).

Baker, D.V. (1961): Pottery Today: Oxford University Press, London. (pp. 81 - 113).

Barford, G. (1963): Clay in the Classroom: a means to creative expression. Worcester: Davis Publication (pp. 5 - 118).

Bunn, R. (1979): Pottery and Ceramics. A Wheaton Company Ltd. Exeter, Great Britain. (pp. 10 - 100).

Cardew, M. (1963): Pioner Pottery. Longman Group Limited, London. (pp. 6 - 55).

Conrad, J.W. (1980): Contemporary Ceramic Formulas. Macmillan Publishing Co., Inc. 866 Third Avenue, New York. (pp. 34 - 37 and pp. 151 - 169.

Ewule, E.E. (1990): The Ceramic Stains: Colours from Nigerian Raw Materials (A case study of Zaria and its Environs). An unpublished M.A. Thesis.

French, N. (1972): Industrial Ceramics - Table Ware. Oxford University Press, Ely House, London W.I. (pp. 13 - 33 and pp. 42 - 45).

Grebanier, J. (1975): Chinese Stone Ware Glazes. Sir, Isaac Pitman & Sons Ltd, 39, Parker Street, London WC 2B, 5PB, Great Britain. (pp. 38 - 96).

Gukas, H.J. (1985): Feasibility Studies for Formulating Some Porcelain Bodies From Raw Materials in Kaduna State. Unpublished M.A. Thesis, A.B.U., Zaria.

Hamilton, D. (1978): The Thames and Hudson Manual of Architectural Ceramics. Cox and Wyman Ltd., London, Great Britain. (pp. 66 - 157).

Harmer, F. (1975): Potters' Dictionary of Materials and Techniques. Pitman Publishing, 39, Parker Street, Kingsway, WC. 2B. 5PB.

Hughes, G.B. (1977): The Country Life Collector's Pocket Book. Hamlyn Publishing Group Limited, Astronaut House, Feltham, Middlesex, England. (pp. 80 - 129).

Ibe, R.C. (1990): Artisan, Instructor and Mould Maker, Projects Development Institute, Enugu, Enugu State, Nigeria.

Leach, B. (1976): A Potter's Book. Faber and Faber Ltd., England. (pp. 74 - 242).

Nelson, G.C. (1971): Ceramics - A Potter's Handbood Presses Centrales, Laussane, Switzaland (first print). (pp. 249-256, pp.299-234).

Nelson, G.C. (1978): Ceramics - A Potter's Handbook. R.R. Donneley and Sons Company, New Jersey, United States of America. (pp. 256 - 257).

Northon, F.H. (1956): Ceramics for the Artist Potter. Addison - Wesley Publishing Company, Inc., Cambridge, 42, Mass. (pp. 31 - 48).

Okoruwa, P.E. (1986): The Utilization of some Selected Raw Materials for Porcelain Slip Casting of Moulded Ceramics. An Unpublished M.A. Thesis, Ahmadu Bello University, Zaria, Nigeria.

Okwor, C. (1990): Artisan, Instructor and Clay Maker, Projects Development Institute, Enugu, Enugu State, Nigeria.

Onuora, N. (1990): Artisan, Instructor and Jigger Operator, Projects Development Institute, Enugu.

Pottery Crafts Catalogue (1989): Pottery Crafts Ltd., Campbell Road, Stoke-on-Trent ST4 4ET., London.

Singer, F. and Singer, S.S. (1963): Industrial Ceramics. Chapman and Hall Limited, 11, New Fether Lane, London, EC.4. (pp. 97 - 291, 465 - 1180).

Sulaymam U.A.A. (1987): Report on Industrial Attachment at the Industrial Development Centre (I.D.C.) Zaria and Basawa Industries Ltd., Zaria, Nigeria (September - October, 1986). Unpublished B.A. Industrial Training Report.

Uduigwome, G.E. (1989): An Inquiry into Selected Local Raw Materials for the formulation of Electric Porcelain body in Nigeria. Unpublished M.A. Thesis, Ahmadu Bello University, Zaria, Nigeria.

Umar, A. (1987): Utilization of Selected Local Raw Materials in the Production of Bone China. A Seminar Paper Presented to the Department of Industrial Design, Ahmadu Bello University, Zaria, Nigeria.

Waye, B.F. (1967): Introduction to Technical Ceramics. Malaress and Sons Limited, London. (pp. 15 - 95).

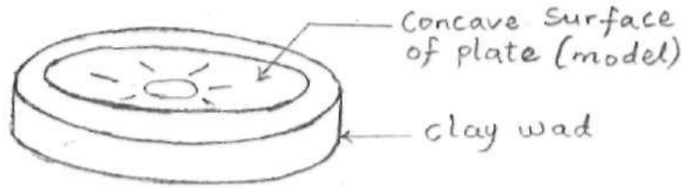



Fig.5: Plate sunk into a clay wad.

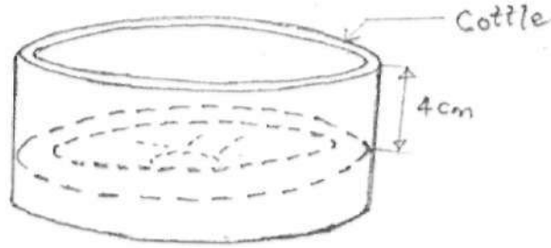



Fig. 6: A cottle banded onto the clay wad.
(First piece of a plate mould).

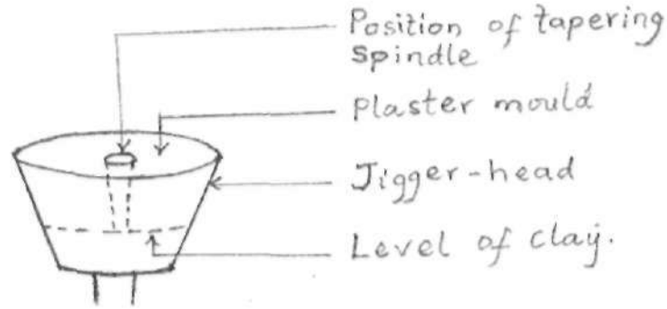



Fig.7: Second piece of a jigger mould casted in a metal jigger-head.

APPENDIX I

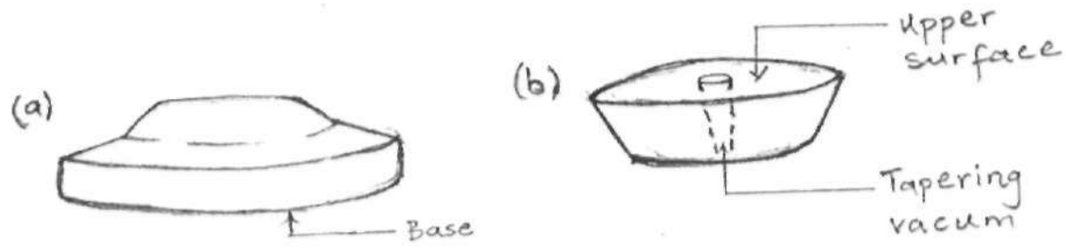



Fig.8: Unjoined pieces of a plate mould.

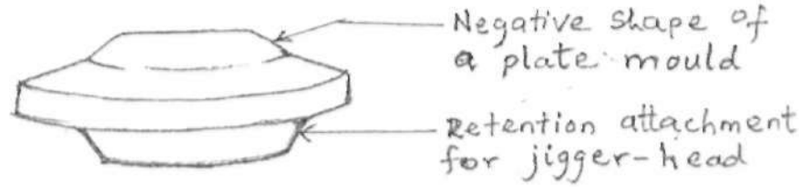



Fig. 9: A completed plate mould.

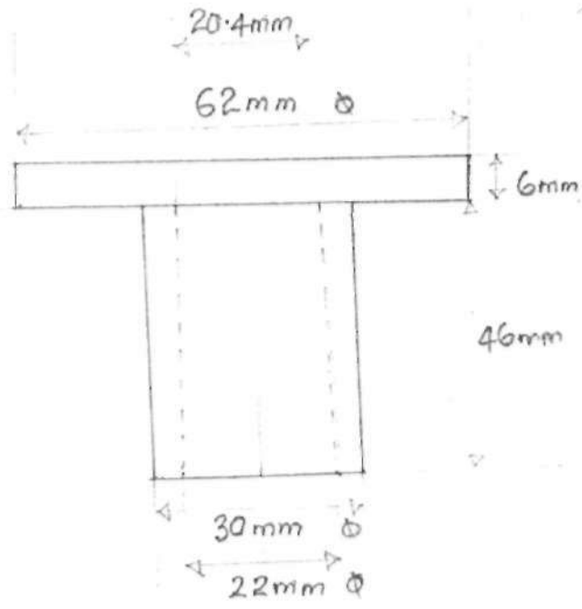



Fig.10: Cross-sectional view of a metal bearing.

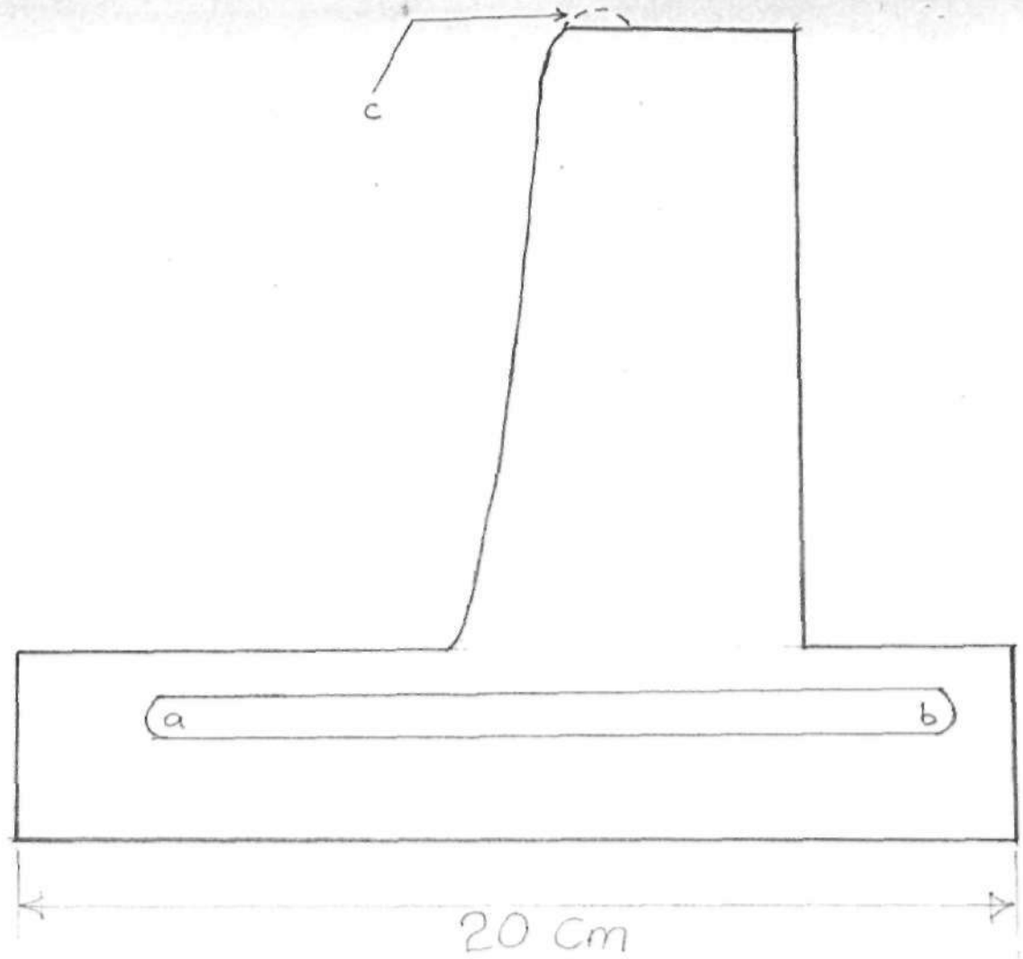



Fig.11: Side view of Cup template.
Note: The spaces between 'a' and 'b' in figures 11, 12 and 13 are carved out hollows that provide points of attachment between the templates and the jigger machine. The broken lines marked 'c' in figure 11 and 12 show foot rim sections cut away to avoid furrows.

APPENDIX I

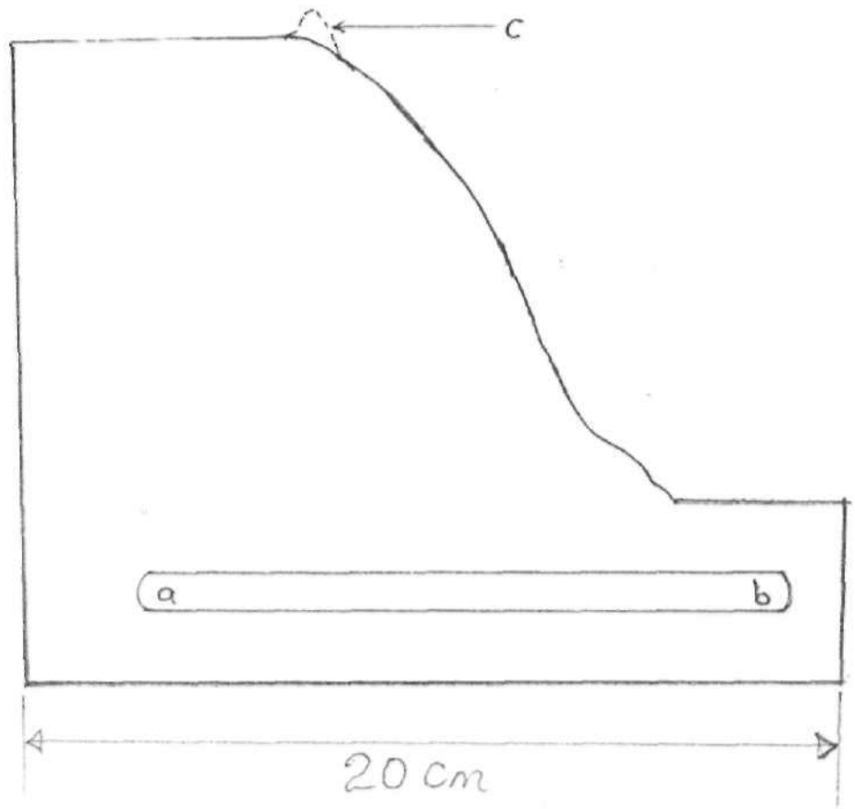



Fig.12: Side view of Dish template.

APPENDIX I

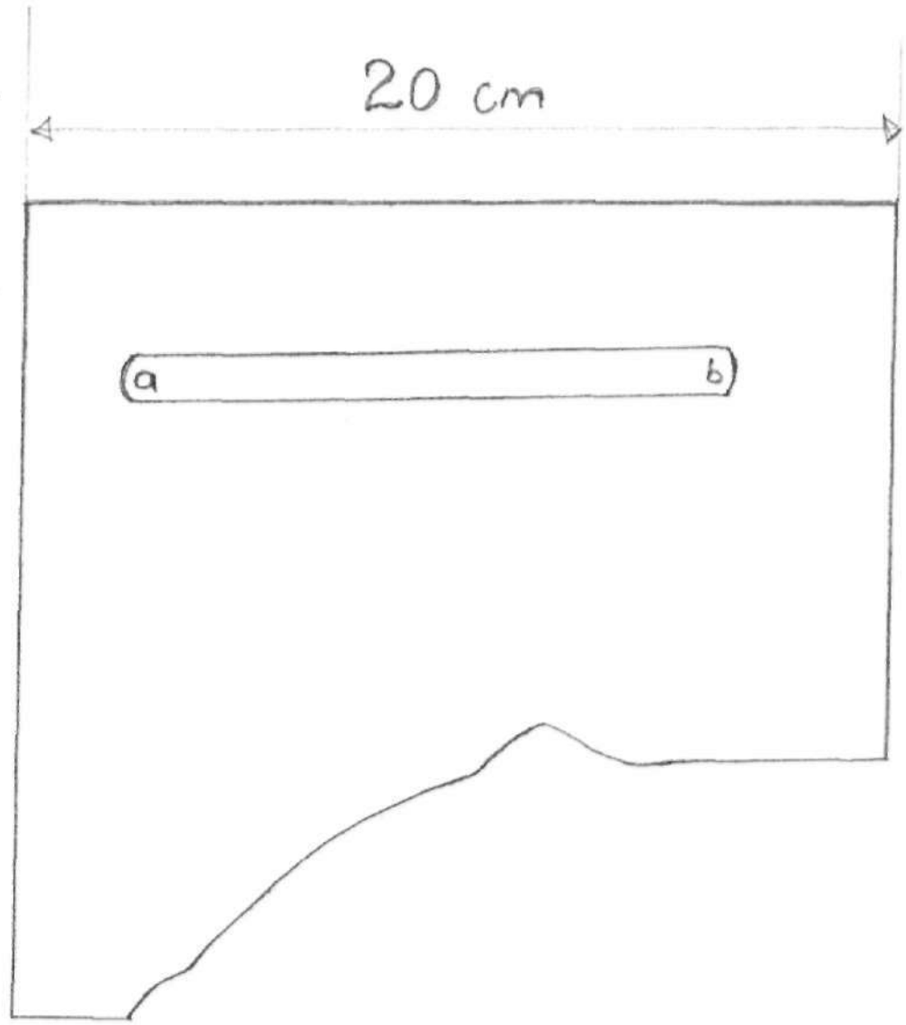



Fig.13: Side view of Plate template.

APPENDIX II



e I: Completed set of Dish, Cup and Plate Moulds.



teII: Improvised plaster jolley-head.

APPENDIX II



late III: Side views of Dish, Plate and Cup Templates.

# APPENDIX II



Plate III: Side views of Dish, Plate and Cup Templates.

# APPENDIX III

Plate IV: Pre-fabricated Metal Case-mould.

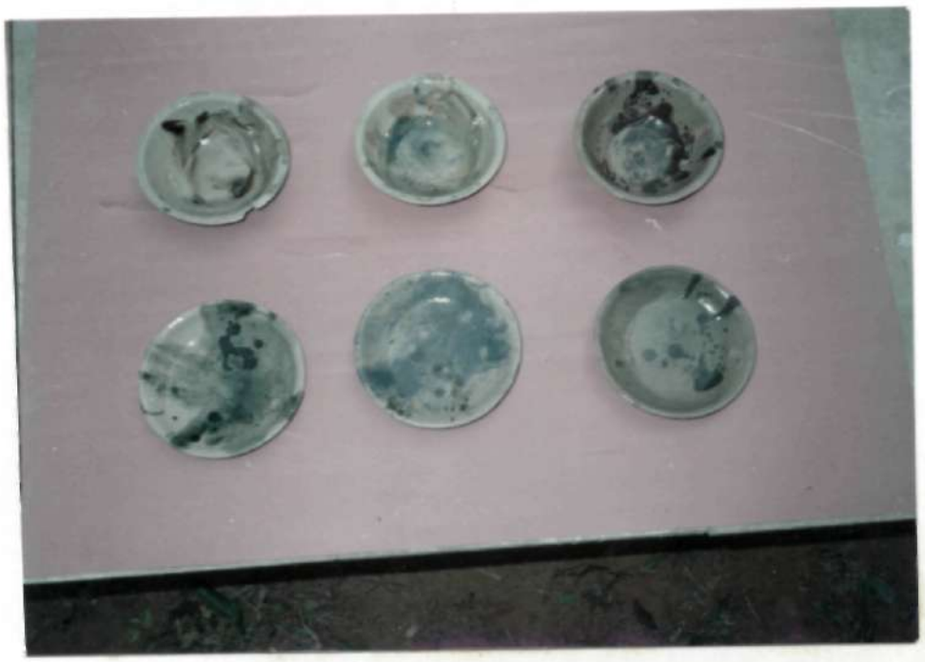


Plate V: Results of Viscous slip application tests.

APPENDIX III



Plate VI: Results of Plastic slip application tests.



Plate VII: Results of Plastic slip application tests.

APPENDIX III




VIII:The Researcher in a Practice Session.