Processing Ceramic Wastes Into Workable Casting Slip

Osariyekemwen, D. N., Kalilu Rom, R.O.

Abstract
The most known and used universally for industrial ceramic mass production is casting slip with help of Plaster of Paris mould. The raw materials for this casting slip are clay, feldspar and flint sourced from natural raw materials at various locations. This study has been able to reduce the need for searching for ceramic raw materials from various locations before use by processing sanitary ware wastes and ball clay into ceramic workable casting slip because sanitary ware wastes consist of the required body constituents and ball clay has adequate plasticity. Line body compositions A-J both in percentages and batches were formulated and tested for suitability for use. Test results conducted confirmed that sample E and F are best suitable for production because of the adequate and moderate plasticity, shrinkage, mechanical strength and vitrification. It is recommended that body composition from ceramic wastes are best suitable for ceramic production because all the constituents in the sanitary ware wastes have undergone firing before and so subjecting same for second firing will not result to major firing casualty.

Introduction

Ibude, Otimeyin and Osariyekemwen (2012:1) citing Norton (1974), defined ceramics as a field primarily concerned with the treatment of non-metallic minerals by various processes including the application of heat aimed at producing articles with aesthetic and utilitarian properties, such items can be found everywhere; glass in windows, tiles and plumbing fixture in the bathroom, table ware in the dining room, bricks in building walls and the fire places, asbestos roofing sheets and cement in the collar floors including electrical porcelain and other refractory products. Summarily, ceramics raw material is simply defined according to Otimeyin (2015:1) as the application of heat on any earthly raw material and such earthy material could be clay, sand, limestone, feldspar, coal, granite, gypsum etc, but of all these clay is by far the most widely used and most salient.

It is pertinent to note here that, ceramics production is incomplete until it passes through heat treatment which transforms the clay and clay related materials from the natural state into a rock like, irreversible and impervious to water. (Osariyekemwen (2015:2). Most of the major ceramics raw materials in use in Nigeria today are sourced from their natural places of origin and processed to have ceramic products. Raw material development is nonetheless critical to the success of the ceramic sub-sector of the nation's economic and industrial growth. Ceramic raw materials are earthly raw materials which may be principally clay or mixture of suitable materials for body and glaze compositions. The possible body composition ingredients are kaolin, ball clay, grog, feldspar, flint, quartz and bentonite, while that of glaze composition includes basic oxides, acidic oxides and amphoteric oxides. .(Osariyekemwen (2015:2). One of the principal materials for ceramic production is

[1]Department of Ceramics, School of Art and Design, Auchi Polytechnic, Auchi
[2]Department of Fine and Applied Arts, Faculty of Environmental Sciences, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

clay, which when fired becomes rock like and when crushed into powder it becomes grog. Grog itself can be recycled and added to a ceramic body as filler. This is why Olatunji (2011: 7) said that:

> Clay body simply means the process or processes of mixing different clay together to suit the particular needs or requirements of a ceramist. A typical clay body might contain china clay, ball clay and flint. Too much ball clay may make the clay to be more plastic but may make it to shrink too much and warp in the Kiln in the process of firing. But, an increase in the silica will make the body more refractory, and it can with stand a higher temperature. Among the ceramic bodies formulated from clay as principal materials are, earthen ware bodies, stone ware bodies, and porcelain bodies.

Olatunji (2011: 7) describes earthenware as:

> Is a mixture of clays and clay materials which may mature at around 1150^{o}C and still porous. It does not hold liquid especially water unless glazed fired. The colour usually is buff, red or white. When fired beyond its temperature it will begin to melt or liable to crack. He went on to say that: stone ware body is a high fined body hard vitreous body. It is a mixture of clay and materials like feldspar which serves as a fluxing material. It matures at about 1250^{o}C produces dense non porous vitrified pottery. While porcelain bodies is the highest body in terms of temperature, this body that requires a high firing temperature.

Bone ash and feldspar for bone China or porcelain and fieldspar for the porcelain bodies produce dense non – porous verified potter (Olatunji 2011:8).Similarly, grog is formulated from clay. It is a product of fired art work ground into powder. Grog is to prevent warping and cracking of a piece of ceramic wares during drying and firing. When added to clay it provides openings through which moisture can escape easily without any harm done in to the ware.

Methodology and Production Steps

Formulation and Test on Body Sample Compositions

After carrying out the milling of the ceramic waste, including ball clay, elemental and sieve analysis tests were carried out on the materials. Thereafter the formulation test on the body compositions using the line blending method on samples A to J with the use 100% of waste in the composition of sample A, while others bodies were compounded with the milled waste and ball clay at different percentage level. The purpose of these compounded body compositions was to enable the researchers perform further tests such as plasticity, shrinkage, tensile strength and porosity so as to justify and select the most efficient composition for the reproduction of new ceramic items. The line blending percentage (%) composition test samples A to J is stated in table 1 below.

Formulation of % Line Blending Test Samples Compositions

	SAMPLES									
Material	A	B	C	D	E	F	G	H	I	J
Ball clay	0%	05%	10%	25%	20%	25%	30%	35%	40%	45%
milled ceramics wastes	**100%**	**95%**	**90%**	**85%**	**80%**	**75%**	**70%**	**65%**	**60%**	**55%**
total of body composition	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 1: Presents the % test samples compositions

For the purpose of making sample tests into compositions for easy batching and weighing, the various composition were converted into weight (grams) as presented on table 2.

Formulation of Line Blending Batch Test Samples Compositions

	S A M P L E S IN GRAMS									
Material	A	B	C	D	E	F	G	H	I	J
Ball clay	0	05	10	25	20	25	30	35	40	45
Milled ceramics wastes	100	95	90	85	80	75	70	65	60	55
Total of body composition	100grm	100 gram	100	100	100	100	100	100	100	100

Table 2: Presents the line blending batch test samples compositions for weighing

After the formulation of % test samples compositions, the % compositions were converted into 100 grams batches. After weighing samples compositions into batches A-J adequately in order to determine the suitability of the data collected for formulation of body compositions for use, hence the following tests were carried out on them chronologically, the tests are: plasticity, shrinkage, porosity and tensile tests.

Plates 1-3 illustrate how the test Compositions were formulated with milled ceramic wastes and ball clay. This was done in order to select the final suitable body composition both at the physical drying shrinkage, plasticity state and verification state with the aid of electric test kiln in Ceramic Department, Auchi Polytechnic, Auchi, Edo State.



Plate 1: Weighing of test sample compositions into batches



Plate 2: The proper weighing of test sample compositions with Bean Balance



Plate 3: Application of water for plastic mix of test sample compositions



Plate 4: Mixing of test sample compositions with Finger

Plasticity Test

Plasticity is a very important property required by clay body to be deformed continuously under a force so as to make the clay body to retain a new shape when a deforming force is removed. All clay bodies contain some degree of plasticity. Plasticity describes the ability of clay to undergo unrecoverable deformation at constant volume without cracking or crumbling. Plasticity is due to the presence of clay minerals or organic material, depending on its water content. A clay may exist in such consistency state as liquid, plastic, semi-solid or solid. In this test two moisture contacts are measured viz the (1).Liquid limit and (2).Plastic limit.

Liquid limit (LL) can be defined as the moisture content at which clay stops acting

as a liquid and starts acting as a plastic solid.

Plastic limit (PL) occurs when a more moisture is driven from the clay and exhibits no permanent deformation and simply fractures. So, it is the limit between plastic and brittle failure.
Shrinkage limits (SL). This is the limit between semi-solid state and solid state of the clay (or the water content at which the volume of clay reaches its lowest value as it dries out).

Apparatus

(1) Metal cups
(2) Pallet knife /spatula
(3) A distilled water bottle
(4) Bean Balance scale

Sample A – J were put into different metal cups and were weighed as 20grams and were noted as dry weight (DW1) A little distilled was added until they were mixed samples A – J to homogenous paste and the weight were noted as wet weight (WW2) see plates 64 through 67. **Note:** It is pertinent to note here that samples A – J initial dry weight were 20grams respectively before water was gradually added to them in order to make the samples pasty

Plasticity Formula

$$\frac{WW2 \quad DW1}{DW1} \quad \frac{100}{1}$$

Where: DW1 = Dry weight of sample
WW 2 = Wet weight of sample
Source: (Rhodes 1996: 310)
Calculated results of plasticity are tabulated below

Procedure

SAMPLES	DW 1	WW 2	% PLASTICITY
A	20 grams	26 grams	30%
B	20 grams	26 grams	30%
C	20 grams	28 grams	40%
D	20 grams	28 grams	40%
E	20 grams	29 grams	45%
F	20 grams	29 grams	45%
G	20 grams	30 grams	50%
H	20 grams	30.5 grams	52.5%
I	20 grams	31 grams	55%
J	20 grams	31 grams	55%

Table 3: Shows the calculated results of plasticity test of sample A-J

Shrinkage Test

Furthermore the shrinkage in drying and firing of the prepared body composition A – J sample have to be established accurately in order to select the most suitable body composition for the final production from ceramic waste compositions. Shrinkage in clay body occurs during drying and firing. Generally, good clay body shrinkage ranges from 5-12% in drying stage, with 8-12% shrinkage after firing with a total shrinkage of at least 13%. (Rhodes, 1996:310, Glenn 1984:13).

and the dry length were taken and noted to determine the shrinkage that occurred during drying. Again the dry slabs were

Apparatus

1. Slab guides and rolling pin
2. Ruler
3. Knife
4. Kiln
5. Weigh balance

Procedure

The various samples A – J were accordingly mixed into a plastic mass. There after each sample was pressed into slab as shown in plate 6 with two vertical lines of 8cm a part mark on the surface of the test pieces (slab). After which the slabs were left to dry in an open air drying method within room temperature for about 24 hours taken into the kiln and were fired to 1200°C and left to cool down for 6 hours and the two vertical lines on the surfaces of the test

slabs were measured in order to determine the firing shrinkage. See plate's 5-9 spectively.



Plate 5: Marking out of slab guards for making of test slabs



Plate 6: The process of making of test slabs from composition A-J



Plate 7: Produced test slabs from composition A-J



Plate 8: The process of drying the produced test slabs from composition



Plate 9: The fired test slabs from composition A-J at 1200°C in a test Kiln

Formula

% Drying Shrinkage =

$$\frac{Wet\ Length \quad Drying\ Length}{Wet\ Length} \quad \frac{100}{1}$$

% Firing Shrinkage =

$$\frac{Dry\ Lenth \quad Fired\ Length}{Dry\ Length} \quad \frac{100}{1}$$

% Total shrinkage =

$$\frac{Wet\ Length\ Fired\ Length}{Wet\ Length} \quad \frac{100}{1}$$

Source: Rhodes, 1996:311

Summary Table of the Calculated Shrinkage Test Results

Samples	Wet Length	Dry Length (120°C)	Fired Length (1200°C)	Total % Length
A	8cm	8	8	0%
B	8cm	7.9	7.8	2.5%
C	8cm	7.8	7.6	5%
D	8cm	7.8	7.6	5%
E	8cm	7.7	7.5	6.3%
F	8cm	7.7	7.5	6.3%
G	8cm	7.6	7.4	7.5%
H	8cm	7.6	7.4	7.5%

I	8cm	7.5	7.3	8.8%
J	8cm	7.5	7.3	8.8%

Table 4: Presents the summary of the calculated shrinkage test results

Although all the samples verified very well, samples A – C were fragile to handle during production process. This is as a result of lack or less ball clay as plastic material in them. However, samples H to J shrinkages fell between 7.5% to 8.8% and these shrinkages ware in excess for productions when compared to others, because in Ceramics production, normal shrinkage for slip casting in ceramic production should be between 2% – 12%. Samples E and F fell within the mid range of 6.3% and therefore were selected as the best for the production because had have moderate shrinkage and the plasticity were enough for physical handling and also they vitrified well.

Porosity Test

Porosity test was carried out on samples after shrinkage test because of the importance. Porosity test which is also known as water absorption test, it helps to give information on the degree of water that penetrates into all open pores. Also porosity of a Ceramic ware directly related to the hardness and vitrification. Hardness and vitrification of Ceramic ware shows the level of maturity of a body or density of a ceramic body, because dense of a fired Ceramic body in often hard.

Apparatus

(1) Electric stove
(2) Cooking pot
(3) Weighing scale
(4) Slabs (specimen)

Procedure

The test slabs A – J were fired to the maturing temperature of 1200°C and were weighed as first weight. After which the slabs were put into the water in cooking pot for an overnight in order to allow them soak well as required in water. After overnight soaking, the samples were boiled in a cooking pot for four hours. After boiling period of four hours, the cooking pots were cooled down to a room temperature. After removing the adhering water from the surface of the boiling samples with a moist sponge, the samples were reweighed to determine the degree of water that penetrated into the pores. The reason for the boiling was to show the percentage gain in weight, which stands for the porosity of the samples. This process helped to determined the porosity of the boiled samples.



Plate 10: First weighing of the slabs (specimens) before soaking them in water



Plate11: The placement of slabs (specimens) into cooking pot for an over night soaking



Plate 12: Placed slabs (specimens) in a cooking pot being kept for an overnight soaking



Plate 13: The placement of cooking pot containing soaked slabs on electric stove



Plate 14: The boiling point of cooking pot for 4 hours of cooking pot on electric stove help to determine the how intect the samples were.



Plate 15: The cooling down of the cooking pot to a room temperature and thereafter the removal of the adhering water from the surface of the boiled samples with a moist sponge commenced and the samples were weigh to determine the level of water intake in the pores.



Plate 16: How the samples were reweighed in order to determine the degrees of water that penetrated into the pores



Plate 17: The reweighed samples kept in a plastic containe

Calculated Formula

The recorded fired weight and soak weight of the specimens were calculated with the following formular

$$\% \text{ water Absorption (WA)} = \frac{Soaked\,Weight \quad Fired\,Weight}{Fired\,Weight} \quad \frac{100}{1}$$

The table below showns the Porosity Test of Specimen A – J

The calculated Porosity Test of Specimen A – J results

SAMPLES	FIRED WEIGHT GRAMS	SOAKED WEIGHT GRAMS	TOTAL % POROSITY
A	77.5 grams	80.1 grams	3.3 %
B	77.5 grams	79.8 grams	3.0%
C	77.6 grams	79.6 grams	2.6 %
D	77.7 grams	79.6 grams	2.4 %
E	77.8 grams	79.5 grams	2.2 %
F	77.8 grams	79.5 grams	2.2 %
G	77.9 grams	79.4 grams	1.9 %
H	77.9 grams	79.4 grams	1.9 %
I	78.0 grams	79.2 grams	1.5 %
J	78.1 grams	79.2 grams	1.4 %

Table 5: Presents the porosity test of samples A – J Results

Modulus of Rupture Test

Modulus of rupture which could be called bending strength or tensile strength is a property that is very important in ceramic manufacturing industries because a well vitrifed ceramics tends to have high strength and well reduced brakages during handling and when put in use. The use of conpressive test machine at the Civil Engineering Department in Auchi Polytechnic, Auchi proved abortive, as the machine was designed for larger samples and as such the compressive impact reading became impossible. See plates 81 and 82.



Plate 18: Tensile strenght test
Source: Civil Engineering Department Auchi Polytechnic, 22, April 2014



Plate 19: The point of brakage
Source: Civil Engineering Department Auchi Polytechnic, 22, April 2014

However, the use of an altternative to carry out the tensile strength test (modulus of Rupture) on smaller item was used see plate 84 and 85.

Apparatus:

(1) Locally fabricated modulus of Rupture machine
(2) Loads of rapture
(3) Supports



Plate 20: Locally fabricated Modulus of Rupture Machine



Plate 21: Basket containing breaking load applied for MOR



Plate 22: Locally fabricated Modulus of Rupture Machine with load applied



Plate 23: Weighing of the basket containing load applied one slab for MOR test

Note any suitable method can be used, provided a uniform rate of direct loading can be maintained using the prescribed specimen. More so a regular weight increase/unit of the sample must be guaranteed.

Test specimens (A –J)
(1) 10 sample were controlled

Procedure
The samples A – J Specimens were placed on the two of the MOR edges see plate 86 with the specimen overlapping each end by a least 1cm. The load was therefore applied at the right angles on top of the loads support pan of the machine which has a midiray pencil like road between the supporting edges. The loads were applied uniformly at the approoximate rate of 1020kg/cm to 20kg/cm per second until breakage occurred.

The modulus of Rupture of A - J Specimens were calculated from the following formular

Modulus **=** $\frac{3PL}{2ab2}$

Where P = Load of Rupture
L = distance between supports
A = Width of specimen
B = Thickness of specimen
3 and 2 are constant

Source: Introduction to Industrial Ceramics by S.J.E Igbinedion 1995, Page 13

Note: The tensile strength test conducted on samples show that samples E and F respectively are best suitable samples for normal production. See summary result below table 10 below

Summary results of the tensile strength test conducted on samples

MOR Specimens	Fired Length cm	Fired Width cm	Fired Thickness cm	Breaking Load Applied Kg	Caclulated Results Kg/Cm2
A	8 cm	4 cm	1.5 cm	14.9 kg	19.9 kg/cm2
B	7.9 cm	4 cm	1.5 cm	15.6kg	20.5 kg/cm2
C	7.8 cm	3.9 cm	1.5 cm	16.2 kg	21.6 kg/cm2
D	7.8 cm	3.9 cm	1.5 cm	16.5 kg	22.1 kg/cm2
E	7.7 cm	3.9 cm	1.4 cm	16.8 kg	25.4 kg/cm2
F	7.6 cm	3.9 cm	1.4 cm	16.8 kg	25.5 kg/cm2
G	7.6 cm	3.8 cm	1.3cm	16.9 kg	30.1 kg/cm2
H	7.5 cm	3.7 cm	1.3cm	16.9 kg	30.4 kg/cm2
I	7.5 cm	3.7 cm	1.3cm	17.1 kg	30.8 kg/cm2
J	7.4 cm	3.6 cm	1.3cm	17.3 kg	31.5 kg/cm2

Table 6: Shows the result of the Tensile Strength (MOR) test

The Process of Preparation of Batch Compositions Casting Slip

The main objectives of this study are centered on the possibility of using recycled ceramic wastes from sanitary to reproduce new ceramic items. This was most achievable with the aid of studio application and material analysis. In furtherance to achieving this objective of this study, compositions E and F were adequately selected based on the initial tests carried out on the line blending composition tests of A to J.

Below is the chart of studio applications and materials analysis of the selected samples compositions E and F for slip casting preparation for use.

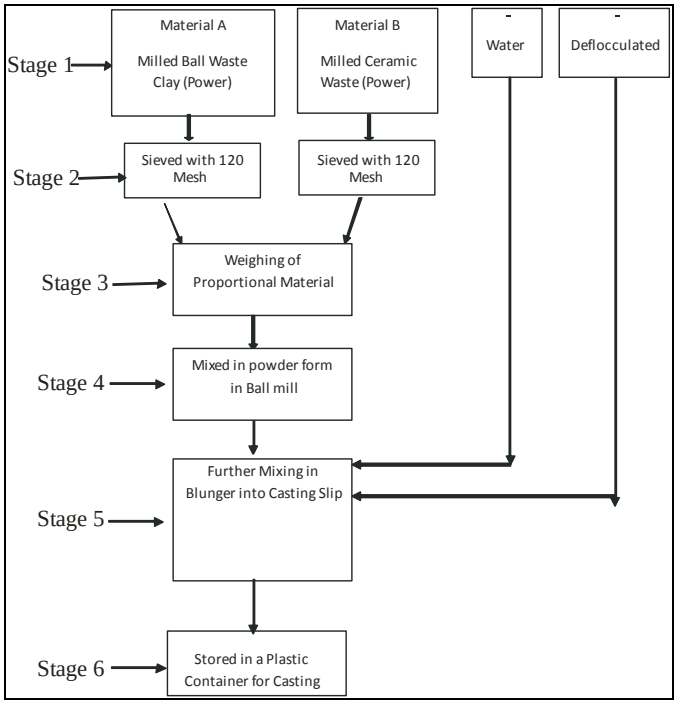


Chart 1: The process of body composition preparation for studio application

Materials A and B are milled ceramic (sanitary) waste and milled ball clay in powder form for final body formulation from sample E composition for the production of contact insulator fuse and sample F composition for the production of miniature sanitary ware. The reasons for the choice of these samples E and F compositions were based on the results of the chemical and physical tests carried on the materials A and B including the further tests conducted on the line blending of the samples A through J. The result of the tests carried out on the test samples show that samples E and F have adequate plasticity, physical strength, porosity, shrinkage and vitrified well within 1150^{O}C as required for production. Hence 20kg batch of compositions E and F were prepared for casting respectively. Find below the batch compositions of E and F adequately selected from the percentage compositions A-J

Composition E
Ball clay ---------- 4kg
Ceramic waste ---------- 16kg
TOTAL 20kg

Composition F
Ball clay ---------- 5kg
Milled Ceramic waste **----------** 15kg
TOTAL 20kg

The compositions E and F were weighed and mixed separately in a ball mill in the Ceramic Studio, Ceramic Department, Auchi Polytechnic, Edo State. The ball mill consists of a cylindrical steel drum which rotates horizontally. It is lined with hard porcelain blocks and it contains a charge of great number of porcelain pebbles of different sizes which rotates at a critical speed that enables the pebbles to continuously cascade against one another which in a part gradually reduces the ceramic wastes and ball clay to a finer particles and proper powder mixture. This process lasted about 3hours and 25minutes. The mixed powder compositions were then discharged from the Ball mill into a storage plastic container for blunging. The

mixed powder compositions were taken to the blunger to be mixed thoroughly into a casting slip with adequate water and deflocculant (sodium silicate).

This was done in the Ceramic Studio of Auchi Polytechnic, Auchi. This blunger has a hexagonal shape with a central vertical shaft aided with electric motor. Fitted to this shaft are blades or peddles. These were fastened at angles so that when the shaft rotates the paddles or blades force the mixture to mix homogenously. See plates 24 – 26. The procedure was that the required amount of water was first poured into the blunger and adequate defloculant was introduced into the water as a disperser that helps to keep the homogenous casting slip into suspension before the powder compositions E and F were introduced into the blunger as separate batches while the blunger was on motion with rotating blades. After blunging for about 2hours and 30minutes the homogeneous casting slips were brought out and kept in separate plastic containers in preparedness for casting. See plates 26 A & B.

The importance of using ball mill and blunger to mix these body composition E and F, is that, it helps to guarantee quality assurance of casting slip which includes the following according to Igbinedion (1995:64), is that a well blunged casting slip should have the following qualities: it must be pourable, must be able to fill the recesses of the mould, the particle must not settle out, the rate of casting must be high, but not so high as to make casting control difficult and there must be a sharp demarcation between cast and surplus slip and the latter must drain well. Also there must be a small drying shrinkage, enough to allow the cast to be retained on the mould but not enough to give warping and cracking during drying. The cast must be firm and sufficiently high green strength and the casting slip must not contain air bubbles which might subsequently appear as pinhole in the cast. Normally, the casting slip should contain as little water as possible to avoid excessive saturation of moulds and excessive drying shrinkage.

In the light of the above compositions, E and F were used as the final compositional bodies for the production of good casting slip. These are evidential going by the various results conducted on the sample compositions. The 20kg batches of sample E was used to cast the contact insulators fuse and composition F was used to cast miniature closets (WC), water tank and wash hand basin.



Plate 24:
Weighing ceramic waste powder for 20kg batch compositions E and F each for casting slip



Plates 25a, b, c and d:
The various stages of blunging ceramic waste powder and ball clay for 20kg batch compositions E and F each from above formulae for casting of slip



Plate 25 B



Plate 25 C



Plate 25 D



Plate26: The researcher watching the blunger progressive blending of the casting of slip



Plate26 A: The prepared batch compositions E and F casting slip in plastic containers Containers



Plate26: The prepared batch compositions E and F casting slip in plastic containers Containers

Casting Process

The casting commenced after the preparation of two different batch compositions E and F which were kept in two different plastic containers. Composition E was used for casting contact insulator because it has adequate plasticity that guarantees good of casting slip which can be controlled with sufficient high green strength of physical handling for solid casting while composition F has the same qualities and advantages but had more plasticity over composition E, thus makes it more viscous for pouring into the mould so as to fill the recesses of the mould and after attaining the required thickness, the latter slip can drain or pour out.

The casting process of miniature sanitary wares consists of the pouring in the casting slip into the Plaster of Paris mould and was allowed for about half an hour drying period of time. During this time, the physical water passed from the slip to the mould by an action, called capillary suction, leaving a thin layer of cast of about 0.5cm on the surface of the mould. There after the excess casting slip was poured out and the cast on the surface of the moulds were allowed to dry a little for about 10 minutes in order to permit sharp demarcation between cast and the moulds for easy removal. See plates 27 - 29. However, in the process of casting of the contact fuse, there was a slight difference in this case, the cast is solid cast. The slip was poured into the moulds, the whole of the casting slip in the moulds were allowed to form the solid cast. In this process there was no excess casting slip to be poured out rather the solid cast took about 1hour 30 minutes for each cast. The casting slip was continuously poured into the mould until the mould no longer accepts casting slip. Also, the period needed for drying of the cast in the mould before removal was about an hour which is higher than the casting of immature sanitary wares which is hollow cast.

In the process of the solid casting, the volume of physical water absorbing rate by the mould was much less than the total pore volume created in the casting mould hence creating an effective constant capillary suction occasioned by the suction pressure. During this time, the cast increases in thickness and there arises the resistance of the passage of water from the casting slip to the mould thereby leading to a decrease in casting rate. This implies that casting resistance is directly proportional to the solid casting pieces.

Casting of models from casting mould



Plate 27 A: Pouring of casting slip into contact fuse moulds to form solid cast models at various stages



Plate 27 A: Pouring of casting slip into contact fuse moulds to form solid cast models at various stages



Plate 28: Pouring of casting slip into Sanitary Moulds to form hollow cast Models



Plate 29 A: Draining off of casting slip from Sanitary Moulds after forming hollow cast layer at various stages



Plate 29 A: Draining off of casting slip from Sanitary Moulds after forming hollow cast layer at various stages

Conclusion

Knowing what proportion of recycled ceramic waste and ball clay for ceramic body compositions for slip production was not stressful because of the tested samples A-J which made it possible to select the adequate compositions for final production. The appropriate body composition for casting hollow and solid cast falls within 80% - 85% of ceramic waste and 20% - 25% ball clay were used for preparation of casting slip. The plasticity in them gave a good physical handling and strength, with minimal shrinkage and lesser porosity including better body and glaze fitness. A total number of ten different body composition A - J were formulated starting with 100% of ceramic waste as body composition sample A, 95% of ceramics waste to 5% of ball clay as plastic materials from body composition of sample B, 90% of ceramic waste to 10% ball clay for sample C, 85% to 15% ceramic waste and ball to clay for sample D , 80% - 2-% of ceramic waste and ball clay for sample E, Sample F G H I J, had 75% of ceramic waste and 25% of ball clay, 70% of ceramic waste and 30% ball clay, 65% of ceramic waste to 35% of ball clay, 40% of ceramic waste to 60% of ball clay and 45% of ceramic waste to 55% of ball clay respectively.

All these samples composition were suitable for production, going by their level of vitrification because sample A had no plasticity, hence during slab formation, the physical handling strength became problematic. Similarly Samples B, C, and D had less plasticity and lesser physical strength for handling during production of test slabs. Therefore sample E and F were selected as most suitable body compositions for reproduction of new ceramic item because both samples compositions had 20% to 25% of ball clay as plastic material in them. Hence the physical handling and strength were not too difficult to manage because the shrinkage rates were moderate. Sample E composition has less plasticity and

shrinkage than sample F. It was therefore used for the production of contact fuse production which involved solid casting. While the sanitary wares were hollow casts hence sample F was used because it has more plasticity and shrinkage which was quite moderate. However samples G, H, I and J had better plasticity with excessive shrinkage rate and could not be used for that reason. The suitable forming methods and techniques used for this production in this study did not give any studio challenges, it was easy during preparation of casting slip.

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