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ADDRESSING THE CERAMICS STUDIO EQUIPMENT CHALLENGE IN NIGERIA: UTILIZING RE-USED MATERIALS FOR THE PRODUCTION OF A BALL MILL JAR

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Abstract

It is already well established that ceramics require the use of equipment for production. Also well known is the fact that most ceramists in Nigeria are unable to procure and utilize major equipment for ceramics production due to the exorbitant prices of imported ceramics studio equipment and technology on which the country currently depends. Deploying the descriptive approach, this article describes a successful attempt to address this problem by fabricating of the grinding chamber of a ball mill, which is a major component of very important ceramics studio equipment. In doing this, it practically engages the major challenge of producing a porcelain ball mill jar in a typical local ceramics studio/workshop in a developing economy such as Nigeria.

Keywords: Ceramics studio equipment, Ceramics production, Nigeria, Re-used materials, Ball mill

Introduction

It is a well established fact that the necessity of equipment in ceramics production cannot be over emphasized. In spite of this, most ceramists in Nigeria are unable to procure and utilize most of the equipment. The chief reason for this is that they are usually imported, hence, very expensive. This dependence on imported technology has hampered the growth and development of ceramics in the country.To stem this, researchers such as Ebeigbe and Omem (2010) and Bada (2010) suggest that rather than depend on imported equipment, local adaptations of the required tools could be produced to meet the needs of ceramists in the country if adequately researched.

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The dearth of equipment in ceramic studios and the need for local interventions by ceramists and potters is not peculiar to Nigeria alone. Digitalfire.com (2008), affirms this when it stated, "No industrial plant that mixes its own raw glazes would be without a ball mill. Yet potters lack them for a couple of reasons: Expense and awareness." This implies that it was not just the cost of most ceramic equipment that prevented their use but also the lack of awareness that some of these equipment could adapted and fabricated by the studio potter/ceramist. To lends credence to this it went on to describe in details how to make a functional ball mill stand that can serve an average ceramics studio which is quite easy and inexpensive to construct. Other researchers like Thorsgaard (2004), Ojie and Esosuakpo (2011) and Davis (2014) have documented their own efforts at producing various functional and less expensive models of ball mills from materials available within their local. Ceramists all over the world have been known to have to fabricate most of the specialized ceramics studio equipment especially the potters' wheels, and kilns on their own. However, this is not the case where it comes to some other studio equipment. This article documents one of such researches cumulating in the successful production of a major component of ceramic equipment locally. It describes the production of the grinding chamber of a ball mill utilizing re-used materials obtained locally.

What is a Ball Mill?

A ball mill is described by Fournier (1977) as "a machine for grinding rocks and minerals consisting of a horizontal cylinder made from, or lined with an abrasion resistant material (for example, stoneware or porcelain), and of some mechanical means of making it revolve." Similarly, Otimeyin (2015) described it as a device which consists of a cylindrical porcelain container with porcelain balls or pebbles meant to grind ceramic raw materials while revolving on a roller. It is used in diverse fields and industries. According to Scott (1991), it is used in the field of engineering, "for grinding mineral, cement, clinkers, et cetera." In ceramics, Chavarria (1994) notes that it is "used instead of a pestle and mortar for mixing and grinding ceramic materials (clay, oxides, glazes, et cetera) in dry or damp state."

From the introduction of this paper, the importance of a ball mill as a critical equipment needed in the ceramic studio for the production of glazes for local raw materials has already been established. The reason for this as Parmelee's (1973) explains is that "No step in the preparation of glazes is more important than the operations designed to give a homogeneous mixture ready for application to the ware."

Therefore, it is absolutely necessary to utilize a ball mill, a device which guarantees this process. One of the major components of the ball mill is the grinding chamber which is the main focus of the paper.

The Grinding Chamber

The grinding chamber of a ball mill is called the 'jar' of the mill. This is because it is essentially a cylindrical jar of stoneware or porcelain. King (2002) described it as, cylinders with a capacity of about 0.5 litres to 2.0 litres which may be larger depending on the specific needs of the studio. The jar comes with an opening for loading and off loading, and a clamp for holding the stopper in place. The opening of the cylinder maybe coaxial with the cylinder or it could be located at the circumference. The stopper is conventionally made of the same materials, somewhat thicker than the walls of the jar. If necessary a plastic lidded jar can be used. This is even preferable as Cardew (1971) previously noted that it is more convenient as the clamp arrangement is then much simpler. As well as opening the lid after the milling session for discharging becomes much easier, whereas stoneware stoppers sometimes cause trouble by getting stuck tight.

The Major Challenge of Producing a Ball Mill Jar Locally in Nigeria

In ceramics, stoneware or porcelain is usually the preferred material of choice for the production of a ball mill jar. This is due to two major reasons. The first is that much of the grinding that takes place in a ball mill occurs between the balls and the jar. It is therefore important that hard abrasive materials durable enough and which enhance the process such as stoneware and porcelain are used for the grinding chamber. The other reason is that apart from stoneware and porcelain, most of the other materials that can be used introduce contamination directly or indirectly into the milling batch. For small mills typically used in a regular ceramics studio/workshop, the stoneware or porcelain jar is usually cast whole and fire to 1270^{0}C and above, the temperature needed for porcelain to vitrify. The major challenge with this is, however, that most of the kilns found in most ceramics studios/ workshops in Nigeria cannot fire up to this temperature. This makes it almost impossible for the ball mill jar to be successfully produced from porcelain locally.

Addressing the Challenge: An Alternative Process

In view of the foregoing challenge, we seek to proffer a viable alternative for this process using locally sourced materials in this study. We hope to do this by means of the technique used in the production

of the grinding chambers of large scale mills. As Omem (2012) illustrated, that in larger mills where casting in one piece is impracticable, the grinding chamber is usually made up of stout cast iron or sheet-iron cylinder with the inner surface lining made from hard abrasive materials. These linings are laid in ordinary strong cement mortar with the joints of the lining kept as small as possible.

Some Materials Used as Linings in Ball Mills

Sequel to the aforementioned process, it would be pertinent to mention briefly some materials used as inner surface lining of the ball mills. Abbe (2008) lists them to include: porcelain, and other natural silica rocks of very fine crystalline texture such as silex (burrstone), chert, flint, jasper, and rubber or metal.

i. Porcelain: This is a dense, tough structured and very durable ceramic material suitable for use as the lining for ball mills. It is usually white in colour. In some cases high alumina porcelain, which is usually of higher density is used. It is the toughest and most abrasive-resistant synthetic linings, and is by far more durable than the normal porcelain. It is especially useful where jacketed mills for temperature control are required. Since these bricks are formed in moulds they are usually very regular in shape, hence the joints between block is minimized therefore product contamination is drastically reduced.

ii. Burrstone (Silex): This pure flint lining is noted for its toughness and exceptional durability. Its naturally rough surface helps to prevent the charge from slipping thus ensuring a more efficient grinding action. The only major disadvantage is that the blocks are usually irregular since they are usually prepared by splitting and breaking from massive rocks, hence the probability of contamination of the batch by the cement is increased.

iii. Rubber: This type of lining is used preferably only for wet grinding operations as dry rubber tends to abrade excessively. Rubber linings are usually vulcanized to the shell, although it can also be laid in removable sections. Natural rubber is most generally used as it seems to be most resistant to abrasion. Synthetic rubber, like Neoprene or Hycarr, can be used alternatively.

iv. Metal liners: The cylinders of batch type steel ball mills are usually made of an abrasion resistant alloy steel like chrome manganese. It is also possible to obtain them in a range of other metals including chilled iron, manganese, high carbon steel,

bronze, Monel, et cetera. The major disadvantage of metal liners is batch contamination.

Among these materials enumerated above, porcelain lining was opted for use in this study due to the numerous advantages in the milling of ceramic materials as already mentioned earlier in this paper.

Constructing the Ball Mill Jar

Consequently, the ball mill jar produced in this undertaking comprises a cylindrical metal container and a lid with their interior surfaces lined with porcelain strips as described in the following stages:

i Constructing the Metal Case for the Jar
An empty refrigerator gas refill cylinder was used to construct the metal case for the jar. The bottom part of the cylinder was cut off and a flat metal sheet welded in its place. This reduced the bulge at the bottom of the cylinder, thus reducing the amount of mortal needed to provide a flat bed for laying the inner lining for the base of the jar. This also eliminates the extra weight that would have resulted.
The top part of the jar was cut off leaving a slightly smaller hole than the bottom part. The curved surface was flattened with a mallet after the interior lining had been laid and set. On this surface, three screw-like protrusions are welded equidistant from each other. These three protrusions go through corresponding holes in the lid which is held and fastened to the jar with bolts.

ii. Obtaining and Preparing the Porcelain
The porcelain used in fabricating this jar was obtained from old and discarded rectangular ceramic sinks (see Fig. 1 below). These were washed to rid them of dirt before use. Having cleaned the sinks, a diamond cutting disc driven by a powerful angle grinder was used to cut them into slices of approximately two (2) inches in width. These slices were then further cut into long strips of porcelain bricks as shown in Fig. 2 below.

Fig. 1: Old Rectangular Ceramic Sinks used

Fig. 2: Some Sliced Strips of Porcelain

Source: Photographs by Valentine I. Omem (2011)

iii. Grinding off the Glaze and Dressing of the Bricks
Normally, rectangular ceramic sinks are glazed but this glaze is not needed in the inner surface of the ball mill jar. Therefore, the glaze on the surfaces of the bricks cut out of the sinks had to be removed. This was done by using diamond cutting disc to grind off the glaze. In the way, the bricks were given proper dressing in order to achieve the desired thickness and remove any other unwanted elements.

iv. Laying of the Mill Linings
At this stage, the porcelain linings having been properly prepared were laid into their respective positions starting with the base. These were first cut into shape to form a circle which would fit into the bottom of the cylinder. A strong mortal mixture of cement, fine grained sand which had been sieved previously and Waterseal (a powdery substance usually added to mortal to make it water proof) was use to hold the bricks in place. This was carefully applied and used to lay the porcelain lining inside the cylinder. Care was also taken to ensure that the joints were kept as small as possible. See Fig. 3 below.

Fig. 3: The Jar Showing the Porcelain Lining Within
Source: Photograph by Valentine I. Omem (2011)

vi. Constructing the Lid

The lid of the jar comprises a circular metal pan (obtained from a discarded ceiling fan). Using a drill, three (3) already existing holes on the pan were widened to the appropriate size to serve as holes for the screw-like protrusions on the jar used for fastening the lid. It was then lined with strips of porcelain thicker than those used for the sides of the jar cut to fit the shape of the pan. A circle slightly smaller than the jar opening was mark out on the bricks lining the lid and the areas around it cut off leaving behind a protruding part to act like a cork on the lid. In laying the porcelain lining, caution was taken not to cover the holes already drilled into the metal pan. This is illustrated in the planar view of the lid in Fig. 4 below.

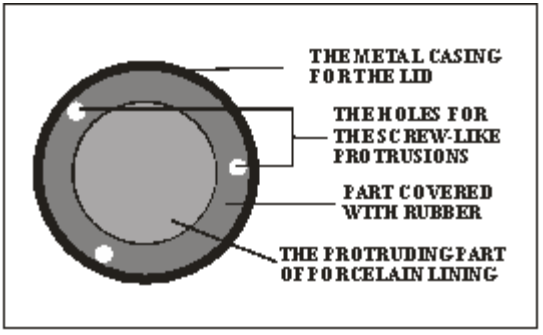

Fig. 4: The Planar View of the Lid
Source: Illustration by Valentine I. Omem (2011)

To help improve the sealing when the lid is fastened to the jar, a rubber strip was used to line the area around the elevated section on the lid as indicated in the diagram above.

vii. Finishing
After the jar and its lid had been successfully constructed, it was then properly finished and painted as shown below in Fig. 5 and 6.

Fig. 5: The Jar and Lid

Fig. 6: The Finished Grinding Chamber (jar)

Source: Photographs by Valentine I. Omem (2011)

Conclusion

The objective of this study was to give a detailed description of a successful fabrication of a functional ball mill jar from locally available materials and technologies. This article buttresses the fact that most ceramic studio equipment can be fabricated locally to provide cheaper alternatives for the rather expensive imported ones. This, to a great extent, will help to address the problem of equipping ceramics studios and workshops in Nigeria. Based on the foregoing, the study calls for further studies this area and indeed other areas of national life in Nigeria, with a view to reduce the over dependence on imported goods and technologies.

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