Fabricating Kiln Shelves and Props Using Materials from Nigeria

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Abstract

Pottery wares that are fired in a kiln are usually placed on some shelves which are capable of withstanding high temperature during firing. These kiln furniture are very often expensive to import from foreign countries, especially as it applies to developing countries, where students are taught ceramics and need to fire their wares. Local materials such as kaolin, grog and clay have been discovered efficient in the making of refractory shelves and props, and these are easy and cheap to come by. Processes of making the shelves and props entails molding, drying, firing, crushing, sieving, weighing, mixing, beating and firing. It has been discovered that good kiln furniture can be made at a cheap rate using locally available raw materials found in Nigeria. This Paper explores the possibility of such refractory furniture with local materials.

Keywords: Fabricating, Kiln, shelves, Props**,** Locally sourced Material

Introduction

Pottery, whether bisque or glazed wares that are fired in a kiln, are usually placed on some shelves which are capable of withstanding high temperature during firing. These shelves are usually made from selected refractory ceramic materials. A successful modern firing in a kiln requires the use of refractory kiln shelves and props. Lack of these facilities has made the glazing of ceramics wares sometimes impossible. The objective of this study is to make kiln shelves from locally available ceramics raw materials. According Ameh and Obasi (2009) in Umaru et al (2012), Refractory materials are materials that are capable of withstanding high temperature both physically and chemically. High quality refractory materials resist high temperature fluctuations between 1000^{o}C and 1500^{o}C. They are also good thermal and electrical insulators. Chester (1973) states that there are many types of refractories that ceramists use because of the high temperature they fire their wares to. Example of such refractories are:

(a) Clay refractories: fire clay and kaolin normally consist of kaolinite ($AL2^{0}{}_{3}Z510_{2}$) and 45% impurities including exiles and alkalis. Fire clay has alumina content of 25-45%.
(b) Sillimanite refractories: this group includes sillimanite, kyanite and andalusite. They are naturally occurring minerals of general composition $AL2^{0}{}_{3.}Sio_{2}$ with 45-65% alumina content.
(c) Buxite rock $AL2^{0}{}_{3}ZII^{0}{}_{2}$: this is also naturally occurring mineral with the alumina content of 79-90%, so it is very refractory. It contains in addition to alumina, some impurities such as iron oxide and silica.
(d) Corundum ($AL2^{0}{}_{3}$): this is another refractory materials. It contains 90-100% alumina. It is also present in natural form. Gemstone such as sapphire and ruby consist of corundum with traces of other oxides.

The high strength exhibited by the primary chemical bonds of the foregoing, made the materials to possess unusually good combinations of high melting point and chemical inertness. This makes them useful as refractories (Mason, 2016). Refractories ceramists use are in two basic shapes, namely: saggars and shelves. Saggars are used with carbonaceous fuel types, especially wood and coal that can easily deposit ashes on the waves, shelves, props, pins and points on the other hand are used with electric kilns and other fuel types like liquid oil fuel types since they do not deposit ashes on the wares during firing process. Both saggars and shelves are made of refractory clays (Gukas and Datiri, 2001). Since Kaolin is a good source of refractoriness, and with the abundance of the material in Nigeria, it becomes really important to explore for self-sufficiency and sustenance.

According to Rhodes (1971), kaolin is highly refractory and has the melting point of 1500^{0}C and fire clay resists fusion or formation up to 1500^{0}C. He also points out that fireclay are useful in a great variety of products including fire bricks and refractory parts of kiln, furnaces, boilers and melting pots. Chadler (1967) opines that Kaolin consist of 40% alumina and 54% silica and the melting point is about 1750^{0}C. Looking at the views of different authors, it is clear that fireclay resists high temperature and has the melting point of 1800^{0}C. By this quality of fire clay, it becomes a concern to use fire clay for the fabrication of the shelves and props.

For Kaolin to be used in making kiln shelves and props, it is first molded, dried and fired before it is crushed into grog. Grog is needed as an opening material for refractory (Molokwu, 1991). Chadler (1967) remarks that in general, the more the grog content in the body mixture, the greater the thermal shocks resistance. The importance of grog has been highlighted by the authors and it shows that grog is indispensable in the production of refractories. This study is of the view that since grog made from broken saggars or fired clay is far cheaper and very common even in Nigeria, and also very effective, ceramists should explore it. It is not only refractories that is required for good kiln furniture. Good composition of the materials to be used and good production process are also very essential for good kiln furniture he added (Molokwu, 1991). First, batts and saggars that are very thick are wasteful of kiln space. Second, their refractoriness will be considerably above the operating temperature to be able to stand load put on them. Third, batts and saggars have to be able to resist a good deal of thermal shock. Forth, the potters mix needs to be plastic if it is to be shaped with hand method, and plasticity is a difficult property to compare with refractoriness. Singer and Singer (1871) suggest two part grog and one part plastic materials. This means grog 66.6% clay 33.3%. They explain the degree of suitability and the advantages of different types of clay to be used as binder for the grog.

- Kaolin has the advantage of low alkaline content.
- Store ware clay has the advantage of high plasticity.
- Bentonite should not be used because of its high flux content which is up to ten percent.

Ewule (1988) shows that he used clay for making the shelves and uses the following proportion:

High fire grog made from kaolin	70%
Levigated kaolin	15%
Levigated secondary clay	15%

Kaolin and fire clay are refractory materials good enough for making of potters kiln shelves provided enough grog is used. They are refractory enough and easy to get. High refractory materials are scarce expensive and inaccessible to a pioneer potter who wants to make the kiln shelves by themselves. According to Rhodes (1974) the potter who is bent towards self-sufficiency will mix his materials to a stiff plastic consistency and pound it in a mould with a wooden mallet. This method is the least technical method of making kiln shelves and its takes much time. It is evident that the mechanical press does not give an effective result as that of the manual falling weight method. This study employed the manual method in fabricating the shelves and props for effectiveness. This entails the use of a falling weight (rammer) to pound into stiff tightness refractory materials in a metal frame.

Materials and Methods

The secondary clay used came from Bomo village which is a small settlement north of Samaru village in Zaria. It has been tested and found fit for use as binder. The sieving method was employed to remove the impurities. The sieved clay was kept as a slip for use in the batch. Kaolin used in this study was got from Kankara in Katsina State. Just like the secondary clay, the kaolin was also soaked for two days and sieved (see Fig. 2). The thick slip was used in mixing the batch for both the shelves and probs. Metal parts were gotten from scrap shops in Sabon Gari, Zaria which were needed for both the moulds for shelves and the cylinders for props. Four pieces of angle iron with 4 cm thickness were used. Two pieces of equal length measuring 22 inches were cut to form the length of the mould. While another two pieces measuring 12 inches formed the width. Both sides were made to fit together at the four angles. The angles were made in a way that they could be screwed together into a rectangular shape and unscrewed (see Fig. 4). Bolt 16 was welded at the two ends of the angel irons where they could be detached for easy removal of the shelves from the frame. The rammer for the shelves was constructed using a metal pipe 4.3 cm in diameter and a thick metal with flat surface. The metal pipe was welded on the thick flat metal for effective grip of the rammer.

Moulds for the Props

One graded metal was constructed with a hole in the middle where a treaded iron rod measuring 15.9 inches long would go in and be tightened with a nut underneath. An iron cylinder measuring 13.3 inches long and 6cm in diameter which was worn on the iron rod, a thinner cylinder which served as the piston measuring 21.3 inches long and 3cm in diameter, a flat metal disc that has the same diameter of opening in between was welded to the end of the piston cylinder to serve as the pusher. All these were gotten from the scrap shop and taken to the workshop to be made into the proper mould for the props (see fig. 7).

Process of Making the Shelves and Props

A portion of the sieved kaolin was mixed into a thick strong paste and molded into bricks which was left to dry under the sun. After drying the bricks were fired in a kiln to approximately 1220^0C.After calcining, the fired bricks were then crushed by beating into different particle sizes for making the shelves and props (see Fig. 1). However, the grog for the props was sieved with mesh that gave a finer grade of grog needed for the probs.The coarse grade of the grog was measured on a scale to know its weight. The weight of the whole coarse grog used for the entire kiln shelves was measured to be 112kg. This was taken to be 70% of the whole batch. The rest of the materials are kaolin 18% and Bomo clay 12%. In order to get the actual weight of these materials, the following method was used in calculating them.The proportion of kaolin in kg was calculated as:

$$\frac{\text{Material}}{100} \times \frac{\text{weight of grog}}{1}$$

That of kaolin was worked as

$$\frac{18}{100} \times \frac{112}{1} \times \frac{56}{50} \times \frac{28}{25} = 20.2\text{kg of kaolin}$$

To know the proportion of Bomo clay in kg, it was calculated:

$$\frac{12}{100} \times \frac{112}{1} \times \frac{56}{50} \times \frac{28}{25} = 13.4\text{kg of clay}$$

The crushed grog was poured on the floor with a hollow space created in between where the slip clay and kaolin were poured (see fig. 3), followed by mixing of the batch into thick semi dry pace in such a way that when it was fetched with the hand and compressed it stuck together, thereby forming a lump. By this simple test, the batch is set for beating. The batch for the props though finer, but mixed in the same manner. Constructed frame was kept on the floor and the well mixed batch poured into it. A rammer was used to beat down the batch to the level of the frame (see Fig. 5). The shelf was turned upside down so that the reverse side was also beaten. The shelves were really compressed and tight, the beating process was effective and the compressed shelves were transferred unto a board. It was on the board that the unscrewing to free the shelf from the frame was done and the frame was removed in two pieces. The shelves were carried on the board to a place of drying (see fig. 6), after a day or two, they were turned for proper drying.

The beaten shelves and props that were kept in room temperature for not less than two weeks to dry were carefully carried and arranged in the kiln. The shelves were arranged in a standing position close to each other but not touching each other. They were supported with small refractory bricks to support them while standing. As the first line of the shelves was arranged, the second line on the shelves were also arranged on top of them but in a cross wise position. This method of arrangement was repeated until the shelves were properly stacked. The props also were kept standing in the kiln while the kiln was fired to between 1220^0C and 1280^0C.

Fig. 1 crushed grog

Fig. 2 sieved semi water kaolin and secondary clay

Fig. 1 shows the crushed grog. Crushing is necessary because it enables easy mixing of the batch with other needed materials. Fig. 2 shows primary clay and secondary clays that have been sieved and left in the watery state ready to be mixed into the grog as binder to hold the batch together when compressed.

Fig. 3 mixing of watery clay and grog

Fig. 4 constructed form work for kiln shelve

Fig. 3 shows watery clays in the middle of crushed grog ready for mixing. This system of pouring is important to avoid the spillage of the watery clays. Fig. 4 shows the fabricated metal frame with detachable angles for easy release of refractory shelves after beating.

Fig. 5 beating of batch in the form work

Fig. 6 positioning the shelves for drying

Figures 5 and 6 show the beating of the batch in the frame with a falling rammer and positioning of the compressed shelves in a standing position for drying. The drying is usually done in the room temperature.

Fig. 7 fabricated metals for producing props

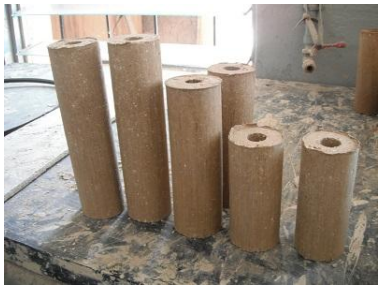

Fig. 8 extruded props positioned for drying

Fig. 7 shows the fabricated rods and pipes with suitable base rest for the batch before beating into props. The props are extruded and kept also in a standing position for drying as shown in Fig. 8

Conclusion

From the locally available ceramics raw materials in Nigeria, it has been discovered that good kiln furniture can be made at a cheap rate. Making of the shelves and props are not too different where the technical knowhow and right materials are available.

The process of beating the shelves and props was discovered to be rather strenuous, as such the researcher is advocating for a study to discover an easier way of beating the frontiers.

The fire grog used for the props, the researcher thinks can also be used for the shelves to have a fine and stronger shelves.

The firing of the shelves and props were successful as there was no casualties. The researcher believes this was due to the even pressure applied during beating, the reverse will be the case when the pressure applied is not even.

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