INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Local Crucible Production for Metal Casting: A Case Study of Atonsu-Agogo

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Abstract:
Crucibles are very important to the local jewelers in Ghana. Presently, local jewelers in Ghana purchase local crucibles since they are easy to come by and they are also less expensive unlike the foreign crucibles which would impair profit since they are very expensive. Research and observations has revealed that the locally manufactured crucibles which are being used by the local jewelers and goldsmiths as well as the casting industries are not durable as the foreign or imported crucibles. This study seeks to discuss the production of local crucibles at Atonsu – Agogo and how they can be improved to increase its durability and performance. Experimental and Descriptive Research methods based on the qualitative research approach was employed in this study. The study is aimed at identifying the right materials to be used in the production of the local crucibles of Atonsu – Agogo craftsmen and also to work on the lifespan on the ones being produced presently.The research investigated and experimented with other materials such as clay additives to improve the life span of local crucibles and document the working processes used in the research and that practiced at Atonsu-Agogo for producing local crucibles. The proportion of graphite to clay, borax to clay and grog to clay as used in this research must be adhered to and borax flux should not be used on melts when clay-graphite crucibles is used are some of the recommendations made. It is also recommended that Clay-borax crucibles should be used for metal refining.

Keywords: *Crucibles, casting, furnace, clay, melting*

1. Introduction

The local name given to crucibles in the Akan language is 'nsemua'. Crucibles according to Sias (2005), are ceramic or refractory containers for melting metal. Other crucibles come in metallic bowl forms that are lined with refractory material.

Two common shapes of crucibles are known namely: BILGE SHAPE and A-SHAPE. Three types of crucibles were commonly used in the early twentieth century namely: Clay crucible, Siliceous crucible also called white or hessian crucibles and Graphite sometimes called plumbago or black lead crucibles (Hurst, 1996).

Finck and Heumannskaemper (2013), attests that modern crucibles are very heterogeneous, graphite-based composite material, which relies solely on its material composition. It also relies on the control of the structural alignment of the graphite to achieve the desired results. Crucibles in general may be as little as teacups or bigger to hold several tons of metal. They may be fixed in place within a furnace structure or may be designed to be removed from the furnace for pouring at the end of each melt. Crucibles are used in fuel–fired furnaces, in electric resistance furnaces, in induction furnaces or simply to transfer molten metal. They come with or without pouring spouts and in a wide variety of traditional and specialized shapes.

Several researches have been done on crucibles, the Intermediate Technology initiated research into crucibles using local materials from Malawi. Crucibles produced from Atonsu-Agogo are of great importance to the local jewellery industry in Kumasi for melting and refining of metals and yet less is known of how they are manufactured. The crucibles when compared with imported ones which are expensive and difficult or sometimes impossible to obtain locally, have very short life span. This research therefore seeks experiment with materials to improve upon the durability of the local crucibles.

2. Research Methodology

The research methods which were used in this study are the Experimental and Descriptive which are based on the Qualitative Research approach. The Descriptive Research method was used for documentation and describing the production process. It was also used to analyze the data to come out with the right results. The Experimental Research however, was used to derive the suitable materials for the crucible composition by varying the materials to study their response to intense melting conditions. Experiments were conducted to determine the problem with the composition used by the people of Atonsu – Agogo in the manufacture of their local crucibles. Experiments were also conducted to obtain an ultimate solution to extend the life span of these crucibles and to make them stronger and ideal for any metal melting temperature as far as jewelleryproduction is concerned.

2.1. Production Stage

2.1.1. Atonsu – Agogo Working Process

Since clay is the primary material used to produce crucibles by the people of Agogo, it had to be processed through some stages to get it ready for the manufacturing process. The clay after it has been collected from clay site at Atonsu – Bokuro, it is prepared by pounding if dried and sieved with an 80 mesh size and mixed with water to obtain the correct constituent suitable for making the crucibles. The pounding is done using mortar and pistil. When the clay is ready, it is then hand formed into various crucible sizes and then dried under shade. The firing of the clay crucibles was not done in the foundry but rather in a local furnace. The local furnace comprises a metal barrel which is fed with charcoal and firewood as the source of heat. The barrel is able to accommodate more than hundred crucibles. Fire is introduced form beneath the barrel. The heat is however controlled due to the nature of the furnace since the heat is contained within the walls of the barrel to cause enough heat for the firing of all the crucibles. The firing was however done under low heat and left over night. Several of them were arranged in the barrel together with the firing with charcoal and wood. After firing they are allowed to cool down after subjecting them to intense heat, they were then packed for sale.

Figure 1: Forming of crucible

Figure 2: Shaping of gate

Figure 3: Various sizes of local crucible

Figure 4: Crucibles after firing in barrel

Several combinations and proportions of variety of materials such as graphite, borax flux and grog were mixed with clay and tried to achieve formulation with desirable characteristics for crucibles. After the clay was obtained from the clay site it is further processed into grog. The grog was achieved by calcining small balls of clay after it has been fired in biscuit temperature before subjecting it to intense heat of about 1170 C°.

In preparing clay bodies three different compositions 'A', 'B' and 'C' were made calcined and uncalcined clay. Below is a chart showing the amount of calcined, uncalcined and moisture content used in compositions.

Compositions	Calcined	Uncalcined	Moisture	Weight
A	50%	50%	40ml	200g
B	70%	30%	45ml	200g
C	40%	60%	40ml	200g

Table 1: Amount of the different compositions of the calcined, uncalcined and moisture content

The weight of both the calcined and the uncalcined were measured on the weighing balance to get the total weight. Graduated cylinder was used to measure the water content which was then added to the mixture in a bowl mixed. It was again sieved through the 10 mesh before pressing

Hand forming was used in moulding crucible and fired to temperatures between 800-1000°C.

Test was done on crucible's resistance to thermal shock, tendency of metal not to oxidize, melting test and crucible re-usability. One each was taken from each composition for the test. The first test was the thermal shock test which was done at the Metals Section of the Industrial Art Department. The crucibles were heated in the electric test kiln which tool almost one hour fifteen minutes to reach 800°C red hot and quenched under running water. The next test was the slagging test which was conducted with the brass casters at Allabaa in Kumasi. The crucible was packed with brass scraps and placed in their small furnace pot. When molten it was poured and repeated until all the three crucibles complete five cycles of casting. Because their source of heat is very fast, each melting took 20minutes.

Before this test the 'B' engaged in an accident so some part of the mouth broke. But it was able to go through the slagging test. The slagging test didn't end there, it was continued at the Metals Section to find out about metal weight the crucible can melt as compared to the crucibles weight and also the time and the temperature it will take to melt. The crucibles were packed with the same brass repeated in the same way with the 50g and melted simultaneously in the electric test kiln. It was repeated in the same way with the 80g and 110g.

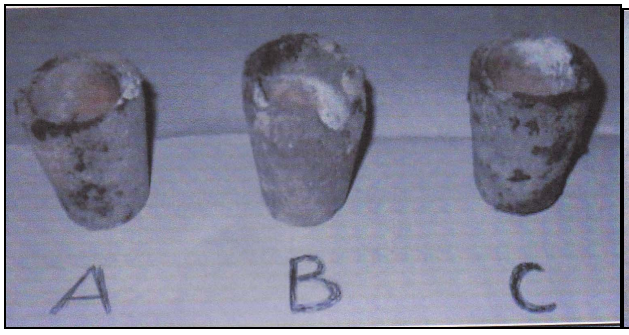

Figure 5: Three sample crucibles tested

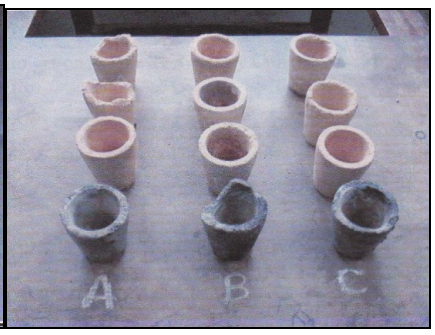

Figure 6: Various sample crucibles tested

Figure 7: Melting test

Figure 8: Removing crucible from furnace

3. Result and Discussion

Gold and silver are precious metals and as such, they are expensive especially gold. However, crucibles which will be used in the melting of these precious metals should be handled with special attention. The crucibles which will be used in casting gold alloys for instance must be kept clean by covering the inside of the crucibles with moistened strips of heat resistant material and relining them for reuse. Whereas silver is best melted by using a heavily fluxed crucible without the moistened strips of heat resistant covering.

Three crucibles with different compositions were used in this experiment. They were all subjected to identical conditions. The various compositions yielded contrasting results.

The forming method which required extra care and patience. Local craftsmen practice the hand forming techniques. Dry pressing gives the crucibles accurate shape and dimensions; it also makes the clay body's compact which supersedes the hand forming technique practiced by the local craftsmen. Composition 'A' and 'C' had the moisture content of 40ml whiles 'B' had 45ml, it was observed after the drying process that the mouth of the 'A' and 'C' crucibles were not compact because of the low moisture content, so whenever you touch the mouth it breaks gradually.

The exact moisture content for dry pressing of 200g of clay with calcine materials is 45ml. This problem of low moisture content happened in the first experiment, so was solved in the second experiment. All the samples of the three different compositions were able to survive the entire test without cracking or damaging. Below is a table showing some of the observations from the test.

	Crucible 'A'	Crucible 'B'	Crucible 'C'
Thermal shock	No damage	No damage	No damage
Slagginf test	5 cycles	5 cycles	5 cycles
Crucible weight	85g	85g	85g
Weight of metal	50g, 80g, 110g	50g, 80g, 110g	50g, 80g, 110g
Temperature	960°c, 960°c, 980°c	960°c, 960°c, 980°c	960°c, 960°c, 980°c
Time	1hr 45mins -2hrs	1hr 30mins-1hr 45mins	30mins-1hr

Table 2: Test results

The kiln used has a gradual heating source that is why it took a longer time to melt as compared to the furnace which takes a few minutes to melt. The weight of the crucibles was 85g and it was able to hold:

1. A metal whose weight (50g) is less than the crucible's weight.
2. A metal whose weight (50g) is almost equal to that of the crucible
3. A metal weight (110g) which is more than that of the crucible.

4. Conclusion

The presence of gas porosity resulting from atmospheric gasses trapped in the melts is a major cause of the structure of the crucibles.

The experiments indicated that the local crucibles from Atonsu-Agogo could not withstand thermal-shock.Crucibles compositions made up of clay-borax, clay-grog, and clay-graphite were improvement of the local crucibles. However, machine and equipment such as pressing machine and a kiln should be readily available to students of Kwame Nkrumah University of Science and Technology.

From the analysis, I can boldly say that this experiment is a successful one indeed. All the crucibles were able to survive the thermal shock test and the slagging test which is a great achievement.

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