THE PRODUCTION OF FURNACE WITH LOCAL SOURCED MATERIALS FOR CASTING METAL SCULPTURE

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Abstract
This study was necessitated by the high cost of purchasing and operating foreign made furnaces by Fine and Applied Arts Departments in Nigerian Tertiary institutions. Consequently, upon this, a furnace was designed and fabricated for Sculpture foundry with a view to providing an alternative furnace for founding using locally sourced materials. The research attempts at constructing an efficient furnace by enhancing the energy efficiency and cost. The researcher started with gathering of information for the research, which came from both primary and secondary sources. The primary sources were mainly oral while the secondary sources were from written materials. Materials used for the furnace were sourced locally and was technically constructed based on improved local technology. Source of heat energy was from cheap fuels- charcoal and waste engine oil with combustion air from electric fan blower. The furnace was tested and the heat energy produced was up to 1000^{oc}. Bronze melted within one hour. In addition, it is easy to operate, repair and maintain. It is also energy efficient and economical. This project calls for more researches in this area of study and in line with Nigeria's quest for self-reliance.

Key words: Furnace, casting, metal sculpture, local sourced and production.

Introduction

Someone, somewhere, made the first arrow and the first spear, and someone made the first bracelet and the first necklace- from metals. The shaping of metals began in 300BC (Roy 1992). The primitive methods of working on metal developed from heating of ore such as hematite in wood or a charcoal fire, later, furnaces were developed. It was built out of fire place and store owing to the availability of coal or charcoal for heating. Here, blast of air is into the furnace sent by bellow. Consequently, metal shaping remains a mystery that started as far back as 300BC and has enhanced till present. The metal casting as ancient technology for shaping metals is fundamentally an art of production that requires improvement.

Metal casting has been one of the most useful and appreciable method in creation of objects of art. The metal can be shaped by pouring them in the molten state into moulds. This takes place in a foundry where furnace is used. However, the fabrication or acquisition of the furnace has been a hectic problem to educational institutions and up-coming sculptors. Most times, this problem has led educational institutions to avoid practical study of metal casting and to base their study mainly on theory.

Designing and production of metal sculpture has always had a place in foundry, and what it required is energy efficient furnace as well as furnace with low cost of operation and maintenance cost benefit. Wikipedia (2013), defines a furnace as a device used for heating. Also, it is "a structure in which useful heat is produced by combustion or other means." Wikipedia went further to, describes it as: "an enclosure which energy in a non-thermal form is converted to heat; especially such an enclosure in which heat is generated by the combustion of a suitable fuel." In the words of Rajiv (2006), "A furnace is am equipment

used to melt metals for casting or to heat materials to change their shape or properties (heat treatment)".

Sculptors and art schools are constrained by lack of furnace in making a full contribution to the field via foundry technology. To fill this gap, an effective portable crucible furnace was designed for use in the field of sculpture, especially for the colleges and other higher institutions of learning were courses in Fine and Applied Arts are offered. Consequently, local technology in use of waste and local sourced materials was used for construction to reduce the high cost of production and make it affordable when compared to with cost of foreign the researcher imported ones.

In view of all these, embarked on practical research that would feature every necessary idea and advantages, with an aim to improve on the foundry by Portable Crucible Furnace. It is a fact that most folk pit furnaces are unsuitable for art schools, while foreign ones are expensive, hence the need to construct a reduced energy cost furnace with cheap and affordable fuel and that which can effectively melt nonferrous metals within a considerable time. It is worthy to note that the research was mainly motivated by economic reasons owing to the inability of artists (sculptors) to procure and maintain a conventional furnace.

Significance of the Study

The fabrication of the furnace will satisfy the need of metal shaping in the areas of Fine and Applied Arts – that in sculpture and ceramics as well as engineering. It will also go a long way in stimulating the interest of students in appreciating metal casting and to venture into use of locally sourced materials for production of a cheap and affordable furnaces.

Review of Related Literature

The review of related literature and other knowledge were engaged. The study made vital review on past research in the area of study. This enabled the present researches to profit from the past experiences and in-turn also serve as supports and bases for improvement.

Furnace by definition is a device for heating materials to a predetermined temperature. According to Gupta (2010), "furnace is a device in which the chemical energy of fuel, electricity, even solar energy is converted into heat which is then used to raise the temperature of materials called burden, charge or stock placed within it for the purpose". Since every type of furnace consume fuel and need dependable material, extra consideration should be put into the construction. Furnace as user of energy is used to obtain fire (heat Energy) in greatest amount from the fuel employed. Energy consumption is the main feature of furnaces both traditional and modern state- of- art model in terms of the class. Based on this reason, quality charcoal produced from angiosperms (hard woods) combined with waste engine oil are good for quality energy supply as was used in this research.

In this connection, Schaffer, Saxena, Antolovich, Sender and Warner (2004) State in their: "Science and Design of Engineering Materials" that: "throughout history most major breakthroughs in technology have been associated with the development of new materials and processes." This work emphatically adopted materials as the core of all technological advances. Mastering and manipulating developments, synthesis and processing opens wide opportunities that bring conceived idea into reality. Products of our societies today illustrate the key principles of materials science and engineering, resulting from innovative processing methods which usually provides new combinations of properties that offered development of technology. From this, it is obvious that successful use of a new or existing material depends on finding reliable, reproducible, and cost-effective fabrication processes that would transform materials into the determined shape. In one way or other, development of the new product by upcycling material significantly made the innovation possible and practical ability

of the researcher to develop and work with advanced materials this idea resulted in the combination of the cheap solid and liquid fuels combusted with an induced draft model blower.

Bolton (2002), in his book: "Newness Engineering Materials", identified clay as metallic and non-metallic heat-resistant substance used in construction of furnace. In this case, it was considered the main material employed in the construction due to its composition. Banga, Agwral, and Manghnai (2007), posit that: "Refractories are the backbone of the foundry" They also state that refractory heat resistant materials such as clay are used to serve as receptacles for molten metal, crucible, furnace sides and bottom containing molten metal are made of refractories. In this same vein, the researcher explored the potency of clay materials for insulation. Fiberglass was added to the specimen used to improve the thermal capacity. Basically, clay materials formed part of the linings in the combustion chamber to boost other materials ability to step up temperature. In the same way, refractory linings improve a whole lot on fuel economy, heat retention and prevention of radiation losses from the shell. Thus, increase heat energy and effectively reduces fuel consumption and cost of energy. Therein, similarities exist in use of clay that makes it easy for heat conservation in the hearth.

Gupta (2014) also, highlights the mineral properties of clay refractoriness as used for preparing fire brick. He avers that: " A good furnace with fire bricks can conserves a great quantity of heat for smelting even ferrous compounds". Consequently, it was observed that clay increases tensile strength and yield insulation at high temperature because of the mineral properties in clay content - ferrous and felsper. Apparently the characteristics are known for fireclay and kaolin. That is why Bolton (2002) notes that: "There are special materials used in furnace construction, which are capable of with-standing high temperatures. One of the most widely used refractory materials consists of silica and aluminum." Typically, clay is constitute of the above elements and are produced from suitable clays, fireclays, dolomite and similar materials. They are fireproof materials very heat resistant materials best used in furnace walls as brick and insulator. This refractory is specifically responsible for the increase and stability of furnace heat energy. The energy loses in any furnace are inevitable but can be ameliorated because "abrupt failure of the lining materials in operation may result in great loss of time, equipment, energy and products" Apeh et .al (2010).

Ude (2004), in a research entitled: *Production of Refractory Insulating Bricks for kiln Construction.* Aimed at improving insulation of brcks for kiln using saw-dust. He evaluates the brick of sawdust produced as refractory insulating brick used as heat insulator and resistor to heat shock for construction of kiln refractory. He reveals that:

> Insulating bricks are made of a mixture of refractory clay body and saw dust. Other combustible materials such as coal, rice husk, lignite can also be used as fillers. The sawdust (fillers) will burn away in the kiln and leave numerous holes in the bricks. The holes make the brick better heat insulator when they become part of a kiln structure. This is because heat cannot pass through motionless air which is entrapped in the holes.

This action condenses heat much more in the hearth. On the other hand, the to admixture of chop fiberglass in brick improved furnace energy efficiency and economy for the furnace understudy. However, clay-body and the refractory brick are specifically responsible for the increase and stabilizing furnace temperature. The retention of thermal capacity with densely pressed brick prepared and molded from fireclay proves effective.

As Okonkwo (2012) in his article, “The Design and Construction of Kerosene Firing down Draught Kiln, using Locally Source Materials” demonstrates the importance of the knowledge of the sources and property constituted which the materials used for refractory. Consequent upon this, degree of heat melting point of metal is factor contribution of the refractory materials. He put it succinctly that: “The exact choice of refractory for constructing ceramics kiln will depend primarily on the maximum temperature to which the ware is to fire.” He also notes that the various combinations of conditions in which refractory are used, make it necessary to manufacture a range of materials with different properties that can withstand any thermal conditions. He further buttressed these points by presenting table of some clay sample in their chemical percentages. The research on kiln construction using locally sourced materials has same materials requirements with the furnace fabrication, based on its use of refractory -insulation products from clay as the main raw material for construction. Also the analysis on fireclay helped the researcher to choose a suitable sample for the project.

Pertaining to the furnace efficiency, the researcher’s furnace produces a lot more heat from the fuel burnt and heat energy produced effectively increases when constantly fired for hours. According to Wisegeck.com. (2013) what is furnace efficiency? Furnace efficiency measures the amount of heat produced compared to the amount of fuel burned. The percentage of fuel that a furnace turns into actual heat is called Annual Fuel Utilization Efficiency (AFUE). Anyway, it becomes clearly relevant that any of the fuels employed by the researcher for the firing must be quality materials that produce commensurate heat. For fuel, it has to be efficient and local sourced materials to suit the design specification.

Furnace designs vary as to its function, heating duty, kind of fuel consume and sources of air for combustion. For heat from the fire to melt metal, the improvised blower should effectively blast hot air at the high rate. Base on this, Furnace motor efficiency is an important component of the system responsible for the overall combustion efficiency. Descriptively, the furnace consists of an induced draft model blower. With an aluminum metal of I mm thick and has 5 backward curved blade for efficient air drafting. “The blower motor is usually the part of your furnace that has to work the hardest, since it is responsible for circulating your heated air. Blowers come in several different forms, depending on the furnace technology (Ramsey 2012). On this note, it is not ideal to construct a heating system such as furnace, intended to burn with solid fuels like the charcoal without an efficient blower. Because the blower is uniquely responsible for circulation of the heated air to reach its intended destination - that is in heating and melting the metal. So a furnace needs a plentiful supply of combustion air to “inhale” in order to operate properly. Therefore, the researcher recapitulates that blower is an indispensible component in furnace fabrication.

Bhamare, Wagh, More, Zole and Sonaye (2017) designed and developed a portable gas-fired crucible furnace from locally accessible materials for melting scraps of aluminium, recycling as a secondary aluminium generation for industrial production. The research reveals that glass wool can insulate temperature up to 250 ^{oc} which is favourable to the aluminum melting. In the furnace glass wool was used for insulator to play down mass as a distinguishing feature of their furnce. Though, weakness of the glass wool was revealed to be inferior, a lower capacity insulator. They therefore suggested to have the glass wool substituted with superior insulator in order to conserve abundant heat for a much higher melting temperature metal. Also, the LPG was considered unsuitable because of pollution and that can be replaced with CNG (Compressed Natural Gas). Although, it was stated that is good but costly and the availability is a matter. As a result,it is out of place because it is expensive and uncommon in our clime. Based on this reasons use of waste engine oil and charcoal still have advantage over these fuels. Comparably, the glass wool is permeable; it

results to heat loss outside the hearth. Furthermore, heat conservation of glass wool is below capacity of a clay body.

Ekpenyong (2005) carried out a research which constructed a Foundry-Oven for Uniform heating of foundry equipment and materials. The project was fabricated with locally sourced materials. The researcher focused on uniform heat at which every part of the material surface layer heated at the same temperature. the researcher adopted principle of conventional flow of air to achieve the aim of the construction. According to the researchers explanatory note, tests were carried-out; first, objects were enclosed in two columns – the inner and outer columns. Second, the pressure of air is regulated to reduce the inner column below than that of the outer column, and third, the difference in pressure caused the air to flow from the outer into the inner column causing proper flow and rate of heating to the required surfaces. Thus, he observed that the rate of heating of the two considered surfaces – the upper and the lower surfaces therefore depends on the rate at which conventional heated air is passed to them.

The researcher recommended it for precision castings for avoidance of defects that usually cause by core baking, mould and heating of foundry accessories. It was revealed that the approach is applied for the study to make the operational practices effective; heat evenly distributed on charges during processing. Alternatively this furnace constructed for melting of metal for sculpture can be used to dewax and bake an investment mould of cire-perdue.

Ikechukwu and Atanmo (2018) explored the approach of construction to design and produce an improved crucible furnace with scraps. The furnace is a simple low cost diesel fired furnace for melting non-ferrous metal. The study considered diesal to eliminate both poor heat surfaces and harmful effect of molten metal contamination when used coke or coal. It revealed how self-made refractory bricks were used: the recipe of home-made mixture consisting of Portland cement ratio – 1, clay ratio – 1, partite ratio – 7 and silica sand ratio were used as ingredients for insulator lining in the diesel fired furnace. The researchers remarked that the partite can expand and becomes porous when heated about 850 ^{oc} - 900 ^{oc} to about 4 to 20 times its original volume due to the presence of 2% to 5% combined water. The study observed that by this action the insulator entrap air that disallows heat to travel beyond certain layer in the brick. A similar experiment was done for the furnace understudy. On the other hand, chopped fiberglass was admixed into clay while preparing the bricks used it. In addition, the dissimilarity is on fuel however, their operations exhibit quality energy delivery. However, the current model is a hybrid furnace built to run with bi-fuel (waste oil and charcoal). Their source of energy were selected based on availability, cheapness,and effectiveness.

Olalere, A.A, Dolunsi, A.O, Akintunde, M.A and Tonimola, M.A. (2015) carried out a similar study on “Development of a Crucible Furnace Fired with Spent Engine Oil Using Locally Sourced Materials”. The researchers adopted locally sourced materials for the construction of furnace fired using spent engine oil. During testing analysis and experimental investigations was carried out on the furnace energy efficiency and temperature attained 1500oC. The efficiency evaluation was recorded 40.75 percent for the sum total energy produced on a melting period. Hence, it was observed that the operational cost is cheap and source of provision of spent engine oil is reachable. This study and the one understudy were achieved through consideration of the efficiency and economic significance of spent engine oil for operation of furnace and beneficial to the foundry practice. This fuel costs less when compared to diesel, gas and electricity. The study revealed that the performance of the equipment is better than the traditional ways of non-ferrous metal recycling operation and adequate imparts to conversion of waste engine aluminum (Al-si) alloy scraps to wealth. Uses of the waste engine oil/charcoal improve melt rate and are cheaper and locally supplied.

Golunishola, A.A, Ojaomo, E.K and Onibon, G. (2019), carried out research on: Development of a Spent Oil –Fired 100kg Crucible Furnace for Small Scale Foundry Industries", where the furnace was developed with materials locally sourced from waste aimed at reducing cost of melting iron in Nigeria. The experimental temperature achieved at 1280 ^{o}c whereas, it was proposed to operate at temperature of 1400^{o}c. Thus, efficiency of the crucible furnace was calculated 59.4% as against the anticipated efficiency of 63%. However, it is observed that cast could equally melt at 1280^{o}c using the furnace. The research reveals that given the right environment and necessary support, local raw materials can be effectively used to fabricate a heating device which can be used in small and medium scale foundry for spare parts. Ordinarily spent engine oil has comparative cost advantage over use of gas or electric imported furnaces, these reasons make whole essence of these present studies. Both researchers aimed at exploring local sourced materials to improve small and medium scale foundry and laboratory.

Yusuf, Baharr and Awati (2022), worked on a similar research in which a crucible furnace was fabricated to assist in recycling and processing of the metal scraps of machining chips into raw materials. It was tested; Liquefied Petroleum Gas (LPG) was used to fire the furnace and 6kg of aluminum machining chips melted at 640^{oc} temperature for 52 minutes. The researchers revealed that the crucible furnace was designed hopeful to attain a maximum temperature of 700^{oc}. Hence, from results of the design test, the researchers confirmed that the fabrication and assembly of the melting furnace was made according to design principle of mechanization. Distinctively, the crucible furnace maximizes the efficiency of power transmission by turning of the wheel gear to discharge molten metal direct into mould.

Ford (1998) while writing on the innovations on foundry materials, posits that: "Many of the new processes are developments of existing processes or combination of two or more existing processes and any better understanding of fundamentals of the traditional process would be of real help to those new process." It would be note worthy to point out that the new process (portable furnace) is a prototype for sculpture and designed with principle of heat transfer. Significantly, from these the researcher adopted the basic knowledge of the construction. On the other hand, Oraefo (2012) believes that, for continuity change to be constant in foundry technology, the knowledge of ceramist must be required to come in. On this note, the researcher admits the proposition on the ground of chemistry analysis and formation of the refractory material, which a ceramist has an in-depth knowledge of. However, the goal was to improve founding by making difference on the existing idea with an invention. Consequently some fundamental shortfalls of the traditional processes and some recent innovation were synthesized to have a "new thinking".

Therefore, the feasibility study of the existing process helped in the exploration of materials to execute this research. Moreover, the achievable execution was largely determined by the physical environment in the sense that all materials used were sourced locally and the project work is economical and beneficial to sculpture production.

Research Methodology

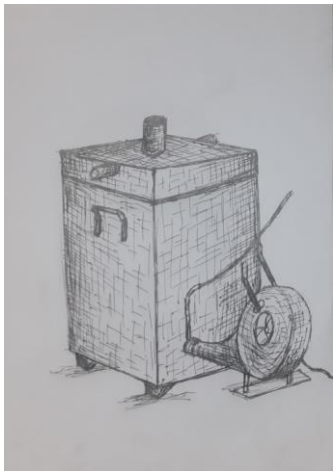
The research is a studio based research; the method was adopted to produce a furnace. It explored locally sourced materials like metal junk, clay and discarded electrical system with a view to achieve "practical research. The study was also employed some data. The search for data includes; gathering of primary data like oral information, and secondary data – literary materials, information from library, internets, photographic documentation of visual exercises supported with oral interviews.

PRODUCTION PROCESSES

To set this project on course several arrangements were made in order to reproduce the conceived idea into a suitable model. The entire production process entails eight (8) stages which are as follows:-

Stage 1: Sketches / Designing of the Model

The conceived model was first put into few sketches, later produced to a free hand drawing. The concept was depicted in components: the shell –combustion chamber, the oil tank and blower. Later, they were transformed to technical drawing in isometric projections to show the ground plan, section view and plan view as it regard to the 3 dimensional plan.



Figs: 1 & 2: Presents Sketch of the Proposed Model I and II

Fig. 3: Shows sketch of the oil tank

Stage 2: Construction of the Shell (combustion chamber)

The researcher used gauge 18 sheet metal for this purpose, because the thickness and appropriateness. From it a cylinder drum 72 inch height x 24 inch diameter was formed by rolling improvisely with a table, then a circle plate of 12 inch radius was cut, used to cover the cylinder. Below the shell base, a hole was open for the in-let draft. Subsequently, the 3 wheels were fabricated with discarded pulleys for the drum.

Hammering the Rolled Sheet Metal
Photograph by Gaius Ikenna

Plate 1: Showing the Researcher

Plate II: The Researcher Joining the Formed Shell Using Arc-welding Machine.
Photograph taken by Gaius Ikenna

Stage 3 Three: Forming of the Furnace cover
Forming of Lid/Cover of the furnace

The remaining part of the shell which covers the hearth. During the fabrication the top end of the shell was measured and marked 5 inches round to realize the part that will form the cover. The cover faces upwards with projected vents fitted side by side. Firstly, a plate of 18 gauge sheet metal was cut in octagon shape for the center, subsequently, patterns for the extend parts were cut which aimed at creating slanted ends of the octagon lid. Later, an angle grinder was used to cut long the marked space to have the cover separated from the shell. The idea was to achieve alignment on both parts. Subsequently, both ends were seemly rimmed and welded in-between with 5mm metal bar leaving 1 inch allowance which was bent in to reinforce the edges of the refractories against collapsing. Those rims were aligned and welded onto the cover too so as to prevent escaping heats through the opening. Later, on the top of the lid, at the two ends of the central octagon there are openings for the vents which were bent slanted. A pivot was formed with 20mm pipe and the ring formed with metal bar.That were welded tangentially from inside wall of the heat chamber to connect the cover from the inside wall. On wall of the lid where both sides connected to each other, a 1.5 inche pipe was inserted through the connecting hole to enable the lid move tangential on horizontal axis when wish to open the furnace. Finally, a socket was fixed for the handle to carry and slide open the furnace cover open when need to feed in charcoal or bale in and out the crucible.
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Plate III: The Researcher Welding the Cover on the Shell
Source: Photo by Gaius Ikenna

Plate IV: The Researcher is Shown Cutting Open Spaces for the Vents
Source: Photo by Gaius Ikenna

Stage 4: Construction of the Blower

The furnace blower is the main source of air for combustion of the fuel. By this reason, it is constructively planned in consideration of the quality and quantity of the air to be drafted in. An air condition motor and blade with rotating speed of 1240 RPM was used. Two circle pattern plates were cut out from a sheet metal. These sized the blade circumference wise. Another pattern plate of 8.25inches diameter was rimmed with a stripe plate of metal measuring 5x35inches long. These were fabricated in cylinder form with the center cut open to draft in air and a channel created on the wall for the outlet into combustion chamber. A rim was welded on the cover edge (circumference), on this cover the fan & motor and mounted

Lastly, it was finished by filling some holes and part with auto body filler after wards it was painted in ash oil colour paint.

Stage 5: Construction, Mounting and Connection of the Motor-Fan

The blower is the source of air for combustion which helps the fire to convert the energy in non-thermal (matter) state to heat energy. Here transfer of mechanical energy is usually accomplished by a rotating shaft of fan of the blower. On duty, the internal energy surroundings of the hearth will increase by an amount equal in magnitude to heat supplied as it blast-in air. The blower has remarkable point of difference between use of bellow in traditional furnace and this furnace understudy. With the refinement been considered, it is crucial to construct suitable sources of air-drafting device that would effectively supply the energy: reduce physical energy exertion in a way of aiding combustion. Based on this, some trial tests and experiments were carried out with 2 different electric motors, one from usual room standing fan and another from an air condition. Later, air conditioner motor was selected. This preferred type of fan motor was because of it high velocity, which the rotating speed is at 1240RPM.

Mounting of the fan was done with the assistance of an electrician. The earlier planned capacity of a motor was changed, because the propelling capacity could not draft-in enough air for combustion of energy. The motor was collected from a discarded air conditioner and was used in constructing the blower which was installed on the cover part.

The electrical wires were properly joined to avoid electric shock. The capacitor was fixed on the air box with off / on switch circuit connected to it.

Plate V: The researcher forging the Blower Casing
Source: photo by Gaius Ikenna

Plate VI: Mounting of the Motor Fan blade on the cover part.
Photo by Ikenna.

Stage Six: Fabrication of Oil tank with a Stand

A discarded car exhaust drum was cut open at one end and remove the inner metal compartment features. It was also cleared of the soots and carbon remains, and washed. Later, the cut part replaced and welded with oxyacetylene. Then the terminal pipe was constructed with a 2 and half inche pipe for the filling mouth and cover. Under the drum, a half inche hole was bore and weld in small traded metal pipe used to couple with flexible hose for distribution of oil into the combustion chamber.

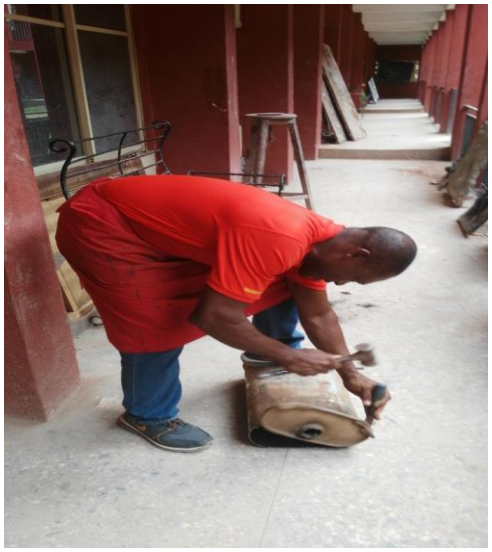

Plate VII: The Researcher Cutting the Car Exhust Tank
Photograh taken by Gaius Ikenna

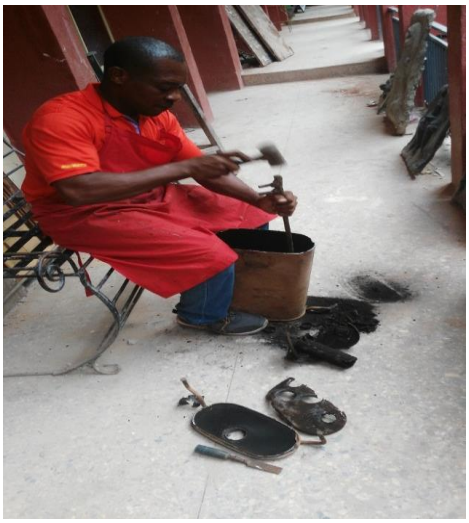

Plate VIII: The Researcher Shown Cutting and Removing the Exhaust compartments
Photo by Gaius Ikenna

Fabrication of the oil tank stand starts with the selection of suitable scrap. Next,, a frame was produced to serve as the base. This was followed by the stand where 14mm rod was cut 5feet, bent curve at one end and latter welded to support the two sides of the framed channels. It was also reinforced in-between with 2 pieces of 14mm metal rods. A 14mm rod cut into 2 pieces of 18 feet bent curve and welded perpendicular projecting to serve as the hanger for the oil tank. This was also connected across with metal rod. Then, on the top of the stand is a locket which was formed and welded using angle bar and curved flat metal bar. Two Holes were bore on two sides for the nuts and bolts finally it was painted with gray enamel paint.

Plate IX: The Researcher Fabricating the Oil Tank Stand
Photo by Gaius Ikenna

Plate X: The Researcher Mounting and Examining the Oil Tank Stand
Photo by Gaius Ikenna

Stage Seven: Production of the Heat Chamber

3.9.6.1 Preparation of the Refractories

The clays were locally sourced from a lake side at Amaokpala community, Orumba South Local Government Area of Anambara state and were used for the linings. Fireclay and kaolin mixed with terracotta grog used for insulator. First it was layed on the wall densely pressed and rammed before laid brick on it. The already made clay bricks angle were grinded with machine and chisel. After clay mortar admixed with chopped fiberglass in ratio 3: 10 was used to fix the bricks. While laying the brick, air duct was taken care of with brick fixed around it.

Lastly, the joining was filled properly finished to avoid loss of heat. (See Plate XI & XII as the research was laying and plastering the bricks).

Plate XI: Showing the Researcher Pounding the Clay Used for the Refractory.
Photo by Gaius Ikenna

Plate XII: Picture Showing the Researcher Sieving the clay
Source: Photo by Gaius Ikenna

Stage 8: The Pre-Heating of the Furnace Hearth.

It is ideal to pre-heat the hearth after construction before the actual firing test for casting. Now, charcoals already sprayed lightly with waste engine oil and ignited with match. The light was allowed to steady before the blower was fixed unto the socket and switched on. The pre-heat lasts up to hour and half with the combustion chamber covered but vent was open. The process was to burn-out the remaining water in the clay Mortar was also used for bricklaying and to get the lining ready. At the end refractory materials baked before it was used for melting metal.

Design and Evaluation

Although the recent level of technology has designed series of furnaces which may be fired with solid, liquid, or gaseous fuels, the idea of this research focused on how to construct an affordable furnace from locally sourced materials. Thus, the researcher adopted a practical approach with local technology. To achieve the design, idea from a foreign made furnace was adopted in the fabrication. The outcome of the research is the portable crucible furnace. It is a simple design, movable and portable. The mobility offers significant assistance in decongestion of studio because of the wheels. It has three main components – the shell, blower and and an oil tank. The shell is round - combustion chamber of the furnace housing the refractory of densely pressed lining and bricks. During operation the combustion chamber receives premixed air with oil from the tank through run down through channel connecting the blower. Blower is part with mechanical component responsible for blasting air into the hearth. As combustion continues heat temperature intensifies with the fuels combusting. As a result, the aluminum charge placed on it began to melt within 35minutes at 660^{o}c.

Evaluation of the Research

The final evaluation will combine a number of aspects of the furnace, such as: a look back on the development of the furnace; the evaluation of furnace in comparison in terms of cost and efficiency; the testing and use of the completed locally produced furnace for casting sculpture in metal; and to ascertain the potentials inherent in used engine oil and charcoal as energy source with low cost of operation and maintenanc lastly, to ascertain what is the

overall assessment and result of strategies for improving the use of locally produced furnace in teaching and learning sculpture.

The production assessment of the portable furnace fired with waste engine oil and charcoal proved the possibility of using of locally sourced materials, charcoal, and used engine oil for the fabrication and operating portable furnace. It was also observed that portability offers significant assistance in decongestion of studio because of the movable wheels. Furthermore, it will ultimately lead to achieving efficient teaching of foundry techniques in Art schools in South- eastern Nigeria.

This is faster and energy is cheaper compared to some furnace operate with costly fuels. Again, comparing the exorbitance prices and higher cost of maintenance of foreign made furnace, hence the advantage offered by use of this local fabricated portable furnace are affordability, economical and easy operation.

Testing of the completed furnace based on the followings: aim, materials / tools, procedure, observation and outcome.

Aim – To examine how faster the furnace and materials used for fuel can melt brass scrap for casting.

Materials : 1 sack- bag of charcoal, 1 sack- bag of kernel char, 1 liter of Condemned oil; 2kg brass scrap, some scrap of aluminum, flux, a match box.

Tools: The furnace, crucible, ladle, poker rod, tong, angle grinding machine pneumatic-drill, cold chisel and hammer.

Procedure : Quarter bag of charcoal and 3 litre of waste engine oil were used. The crucible was charged with 2kg brass scrap and placed at the middle of the combustion chamber. Again round the crucible was filled with charcoal. Fire was ignited, as the fire intensified, the blower was connected, switched on and oil tap was turned on. At a stage, the cover was opened to check the temperature while the blower was inducing heat as it blasts.

Observation : At this point, temperature in the crucible rose to $980^{oc,}$ as it was checked using Thumb rule method. The flame surrounding the crucible emitted less monoxide gas and was almost bluish. The thermal capacity estimated reached 1000^{oc} within 60 minutes continues firing. The fume from the scraps, in the crucible was light yellow. At this moment, the researcher poked the scraps so as to push down scrap remnants into the molten charge to have them melt too. In as much as the metals melt fast, the hearth transferred heat maintains a constant fluidity that also helps for free flow of molten metal while casting. Next slag was removed and molten metal poured into an already made mould. When the cast solidified, it was released by knock- out of the sand mould. On completion of this process, it was observed that no technological transfer is needed rather than a synergy between artists – sculptors and ceramist for more innovation.

Since the practice is expected to cater for the mind, the head and the hands and to develop self-reliant individual, the fabrication skill can help individual to effect changes on the existing resources of the society in this area of study.

In addition, because this research agrees with our national philosophy of education, it offers skill in vocation, technical and technological manpower needed for effective set-up and operating foundry industry.

Foundry being source of technical and technological development, the productivity valuation and utilization of this local product is hoped encourage foundry practice in the Fine and Applied art Departments in Nigeria.

Plate XIII: Pouring the Molten Metal into the Already Made Mould.
Source: Photo by Gaius Ikenna

Plate XIV: The Samples of the Caste metal.
Source: Photo by Gaius Ikenna

Conclusion

For any technological development to be achieved in the area of metal shaping (metal sculpture casting), there must be a furnace and required foundry equipments and materials which could help in achieving the great objectives. The equipment play a predominate role in collective aim and aspiration of sculptors in field of arts and engineering. Practice of metal melting and casting into given form of object requires an effective furnace.

Furnace, a device for founding is "a heater" for melting metals or glasses. The project focused on use of locally sourced materials in construction of an effective furnace fired with used engine oil and charcoal for casting metal sculptures. It is locally fabricated with following materials:- sheet metal, discarded automobile parts, clay (refractor brick and clay-body), waste engine oil and charcoal for fuel. These materials were put into use to construct furnace. These fuels effectively combust with the aid of electric blower that produces the air.

This furnace is suitable for medium and small foundry workshops. The use of such foundry in the cottage foundry industry will increase returns and improve the economy. The exploration of waste materials for the visual and literary documentation will serve as reference materials to foundry students, researchers, small and medium scale foundries. The study recommends that Art schools should work to construct their own furnaces using local sourced materials for enhanced teaching and learning

In all, it is assumed that with this furnace, metal founding in Fine and Applied Arts will be an easier task. Therefore, the cost benefit will also give additional impetus to students for foundry practice with cheap and effective locally fabricated portable furnace in Nigerians art schools especially Nnamdi Azikiwe University, Awka.

Recommendations

The study masks the following recommendations;

1) Art Students majority is sculpture should be encouraged to produce works in cast metal to improve their Technological capability.
2) Universities that have Art Departments should financial support students practical projects that involves metal casting and production of furnace.

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