DESIGN AND FABRICATION OF A CENTRIFUGAL FAN AS AN ALTERNATIVE TO THE MANUAL BELLOWS OF THE MASAGA GLASS BEADMAKING FURNACE IN NIGER STATE, NIGERIA

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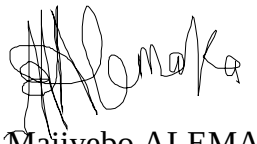
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DECLARATION

I declare that the work in this dissertation entitled "DESIGN AND FABRICATION OF A CENTRIFUGAL FAN AS AN ALTERNATIVE FOR THE MANUAL BELLOWS OF THE MASAGA GLASS BEADMAKING FURNACE IN NIGER STATE, NIGERIA" has been carried out by me in the department of Industrial Design. The information derived from literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.



Emmanuel Majiyebo ALEMAKA _____

Student's Name & Signature Date

CERTIFICATION

This thesis entitled "DESIGN AND FABRICATION OF A CENTRIFUGAL FAN AS AN ALTERNATIVE FOR THE MANUAL BELLOWS OF THE MASAGA GLASS BEADMAKING FURNACE IN NIGER STATE, NIGERIA" by Emmanuel Majiyebo ALEMAKA, meets the regulations governing the award of Doctor of Philosophy in Industrial Design (Glass Technology), of Ahmadu Bello University, Zaria. It has this day been approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to the Almighty **JEHOVAH**, the God of Abraham, Isaac and Jacob, the One who keeps covenants to a thousand generations of them who fear Him and obey His commands; the only wise God, the beginning and ending of all knowledge and wisdom.

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ABSTRACT

This thesis titled "**Design and Fabrication of a Centrifugal Fan as an Alternative to the Manual Bellows of the Masaga Glass Bead Making Furnace in Niger State, Nigeria**" was undertaken to address the furnace operational problem of the artisanal Masaga Glass Bead Makers in Bida, which is the focus of this research. The air supply to the furnace through manually operated bellows is critical to the operation as the operating manpower is depleting leading to the gradual extinction of this trade. Following the appraisal of the work practice of glass bead making in India, Ghana and Egypt that use local furnaces, the research came up with the design and fabrication of an electrically operated centrifugal fan in place of bellows. The centrifugal fan was fabricated from locally-sourced components and an electric motor to make this setup. A customized insulation brick furnace was constructed to complement this setup. The insulation bricks were made from a mixture of sawdust and kaolin in the ratio of 1:1. The design and fabrication of a centrifugal fan to supply compressed air to aid combustion and the design modification of the Masaga glass bead making furnace worked successfully in operation resulting in an increased capacity and consistency of air supply leading to the speed up of the bead making process. On operation, it was possible to achieve the desired temperature of 1200^0C within about twenty (20) minutes of working the setup. The furnace, being constructed using insulating bricks, provides the much needed protection for the workers against the searing heat of the work environment. In this way increased efficiency and a safer and neater working environment was achieved. The furnace setup is of potential benefits to small and medium scale enterprises that specialize in pyrotechnic artisanship like glass bead making, blacksmithing, and calcinations kilns. If this process is encouraged in the glass bead making industry nationwide, it would make bead making less expensive compared with foreign ones.

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DEFINITION OF OPERATIONAL TERMS

Bead	Small, usually round object made of glass, wood, metal, nut, shell, bone, seed or the like, pierced for stringing.
Fan	a device which moves gases by producing a low compression ratio, as in ventilation and pneumatic conveying of materials
Furnace	a device in which the chemical energy of fuel or electrical energy is converted into heat
Glass	an amorphous solid completely lacking in long range, periodic atomic structure, and exhibiting a region of glass transformation behavior
Impellers	rotating fan blades that move air

CHAPTER ONE

1.0 INTRODUCTION

The glass technology industry is yet to flourish in Nigeria. This is in spite of the fact that Nigeria is richly endowed with a substantial volume of requisite raw materials and manpower for a thriving glass technology sector. As with every developing economy, a great demand exists for infrastructural development, which will require immense material utilization, such as iron and steel, cement, glass, wood, plastics, composites etc.

The demand for glass as a material can never be overemphasized considering its deployment in the Information and Communications Technology sector, whether as components of computers or optical fibres as well as in the Construction industry and engineering/automotive industry to mention just a few. However, the technologies germane to the growth and development of the glass technology sector such as ceramics engineering and metallurgical engineering amongst others, are still not fully established in Nigeria as to facilitate and guarantee sustainability in the glass technology sector, that is, particularly considering the level of developments in the area of refractory materials, which are necessary for furnace construction. The resultant effect of the slow rate of development in these aforementioned areas is the heavy dependence on imported glass products as well as the relevant paraphernalia for glass production in the country, which inevitably translates into heavy foreign exchange

expenditure and consequent dependence and reliance on expatriate technical recommendations.

The call for technology transfer has left us neither here nor there since there is also the need for appropriate and viable technology. In my opinion, I want to advance that, it is unreasonable to think that the developed nations of the world, whether in the West, Europe or recently in Asia, will expend mental and financial resources as well as time to develop technologies and then turn around to transfer such to developing or less developed countries without strings attached in form of withholding key technical information necessary for sustaining such technologies. Usman (2013) asserted that a country can only lay claim to development when a critical mass of its indigenous manpower resource is able to utilize the available raw materials to produce goods and services for the people. This leads us to argue in favour of developing indigenous and appropriate technologies. Indigenous technology provides the opportunity for a systematic, step-by-step experience, in contrast to adapting up-to-date, ready-made and difficult-to-maintain technologies from advanced countries.

Glass bead making is a craft, which has become part of the culture of the Nupe indigenes of Masaga in Niger State of Nigeria and it occupies a place among the local indigenous industries in Nigeria. Unfortunately, the glass bead making industry among some others identified by Essien (2011) such as traditional soap making, blacksmithing, fishing, wood carving, traditional medicine, weaving/dyeing, calabash carving, small scale farming, brewing and distilling, and pottery, is on the verge of

extinction. One major reason I have identified to be responsible for the state of decline in the glass bead industry is the fact that the craft involves a number of participants, who are mostly closely linked by family ties with the younger members of the family having to work the manual bellows without which the whole operation becomes impossible. The younger ones may desire to acquire higher education or alternative vocation, which may take them away from the glass bead making workshop and if that happens it can result to a standstill in the industry.

To some extent, the Masaga glass bead makers have become familiar with some of the properties of glass especially its behaviour at elevated temperatures and they have acquired some expertise, from experience, in handling the material. It is assumed that the craftsmen would easily adapt to a gradual introduction of modern technology to the already established process of glass bead making without much problems.

1.1 Statement of Research Problem

The design of the furnace is such that the combustion air has to be supplied by means of bellows, which must be operated by an assistant all through the process of glass bead making. This implies that if there is no assistant to work the bellows, the whole operation of the glass bead making will be impossible. Secondly, the fact that a minimum of about two people are involved in the process of glass bead making, it makes the glass articles relatively more expensive than they should be.

1.2 Justification for the study

Presently there is no record of any study in the immediate past or in recent times carried out on the area under investigation. It is also my view that if no such research effort as this study is directed at this population, the likelihood of the craft as well as the indigenous technology therewith being lost is very high. Historically, two indigenous centres were reported to be involved in glass bead making in Nigeria – the Yoruba glass bead making centre located in Ife (Ige, 2006) and the Nupe glass bead making centre located in Masaga in Bida. Presently I am unaware of any available record or activity to suggest that the Yoruba centre is still functional, however, the Nupe glass bead making centre, specifically located in Masaga in Bida, which is still operational, functions only on a diminutive level.

It is in my view that in order to attain a fully developed and thriving glass technology sector of the national economy and to achieve the first and the second of the Millennium Development Goals, that is, firstly to eradicate extreme poverty and hunger and secondly, to give all children a primary school education (Developments, 2005), there need to be efforts geared towards research into indigenous technology. It is also advocated here that systematic development in indigenous technology to international standards will result in significant impacts on the national economy. Indigenous technology can easily be maintained without recourse to expatriate recommendations and consequent foreign exchange dissipation.

1.3 Aim and objectives of the study

The aim of the study is to design and fabricate a centrifugal fan as an appropriate substitute for the manually operated bellows used to provide combustion air in a glass bead making furnace for greater efficiency and sustainability. The objectives of the study are to:

i. design and fabricate a centrifugal fan to supply of compressed air to aid combustion

ii. modify the design of the current furnace;

iii. design and produce refractory bricks from the design drawing;

iv. construct the modified furnace structure using the refractory bricks;

v. test the furnace and the centrifugal fan.

1.4 Significance of the Study

The study is significant in the following ways:

1. The study is a major step towards developing indigenous technology for glass bead making and it opens up the field for further Research and Development (R&D) endeavours.

2. It simplifies the process of glass bead making by reducing the number of hands needed in the operation of the furnace.

3. The research contributes to rescuing the craft from decline and eventual dying out.

4. The research report contributes to the number of literature available for research purpose especially on the Masaga glass bead making industry.

5. The research advances the frontiers of knowledge in the studies of glass bead making among the Nupe of Masaga in Niger state of Nigeria.

1.5 Scope of the study

The scope of the study is to design and fabricate a centrifugal fan and to modify the design and construction of the glass bead making furnace. The study is also delimited to the Masaga Glass Bead Makers' Guild located in Bida of Niger state, Nigeria.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Beads

Beads are small perforated objects, usually spherical, that may be strung into necklaces and bracelets or attached to clothing or furnishings. The New Encyclopedia Britannica (2007) asserts that beads could be made of glass, wood, metal, nut, shell, bone, seed or the like, pierced for stringing; also that beads were worn among primitive peoples as much for magical as for decorative purposes and little variation was allowed in their shapes and materials. The word 'bead' is derived from the Anglo-Saxon word *beade* or *bede*, meaning "prayer," and was originally applied to prayer beads. Prayer beads are aids to prayer. They enable a worshiper to count the prayers he or she is praying. The use of beads to count prayers originated with the Hindus of India in the 6th century BCE. As religious artefacts, they are also used in the Christian and Islamic faiths (Encarta 2009 as cited in Affum, 2009). According to the Corning Museum of Glass (2013) glass beads symbolizing power, enabling ornamentation and facilitating trade, are masterpieces that have played significant roles throughout time and across cultures.

The Smithsonian Education (2014) advanced that, since ancient times, African peoples have cherished beads and appreciated their beauty. Beads are made of an assortment of materials, are small, perforated, and often rounded objects found throughout the world. Some of the materials from which beads are made in Africa

include a fusion of twigs, shells, glass, and bones which are put on a necklace or some other ornament in a manner which is apparently random making the object appear to have no design (Avotri, 2009). Glass beads, in particular, are a common element of African adornment and are widely used in African clothing and regalia.

Smithsonian Education (2014) again asserted that beads have played an important role in the personal lives of Africans and in the court life of African kingdoms; they have been valued as currency and as artistic medium. The Venetian Bead Shop (2014) informs that, beads have been made of glass for over 5000 years and that the discovery of fire was the essential step in glass bead making.

2.1.1 Beads in Ancient Egypt

Varshneya (1994) asserted that glazed stone beads from Egypt date back to 12, 000B.C and that several of the artifacts which were unearthed from the tombs of the pharaohs, exhibit excellent glass inlay work in a variety of colours. Filstrup (1982) as cited in Affum, (2009) advanced that solid glass beads had been discovered in Egypt which date from 4000 BCE. The New Encyclopedia Britannica (2007) however reports that rather than the solid glass beads the Egyptian beads dating about 4000BC were generally made of stone, usually steatite (soapstone), covered with a near-glass glaze.

Alden (2008) as cited in Affum (2009) claims that the oldest true glass beads from ancient Egypt are 3,500 years old and maintains that although the technique for

making glass was well known in very ancient times, it was only in the fourth century B.C. that the unbroken tradition of fine glass bead making really began. Saunders (2009) as cited in Affum (2009) attributes the discovery of glass making in Egypt to the rise of civilization there with glass beads being the natural outcome of such a discovery. This period also saw the Egyptians perfecting the skill of combining glass beads of various shades and hues and combining glass beads with other precious and semi-precious metals and gemstones resulting in high quality and beautiful pieces of highly sought after jewellery world wide.

2.1.2 Beads and Beads-making in Ghana

In Ghana, beads made of natural materials such as shell, stone and bauxite have been discovered and dated to about 1450 B.C. Originally beads were made from natural materials but they were later replaced by glass beads which European traders brought to trade for slaves, salt, gold and spices. Adegbeye (2008) asserts that bead making factories exist in Koforidua, Odumase, Kumasi and surrounding areas and most, if not all, of the glass beads made in Ghana today are produced either by the Asante people in villages just south and west of Kumasi, or by the Krobo people in villages in the Akuapem hills and in the coastal plains east of Accra. The Krobo are reputed to be one of the most important glass beads producers in Africa with a culture that employs beads copiously. Affum (2009) asserted that although Krobo beads are decorative, they have overwhelming uses and symbolism other than for decoration. Furthermore, Affum (2009) lamented that many Ghanaians associate Krobo beads only with the initiation

ceremony for adolescent girls known as and neglect the many other aspects of the beads application.

Adegbeye (2008) again asserts that Ghanaian glass beads are broadly classified into two groups based on their method of production; the wet-core powder glass beads (Bodom beads) produced by the Asante for their nobles and royalty and, the dry powder glass beads produced by the Krobo. The powder glass beads of Ghana differ from the furnace wound beads of the Masaga of Bida in Nigeria in the sense that powdered glass derived by crushing glass in a mortar (see Plate 2.1.2a) is placed in molds (see Plate 2.1.2b) produced from clay materials and placed in a kiln and fired.



Plate 2.1.2a: Mortar used for crushing glass into powder
Source: Ventura (2014)



Plate 2.1.2b: Clay Molds into which powder glass is placed for firing
Source: Ventura (2014)

The Krobo glass bead makers carry out their work under thatched open sheds (see Plate 2.1.2c) unlike the Masaga glass bead makers of Bida in Niger state.



Plate 2.1.2c: Open thatched shed working area of the Krobo people
Source: Adegbeye (2008)

2.1.3 Bead making in Nigeria

Bead-making is an ancient craft universally practiced among the various ethnic groups of Nigeria dating to antiquity. Nok culture provides evidence of the earliest civilization in Nigeria with some of its terra-cotta figures depicting human beings, wearing what are presumably strings of stone beads around the necks, wrists and ankles. It is also said that a large quantity of beads was recovered from the tomb of a priest-king dated 9th century from the Igbo-Ukwu excavation. At Ilesha in the present Osun State, a necklace of red stone beads was among the treasures excavated at the tomb of an Oba (Ibebabuchi, 2012).

2.1.4 Glass Bead Making among the Yoruba of Nigeria

Aremu (1999) as cited in Ige (2006) informs that Yoruba oral traditions specify the existence of an ancient glass bead making industry at Ife, with the first bead maker being *Olokun*, a Yoruba deity associated with the sea, wealth and bead making. Ibebabuchi (2012) added further that the wife of Oduduwa, Olokun Senaide is thought to have established the art of glass bead-making in the ancient city of the Ile-Ife, and Igbo-Olokun (Olokun Grove) is known to be her workshop. Ibebabuchi (2012) informs that many of the Ife terracotta and brass sculptures include depictions of ornaments suggesting both large and small beads. In some cases, these beads may be identified by shape and traces of applied paint as indicating the red stone beads, *Iyun*, and the blue glass beads, *segi*, still precious to the Yoruba.

Euba (1982), Eluyemi (1986), and Willet (2004) as cited in Ige (2006) claim that there is abundant material evidence based on excavations, to support a claim of early glass working and bead making in Ife. The excavations in the Olokun Grove, a ten-acre forested area sacred to Olokun on the outskirts of Ife, yielded beads and bead fragments. They also revealed broken crucibles and the remains of furnaces thought to be used for bead-melting, in addition to iron melting pits, iron and slag. Presently, as at the time of this study, however, and according to current information available to me, glass bead making among the Yoruba is either non-existent or it is not of any significance in terms of volume or commercial activity.

2.1.5 Glass Bead making among the Nupe

According to Harris (2014) the first reference to glass bead making in Nigeria, was published in 1857 by Bowen. Bowen (1968) as cited in Harris (2014) stated that the Nupe were the only people in Sudan who still retained the art of manufacturing glass and this art is confined to three towns; Usman (2013) provided the names of these three towns to be Gbongbofu, Tswatako and Tswata-Mukun area of Bida. Harris (2014) opined that apart from Egypt, Nigeria is the only other known place in Africa where glass beads were not just recycled from imported glass beads or fragments but were produced from sand, furthermore that Bida beads (Masaga furnace wound) of Niger state, Nigeria are very popular as the tradition remains till this day (See Plates 2.1.5a & 2.1.2b).



Plate 2.1.5a: Masaga neck beads
Source: Field trip Report Alemaka (2009)

In Plate 2.1.5a can be seen different types of glass beads that are worn particularly around the neck; while in Plate 2.1.5b can be seen neck beads as well as glass articles made for decorative purpose especially the articles with snake forms.



Plate 2.1.5b: Masaga glass beads and coiled snake figures
Source: Field trip Report Alemaka (2009)

Forbenius (1913) cited in Harris (2014) is recorded to be the first to publish the discovery that glass was actually made at Bida for the beads and bangles turned out there by the Masaga guild. Meek (1925) in Harris (2014) reported that the Masaga had started recycling bottles fifty years before, and gave an incomplete account of the old glassmaking process. First hand information available to me on the activities currently ongoing in Masaga is that the bead making is based on recycling of wine bottles and other types of glass rather than the actual making of the glass from the raw materials as can be seen in Plates 2.1.5c and 2.1.5d.



Plate 2.1.5c: Wine bottles for bead production by Masaga workers
Source: Field trip Report Alemaka (2009)



Plate 2.1.5d: White and orange glass from Mecca used for bead production by Masaga workers
Source: Adegbeye (2008)

2.2 Masaga Glass work in Masaga Bida

Nadel (1951) as cited in Usman (2013) asserted that Bida town was an administrative district in the British protectorate of Northern Nigeria, the capital of the province of Nupe founded in 1859 when Fularule was established in Nupe; it is walled and of considerable size. It was noted by Nadel (1951) cited in Usman (2013) that the inhabitants, mostly Nupe and Hausa, carry on an extensive trade and are especially noted for their embossed brass and copper work. The Bida goblets, in which brass and copper are beautifully blended, are of extremely elegant design. The town also boasts of a glass factory. The preparation of indigo and the dyeing of clothes are other flourishing industries. The streets are planted with huge shade-trees, so that as Bida is approached it looks like a forest.

Usman (2013) asserts that Masaga in Bida is a wonderful tourist resort town. The glasswork involves heating present day bottles to softening point as raw material. The melting process involves intense application of heat to the bottles over a furnace in a traditional parlour known as '*Katamba'* (see Plate 2.2a) in Nupe language, dedicated to melting bottles and glasswork.



Plate 2.2a: *Katamba* (round hut in the background)
Source: Field trip Report Alemaka (2009)

The broken bottles placed on fire normally soften into a molten liquid that is manipulated using various tools to make different types of ornaments such as bangles, bracelets, beads, snake like toys etc, which are then displayed in a showroom (See Plates 2.2b and 2.2c) for prospective customers and as tourist attraction (Alemaka, 2009). Interestingly, only members of this family can melt and mould bottles in this *Katamba*. No other person outside the family of the glass workers can practise this trade.



Plate 2.2b: Outside the Masaga Bead makers' showroom
Source: Field trip Report Alemaka (2009)

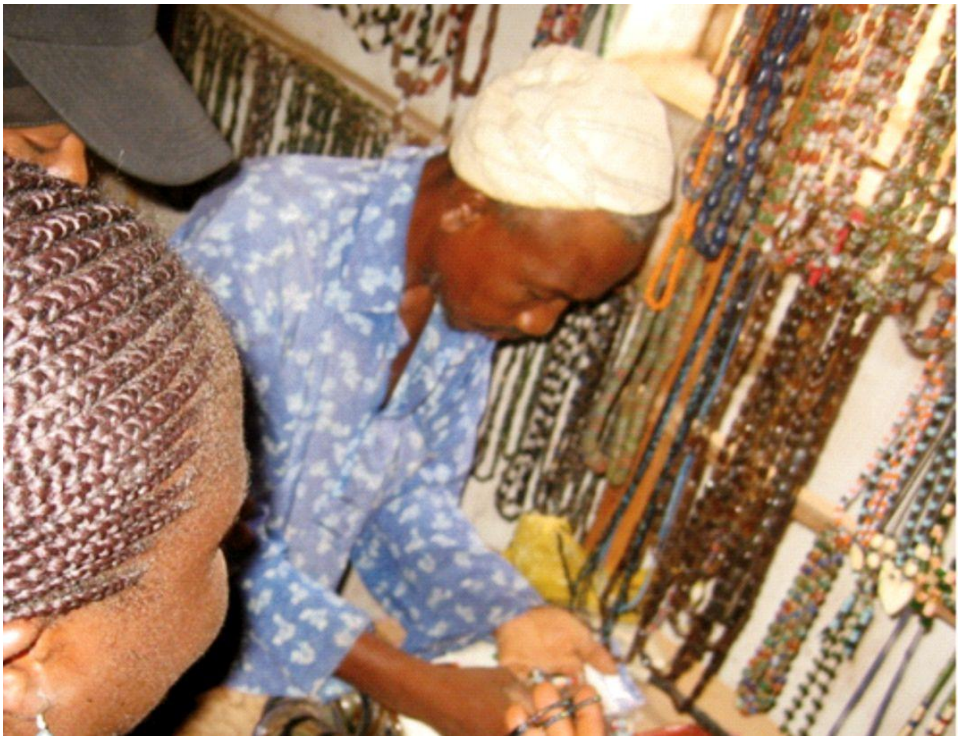


Plate 2.2c: Inside the Masaga Bead makers' showroom
Source: Field trip Report Alemaka (2009)

The traditional industries, especially guild-organized crafts in which membership is largely hereditary, are done by men. These trades include blacksmithing, brass and silversmithing, glassmaking, weaving, beadwork, building, woodcarving, and carpentry.

Plate 2.2d presents a typical Masaga glass bead making process. The head glass maker or 'gaffer' is seen with appropriate tools working on the glass while in the direct opposite corner the 'boy' can be seen working the bellows which supplies the combustion air for the furnace. At the extreme left hand side of the picture and sitting atop the pile of sticks, another assistant can be seen whose main occupation is to replenish the wood fuel in the furnace.



Plate 2.2d: Glass bead making session at the Masaga furnace
Source: Field trip Report Alemaka (2009)

2.3 FURNACES

A furnace is a device in which the chemical energy of fuel or electrical energy is converted into heat, which is then used to raise the temperature of material, called the burden or stock that is placed within it for that purpose (Gupta, 2006). Furthermore, a furnace is an apparatus in which heat is liberated and transferred directly or indirectly to a solid or fluid mass for the purpose of effecting a physical or chemical change (McGraw-Hill 2002b). Furnaces operating at low temperatures are often called ovens depending on their purpose. There are also others used for higher temperatures for different purposes. When associated with the ceramic industries they are called kilns (Gupta, 2006).

Furnaces have been classified on the bases of type of fuel used for example, oil-fired, gas-fired, coal-fired and electric-fired; mode of charging of materials for example, intermittent/batch (periodical) and continuous; mode of heat transfer for which we have such examples as radiation and convection; and mode of waste heat recovery for which we have recuperative and regenerative (Energy Efficiency Guide for Industry in Asia, 2006). Gupta (2006) however asserts that no particular classification is exhaustive of the types of furnaces that exist.

2.3.1 Glass Bead making Furnaces

Melting of glass by the Masaga glass guild is carried out in furnaces similar to that used by the Egyptians for melting glass. The Egyptians melted glass in small

furnaces shaped like beehives, the type of which is illustrated in Fig. 2.3.1 below. It was observed by Mickelsen (2014) that wood was the primary source of energy and the compounds used to make glass were placed in ceramic crucibles. The air needed to fuel the combustion was introduced through portals at the bottom of the furnace and let out through a round exhaust vent at the top.

The tools used were very simple and were used to draw canes out of the small molten blob within the crucible. Giberson (1995) in Mickelsen (2014) describes what he calls a "hot volcano" as a cone-shaped furnace that allowed heat to escape through a narrow opening at the top while the escaping hot air was replaced through some opening at the bottom. The result was a jet of very hot gas and flame exiting the top of the "volcano" that was sufficient to melt and form glass.



Fig 2.3.1a: Section through an early Egyptian Wood-fired Glass Furnace
Source: Dudley Giberson (1995) in Mikelsen (2014)

Although there was no actual lamp or burner involved, there was often a visible flame coming from the vent (hole), though this is not the fixed flame associated with lampworking as it could not be directed at specific areas of the object. These "beehive" furnaces have been recorded in a great many civilizations, confirming that glassmaking and working may have originated from a single source. Furnaces found in North Africa as shown in Fig. 2.3.1b are nearly identical to those found in Japan. These furnaces dominated glassmaking worldwide before the birth of Christ.

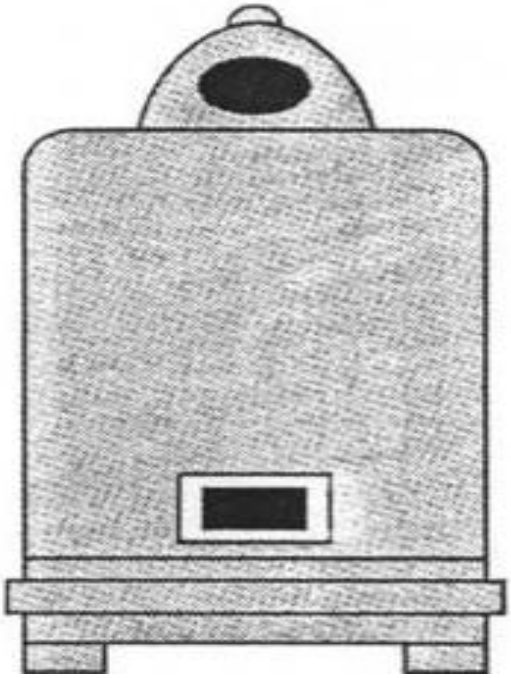


Fig. 2.3.1b: North African Charcoal-fired furnace
Source: Dudley Giberson (1995) in Mikelsen (2014)



Plate 2.3.1a: Ghanaian Wood-fired kiln with Moulds
Source: Ventura (2014)

The Ghanaian furnaces or kilns, used for making glass beads are constructed from termite mound clay as can be seen in Plate 2.3.1a above. This type of furnace is employed in making beads using the powdered glass method. The moulds used for making the beads are placed on automotive leaf springs that are supported by recycled car axles. In Plate 2.3.1b can be seen how the fuel for the Ghanaian furnace is replenished (Ventura, 2014).



Plate 2.3.1b: Ghanaian Wood-fired furnace (kiln) being fed with Wood
Source: Ventura (2014)

The furnace which is used by the glass bead makers of Bida bears similarities with the early Egyptian wood-fired furnace as can be seen below in Plate 2.3.1c.



Plate 2.3.1c: End elevation of the Masaga Wood-fired Furnace
Source: Field trip Report Alemaka (2009)

The furnace used by the Masaga glass bead makers is usually made of red clay material with pieces of broken ceramic pots used to reinforce the top opening of furnace (see Plate 2.3.1d) particularly in spots where the metal tools will rest while forming the glass beads/articles, and also to cover the opening where the bellows are connected to the furnace.



Plate 2.3.1d: Top elevation of the Masaga Wood-fired Furnace
Source: Field trip Report Alemaka (2009)

2.4 Furnace Modification

Furnace modification activities are usually carried out in order to upgrade technology for energy productivity improvements. In India according to Bureau of Energy Efficiency (2014b) there are about 1,300 small units in and around the town of

Jagadhri manufacturing brass, aluminum and stainless steel utensils using raw materials such as metal scrap, sheets, billets and ingots and these units were found to be operating on very low profit margins. The Small Industries Development Bank of India (SIDBI) entrusted a study to National Productivity Council (NPC) to suggest improvements over the existing technology used by these clusters and to demonstrate the relevance of productivity techniques to a few interested units.

It was observed that the annealing process had a significant role in product quality but that the annealing furnaces in the cluster were of very old design. It was discovered that there were several limitations in the existing furnace and the techno-economics in adopting modified furnaces was very attractive. The main objective in redesigning the furnace was to overcome the technology gaps with small investments (Bureau of Energy Efficiency, 2014b).

The Bureau of Energy Efficiency, (2014b) identified that the major shortcomings discovered in the existing Jagadhri furnace were: no proper provision for supplying combustion air – the combustion air intake and flue gas exit takes place from the front of the door through which the material is fed; inadequacies in maintaining and controlling uniform furnace temperature results in uneven surface hardness; excess temperature results in oxide formation in the surface of products; higher rejection rates of annealed sheets and the absence of a chimney leading to hazardous working conditions. In Fig 2.4a is the layout of the furnace before modification was carried out.

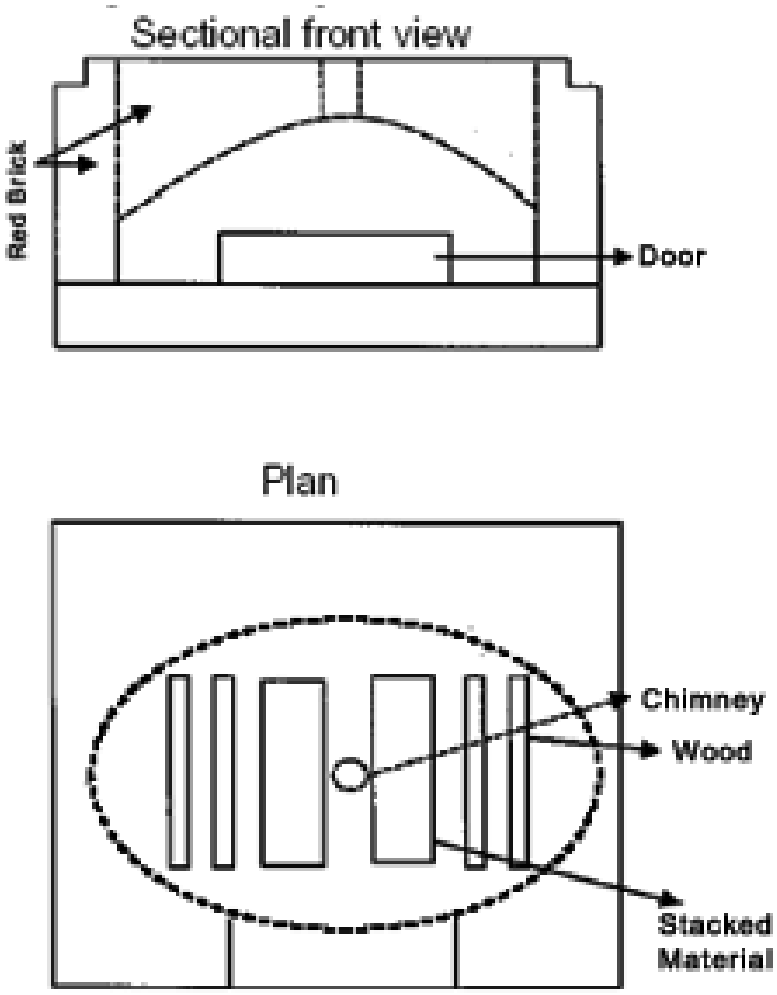


Fig. 2.4a: Jagadhri furnace before modification
Source: Bureau of Energy Efficiency (2014b)

The major changes observed in the modified furnace (see Fig 2. 4b) are: proper flue gas passage provided through the floor of the furnace and provision of chimney with damper, which has created proper draft for the combustion; separate passage for the combustion air through the side of the furnace; thermocouple provided to monitor and control the furnace temperature; and mineral wool packing for better heat retention.

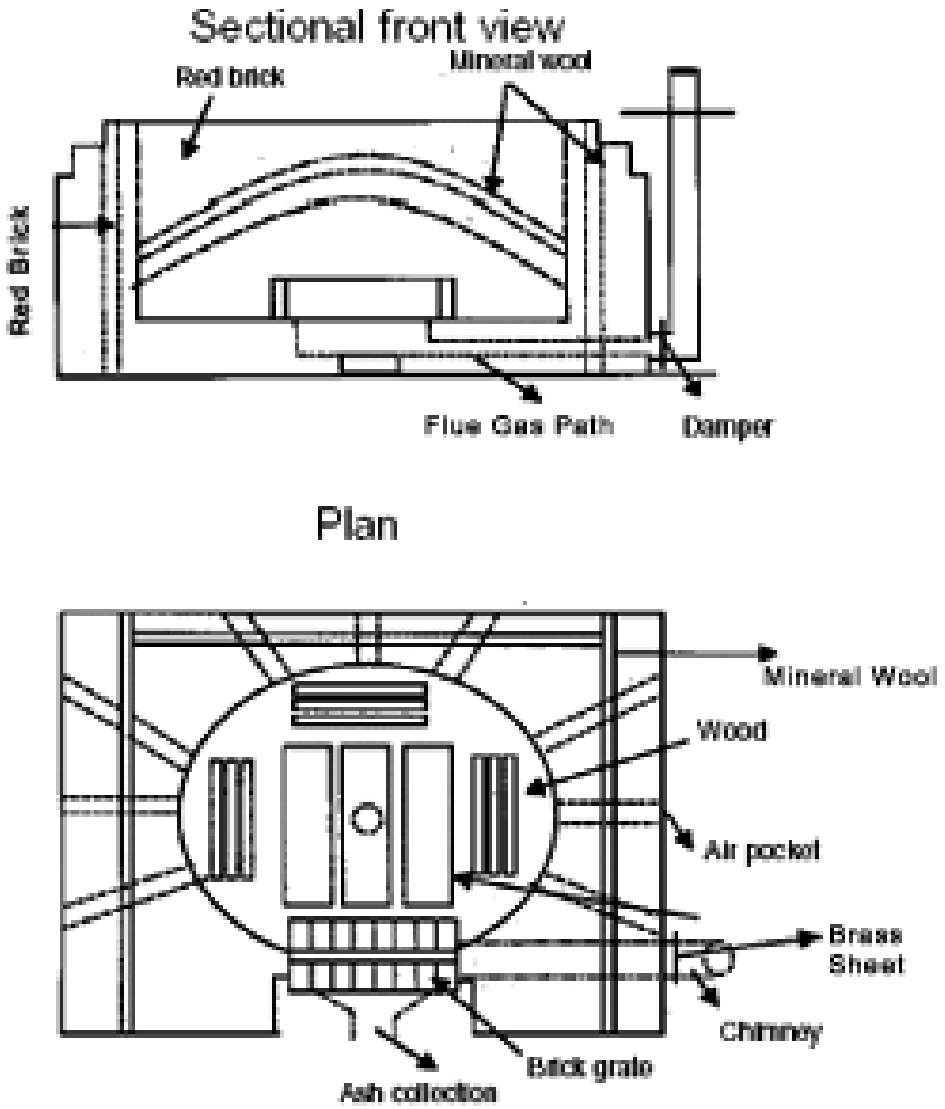


Fig. 2.4b: Modified Jagadhri furnace
Source: Bureau of Energy Efficiency (2014b)

2.5 BELLOWS

Wikipedia (2010) asserts that a bellows is a device for delivering pressurized air in a controlled quantity to a controlled location; Bellows can also be described as an instrument contrived for propelling air through a pipe, employed for blowing fires, supplying air to ventilate mines, filling the pipes of an organ with wind, and other purposes (The Green Book 2012b). Bellows is basically a deformable or collapsible container, which has an outlet nozzle. It is believed that originally bellows were nothing more than the skin of an animal closely sewn except at one part, to which a spout or delivery-tube was attached, also serving to admit a further charge of air when the sides of the bag were pulled apart.

Bellows provide the fuel with additional air and in so doing increase the rate of combustion and which causes the heat output to be increased. The combustion air for the Masaga furnace is supplied by manually worked cloth bellows with a couple of sticks attached to serve as handles as can be seen in Plate 2.5a;



Plate 2.5a: Cloth bellows for the Masaga furnace
Source: Field trip Report Alemaka (2009)

In Plate 2.5b the bead making process can be seen with the manual cloth bellows being used.



Plate 2.5b: Increasing rate of combustion using the manual bellows
Source: Field trip Report Alemaka (2009)

2.5.1 Effort at Mechanising the Bellows in Nigeria

There has been an attempt to improve on the traditional skin bellows used by blacksmiths and brass workers in Nigeria as was revealed during a session of my participant observation of a brass worker attached with the Department of Fine Arts of Ahmadu Bello University, Zaria - Aliu Dosso. In place of the animal skin used for the traditional bellows used by blacksmiths, brass workers and in rare cases, people who carry out repair works on broken plastic containers and articles, a mechanical device incorporating a motorcycle wheel and a centrifugal fan is employed for the supply of compressed air for combustion (see Plates 2.5.1a and 2.5.1b).



Plate 2.5.1a: Motorcycle wheel with handle used as pulley component of the fan
Source: Communications with Ali Dosso (2014)



Plate 2.5.1b: Port with bicycle wheel component as pulley part
Source: A. Dosso (Participant observation October17, 2014)

This device, according to Dosso was put together for him by a Chadian national sometime ago as far back as 1989. There was no information was available to Dosso as touching the origin of this particular fan or information about the inventor.

In Plate 2.5.1c is a close up image of the port containing the fan impeller; the impeller is made of up six a forward curved blades, while Plate 2.5.1d contains the image of the assembly of the mechanical bellows showing the connection of the motorcycle wheel to the impeller port by means of a flexible rubber belt derived from an inflatable tyre tube. The rubber belt is twisted and as revealed by Dosso (2014) during the course of discussion, this is in order to facilitate a better grip between the belt and the contact surface of the wheel.



Plate 2.5.1c: Close-up of the impellers inside the port
Source: A. Dosso (Participant observation October17, 2014)



Plate 2.5.1d: Motorcycle wheel connected by flexible rubber belt to the bicycle wheel part as pulley component of the fan
Source: A. Dosso (Participant observation October17, 2014)

The mechanical bellows is connected to a furnace (Plate 2.5.1e) by means of a hollow metal pipe buried underground, because the furnace is built on the ground level with a dug out center which contains the charcoal fuel for combustion and heat generation.



Plate 2.5.1e: Furnace for brass melting
Source: A. Dosso (Participant observation October17, 2014)

The mechanical bellows is operated by continual manual effort of spinning the motorcycle wheel to which a handle has been attached by welding as can be seen in Plate 2.5.1f where Dosso demonstrates how it is done. This act of spinning the wheel has to be maintained all through the process which according to Dosso, can last between 30minutes to 1hour depending on the quantity of brass that needs to be melted.



Plate 2.5.1f: Ali Dosso demonstrating how the fan is operated
Source: A. Dosso (Participant observation October17, 2014)

2.6 FANS

A fan is an apparatus, with at least one blade, which is used to move air either for cooling or for ventilation purpose and also for increasing the rate of combustion in a fire in order to increase the heat output. A fan has been described as a device which moves gases by producing a low compression ratio, as in ventilation and pneumatic conveying of materials (McGraw-Hill 2002a) Energy Efficiency Guide for Industry in Asia (2006) asserts that most manufacturing plants use fans and blowers for ventilation and for industrial processes that need an air flow.

Fans, blowers and compressors are devices that function virtually by the same principles and can usually be mistaken one for the other, especially blowers and fans since often times these devices look similar. These devices are however, differentiated by certain factors as the mode by which they move the air as well as the system pressure against which they operate (Energy Efficiency Guide for Industry in Asia, 2006). The American Society for Mechanical Engineers (ASME) as cited in Energy Efficiency Guide for Industry in Asia (2006) defines fans, blowers and compressors by using specific ratio, which is the ratio of the discharge pressure over the suction pressure; the differences between fans, blowers and compressors are summarized in Table 2.6 below.

Table 2.6: Difference between Fans, Blowers and Compressors (Ganasean)

Equipment	Specific Ratio	Pressure rise (mmWg)
Fans	up to 1.11	1136
Blowers	1.11 to 1.20	1136 –2066
Compressors	more than 1.20	-

Source: Energy Efficiency Guide for Industry in Asia (2006)

2.6.1 Types of Fan

On a broad basis, there are two main types of fans and these are the centrifugal fans and the axial fans. Centrifugal fans increase the speed of an air stream with a rotating impeller. The speed increases as the air reaches the ends of the blades and is

then converted to pressure. These fans are able to produce high pressures, which makes them suitable for harsh operating conditions, such as systems with high temperatures, moist or dirty air streams, and material handling. Axial fans move an air stream along the axis of the fan. The way these fans work can be compared to a propeller on an airplane: the fan blades generate an aerodynamic lift that pressurizes the air.

2.6.2 Centrifugal Fans

Centrifugal fan (see Fig. 2.6.2) types are three in number consisting of radial fans with flat blades, forward curved fans with forward curved blades and backward inclined fans with blades that tilt away from the direction of rotation.

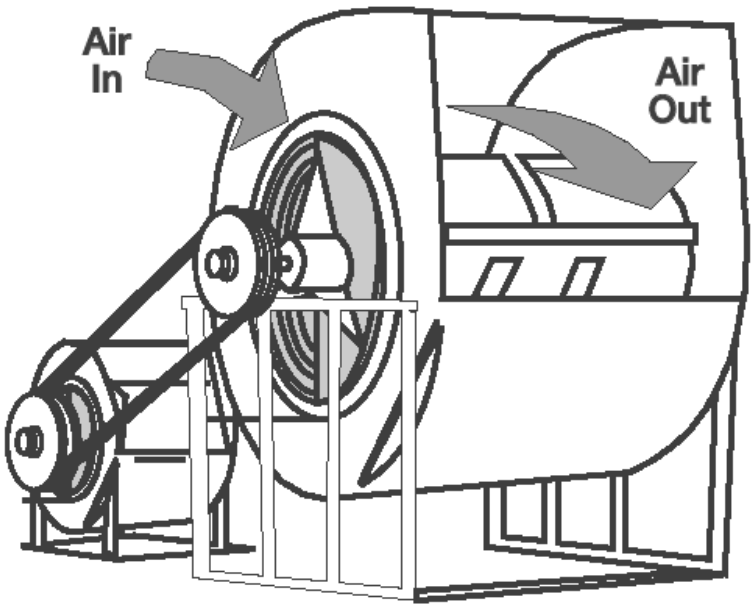


Fig. 2.6.2: Centrifugal fan
Source: Energy Efficiency guide for Industry in Asia (2006)

Radial fans (see Plate 2.6.2) have been described as industrial workhorses because of their high static pressures and their ability to handle heavily contaminated airstreams, also due to their simple design, radial fans are said to be well suited for high temperatures and medium blade tip speeds; Forward-curved fans are used in clean environments and operate at lower temperatures. They are well suited for low tip speed and high-airflow work - they are best suited for moving large volumes of air against relatively low pressures. Backward-inclined fans are more efficient than forward-curved fans. Backward-inclined fans reach their peak power consumption and then power demand drops off well within their useable airflow range (Bureau of Energy Efficiency 2011).



Plate 2.6.2: Radial blade for centrifugal fan
Source: Energy Efficiency guide for Industry in Asia (2006)

2.6.3 Axial Fans

The major types of axial fans are the tube axial, vane axial and propeller fans but they are not suitable for application in furnaces such as is in this study and as such will not be treated in detail beyond the mentioning.

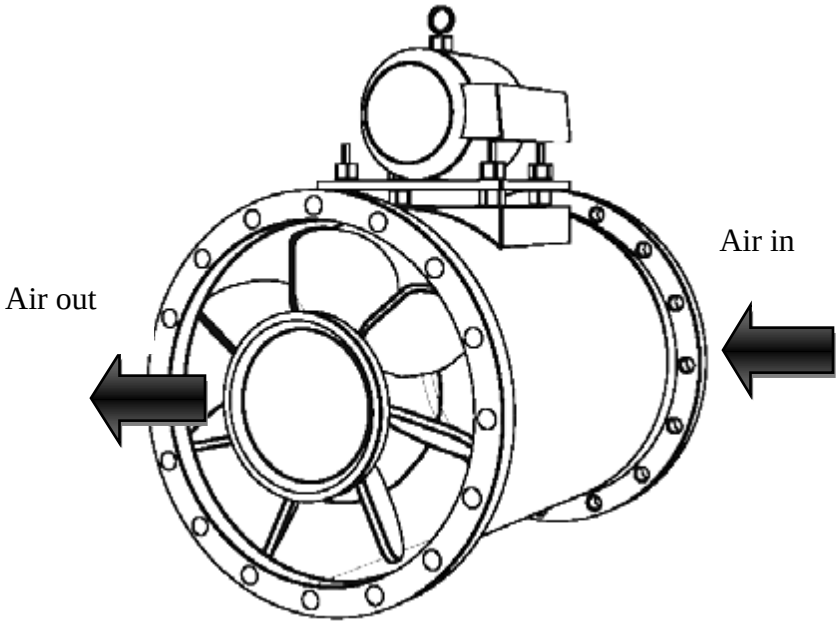


Fig.2.6.3: Axial fan
Source: Energy Efficiency guide for Industry in Asia (2006)

CHAPTER THREE

3.0 METHODOLOGY

According to the online resource Wikipedia (2010), methodology may be a description of process, or may be expanded to include a philosophically coherent collection of theories, concepts or ideas as they relate to a particular discipline or field of inquiry. Also, methodology may refer to nothing more than a simple set of methods or procedures, or it may refer to the rationale and the philosophical assumptions that underlie a particular study relative to the scientific method.

The Free dictionary (2014) defines methodology as a set of working methods; the working methods employed include aspects of the design process which is composed of design brief, product design specification, concept design, detail design, manufacturing and testing, and sales (BLUEPRINT An Overview of the design Process); design modification, drawings, brick extrusion, fabrication and construction, assembling, welding and painting.

3.1 Materials

The materials employed for the furnace and centrifugal fan are:

1. Kaolin
2. Saw dust
3. Water
4. Wooden moulds

5. Metal sheet and circular pipes

6. Kiln

7. One Atlas Electric Motor with the following specifications - 0.74kilowatt, 1Hp, 50Hz, 1440rpm

8. One four-blade impeller

9. Two (2) pieces of 1ft diameter circular metal sheets

10. One (1) 0.25inch radius metal elbow pipe

11. Metal angle bars

12. One (1) connecting metal shaft

13. Elbow connecting pipe

3.2 The Problems Identified with the Current Furnace Design

1. The furnace is not built with refractory bricks, which implies that it has a short life span before it will require rebuilding

2. The furnace wall is relatively light hence the problem of heat loss to the environment with subsequent high fuel consumption necessary to attain and maintain high temperature.

3. The furnace utilizes manually operated traditional bellows

4. The furnace is built on the ground and so it has be worked while sitting on the floor

5. No provision of furniture in the furnace area and hence uncomfortable sitting position has to be assumed for the duration of the process

3.3 Furnace Design Modification

The current design of the furnace cannot accommodate the centrifugal fan and so has to be modified. Design modification was employed first by assessing the design of the current furnace and identifying areas needing modification in terms of materials and method of operation. The modified furnace shape was derived from the "beehive" shape of the current furnace but was made to be circular in such a way which can easily be adapted to modern furnace construction methods with refractory bricks and the resultant design can be seen in Fig 3.3a.

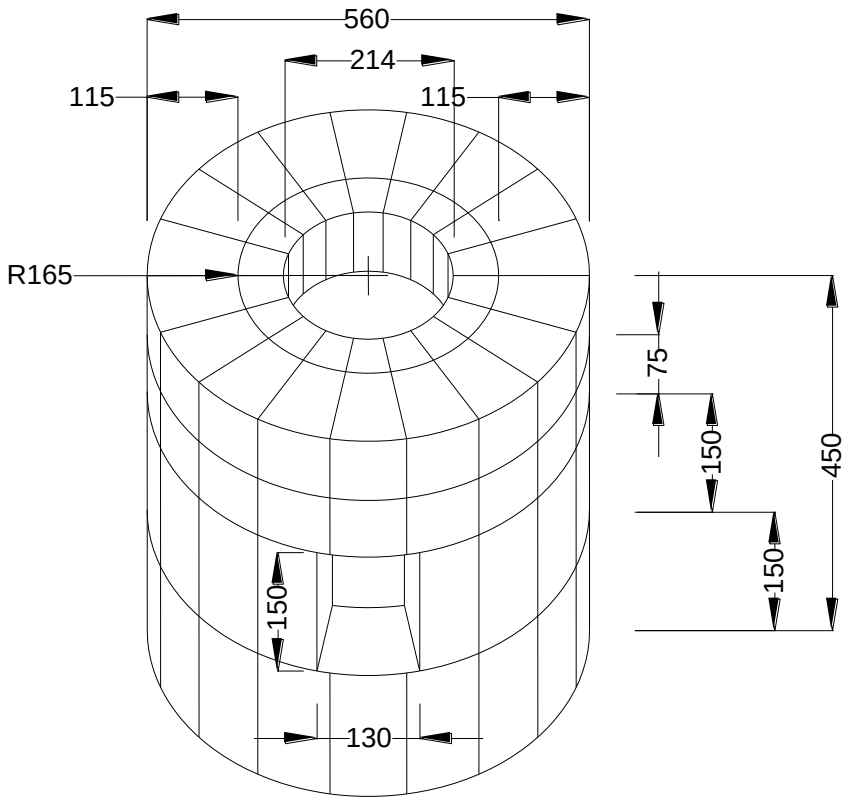


Fig. 3.3a: Isometric view of modified furnace structure with relevant dimensions in mm

A section through the modified furnace showing the internal structure of the furnace is presented in Fig. 3.3b

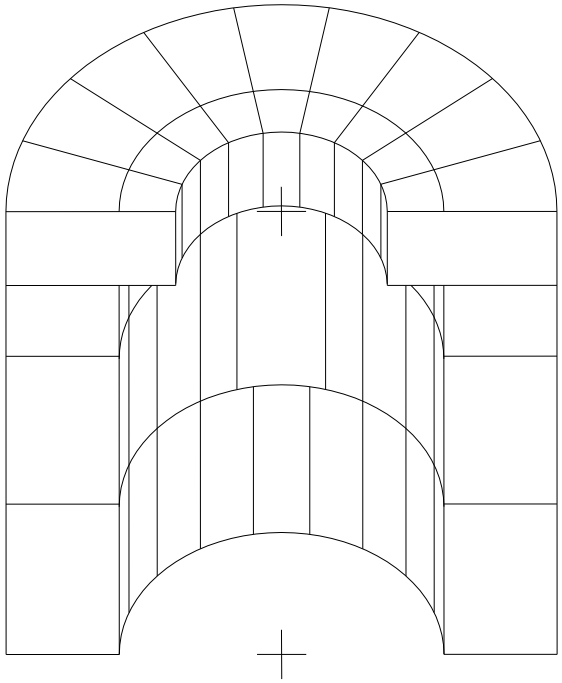


Fig 3.3b: Section view of modified furnace

The different elevations of the furnace with relevant dimensions in an orthographic projection are also presented in Fig 3.3 c below.

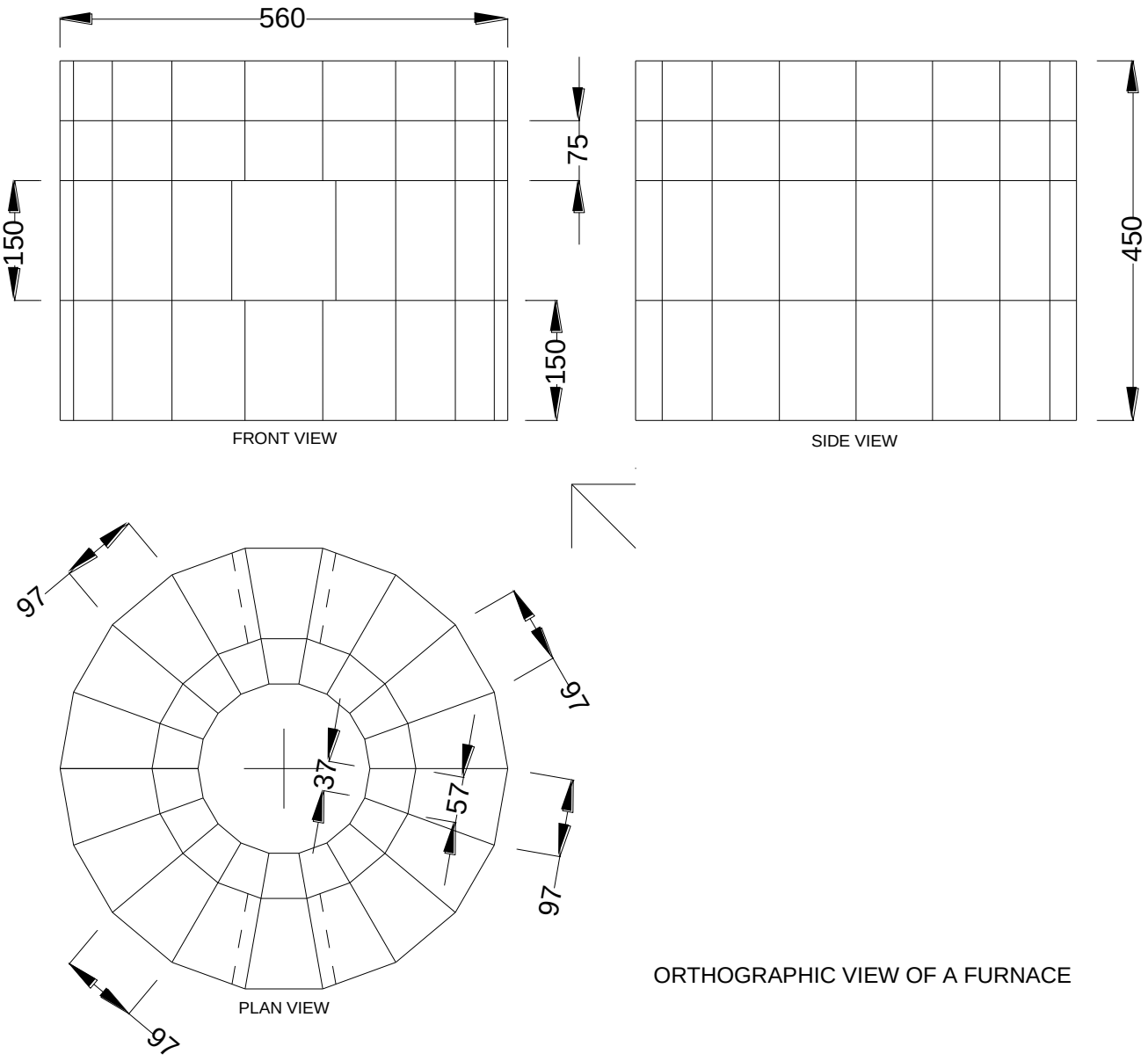


Fig. 3.3c: Orthographic view of furnace

Fig. 3.3d below shows from the AutoCAD design drawing, the different rows of brick to be laid in the construction of the modified furnace

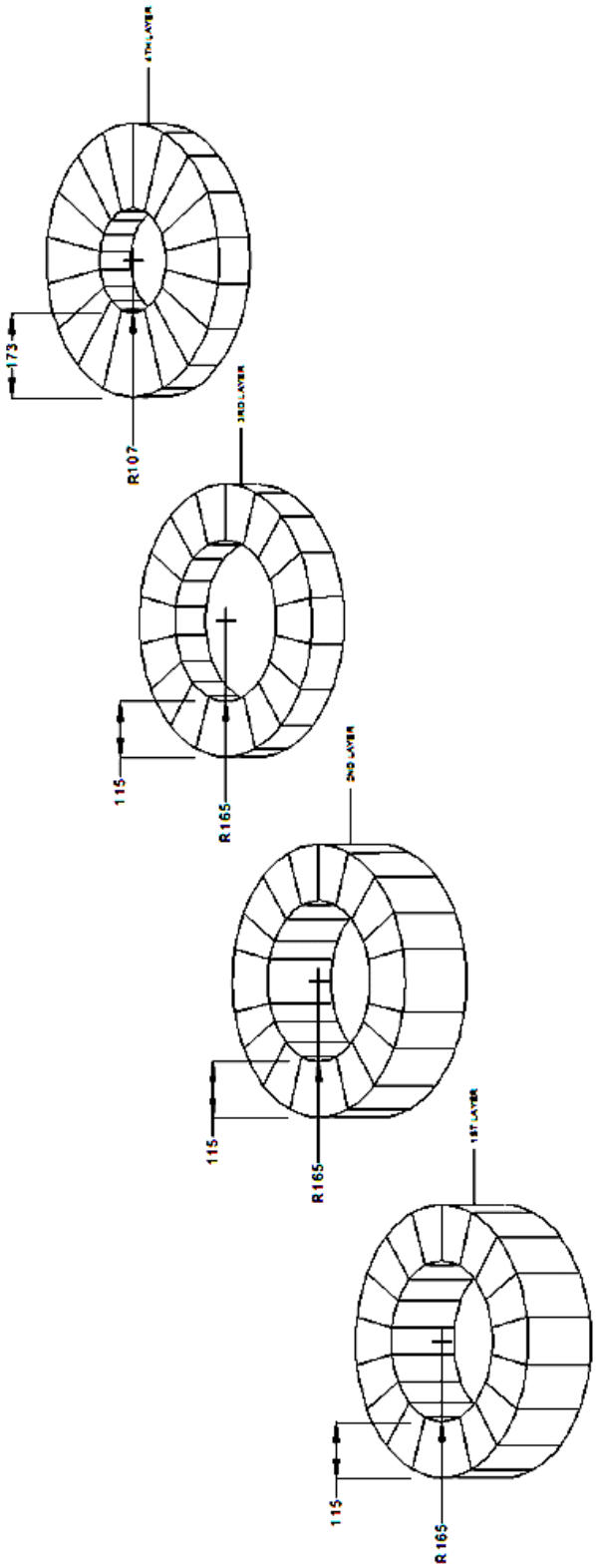


Fig. 3.3d: Exploded view of Modified furnace with respect to layer

Preliminary sketches were made followed by CAD design drawings of the modified furnace from which brick types were derived (see Figures 3.3e and 3.3f). Wooden moulds for the brick types (1 and 2) were then constructed according to dimensions calculated from the drawings (See Plate 25).

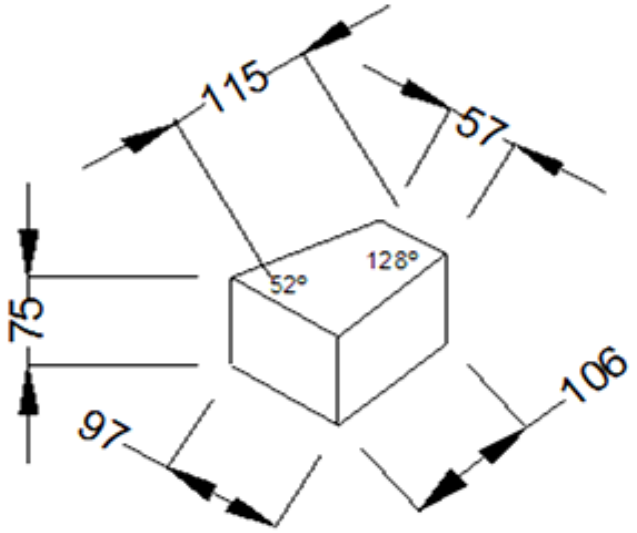


Fig. 3.3e: Isometric view of Brick type 1

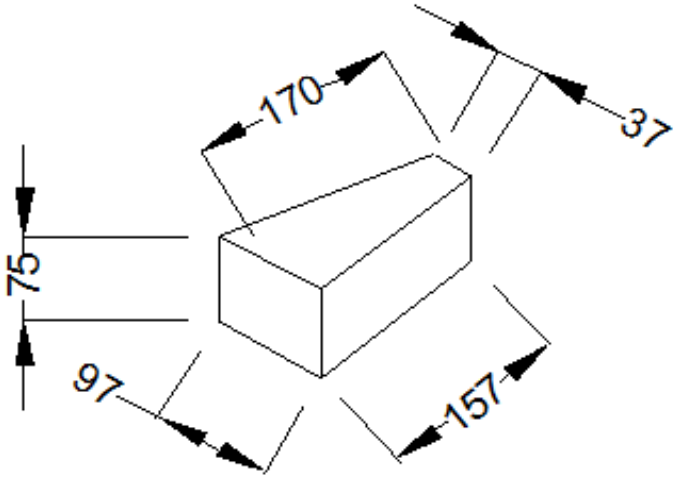


Fig. 3.3f: Isometric view of Brick type 2

Orthographic projections of the bricks (type 1 and type 2) were also drawn to guide in the construction of the wooden moulds that would be used for the extrusion of the insulation bricks. These are presented in Figures 3.3g and 3.3h

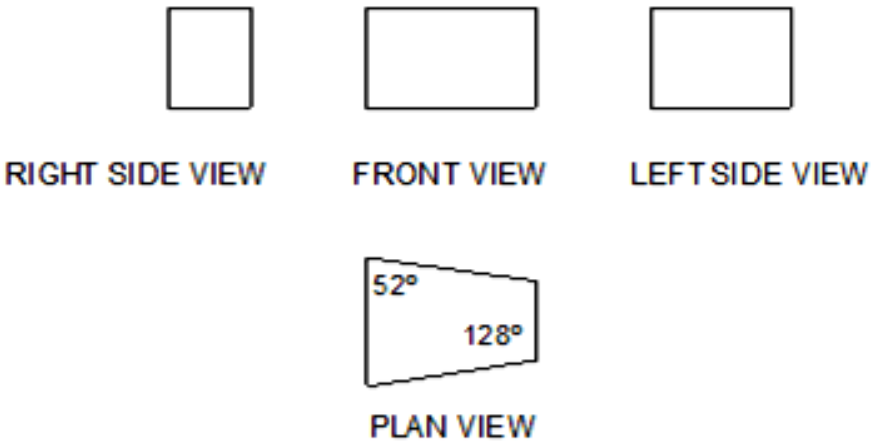


Fig. 3.3g: Orthographic view of Brick 1

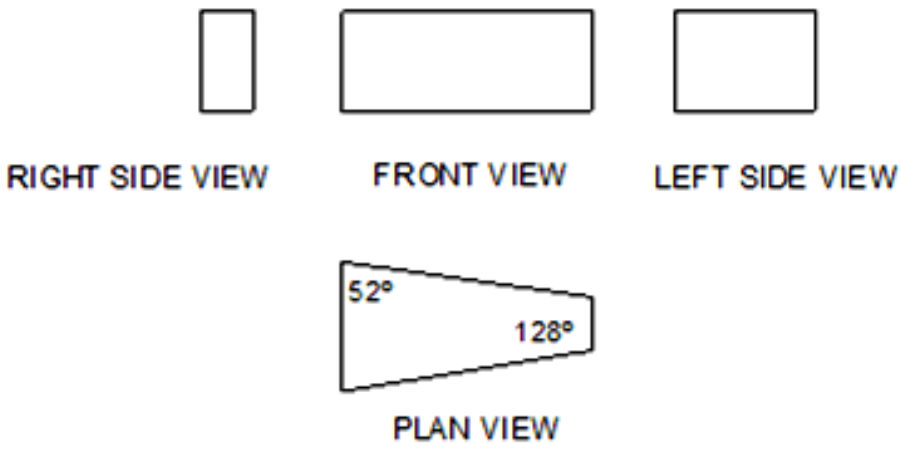


Fig.3.3h: Orthographic view of Brick 2

3.4 Insulation Brick Making

The insulation bricks were made by the following procedure:

1. Sawdust and kaolin were mixed in a 1:1 ratio; made to paste by mixing with water

2. The paste was covered and left to decay for a period of six weeks

3. The bricks were now extruded using the wooden moulds (see Plate 3.4a)



Plate 3.4a: Mould for bricks type 2 and 1 with oil paint for easy extrusion of bricks

The results of the bricks made using the mould for type 2 is displayed in Plate 3.4b below, while results of bricks made using mould for type 1 is displayed in Plate 3.4c



Plate 3.4b: Bricks type 2 extruded using wooden moulds



Plate 3.4c: Bricks type 1 extruded using wooden moulds

4. The bricks were then left to dry in the open for about four weeks (see Plate 3.4d)



Plate 3.4d: Extruded bricks drying naturally in air

5. Firing of the bricks was then carried out in a kerosene-fired kiln to a temperature of about 1200^{o}C for a period of four hours

3.5 Fabricating the Furnace Stand

The metal stand for the furnace was fabricated by cutting metal pipes which were joined together through welding to form legs for the stand. Steel plates were also cut to size and formed into a circular shape by welding. These were then coupled together and painted (see Plate 3.5).



Plate 3.5: The metal bench for the furnace

3.6 Constructing the Furnace

Olsen (1983), provided a detailed account on the different methods of kiln construction and gives instructions on methods of constructing straight walls, which include the header course, stretcher course, alternate header and stretcher courses, rowlock and soldier courses; methods of constructing curved walls, division or common walls, arches such as sprung arches, bonded arches, ring arches, ribbed arches, straight arches, suspended arches and different parts of a kiln; these were instructive to the method chosen to construct the furnace in this study. Constructing the furnace

began first with creating a base for the furnace structure as is shown in Plate 3.6a below.



Plate 3.6a: Base for the Modified furnace

Then the first layer of the insulating bricks of the type 1 was laid (see Plate 3.6b) with the aid of mortar, which is composed essentially of a mix of kaolin and saw dust.



Plate 3.6b: Laying first row of bricks

Using the alternate header and stretcher course method of construction, the same procedure was used to lay the second layer of bricks (see Plate 3.6c);



Plate 3.6c: Laying second row of bricks

The third and fourth layer of bricks of type 1 were also laid (See fig 3.6d).



Plate 3.6d: third and fourth layer of bricks with opening for combustion air

Subsequently the final layers made up of the bricks of the type 2 were laid in the final stage of the furnace construction. The peculiar shape of the bricks used to construct this furnace however did not allow for complete application of the alternate header and stretcher course throughout the entire body of the furnace structure. This does not pose any threat to the integrity of the structure since it is not particularly more than two feet in height.



Plate 3.6e: Final layer of bricks Type 2

The completed modified furnace is presented in Plate 3.6g below



Plate 3.6g: Completed modified furnace structure

3.7 Choice of Fan

According to the Bureau of Energy Efficiency (2011) the selection fan and blower is determined by certain factors such as the volume flow rate, pressure, type of material handled, space limitations, and efficiency. The choice of the centrifugal axial fan with flat blades for this particular study is made on the basis of the following factors, which are considered as advantages by the Energy Efficiency Guide for Industry in Asia (2006); the centrifugal axial fan with flat blades is suitable for high

static pressures and high temperatures; it is a simple design which allows custom build units for special applications; it can operate at low air flows without vibration problems; it has high durability; it has efficiencies up to 75%; it has large running clearances, which is useful for airborne-solids handling services. In the case of this study, the environment in which the centrifugal fan is to work is a bit harsh due to the elevated temperatures that are envisaged, that is, in the region of 1000^0C and above, the pressure type required in the furnace is not too high since a relatively small combustion chamber is to be used for providing the heat. There is hardly any resistance to be encountered by the fan and the space is limited by the fact that the furnace is to be contained in a small workshop or workspace.

3.7.1 Fan Design Considerations

The fan to be designed is the centrifugal radial blade type and certain parameters are considered which include the quantity *Q* of gas (in this case, air) to be delivered by the fan and the head *H* which must be developed to overcome the resistance to the flow of the quantity *Q* in the connected system (McGraw-Hill 2002a). These operating conditions establish the fan dimensions of diameter *D* and rotational speed *N*. The load placed on the fan must also correspond to a condition on its operating characteristic. If the system in which the fan operates presents less resistance than is overcome by the head developed by the fan at the required capacity, more resistance must be introduced by a damper, or the fan speed must be changed, or the excess capacity must be diverted elsewhere. In our case the fan speed was found to be

just appropriate and needed not to be changed nor was there need to introduce any damper.

3.7.2 Fabrication of the Centrifugal Fan

Working drawings of the centrifugal fan were made to dimension as presented in fig. 3.7.2a and fig. 3.7.2b below.

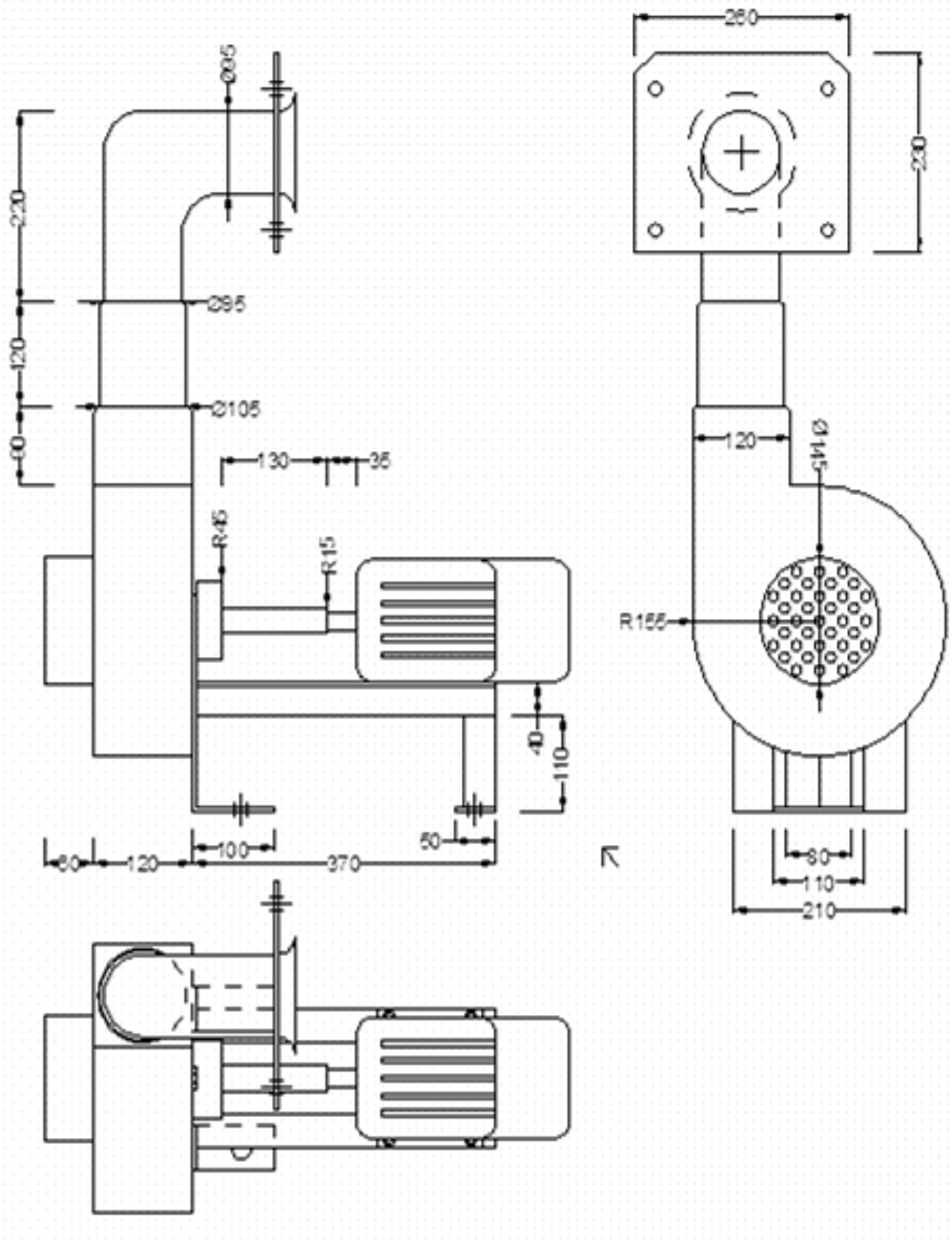


Fig. 3.7.2a: Elevation drawings of centrifugal fan with dimensions

The centrifugal fan is presented with it different parts and their

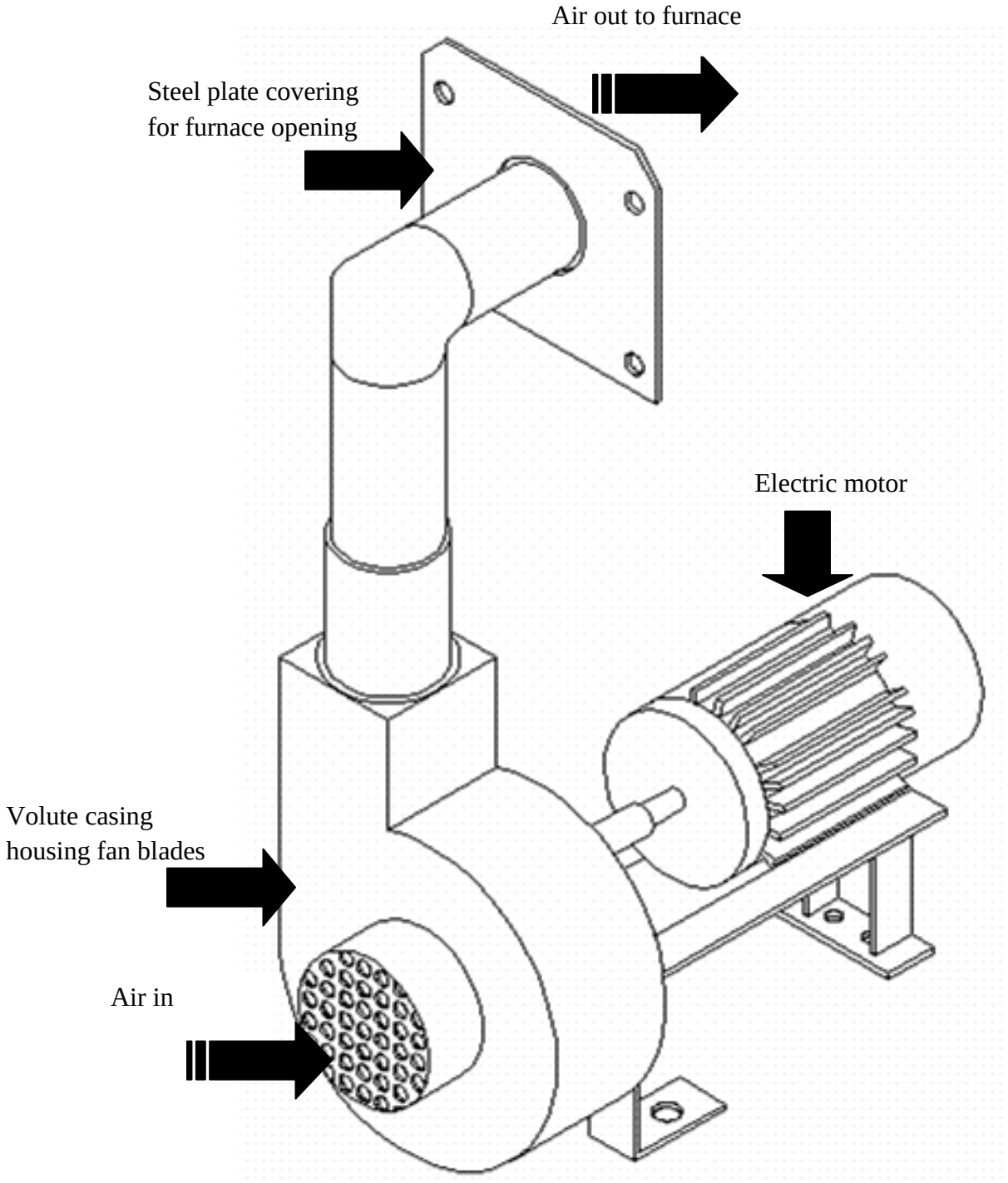


Fig.3.7.2b: Isometric projection of Centrifugal fan

The electric motor of the stated specification was purchased from a local dealer (see Plate 3.7.2a)

.



Plate 3.7.2a Electric motor

The next step in the fabrication was the making of the four-blade impeller, which was achieved by measuring and cutting out the individual blades necessary to form the impeller. This was now welded and attached to ball bearing which was now attached to a metal shaft by a screw (See Plate 3.7.2b).



Plate 3.7.2b: Four-blade impeller attached to a shaft

Subsequently, the port (also known as fan housing or volute) which is to house the blade was cut out from metal sheets and coupled together by welding (see Plates 3.7.2c to 3.7.2f).

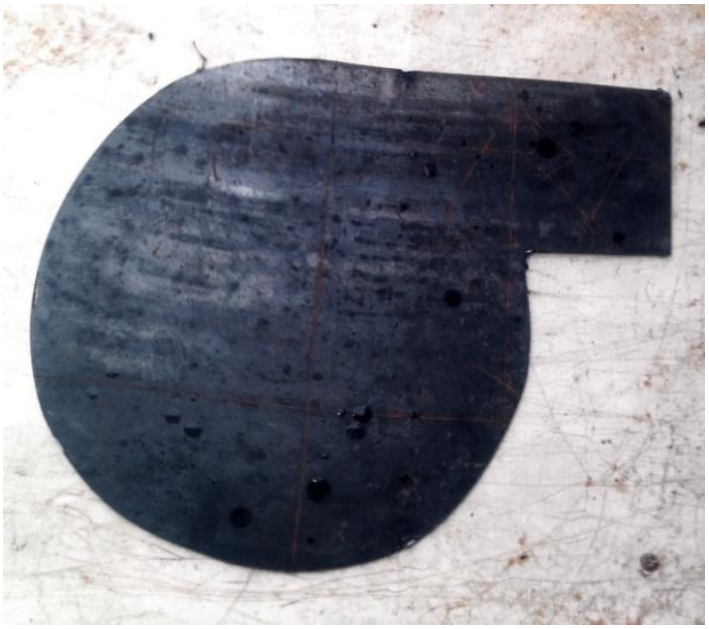


Plate 37.2c: Impeller port cutting out



Plate 3.7.2d: End-view of port



Plate 3.7.2e: End view of port



Plate 3.7.2f: Side view of port

Next the ‘elbow’ pipe, which is necessary to direct the air being generated by the blade to the furnace opening was attached to the port by welding as can be seen in Plate 3.7.2g.



Plate 3.7.2g: Gauging the elbow pipe

The assembly was now attached to the electric motor and the height necessary to reach the furnace opening was gauged. Having measured out the correct height positioning of the ‘elbow’ pipe to the opening of the furnace, the whole device was now coupled by welding and subsequently painted.



Plate 3.7.2h: Estimating coupling height with motor

3.8 Installing the fan

Installing the fan by the furnace required the placement of a brace to hold the fan system firmly in one position and to prevent it from moving in an unstable manner due to the vibration caused by the electric motor and since instability of the fan structure can result in reduced efficiency, it becomes pertinent to introduce the brace made from steel angle bars as pictured in Plate 3.8a.



Plate 3.8a: Brace to hold the fan in place

The brace was fastened to the concrete floor by nailing it with concrete nails and subsequently the fan was now placed into the brace to restrict unnecessary movement (see Plate 3.8b).



Plate 3.8b: Fan mounted on the Brace

3.9 Testing the Fan

Before testing the fan, the furnace was charged with charcoal as source of fuel and then the fan was connected to a source of electric power and switched on.

3.9.1 Sources of fan failure

There are reasons why a fan may fail and these have been identified by Edward (1995) as cited in Oyelami *et. al*., (2008) to include: vibration, lack of performance, excessive noise and premature component failure. Some of the causes of the above listed problems are as identified by Oyelami *et. al*., (2008):

3.9.2.1 Vibration

There are generally eight sources of vibration including but not restricted to:

1. Material build-up on the wheel.

2. Loose mounting setscrews, bearings, bolts, or couplings.

3. Misalignment or excessive wear of belts coupling or bearings.

4. Bent shaft.

5. Material build-up on the wheel.

6. Excessive system pressure or restriction of airflow due to closed dampers.

7. Inadequate structural support or mounting.

8. Externally transmitted vibration.

3.9.2.2 Lack of Performance

The general reasons for lack of performance of a fan are:

1. Incorrect system design calculation or testing procedures.

2. Incorrect fan rotation per minute (rpm).

3. Fan wheel rotating in wrong direction

4. Improper wheel- to- inlet cone clearance.

5. Inlet or discharge air leaks, clogged filters, coils or damper settings.

6. System effect due to improper inlet or discharge connection.

3.9.2.3 Excessive Noise

The various causes of noise during a fan's operation are:

1. Fan operating near "stall" due to incorrect system design or installation.

2. Vibration originating elsewhere in the system.

3. System resonance or pulsation.

4. Improper location or orientation of fan intake and discharge.

5. Inadequate or faulty design of supporting structures.

6. Nearby sound reflecting surfaces.

7. Loose accessories or components.

8. Worn bearings.

3.9.2.4 Premature Component Failure

Component failure will occur due to any of the following causes:

1. Abrasion or corrosion of internal fan components.

2. Vibration due to impeller being out of balance.

3. Lack of lubrication of bearings.

4. Misalignment or power transmission components or bearings.

5. Bearing failure from incorrect or contaminated lubricant or grounding through the bearings while arc welding.

6. Extreme ambient temperature

CHAPTER FOUR

4.0 RESULTS

4.1 Modification of the Furnace

One of the objectives of the study is to modify the design of the furnace by using insulating bricks as well as standard construction methods; sketches and design drawings were made in order to achieve this objective and the result is presented below. In Plate 4.1a is the structure of the furnace as being used by the Masaga glass bead makers showing the boy working the manual bellows in the far left of the picture;



Plate 4.1a: The Glass Bead making furnace currently in use in Masaga

The result of the furnace design modification is presented in Plate 4.1b below showing the furnace constructed with insulating bricks, successfully working and the centrifugal fan supplying combustion air eliminating the need for an assistant to work with the manual bellows:



Plate 4.1b: The modified Glass Bead making furnace in operation

During the process of firing, it was found out that the height of the furnace created an unnecessary volume of space within the furnace combustion chamber which made it require more time to get the temperature at the top opening to get as high as required for bead working. This constituted a problem which had to be solved by reducing the height of the furnace by eliminating one row of bricks from the structure (see Plates 4.1c and 4.1d)



Plate 4.1c: First modified furnace



Plate 4.1d: Reduced modified furnace

The reduction in the height of the furnace ensures that heat gets to the top opening where the flame-working for the glass bead making takes place quick enough and no unnecessarily large volume of space was created since this would result in the use of large quantity of fuel to heat up. The modified furnace structure effectively contained the combustion process as well as the heat generated. No heat-loss through the furnace walls to the surrounding environment was observed as the outer furnace wall was observed to remain cool all through and after the firing period.

4.2 The Centrifugal Fan

The centrifugal fan was designed to replace the manual bellows of the Masaga glass bead making furnace and to make the glass bead making process less laborious. The result is seen below in Plates 4.2a to 4.2c showing the different elevations of the fan.



Plate 4.2a: Front elevation centrifugal fan



Plate 4.2b: End elevation of centrifugal fan



Plate 4.2c: End elevation [II] of centrifugal fan

The fan design was evaluated against the factors identified by Edward (1995) as cited in Oyelami *et. al.,* (2008), in order to determine whether the design is good or not. The fan was checked for vibration, by ensuring that there was no material build-up on the wheel, loose mounting setscrews, bearings, bolts, or couplings, misalignment or excessive wear of belts coupling or bearings, bent shaft, material build-up on the wheel, excessive system pressure or restriction of airflow due to closed dampers, inadequate structural support or mounting, and externally transmitted vibration.

4.3 Furnace Temperature attained

The fan was observed to have effectively supplied forceful air which sustained combustion in the furnace and thus performed the function of the manually operated cloth bellows of the Masaga glass bead furnace. The fan was observed to operate just perfectly, supplying combustion air at an appreciable pressure increasing the rate of combustion of the charcoal and consequently increasing the heat output and invariably the temperature of the furnace. Within about twenty to twenty-five minutes of forceful combustion air supply, a deep orange-to-white fire was attained in the furnace, which coincides with the temperature range of about 1,100 to 1,200^{0}C (Maggio, 2011), which is adequate for any glass-bead working process (See Plate 4.3a). The test-fired glass sample was observed to have successfully softened enough to be manipulated into whatever article of interest (see Plate 4.3b)



Plate 4.3a: Deep orange-to-white flame in the furnace



Plate 4.3b: Sample of glass bottle heated in the furnace

CHAPTER FIVE

5.0 DISCUSSION

From the onset of this study, it was established that the development of any nation is hinged on how well it is able to develop indigenous technology and deploy it to her industries. Essien (2011) observed that efforts by several administrations in Nigeria at redirecting the nation's economic policy reforms and technology is yielding very little result and he attributes this to the fact that Nigeria is over-dependent on imported goods. The same attitude is being displayed towards indigenous technology development, where technology transfer is being preferred to development of indigenous technology.

5.1 Firozabad – The Glass City of India

There are examples of countries like India that have emerged from the level of less developed countries (LDCs) to emerging economies that are gaining global acknowledgment due to the impact of their technology. India, just like Nigeria is notable for glass bead products and a case worth noting is that of Firozabad, a city in India, within the state of Uttar Predesh; Adegbeye (2008) reported that:

> The glass industry of Firozabad is a shining example of craftsmanship in glass. It started in the 15th century when invaders of India would bring along with them many glass articles. These glass articles when discarded were collected by the Firozabad indigenes and melted in a locally made furnace called "Bhainsa Bhatti", which used wood as fuel. These old traditional furnaces are still in use in Sasani near Aligareh and at Purdal Nagar. During this time, only small bottles and

> "Kadechhal Ki Chudi" bangles which had no joints, could be made, one at a time.

The glass industry in Firozabad had a small beginning that was marked with crude items that were not perfected as well as furnaces that were very basic, however, things did not continue like that because there were developments and great successes recorded in the glass making activities that were carried out in Firozabad as reported by (Adegbeye, 2008, p. 87):

> … Slowly and steadily bangles, beads, kangans, kada and similar items were produced in bulk for the general public and remain popular as marriage items in Indian and international markets till date. Known as the world capital for beads, the bead industry in Firozabad is famous for the glass beads it produces which are exported all over the world for use in all kinds of items such as clothing, accessories and shoes. Since 1989, it started production of artistic glass ware in different colors and shades and today about four hundred glass industries are registered in Firozabad which export about 50% of their manufactured units to different countries. Natural gas as opposed to coal is now used to fuel the pot regenerative tank furnaces that characterize this blowing and modeling industry.

The glass bead industry in Firozabad now earns foreign exchange for India, besides the empowerment it provides for the local people and freedom from dependence on government jobs. Firozabad with a population of 279,102 (according to UN data of 2001) boasts of having 75% of this population involved either directly or indirectly in the glass industry and has come to be referred to as "The Glass City of

India" From the humble beginning of the glass industry in Firozabad where only simple glass items were being produced, today, the range of glass products made in Firozabad includes: Glass hardware for decoration purposes, glass art-ware such as toys, candle-stands, crosses, Christmas trees, fruits, bird and animal figurines and images of gods and goddesses, glass domestic wares such as drinking glasses, beer glasses, wine glasses, dinner tableware are made both in cottage industries and automated plants, scientific and laboratory glassware such as beakers, flasks, containers made for college, university and factory laboratories; glass automobile wares such as light bulbs, battery bulbs and other light and sight equipment for two and four wheelers, Glass street-and-domestic light ware for urban and rural areas for lighting and utility purposes are made including miniature bulbs and high power voltage bulbs (further information about Firozabad can be found at https://sites.google.com/cite/rajatresponsible/).

The development experienced in Firozabad is unlikely without a systematic developmental strategy in terms of modification of certain facilities like the furnace and introduction of better fuels like natural gas in place of coal and wood and glass forming methods; another case in point is the recent furnace modification at Jagadhri also in India by the Bureau of Energy Efficiency, which was earlier cited in the literature review of this study.

5.2 Ghana

Ghana, which is a close neighbouring country, is notable for her glass bead making, even though their technique of glass bead making differs from that of the Masaga glass bead makers of Bida Nigeria. The glass bead makers of Ghana, particularly those of the Krobo people, make use of clay moulds, which help them make many beads within a shorter time than it would take to make the same by the furnace wound technique of the Masaga glass bead makers of Bida; their furnace also does not have need for manually worked bellows as is the case with the Masaga bead makers. This makes their work easier with less labour input and hence less overall cost; it is also an enterprise that a single individual can take up and sustain without the help of any assistant, which means that the work can be carried out efficiently and will not be stranded due to the absence of a helping hand. The product of the Ghanaian glass bead makers seem to enjoy greater export market and greater online presence coupled with wider circulation than their Masaga counterparts.

5.3 Nigeria

Prior to this study, there was no known record of any attempt to introduce any form of technology for the enhancement of glass bead production in Nigeria. The techniques and materials for glass bead production, as far as the Masaga Glass Bead Makers' Guild of Bida, Niger state is concerned, has remained the same for several years as far as one can possibly remember. The Firozabad (Glass City of India) is a success story which illustrates the potentials that abound in glass bead making and as

such provides us with a paradigm from which we can draw inspiration as well as the much needed impetus to invest in the local glass bead making industry in Nigeria.

This study, which is aimed at the introduction of the centrifugal fan as an alternative to the manually worked bellows of the Masaga glass bead making furnace, is a significant step in the right direction. The results of the study show that furnace modification as well as the deployment of the centrifugal fan to glass bead making provide the much needed solution to arrest the decline in the trade as well as boost economic activities in the trade. The successful adoption of this centrifugal fan by craftsmen of the Masaga glass bead guild in their work will guarantee less labour input, which translates into less cost of production and hence a reduction in the current exorbitant sales price of the items per unit, which also means that prospective buyers will find them more affordable for patronage.

It has been reported by Osec (2012) that Nigerian merchants are the main customers of the glass beads of the Ashanti region of Ghana, suggesting that Nigeria is currently importing glass beads and inadvertently stifling the local glass bead industry. Also, Osec (2012) reports that glass bead customers for the Ghanaian bead industry are from the US, UK and Canada, who either come to the markets located in Ghana to make purchases or to place direct orders from abroad. It is envisaged that the substitution of the cloth bellows used in the Masaga furnace wound glass bead making with the centrifugal fan will doubtless increase rate of glass bead production as well increase the volume output of glass beads and glass artifacts enough to satisfy the local

market as well as to begin and sustain export activities. This will guarantee a turnaround in the fortunes of the glass bead making industry in Nigeria. Already, the Masaga Glass Bead Makers' Guild attract some level of tourists attraction and patronage, hence the adoption of the centrifugal fan as well as the modified furnace is expected to boost production activities as well as enhance the tourists attraction thereby resulting into foreign exchange earnings, and further open up of Nigeria to the international community and possibly attract foreign investments.

Furthermore, with the adoption of the centrifugal fan for the supply of combustion air to the furnace, the young boys who normally work the bellows will be free to pursue education at whatever level they so desire and since they will normally return home during vacation, they would still be able to engage in the craft of glass bead making. In a discussion during a session of participant observation of the head of the Masaga guild, Alhaji Ndagana 'Baruwanka' also known as 'Baba Masaga' on the 11th of August 2009, after some of the staff of Glass Technology of Ahmadu Bello University informed him about the diploma programme in glass technology, had shown interest and desired to know how he might get some of his children to come to study a diploma programme in glass technology in the University. If this fan is adopted and used to replace the bellows, then it will guarantee that his bead making craft will still be operational even while the children are away to school. I am optimistic that this effort will contribute to sustaining the glass bead making industry in Nigeria and remove the craft from the list of those crafts identified and reported by Essien (2011) as being on the brink of extinction.

CHAPTER SIX

6.0 CONCLUSIONS

The research aimed at designing and fabricating a centrifugal fan as an appropriate substitute for the manually operated bellows used to provide combustion air in a Masaga glass bead making furnace, for greater efficiency and sustainability and in order to realise this aim, a number of objectives were set in place. These objectives were attained in the successful modification of the design of the furnace using standard design methods of drawing, designing and creating moulds for bricks, making the bricks using insulating refractory materials such as kaolin and sawdust; constructing the modified furnace structure with the bricks so produced; providing a suitable furniture (bench) upon which to locate the modified furnace structure; an electrically powered centrifugal fan was also designed and fabricated to supply combustion air and thereby effectively eliminating the need for a manually operated cloth bellows and by extension, eliminating the need for an assistant.

Greater efficiency has been achieved by way of introducing an electrically powered centrifugal fan consequently reducing the physical labour input into the process of the glass bead making also the furnace is made of better insulating materials which guarantees minimal heat loss to the environment and greater temperature attainable within the furnace; and durability has been achieved by the use of viable materials in the design and construction of the furnace.

6.1 Recommendations

The following recommendations are hereby made based on the outcome of the research:

1. It is recommended in the light of the successful deployment of the centrifugal in place of the manual bellows that the Masaga guild of glass bead makers should embrace and utilize this device in order to achieve efficiency and reduced labour input into the bead making process.
2. There should be affordable sources of financing in the form of loans, for operators of such glass bead making venture who may want to acquire small technological inputs as the modified furnace and the electrically powered centrifugal fan in order to raise their output levels while lowering labour input substantially.
3. Since the centrifugal fan is electrically powered and for now Nigeria is not generating enough electricity to guarantee dependable and consistent supply, it is recommended that an alternative source of power such as solar energy or an inverter be incorporated into the fan to augment electricity.
4. Currently, there is need for further research into how to ensure a steady supply of fuel (either wood or charcoal) into the furnace without the need of an assistant.

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