DEVELOPMENT OF THE ART OF GLASSBLOWING IN GHANA: PROSPECTS AND CHALLENGES OF SELECTED GLASSBLOWING UNITS

BY

HOLMAN KWEKU MENSAH

(B.A) INDUSTRIAL ART, CERAMICS

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DECLARATION

I hereby declare that this thesis is my own work towards the MPhil degree and that, to the best of my knowledge, it contains no material previously published by another person or material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

HOLMAN KWEKU MENSAH (20065064)................................ ....

Student Name & ID Signature Date

Certified by:

DR. E.C. NYARKOH ....

Supervisor's Name Signature Date

Certified by:

DR. JOE ADU-AGYEM ....

Heads of Department (Name) Signature Date

ABSTRACT

The objectives of this study are to identify the existing operational glassblowing units in the country; to investigate and document their tools, materials, equipment and methods which are used by these glassblowing units; assess their strengths, weaknesses, opportunities and threats of the glassblowing units. The multiple case study approach was adapted for the study. The target population was 175. The accessible population was 153. The purposive sampling method was used to sample 153 respondents which constituted 87.4% of the targeted population. Questionnaire, interview schedule and observation guide were the main instruments used.

The study identified only three operational glassblowing units in the entire country namely, Glassblowing Unit - Industrial Research Division (CSIR) Accra; Glassblowing Unit - University of Cape Coast (UCC) Cape Coast and Glassblowing Unit - Kwame Nkrumah University of Science and Technology Kumasi. The tools, materials and equipment used by the glassblowing units are of standardised quality however, the purchase of annealing oven and calibration machines would be an added advantage.

The evaluation of the units revealed the strengths of the units as; good infrastructure, competent personnel, quality products and services, among others. The weaknesses exposed included; low publicity, low patronage, poor aesthetic finishing, etc. The opportunities also included; the abundance of local raw materials for glass blowing, total monopoly enjoyed by the glass industry in Ghana, the potential to diversify the glass industry in the country by introducing glass etching, glass incising, etc into their production techniques. Threats identified were aging personnel, high cost of training personnel, unfavourable institutional administrative

impart and lack of awareness about the prospects of glass blowing in the country. It was concluded that the units have some enviable strengths that has to be consolidated and improved by taking advantage of latent potentials and resources. Equally the units have weaknesses if not addressed could lead to the units being totally extinct in the country.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

CHAPTER ONE

INTRODUCTION

Background of the Study

Glass blowing is a novel glass forming technique. It exploits a working property of glass which was previously unknown to the glassworkers; inflation. Inflation refers to the expansion of a molten blob of glass by introducing a small amount of air to it. This property is based on the liquid structure of glass where the atoms are held together by strong chemical bonds in a disordered and random network. Therefore, molten glass is viscous enough to be blown and gradually hardened as it loses heat. There are two types of glass blowing techniques-offhand glass blowing and lampworking glass blowing, (Wikipedia 2008).

The history of glass had its beginning in the mist of antiquity, for it is reported that primitive people living close to volcanic regions formed glass objects using obsidian. They successfully used this to produce arrowheads, knives, ornaments, etc to meet their basic needs. The origin of glass productions is the subject of many debates. Scholars are uncertain as to where the art naturally originated from. Maloney (1967) suggested that glass may have been made in Egypt as long as 3000 B.C, during the 18th Dynasty or even earlier than that. Other scholars like Petrie (1916), Phillips (1948) among others maintain that, there is now much evidence indicating that we must look to Asia Minor, probably Mesopotamia, for its origin. However, it is generally accepted that Egyptians, and for that matter North Africans, have known and practiced glass blowing for centuries.

This means that if one says that glass blowing is an African art it may probably not be out of place. Crowder (1985) supported this claim. According to him, "…The king's palace in Kaumbi had panes of glass long before there were glass windows in European palaces”. The art of glass blowing did not spread further to the rest of the African continent probably because the art of glass blowing was secretly guarded and was kept in family lines. It was passed on from father to son, with glassblowers, even in certain cases, were confined to an island and forbidden not to leave the island the punishment of which was dead. During this period glass was the privilege of only a few patrons, kings, rulers, the clergy, etc.

Glass became a household item with the invention of the blowpipe in about 300 B.C and 20 B.C. This caused an industrial revolution in glass blowing. It changed the use of glass from a luxury into a necessity. Regardless of its long existence glass blowing is still a virgin field as far as artistic expression is concerned in Ghana. Originally, the trans-Sahara trade between the continent of Africa and the Mediterranean countries as well as Europe is accredited for the introduction of glass beads into the country.

As the trade evolved Abyssinia beads were imported, pulverised and mixed with recycled glass bottles to produce local glass beads. The orthodox Christian churches like the Catholic and Anglicans decorated their windows and doors with stained glasses. Some priests of indigenous traditional African religion had mirror fetishes used to spy out thieves. Utilitarian objects, like table wares, mirrors, etc, were gradually imported into the country.

The major landmark as far as glass production is concerned in the country, was the establishment of a glass factory at Aboso in 1960. The factory was established under the wing of Ghana Industrial Holding Company (GIHOC). They produced containers, vertical drawn flat glass, in addition to some glass souvenirs. However, production equipment was probably outdated at the start and never lived up to expectations. Flat glass production was never sustained; container production quickly became outdated, resulting in the factory operating at a loss.

There were some attempts to salvage the situation though, but the overdependence of their furnace on electricity coupled with financial constraints made all the efforts fruitless. From then, the development of the art of glass blowing has not received the needed attention and publicity in Ghana. Artists are still glued to the traditional media like wood, clay, leather, etc in the creation of their works.

However, glass bead work which relies on pulverised recycled glass and imported colouring oxides is still being produced in Ghana, especially in the Krobo area. Lamp working glass blowing has also stood the test of time and is still being practised in institutions of high learning and research centres.

The country currently has only four glass blowing units nationwide. Out of the four glass blowing units, three are attached to Chemistry Department (K.N.U.S.T, U.C.C, and U.G) and the remaining one is housed in a research institute (C.S.I.R, Accra). Only a few artists have received training in glass blowing. The units still have great potentials but laden with threatening challenges. Quite recently attempts are being made to revive the art of blowing in the country.

The Chemistry Department of KNUST has recently rejuvenated its glass blowing and making plans to establish a smelting unit. The Ceramic Department of KNUST is also trying to establish a glass blowing unit. Wellamp Company, the latest in the glass industry in Ghana, is also attempting to produce compact fluorescence lamps locally. The Government is also leaving no stone unturned to attract investors to revamp the glass factory at Aboso. All these efforts show the desire to reactivate the art of glass blowing in the country.

If these attempts are to be successful, it will require a total collaboration of all stakeholders. The role of the artists should be seriously considered particularly in the area of aesthetics to enhance the attractiveness of locally produced glass wares for all purposes. A prudent way to start is by assessing the operational glass blowing units by conducting a thorough situational analysis of the current state of the units and recommendations made for improvement and expansion. What is to be gained if the art of glass blowing is revived in the country is worth more than any investment required.

In the entire West African Sub-region, Ghana is the only country with a glass factory after Nigeria, in the entire West African sub region. The monopoly to be enjoyed cannot be over emphasised. Currently, breweries in the country rely solely on imported glass bottles. Glass table wares, window panes, decorative wares, scientific apparatus, etc are all imported. The development of the art of blowing will set the stage for a glass revolution in this country to create wealth and hones skill development.

Statement of Problem

In the past decades, Ghana has made some effort to introduce the art of glass blowing in the country. Notable among such efforts are the establishment of Tropical Glass Factory at Aboso (Tarkwa), United Glass factory (Accra), glassblowing units on various campuses (K.N.U.S.T, U.C.C, U.G, Atomic Energy, Ghana Standard board, C.S.R.I and Accra Polytechnic) and other private set-ups. It is, however, sad to note that all these establishments, both state-owned and private-owned, have collapsed leaving only glassblowing units that are part of research institutes or educational establishments. Even with these glassblowing units, in recent years, their operations have taken a downward trend regardless of the great demand glass wares have.

It is sad to note that since the inception of the practise of the art of glass blowing in the country the operational glassblowing units in the country have not been identified. There has not been any concrete attempt to properly document their tools, materials, equipment and methods used in the practise of glassblowing. Again there has not being any holistic evaluation of the operations of glassblowing units in the country.

Also, the aesthetic aspects of glass blowing have not been fully developed to boost the production of glass in the country. For example, there is no introduction of colour in the locally produced glass wares, the forms are too basic, concentrating mainly on borosilicate glass wares, decorative glass art like cold working (cutting, incising, embossing, etching, etc,) are totally absent, offhand glass blowing which permits more aesthetic glass blowing techniques in the art of glass blowing is totally extinct in the country. These have limited the units from diversifying their operation to include glass flower vases, stained glass production, plaques, glass table wares, etc.

These developments are worrying and have challenged the researcher to investigate this steadily downward trend in the operation of these units in the country in order to offer the necessary suggestions and recommendations to save this situation. This would promote the art of glass blowing industry in the country to contribute their quota to the socio-economic development of Ghana.

Objectives of the Study

The main objectives of this research are to:

1. Identify the exiting operational glass blowing units in the country.
2. Investigate and document their materials, tools, equipment and methods which are used by these glass blowing units
3. Asses their strengths, weaknesses, opportunities and threats.

Importance of the study

1. The identification of operational glassblowing units would aid any intervention from central government or non-governmental organisations to be targeted towards the real practitioners in the industry.
2. The investigation and documentation of their tools, materials, equipment and methods would throw more light on the prevailing technology in the industry in Ghana.
3. The evaluation of the units would reveal the strength and weaknesses to facilitate policy formation and forward planning.

Hypothesis

The neglect of the development of the art of Glass Blowing and the steady decline in the activities of Glass Blowing Units in the country can be attributed to the lack of awareness of the prospects of glass blowing in the country.

Delimitation

The research focused extensively on lampworking glass blowing practised by selected glassblowing units in Ghana.

Limitation

The absence of a calibration machine made it difficult to graduate locally made glass wares. Again, the lack of an annealing machine to properly anneal glass wares produced is likely to affect the lifespan of the glass wares.

Definition of Terms

Calcined: heated to a high temperature to aid crushing and grinding.

Lampworking: involves heating glass tubes and rods to an extremely high temperature and manipulating it to the desired size and shape.

Offhand glass blowing: producing glass products by manipulating molten glass with the aid of a punty.

Acid etching: The process of decorating cold glass by removal of material can be done in several ways.

Annealing: the process of heating a piece of glass until its temperature reaches a stress-relief point, that is, a temperature at which the glass is still too hard to deform, but is soft enough for internal stresses to ease

Marver: A flat surface made of steel, granite or any other heat resistant material used to shape and manipulate hot glass.

Necking: Shaping the glass to a very small diameter in preparation to change ends.

Punty: A device or technique used to change the end of the glass that is being worked

Stringer: A tool fashioned in the likeness of a cane which is used to aply molten glob of colour over hot surfaces of glass wares.

Abbreviations

G. B.U: Glass blowing unity

K.N.U.S.T: Kwame Nkrumah University of Science and Technology

U.C.C: University of Cape Coast

U. G: University of Ghana

S.G: Specific Gravity

S.P.S.S: Statistical Package for Social Scientist

SWOT: Strengths, Weakness, Opportunities and Threats

S.H.S: Senior High School

E.P.A: Environmental Rights Protection Agency

G.R.AT.I.S: Ghana Regional Appropriate Industry Technology

G.E.T.R.A.D.E: Ghana Export Trade

N.B.S.S.I: National Board for Small Scale Industries

Organisation of Chapters

This research has been organised into chapters. Chapter one which is also known as the introductory chapter comprises the following: introduction, statement of problem, objectives of the study, justification of objectives, hypothesis, limitation, delimitation, definition of terms and list of abbreviations. Chapter two, reviews available literature on the development of the art of glass blowing and prospects and challenges in glass blowing operations. Chapter three entails the research methodology while chapter four deals with the main findings of the research that is, the presentation, analysis and interpretation of the field work. Chapter five is the summary, conclusions and recommendations.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Overview

This chapter reviews related literature to bring out new knowledge and new relationships between established facts. The chapter is centred on the development of the art of glass blowing and the prospects and challenges of glass blowing operations.

Development of the Art of Glass Blowing

Mesopotamian present day Iraq is on record to be one of the earliest cultures to have created glass object such as beads which is dated around 2500 BC. Glass production technique is believed to have spread to Egypt between 1500-1000 BC. This move added to the body of knowledge on glass forming and paved the way for the production of complex and intricate glass forms and pieces (Phillips, 1941).

In the 5th and 4th Centuries BC, the Persians were producing exquisite glass art by using the lost wax method, which was an extension of their proficiency in gold and silver casting. As glass casting techniques became increasingly sophisticated, independent studios sprouted throughout the Middle East producing magnificently detailed work from the 3rd century BC to the 1st century AD.

Maloney (1967) on his part posits that, glass blowing was discovered around 50 BC and revolutionized glass working developed many years afterwards. Form the relevant literature reviewed it can be deduced that there is no consensus on the specific date or even period when glass blowing evolved. However, the Romans are singled out by almost all research publications consulted as master craftsmen in glass blowing. Their contribution led to functional glass objects being widely available even today. Kiln formed glass languished for an astonishing period, almost two thousand years. Until their renaissance beginning in 1870, with the use of a glass paste that is then fused in a kiln.

The revival centre for glass blowing in France was spawn from the great archaeological discoveries of the time in Egypt and in the Middle East. Numerous kiln forming glass techniques were reinvented by French artist like Henri Cros, Argy-Rousseau, Amalric Walter, Lalique, and Frederick Carder of the United State who were interested in the beauty of glass as a material. The industrial revolution fueled this revival by supplying new technologies that aided innovation.

Modern glass art is fast being dubbed, “The Studio Movement”, dated around the early 1950s. Technology for building and maintaining small kiln firing studio has allowed the glass art to be explored in a fashion not enjoyed since Roman civilization. Kiln formed glass techniques are still very labour intensive, involving many time consuming steps; from mould making to lengthy firing and polishing. The works of art produced are still a rarity in the world of glass and are valued accordingly even in the twenty first century, (Modern Glass Art, 2009).

Various Definitions of Glass

Glass has been defined varying by various writers based on the subject matter of which they seek to write about or their academic and professional backgrounds. Stanworth (1950) defines glass as “an inorganic product of fusion which has cooled to rigid condition without crystallizing”. In the researcher’s view, this definition seems to totally exclude organic materials or substances that some scientist considered to be glass. Example is glucose which can be cooled very rapidly such that it becomes appreciably solid without visible crystallization.

Mcnamara and Dulberg (I953) also give two distinct definitions of glass. Firstly they stated that:

> It designates the condition of a substance which has for the most part the property of a liquid but at the same time possesses the rigidity of a solid. This condition is usually designated as the glassy or vitreous state. It is the result of cooling a liquid so rapidly that it is unable to crystallize as liquids usually do when they cooled.

Secondly, they went on to indicate that:

> It designates a group of commercial products which have the characteristics of a vitreous state. These products are familiar to us all in the form of windows, bottles, mirrors and table ware.

The first definition quoted above, appears to suggest that, glass is a liquid that is cooled very fast into a solid without the crystals being given ample time to regroup into the regular crystal structure as is common to all liquids. A liquid of this nature may contain more heat energy than is appropriate for that temperature. In addition, for such a material to be considered as a glass it should possess all the properties of a liquid and have rigidity or viscosity above 10^{13} poise. A requirement below which any object would collapse under its own weight. This view is shared by Maloney (1967).

The second definition also suggests that, the terminology glass embodies all commercial products that have undergone some form of fusion or sintering of its constituent materials and are transparent as well as hard in nature. It further goes on to give examples as windows, bottles, mirrors etc. From the perspective of the researcher, this definition appears to be quite narrow and may be well suited for the definition of commercial glass and not glass in its entirety.

The Encarta (2008) also defines glass as "amorphous substance made primarily of silica fused at high temperature with borates or phosphates. Glass is also found in nature as the volcanic material obsidian and as the enigmatic object known as tektites”. The Encarta definition appears to limit the definition of glass to only silica oxides fused at high temperatures and naturally occurring glass like obsidian (hyalopsite, Iceland agate, or mountain mahogany) formed by the actions of volcanic eruptions and other objects believed to have fallen from the sky when lightning strikes or when there is the impact of meteorites. A typical example is tektites (naturally-formed glasses of extraterrestrial or other origin, also referred to in some publications as obsidianites).

From the above and other numerous definitions of glass, two distinct features of glass stands-out. The first is the assertion that glass is a super cooled liquid. This presupposes that, it has all the inherent properties of a liquid as well as having the required viscosity for a solid. We therefore obtain glass by means of cooling fused oxides very rapidly such that it becomes appreciably solid without a distinct change in it phase. The opposite is through in the case of cooling water into ice. In the instance of cooling water into ice, a distinct physical change is observed from the liquidus phase to the solidus phase.

As alluded to earlier, a super cooled liquid (glass) at this temperature contains more heat energy than is appropriate for that temperature. There is great disparity between the temperatures and chemical reaction that has taken place in the outer surface of the glass and that of the core of the glass. This disparity accounts for the material being quite unstable. The above definition also includes natural glass, which is also formed by the introduction of heat to oxides in the earth crust to produce glass. The only limitation is that it is natural and only limited to volcanic prone areas.

The second feature that comes to mind after considering the definition is its ability to crystallise into a solid without a discontinuous change in its physical properties. There is no visible physical change from liquid phase to the solid phase as has been explained earlier. The only visible observation is that the glass flows less and less and eventually it turns solid.

In conclusion, the researcher would simply define glass as “A liquid formed from the fusion of oxides at elevated temperatures with the resultant fusion having the rigidity of a solid but without regular crystal groupings”. In justifying the definition given above by the researcher, he argues that, the primary constituents of glass whether natural or artificial are all composed of oxides that if introduced to high temperature will vitrify into a substance which if the crystal are unable to regroup into the previous lattices and are able to stand on its own, qualifies to be called glass.

History of Glass Blowing

The development of the art of glass blowing probably resulted from experimenting in picking up heated pieces of cullet on the end of a long, hollow tube through which the glassmaker could force his breath. It was quickly realized that through repeatedly reheating a gob of glass in a furnace and aided by simple tools the gob of glass could be inflated. The inflated bubble of glass could be quickly and cheaply fashioned into vessels of any shape and size.

Other writers also accredit a myth by an ancient-Roman historian Pliny (AD 23-79), who claims some Phoenician merchants transporting stone actually discovered glass in the region of Syria around 5000 BC. Pliny tells how the merchants, after disembarking from their sailing ship, placed their cooking pots on blocks of nitrate for cooking purposes. As the cooking exercise progressed, the intensity of heat also increased, the supporting blocks eventually melted and mixed with the sand beneath the made-shift swish stove to form an opaque liquid.

The true origin of man-made glass in the researcher's view has most likely been lot to history just like the origin of pottery, basketry, painting etc. Even though a lot of claims and counter claims are being made as to where the art originated from. According to Gustavus (1916), early researchers claimed that man-made glass or even glass blowing originated from Egypt. They backed their claim with a very popular Egyptian painting found in the tombs of the VI and XII Dynasties, which they interpret as representing glass blowing. He Gustayus, refuted this claim based on a work made by Flinder Petrie (1924-25) for the following reasons:

(a) No glass of any kind has been found in Egyptian tombs of the VI or XII Dynasties. The very earliest dated specimen is a glass bead with the name of Queen Hatshepset, and this is properly assigned to her reign in the XVIII Dynasty. Glass beads are absent in the XII Dynasty, but exceedingly numerous in the XVIII Dynasty, the earliest type being imitation of similar type made of paste.
(b) No vessel of blown glass have been found in Egyptian tombs or excavations earlier than the Ptolemaic period, although innumerable specimens and fragments of glass vessel have been found which belonged to the long period of over one thousand years between Thohmes III and the Ptolemies.
(c) All these glass flasks, bottles, and vases we know to have been moulded or formed by hand over a core of soft paste or clay, the core afterwards being scraped out.
(d) The earliest vessels of blown glass date from the time of the Ptolemies. They consist of small flasks with short necks. The earliest I have seen was found with a Greek vase of the third century B.C.

This claim by Petrie which formed the bases of Gustavus argument has recently, been refuted by Rehren and Pusch (2005). They jointly publish a paper stating that, new archaeological finds indicate that by 3,250 years ago Egypt had become a major glass producer and was shipping glass in the form of ingots to the entire Mediterranean region for reworking. Other writers mention Mesopotamia, Asia Minor etc as possible places where man-made glass was first made (Luckner, 2008).

Glass and the Ceramic Industry

Glass production or manufacture is just a sector under the broad main stream ceramic industry. Maloney (1967), states that in the initial development of glassmaking, glassmakers simply used glassy coating materials as a decorative glaze for pottery and stone. The earliest glass vessels made in Egypt during 1500-1350 BC (18^{th} Dynasty), were produced by a technique similar to the glazing technique used in pottery production. Sand was modelled in the desired shape and coated with glaze for a number of times till the coating is thick enough to stand on its own. The glass is allowed to cool and the sand mould removed. Threads of soft coloured glass were then pressed into the reheated ware as decoration.

From the explanations' put forward by Maloney, he seems to suggest that glass was first used as a glaze, before the discovery of the other properties of glass which were presumably unknown to the early glassmakers. This consolidates the findings of Petrie (1924-25), who also came to the conclusion that glass was first used as a coating for ceramic wares. Petrie also attributes the genesis of glass fabrication to the core sand casting by the Phoenicians.

According to Colin (1977), glaze is one of the groups of vitreous substances called glasses which are super-cooled liquids of high viscosity at ordinary temperature. Another definition for glaze is a glassy coating melted in place on a ceramic body which may render the body smooth, non-porous and of a desired colour or texture. The primary constituent of a glaze is silica just like the primary constituent of a glass is silica and they are both regarded as super-cooled liquids.

Charlotte and Toki (1999), contends that, the difficulty in grounding glass and simply applying it as glaze are in two folds: one, the glass would be too fluid and would run down the ware onto the kiln furniture and two, it would craze. Crazing is the development of a network of cracks on a glazed ware. On cooling such a glass ware, the glass would contract excessively than the ware and would put the ware under pressure which will result in the formation of the cracks.

Crazing would not occur in glass production, since the glass will be free to contract or expand without any form of resistance from another material such as the clay or body used to produce the ware. The assertions by Colin and Charlotte and Toki concerning the similarities between glaze and glass generates another debate as to what other writers have to say concerning glaze and glass.

Deference between Glass and Glaze

Norton (1953), posits that, glazes for pottery purposes are actually glass, the composition of glazes are altered slightly for the purpose of sticking the glaze onto a ware's surface. He goes on to explain that glass on its own is too fluid during firing to be useful as a glaze but the introduction of alumina in the recipe reduces the fluidity and increases the viscosity of the glaze. Glass which is composed to be used for bottles, windows, etc production must of necessity have a low viscosity. With regards to glazing in the pottery sector, the glassy coating must be stiff when melted so as to fix the glaze to the surface of the ware and not run to either the foot of the ware or on the kilns furniture.

Proceeding further, he claims this stiffness in glazes is achieved as stated earlier, by introducing alumina to the glaze recipe. The alumina added has the potential of increasing the viscosity of the glaze. It is introduced only in small quantities because too much of it make the glaze mature at a higher temperature. It is also possible to produce glaze from glass which is low in alumina and in practise there are some specific glaze colours that are only achieved in the absence of alumina in the glaze batch.

Colin (1977), on his part tries to make some distinction between glaze and glass he asserts that, glazes are made by mixing raw ingredient called for by the glaze recipe, silica, soda ash, potash, ball clay, alumina, tin oxide, zinc oxide etc. These are first dry mixed before ball milled with a measured amount of water. The resultant glaze slip is aplied onto a ware and fired to fix the glaze onto the ware. Glass on the other hand, is melted to the molten state in a crucible or tank, before fashioning it into objects.

Development of the Studio-Glass Movement

Glass art predated studio glass blowing. The pioneers of the studio-glass movement were largely glass artists working in glass factories; who through their love for experiments development the studio-glass movement. Commenting on the origin of studio-glass movement which promoted glass art in the 1870s, Adlin (2001) accredited a French designer Emile Gall as the person responsible for a radical change in the prevailing attitude toward his medium by initiating the signing of glass art just like it is done by painters, sculptures etc.

Adlin (2001) further support the school of thought which suggest that, prior to the early 1960s, the term "glass art" referred to glass made for decorative use, usually by teams of factory workers, taking glass from furnaces with a thousand or more pounds of glass. This form of glass art, of which Tiffany and Steuben in the U.S.A., Gallé in France and Hoya Crystal in Japan, Royal Leerdam Crystal in The Netherlands and Kosta Boda in Sweden are perhaps the best known, grew out of the factory system in which all glass objects were hand shaped or mould blown by teams of four or more men.

Given his submission on the development of the studio-glass movement he further stated that, it was not until the 1960s that the contemporary studio-glass movement was born. Through the ingenuity of a few artists working as glass artists' independent of any factory and with their own sample equipment.

He however mentions a French painter Maurice Marinot as part of the pioneers of the movement starting studio-glass blowing in the early 1910s. In Cleveland in the 1950s, he acknowledged Edris Eckhardt, a ceramicist and self-taught glass sculptor, as being one of the forerunners to invent his own glass formulas, which he melted in a converted electric ceramic kiln.

In 1962, Harvey Littleton, a professor of ceramics at the University of Wisconsin, is reported to have held a series of informal workshops on the ground floor of the Toledo Museum of Art to explore the possibility of hot glass working in a studio. Dominck Labino, the then director of research attended the workshop and contributed his quota by way of his technical competence in later years by devising the first glass formula that melted at a lower temperature. This was also very consistent as well as suited for glass blowing by employing a small portable furnace. The collaboration that ensued between the two, Littleton and Labino unleashed a flurry of creativity not seen before in the field of glass, (Adlin 2001).

Fairfield (2004) also acknowledged the contribution of Prof. Littleton to the development of studio glass movement. He acknowledged him as the founder of the first fine arts glass program at the University of Wisconsin in Madison in 1962 and other forefathers of the American Studio Glass Movement. Dominick Lambino, Littleton's partner in workshops helped to position glass as art; Marvin Lipofsky, who founded the second University glass program in 1964 at the University of California in Berkeley; and Dale Chihuly, who distinguished himself by establishing the glass program at the Rhode Island School of Design also in 1964, and together with other artists, the Pilchuck Glass School near Seattle, Washington in 1971.

In all, the 19th Century is adjudged by historians to be the height of the old glass art movement. This period was characterized by the replacement of manual glass blowing with mechanized glass blowing systems which supported mass production, (Wikipedia 2009).

Today, glass has become an integral part of the international art world. The same quest by glassblowers and artists to experiment with new material, tools, techniques etc, is always pushing the frontiers of the art beyond ones imaginations. The future of studio-glass movement could only be exciting.

Glass Art

Glass art is obviously made up of two words, glass and art. Glass has been well defined and expatiated on in the preceding paragraphs. Art on the other hand is not easy to define to the satisfaction of all.

Phillips (1941), defines art as “skilful and systematic arrangement or adaptation of means for the attainment of some end”. This definition is very broad and encompasses visual art, performing art, verbal art, body art, etc. The emphasis is this definition seems to stress on skills and strict adherence to principles and procedure.

The encyclopaedia (2001) defines art as, “art is a skill in making or doing”. We can then say that someone practices the art of basketry- weaving, of tuning a piano, or hitting a home run. In this sense, there are many arts as many as there are kinds of deliberate, specialized activities for human beings to engage in.

The 21st Century Dictionary (1996) also has two definitions for art that caught the attention of the researcher. The first definition is “the creation of works of beauty, especially visual ones". And the second is "a skill, especially one gained through practise". The above stated definition appears to be more suitable as the definition for visual art and not art in general. It further lays emphasis on constant practise to master an art as a prerequisite for any practically oriented activity.

Another definition that appears to be a little detailed and all encompassing is one given by the Encarta (2008 DVD) it defines art as:

> The product of creative human activity in which materials are shaped or selected to convey an idea, emotion, or visually interesting form. The word art can refer to the visual arts, including painting, sculpture, architecture, photography, decorative arts, crafts, and other visual works that combine materials or forms. We also use the word art in a more general sense to encompass other forms of creative activity, such as dance, drama, and music, or even to describe skill in almost any activity, such as "the art of bread making" or "the art of travel.

Comparatively the Encarta definition is very broad and attempts to define art in its entirety that is visual, performing, verbal, body art etc. From the ongoing discussion one may define glass art as the use of glass as an artistic medium of expressing an idea, emotion or visual concept. Specific approaches include stained glass, working glass in a torch flame (lampworking), glass bead making, glass casting, glass fusing, and, most notably, off-hand glass blowing. The glass objects created are intended to make a sculptural or decorative statement.

The characteristics that distinguish glass art from other art objects is that is one of the few materials which gives light form to light. The result are luster, brilliancy, sheen, luminosity-glass, colour or colourless which gives the ware life to that evanescent creature, light. These characteristic comes along with solidity, freshness, vitality of the product and form, characteristics that are seldom seen in other materials. The nature of glass enables a wide variety of decorative treatment to be applied on the glass, which in some instances enhances their fundamental properties and superimpose additional qualities on their own.

Principles of Glass Blowing

The best known glass forming process is glass blowing. The question as to whether glass blowing is an art or science related course or activity has wag on for years. Mcgee (2008) in trying to answer this question said “Glass blowing has been known traditionally as a scientific procedure. As more people learn about glass blowing, it is becoming more of an art form”.

This position is viewed by the researcher as preposterous to say the least, then one could argue that as more and more people learn about medicine, pharmacy, chemistry, etc, they would cease to be science related course and become art. It is true that major gains in the glass industry came about through the contribution of chemist, mechanical engineers, geologist, etc.

It is also public knowledge that there is some particular category of glassblowers particularly in the United State who are referred to as scientific glassblowers, but this is not because the glass blowing they practise is scientific in itself but owning to the fact that they produce scientific apparatus and they spend years specialising in this field.

Commenting on the issue of scientific glassblowers’ Wheeler (2008) had this to say;

To become an accomplished scientific glassblower in a research environment requires years of experience and exposure to the many fields of science. It is not unusual for a glassblower to spend 10 plus years working in a multi-science environment before they may be considered “Master Glassblowers”. Many scientific glassblowers in the United States learn their skills through an informal aprentice style program specific to the company or school they are associated with.

All said and done, the art of blowing itself that is, manipulating molten glass or a prefabricated tube or rod into an object of usefulness in the view of many scholars like Lyngaard (1991), Mcnamara and Dulberg (1953) and many other scholars, is that, glass blowing is an art form, for it requires the acquisition of skills which is gained through constant practice and the individual`s creative abilities.

According to Phillips (1941) there are two types of glass blowing, offhand glass blowing and lampworking glass blowing, with lampworking being the latest introduction of the two. Offhand glass blowing is the process of forming glass into useful shapes while the glass is in a molten, semi-liquid state. Traditionally, the glass was melted in furnaces from the raw ingredients of sand, limestone, soda ash, potash and other compounds. The transformation of raw materials into glass takes place well above 1100ºC. The glass turns into a burnt orange colour, the glass is then left to "fine out" (allowing the bubbles to rise out of the mass), and then the working temperature is reduced in the furnace to around 1100ºC. A person who blows glass is called a glassblower, glass smith, or gaffer. This view is also shared by Maloney (1967) and many other writers.

The actual blowing exercise starts when the glassblower dips the end of the blowpipe or pontil into a crucible. Free hand blowing is done by adjusting the position of the pipe in space and maintaining a movement of constant and even rotation. Along with the blowing, the shaping of the hot glass requires other motions and various tools in addition to the blowpipes (tubes of steel fitted with cylindrical or conical mouth pieces, approximately 1.4 meters long) containing the molten glass to collect a sizable amount, a process referred to as gathering. Then he or she rolls the gather on the marver in order to establish its centre.

After the marvering the glassblower introduces air bubble into the glass by blowing through the other end of the blowpipe, thereby creating a vacuum in the glass. The blowing action is repeated after successive reheats to form and develop the parison, that is to say the final volume of hollow glass required to create the piece. Other tools include punty irons and gathering irons steel rods used to hold the glass. Blocks, hollowed out blocks of wood used to centre and evenly distribute the glass. Jacks are used for the opening and shaping of the form. Shears are also employed for trimming the glass; and the marver (a steel plate, sometimes heated) for rolling the parison. Soda-lime glass remains somewhat plastic and workable, around 550ºC. Hugh, Tatton-Brown (1991)

Lampworking on the other hand has been described by some writers as a form of glass working using a torch to melt and shape the glass. It is also known as flame working or torch working, as the modern practice no longer uses oil-fuelled lamps. Although the art form has been practiced since ancient times, it flowered in Murano, Italy in the 1300s, and spread from there to the rest of Europe. In addition to artwork (glass beads, paperweights, etc) were created using this technique. Lampworking is used to create scientific tools, particularly for chemistry, Wikipedia (2009).

Lamp workers usually work on already fabricated tubes, rods or cane, into innumerable articles from beads, paper weights to souvenirs. Their works are exhibited at fairs and expositions. In describing the lampworking process Phillips (1941) had this to say, the glass is held over a burner fuelled with gas, compressed air and oxygen, until it reaches the required working temperature that is, between rigidity and liquefaction. At this moment it can be drawn out to many times its original length and it can be bent, twisted and shaped in various forms. The description of materials and processing method mentioned by Phillips (1941) are the same given by most writers.

In describing the insatiable range of artistic expression available under this technique, Keller (1939) had this to say of a work executed by Miss Von Allesch: "...she apliquéd blown glass figures of fish, seahorses, starfish and other denizens of the ocean. Glass strands of coral seem to grow out of the sand and in one spot glass doubloons hint of a wrecked treasure galleon''. An almost infinite variety of object, shapes, colours and forms can be made using lamp working technique.

Mould Blowing

Harden (2009) is quoted to have said that blowing into moulds preceded free glass blowing. According to him the first person to have discovered mould blowing was presumably one of the makers of mould-pressed bowls. Writing to the contrary to this claim by Harden (2009) Luckmer (1994) had this to say; `` within a century after the invention of glass blowing, the technique of blowing glass into reusable moulds was discovered, probably in the vicinity of Sidon on the Syrian coast (now Lebanon). Glass vessels could now be shaped and decorated in a single step''.

In the candid view of the researcher, press moulding technique was the first technique used for glass production by the Egyptians to produce beads some of which were found in the tombs of pharaohs that date as far back as the VIII Dynasty. From there, offhand glass blowing developed with the Romans dominating the industry and eventually moulds blowing also resurfaced. Blowing can be done in moulds in order to create clearly defined shapes and ornamentation. Depending on the desired effect, the blowpipe can turn or remain stationary.

Blowing while the pipe is turning is well suited to the fashioning of round shapes, whereas blowing through a stationary pipe is better suited to angular shapes and ornamentation. Moulds can be made from various materials: traditional wood moulds, moulds in metal, aluminium, bronze, (cast iron or steel for industrial purposes), moulds in graphite, moulds in plaster mixed with silica. According to their material, the moulds are used wet and fitted with holes to allow for the escape of vapour. Gudernrath and Whitehouse (1990) suggest that their research have proven that metal, in particular bronze, moulds are more effective in producing high-relief design on glass than plaster moulds and wooden moulds.

This is an assertion the researcher shares in, because metals would not absorb much moisture and will resist shrinkage or expansion better that wood, plaster or any of its kind. As a result the resultant cast may come out freely devoid of undercuts when the glass has solidified in the mould.

The first semiautomatic paste-mould machine only imitated the old manual glass industry. The human element that is the hand process was replaced by a machine which closely imitated the part played by the human hand. An example of the machine is the Empire Machine Company's Type E past-mould machine. The machine was assisted to operate manually. Glass was gathered by hand on a blow-pipe which was then inserted in the machine and the machine then automatically marvered, puffed, swung and stretched the glass unit the parison was fully developed, then after, it was blown automatically in the paste mould, Adams (1940).

The major drawback facing the glass industry in its early begins was the cloudy surfaces of paste mould products, which made mould blown wares unpopular and relatively inferior to free brown wares which was characterised by smooth, polished surfaced, Maloney (1967).

Machine drawn cylinder sheet

Machine drawn cylinder sheet was the first mechanical method for "drawing" window glass. Cylinders of glass 40 feet (12 m) high are drawn vertically from a circular tank. The glass is then annealed and cut into 7 to 10 foot (2 to 3 m) cylinders. These are cut lengthways, reheated, and flattened. This process was invented in the USA in 1903. This type of glass was manufactured in the early 20th century (it was manufactured in the UK by Pilkingtons from 1910 to 1933) Wikipedia 2008.

Prior to the invention of the mechanized process for window glass, the old glass blowing technique of spinning a cylinder into a flat round plate was employed. After they have obtained the round flat glass, it was cut into the required box or rectangular size required for windows and other purposes, Pilkington (1969).

Glass casting

Glass casting is a process in which glass objects, either for functional or aesthetic purposes, are produced by the means of a mould. More recently glass casting is made possible by two main processes, sand casting or kiln casting. Sand casting involves the use of hot molten glass poured directly into a preformed mould. It is a process similar to casting metal into a mould. The sand mould is typically prepared by using a mixture of clean sand and a small proportion of the water absorbing clay bentonite, Halem (1996).

Kiln casting according to Layton (1996) and Klein (1989) involves the preparation of a mould which is often made of plaster or plaster mixtures. A model can be made of wax, wood or metal and after taking a cast of the model, the model is removed from the mould. This process as described by the authors quoted above in the researcher view have not change much, glass is still cast using wood, wax etc; the dominant technique being the use of a continuous tank furnace. The only major change is that people prefer these days to cast glass using metal for smoother surfaces and easy separation of moulds on small scale bases.

Glass Ceramics

Extracts from Maloney (1967), state that, glass ceramics was accidentally discovered in 1957 when a photosensitive glass that has been irradiated was over fired above it maturing temperature as a result of a faulty furnace. Instead of the glass devitrifying and sticking on the furniture of the furnace, it turned opaque, strong and impervious to water.

Rado (1985) also accredited a famous French scientist, Reaumur (18^{th} Century) who he claims, subjected pieces of glass which has been imbedded in sand and gypsum to heat for several days. The glass devitrified, the crystals formed being pseudowollostonite (CaO_4 SiO_2), possibly resulting from an ion exchanging with gypsum ($CaSO_4$ $2H_2O$). The devitrified product resembled porcelain and was, in fact, the first perceived glass ceramic to be produced.

Glass-ceramic materials have many characteristics common to both glass and crystalline ceramics. It is formed as a glass, and then made to crystallize as a result of heat treatment. Unlike sintered ceramics, glass-ceramics are non-porous. The term, glass-ceramics mainly refers to a mix of lithium-, silicon-, and aluminium-oxides which yields an array of materials with interesting thermo-mechanical properties. The most commercially important of these have the distinction of being impervious to thermal shock.

This discovery has led to the production of a variety of glass ceramics for varying use and purposes including the production of missile nose cones for rockets and intercontinental ballistic missiles. Previously, glass-ceramics was developed for use in the mirrors and mirror mounts of astronomical telescopes, these materials have become known and entered the domestic market through its use in glass-ceramic cook-tops, as well as cookware and bake-ware.

The glass possesses some unique properties like tremendous strength, transmission of radar waves, resistance to thermal shock and rain erosion at supersonic speeds. Oven to tableware could also be produced from glass ceramics. The ware has very minimum thermal expansion and great resistance to thermal shock. A typical glass ceramics are 40% harder than borosilicate glass, with flexural strengths of up to 3500 kg/cm^2.

Glass ceramics is produced by manipulating the temperature rise and fall in the furnace to produce a controlled devitrified body. The crystals of glass ceramic unlike ordinary devitrified bodies are relatively small, very uniform distributed and free from pores or voids. The material is from 70 to 100% crystalline, the rest is filled by the glass phase. The very small nature of the crystals aids the material to be strong and well-bonded.

Maloney (1967) maintains that in recent times glass ceramics is produced using special catalysts or nucleating agents, which are dissolved in a molten glass batch which precipitate at a specified temperature when the glass is cooled. This results in numerous crystal centres per cubic millimetre. These crystals aid the next devitrification process; when the glass is reheated. It would have an atomic structure closely related to that of the crystal being nucleated.

However, Singer and Singer (1963), mention the used of photosensitive glasses as the core ingredient in the making of ceramic glass. To them photosensitive glass contain small amount of coper, gold, or silver which can be precipitated in the form of very small crystal during heat treatment of the glass. This glass upon heating becomes opacified glass at a higher temperature than that which usually develops in firing glass.

Glass ceramics are made in like manner following the usual glass forming technique. From the usual batching to the addition of nucleating agents such as, noble metals, titania, phosphorus, pentoxide, etc. After annealing, the formed glass is reheated to the nucleating temperature again to allow ample time for the maximum number of nuclei to grow. When the nucleation process is completed, the temperature is adjusted upwards carefully at a controlled rate. The rise in temperature is stalled when crystals have formed in the glass, usually around 200-500 °C above the maturing temperature of the original glass. This crystallization temperature is held constant for a specified time, before the temperature is allowed to fall to room temperature.

Prospects and Challenges of Glass Blowing Operations

Glass blowing operations just like any other human operation have prospects which if identified, developed and honed would make that venture worthwhile. In the same light there are a number of challenges that has to be study and overcome to steer the affairs of an organisation aright.

Prospects of glass blowing in Ghana culture

Culture influences all aspects of one’s life. As far as glass blowing is concerned culture has been one of the driving forces in the development of the art of glass blowing. Particularly in Egypt the belief in life after death or the immortality of the soul explains the rationale behind burying the death with glass funerary furniture, beads, unguent jars, small vases etc, particularly during the first and second Centuries, Phillips (1941).

This cultural belief ensured that glassblowers were in business constantly because death is, as has all been inevitable to man. The belief in the immortality of the soul is also shared by the Greece, Romans, Syrians and Italians this may probably be partially responsible for the dominance of the glass industry by the Mediterranean's in general.

The assertion made above is re-echoed by Stern (1999), she attribute the almost total extinction of glass blowing between the fall of the Roman Empire which included part of Northern Africa in the Eleventh Century to the invasion of Western Europe by the barbaric tribes of Germany and also the growing influence of Christianity which prohibited the burial of valuable items with the death.

Again the belief in body adornment or body art also gave impetus to glass blowing. Glass beads and fragments of glass objects are used for body adornment like necklace, bracelet, anklet, armlets, waist bands etc. Some of these armlets, bracelets, etc, are believed to be stuffed with charms and other mystical powers that protect the wearer from evil spirits and bring him/her good omen. The use of mirror fetishes by a cross section of pettish priest in Ghana to spy out thieves also made glass wares popular among the citizenry.

Small jars and other receptacles were made to house perfume and special pigments which were used to adorn both the living and the death. Traditional African architecture had its fare share of glass finishing. Crowder (1985) is even quoted to have said that some prominent palaces in Africa had glass panes. Ancient cathedrals in North Africa and even pre-independence Ghanaian orthodox Christian church buildings had stained glass windows and doors very similar to the stained glass architecture of Italy and other European nations during the Gothic period.

Glass blown articles found in tombs and grave yards in general are of enormous benefit to archaeologist, historians and professionals in allied business in dating objects, determining to some extent the level of civilization attained by the culture under study, in chronicling the histories of extinct cultures, and foretelling the way of life of a people.

Writing on glass by the Greeks and Romans Harden (1934) said this to say, the use of glass as funerary furniture demand our attention, for most of the ancient glass specimens we find in museums have all been fund in tombs. Yet little, if any, ancient glass was made solely for funerary use. The only historical significant exception was in the Second Century A.D, when the practice of cremation was the rule throughout the Western Roman Empire. Funerary furniture was then expressly made for that purpose.

Examples of this funerary furniture include, plain jars, cylinders, rectangular glass bottles sometimes used to contain the ashes of the dead, flasks, blows of various shapes and sizes for containing food and drinks for use by the death in the afterlife. These items in some instances included the household items which were thought to be proper for the dead person's to carry for use in the afterlife.

Aesthetics of Glass Blowing, Decoration and Finishing of Glassware

A glass ware after it has been fabricated is finished by a number of operations before it is annealed to remove strains introduced into the glass during fabrication. These same finishing techniques could serve as functional or aesthetic purposes.

Finishing Operations

Glass is normally fabricated by drawing, rolling, casting, etc. Rods and tubes in particular are sometime already finished in the production process and require no additional finishing. This is also true in the production of simple glass wares, such as dinner plate, casseroles, or fuse plugs. But in the large picture, particularly with blown or press and blow ware, finishing treatments is required.

Cracking, Grinding, Glazing

Beside cutting, engraving, etching, or enameling, etc, tumblers, stemware, electric light bulbs and other allied wares require ``cracking off``. The resultant rough edge must be smoothed either by grinding or glazing or fire polishing. The ware is manipulated in front of intensely hot flames directed at the very spot the glass is intended to crack off. The sudden change in temperature in the glass would cause the glass to crack circularly around the ware. Another method of cracking off is by holding the glass upside down in a vacuum chuck, and even intensified heat is applied on the glass. This would cause the glass to melt and separate, with cracking.

Grinding off glass is also achieved by holding a glass against water-cooled grinding wheel which smooth the edges and grind them square. The surface could further be smoothened by applying a hot gas flame over the edge to melt the edge and render it smooth. This is referred to as the glazing or fire polishing.

Decoration and Aesthetic Techniques

Decorations applied on glass wares may be purely for aesthetical or functional purposes or both. The decoration may be the changing of a transparent to a translucent ware by removing very little glass, as in grinding, sandblasting and etching. Or it may be the transformation of a plain glassware to a ware with intricate designs by removing a sizable amount of glass by cutting. This decoration may entail fire enameling, silvering which partially or completely obscures the glass itself.

Acidic Etching

Acidic etching is the process of decorating cold glass by removing excess glass from a glass ware to enhance it aesthetic appeal. It could be done one of two different techniques: direct engraving (wheel engraving and etching) or indirect engraving (acid etching and sandblasting). Acid etching consists of plunging the cold glass into a bath of hydrofluoric acid. The decoration is affected by the corrosive action of the acid, while any surfaces protected by a painted on coat of bitumen resist the acid and remain transparent.

Bitwork / wraps

This technique incorporates previously prepared elements into a piece of hot glass. This technique can be used for example to create handles or feet for utilitarian glass wares, or to introduce a decoration in relief onto the surface of the piece just like the springing technique in decorating pottery wares. This decoration can be a simple wrap (strands of glass of variable thickness wrapped hot around a turning surface), a filigree, a stopper, or a more elaborate bit like some of those created by Gallé, Daum and the Nancy School. Through exploration of relief and modeling this technique is well suited for a sculptural approach to glassmaking.

Blowing in a Mould

Blowing can be done in molds in order to create clearly defined shapes and ornamentation. Depending on the desired effect, the blowpipe can turn or remain stationary. Blowing while the pipe is turning is well suited to the fashioning of round shapes, whereas blowing through a stationary pipe is better suited to angular shapes and ornamentation. Molds can be made from various materials: traditional wood molds, molds in metal, aluminum, bronze, (cast iron or steel for industrial purposes), molds in graphite, molds in plaster mixed with silica. According to their material, the molds are used wet and fitted with holes to allow for the escape of vapors.

Glass Cutting

Cut glass is a process of decorating cold glass by removal of material, and although it has much in common with the technique of glass engraving, it differs slightly in its implementation and decorative aims. Glass cutting consists of creating motifs of a linear, geometric or prismatic nature, as well as facets, bevels, etc., in a glass object by carving out material with a grind stone or an iron wheel. This is facilitated by the addition of abrasive sand which is moistened by a fine stream of water that flows steadily onto the surface of the wheel.

Whereas a glass engraver would delicately chisel out a decor by placing the piece under the copper cutting wheel, a glass cutter holds the piece above the wheel while carefully exerting pressure to systematically cut into the glass's body. Then, using a sandstone wheel, any ridges or high spots will be knocked down and the piece will be rendered smooth.

Next, a wooden wheel is used in conjunction initially with a slurry of already used sand and water, followed by increasingly finer grit. The piece is now ready to be polished (that is to say rendered transparent), first with a wooden wheel and tin putty, and finally with a wheel of cork.

Crackle Glass

This ornamental technique aims to give glass a deliberately rough and fractured appearance. The hot parison is plunged into cold water during blowing, creating a network of cracks and fissures that continue to grow during successive blowings and reheats. A soft touch is required to maintain the crackled effect well described by the alternative expression “ice glass”. Another technique called “overshot” is used for similar effect. It consists of rolling the still malleable parison in a bed of crushed glass laid out on a marver; the crackled effect staying on the outside while the inner surface remains smooth.

Marketing

Marketing of glass blown products internationally is not the creation of the twenty first country. Egypt in the first century B.C was exporting bowls and dishes to other Mediterranean lands, (Harden 1934). Glass container manufacture in the developed world is a mature market business. Annual growth in total industry sales generally follows population growth.

Glass container manufacture is also a geographical business; the product is heavy and large in volume, and the major raw materials (sand, soda ash and limestone) are generally readily available, therefore production facilities need to be located close to their markets.

Kesse (1985), write that Ghana has substance economic quantities of sand at Aboso, limestone from sea shells from Mouri, Winneba and the entire coastal line of the country and soda ash could be obtained from numerous sources like the ash of cocoa pods, plantain leaves and piles, etc.

A typical glass furnace holds hundreds of tones of molten glass, and so it is simply not practical to shut it down every night, or in fact in any period short of a month. Factories therefore run 24 hours a day 7 days a week. This means that there is little opportunity to either increase or decrease production rates by more than a few percent. New furnaces and forming machines cost tens of millions of dollars and require at least 18 months of planning to replace component of a furnace or purchase new furnaces.

The marketing and production challenge is therefore to be able to predict demand both in the short 4-12 week term and over the 24-48 month long term. Factories are generally sized to service the requirements of a city; in developed countries there is usually a factory per 1-2 million people. A typical factory will produce 1-3 million containers a day. Despite its positioning as a mature market product, glass does enjoy a high level of consumer acceptance and is perceived as a "premium" quality packaging format, (Wikipedia 2007).

Raw Materials Exploration and Development

The raw materials for glass production are varied but the primary constitutes are silica, soda, lime and other oxides of magnesium, aluminum, boron and factions or minute percentages of other oxides. The primary constituent as summarized by Phillips (1941) is captured in table 2.1. However, individuals and organizations have thousand and one formulas for handing, storing and mixing these ingredients for varying purposes because each material comes with its own unique peculiarities.

Table 2.1
Raw materials for glass production

Materials	Theoretical formula	Glass forming oxides	Proportional parts	Theoretical formula	Glass forming oxides	Proportional parts
Sand	SiO_2	SiO_2	1	SiO_3	SiO_3	1
Borax	Na2B4O_7 10H2O	B_2O_3	0.37	$Na_2B_4O_7$ - $10H_2O$	B_2O_3	0.37
Boric acid	$B_2O_33H_2O$	B_2O_3	0.56	$B_2O_33H_2O$	B_2O_3	0.56
Feldspar	K_2O Al_2O_3 $6SiO_2$	Al_2 O_3	.18*	K_2O Al_2O_3 $6SiO_3$	Al_2 O_3	.18*
Alumina hydrate	Al_2 O_33H_2O	Al_2 O_3	0.65	Al_2 O_33H_2O	Al_2 O_3	1.65
Kaolin	Al_2 $O_32SiO_22H_2O$	Al_2 O_3	.39*	Al_2 $O_32SiO_22H_2O$	Al_2 O_3	.39*
Soda ash	Na_2CO_3	Na_2O	0.58	Na_2CO_4	Na_2O	0.58

Table 2.1 Continues

Sodium bicarbonate	$NaHCO_3$	Na_2O	0.37	$NaHCO_4$	Na_2O	0.37
Salt cake	Na_2SO_4	Na_2O	0.44	Na_2SO_5	Na_2O	0.44
Sodium nitrate	$NaNO_3$	Na_2O	0.36	$NaNO_4$	Na_2O	0.36
Glassmaker's potash	$K_2CO_3\ 1_{1/2}H_2O$	K_2O	0.57	$K_2CO_3\ 1_{1/2}H_2O$	K_2O	0.57
Saltpeter	KNO_3	K_2O	0.46	KNO_4	K_2O	0.46
Limestone	$CaCO_3$	CaO	0.56	$CaCO_4$	CaO	0.56
Dolomite	$CaCO_3\ MgCO_3$	CaO	.30*	$CaCO_3\ MgCO_4$	CaO	.30*
Burnt lime	CaO	CaO	1	CaO	CaO	2
Burnt dolomite	CaO MgO	CaO	.58*	CaO MgO	CaO	.58*
Gypsum	$CaSO_4\ 2H_2O$	CaO	0.32	$CaSO_4\ 2H_2O$	CaO	0.32
Magnesite	$MgCO_3$	MgO	0.47	$MgCO_4$	MgO	0.47
Litharge	PbO	PbO	1	PbO	PbO	1
Red lead	Pb_3O_4	PbO	0.98	Pb_3O_5	PbO	0.98
Barium carbonate	$BaCO_3$	BaO	0.78	$BaCO_4$	BaO	0.78
Zinc Oxide	ZnO	ZnO	1	ZnO	ZnO	1

However, there are three guiding principles that govern raw materials handling. These are: purity, better physical condition and affordability.

Silica (SiO_2) according to McNamara (1953) is obtained from quartz sand but Kesse (1985) adds more detail by stating that silica occurs in the earth crust as mineral quartz in unconsolidated sand, sandstone, quartzites and vein quartz. He further goes on to say that the Togo Series is mainly quartzites, sandstone, phyllites, shales, schists and silicified sandstone. These rocks are believed to produce silica for refractories and abrasive. It is also useful in the manufacture of sandpaper, high quality refractive bricks, glass, glazes and ceramic bodies in general.

The Voltaian system comprises mainly sandstone, which could also produce millions of tonnes of silica rocks preferable for numinous purposes. Quartz veins in the Birimain system could be exploited as a source of silica. The most popular deposits of silica found in commercial quantities in Ghana are found at Aboso, Petepong, Asomasi and Kuranti all in the Western Region.

The addition of silica in a glass batch would lower the thermal expansion of the glass, increase it withstands to acids and increases the melting temperature of the glass as well as its viscosity. Silica is an acidic oxide and therefore will not increase the resistance of the glass to alkalies.

Soda ash (Na_2CO_3) - the inclusion of soda ash or salt cake (Na_2SO_4) to a batch would introduce Na_2O to the batch. This oxide would decrease the viscosity and melting temperature of the glass batch. Soda ash increases the thermal expansion of the glass thereby reducing the glass's resistance to thermal shock and at the same time lower the durability of the glass.

Limestone or whiten and dolomite (CaO and MgO)-lime is a coarse, white, solid material produced from crushed limestone when limestone is heated at 900°C. Whiten in a glass batch acts as a glass forming flux and improves the durability of the glass. Dolomite act in the same manner as lime.

The results of a research by the geological survey department Ghana revealed that large deposits of shells suitable for the manufacture of lime occur in the volta river alluvial deposits east of Akuse from Amedica to Bator. The source of the shells was identified to be the brackish-water clam Egeria rapiata which is known locally as afani. The shells obtained from these clams are calcined to 1000°C to obtain the lime.

Boric oxide (B_2O_3) - this oxide is obtained from borax ($Na_2B_4O7\ 10H_2O$) or boric acid (H_3BO_3). When these two substances are used in their right quantities it lowers the level of expansion in borosilicate glasses. Alumina (Al_2O_3) - is introduced in glass batches in the form of clays, feldspar or nepheline syenite. It increases the melting temperature of the glass, increases viscosity and improves upon the durability of the glass making it more resistant to chemical attacks.

Potassium oxide (K_2O) is introduced into a batch as potash (K_2CO_3) or potash feldspar. Its main function is to increase the viscosity of the glass. It is often times used as a partial substitute for soda ash. As stated above these oxides are not the only ingredients used in glass production there are more to this list as can be seen above. The oxides that have been elaborated here constitute the primary constituents of a glass batch (fundamental materials).

Recycling

Glass products are wholly recyclable and the industry in many countries retains a policy of maintaining a high price on cullet to ensure high return rates. Return rate of 95% are not uncommon in countries like Sweden, Norway, Denmark and Finland. Other countries like the Great Britain, Canada etc have a return rate of less than 50%.

Giving the figures of glass cullet recycle in the United States, Reindle (2003) said, US have increased dramatically in glass recycle, although they are still small in comparison to the overall quantity of scrap glass recycled. For example, in 1997, an estimated 55,000 tons of glass cullet were exported for recycling, while three million tons were recycled in the US. And in the July 1999 issue of Resource Recycling, it notes that NexCycle, Inc of Irving, Texas has exported more than 100,000 tons of glass cullet from the US in the last two years, with shipments to Central and South America, the Caribbean, and continental Europe.

These figures could be compared with figures from the UK which state that their glass industry has the capacity to recycle over one million tonnes of glass each year and this coupled with the materials unique ability to be infinitely recycled without compromising its quality creates a compelling case for the recycling of glass. Despite this, glass makes up around 7% of the average household dustbin and in 2001 over 2.5 million tonnes of this material was land filled.

Although many recycling schemes now incorporate glass bottles, a high percentage of glass still often arrives in landfills and as glass is not biodegradable, it does not break down easily over time. Thus recycling and re-using glass is a great way to reduce the waste in landfills, while obtaining a versatile, durable material that can be used in a variety of settings, from road surfaces and storm water drainage systems to reflective paint, fiberglass insulation and of course, decorative tiles in the home for walls and flooring.

However, the environmental impact of runaway water used for washing glassware running into fresh water bodies as against remelting them is of serious concern to many environmentalist. Factors to consider here are the chemicals and fresh water used in the washing, and their afterward treatment and disposal. Also of important consideration in developed countries is the wholesomeness or safety of recycled glass wares products, (Earth911.Com 2008).

Recycling glass in the long term is also very economical, although in the short term it does appear to be economically unprofitable. Most experts contend, however, that the economic consequences of recycling are positive in the long term. Recycling will save money if potential landfill sites are used for more productive purposes and by reducing the number of pollution-related illnesses.

Health Implications of Glass Blowing

Not only is working with hot glass physically draining and mentally demanding, it has its health and safety implications as well. The materials and processes associated with melting, blowing, fabrication, annealing, finishing and packing, exposes the glass artist to a lot of health hazards and diseases. Toxic dust, gases and fumes associated with the practice of the art may be hazardous if inhaled by the artist. Cuts are likely to result from shattered glass and also burns are almost unavoidable particularly for beginners.

Hazards due to the Glass

Extreme caution must be taken by beginners, practicing glass blowing in the first initial weeks to minimize injuries. This could be achieved by handing glass-tube ends and sharp-edged waste glass with optimum care. Fragile glass end-points are very dangerous; they easily penetrate the skin and break off, leaving a small piece of glass embedded in the skin. Bleeding from such sharp cuts can be much difficult to stop.

According to most research books consulted, experienced glassblowers often have a very untidy work bench with fragment of glass tubes, asbestos cloth etc mingled with their tools on the bench. All the same these professional glassblowers have years of experiences to their advantage and have also acquired skills in handling dangerous glass fragments that looks deceptively careless to handle. But it is recommended that all beginners should as a matter of priority keep their bench-tops free from glass fragments and tools that are not needed for a particular exercise.

Burns Hazards

As stated above hand burns particularly are inevitable, but it results almost always from absentmindedness. Barbour (1978) quotes Guy as saying that all minor cuts and burns should be always washed in antiseptic solution and covered with an adhesive dressing. He further goes on to say that more serious injuries should be treated by a professional the least being a first aid officer.

Eye Hazards

Tinny glass fragments sometimes may find their way into the eyes. Should this occur, the eye should be covered with a soft pad. The injured person should be encouraged to keep his/her eyes motionless as possible and then rushed to the nearest health post.

Prolonged exposure to heat, infrared light etc, is attributed to cause cataract in the eyes. Again an ultraviolet light emitted by hot borosilicate and silica glasses is also attributed to cause corneal ulcers. The above mentioned eye hazards are extremely minimised or even totally eliminated if proper eye protection is habitually worn by glassblowers. Sodium glass lenses gives adequate protection from the rays emitted from hot soda glass. Didymium lenses are also recommended for glassblowers working on borosilicate glass wares, (Barbour 1978).

Hazards due to the work environment

According to a study conducted by Gupta, McCann and Harrison (1991) suggests that, many artists are unaware about the chemical they use and therefore fail to take adequate precaution to protect themselves. Glass blowers just like many artists working in the homes are not aware of the dangers they expose themselves and their families to by the practice of their profession. A lot of the oxides used in glass blowing are considered to be very hazardous and these potential toxins include:

ammonia, arsenic oxide, bifluorides, hydrogen chloride, silver nitrate, titanium, tetrachloride, vanadium tetrachloride. Kiln and furnace gasses: like carbon monoxide, chlorine, fluorine, formaldehyde, nitrogen oxides, sulfur dioxide are equally identified to be harmful if inhaled by the artist.

Another research carried out by Wiley-Liss (2007) also attested to the harmful impart of these above mentioned chemicals on the glass blowers as a result of long periods of exposure. Lastly a publication by OSHA (2008) again affirms some of the most associated risks as; wide-ranging lung problems (emphysema), significantly decreased lung capacities and eventually, after years of exposure, silicosis. General ventilation many not be enough to adequately protect artists from exposure to silica, lead, dry metal powders, toxic dust, gases and fumes etc.

Finally on health implication of glass blowing, the researcher wants to emphasis that regardless of the findings above (health hazards) one could enjoy practicing the glass blowing profession by abiding by safety rules some of which has been recommended by OSHA (2008)$_2$ and applying common sense.

This would ensure a healthy and prolonged life for practitioners and minimize the dangers therein. The only advice is that asthma and people already suffering from respiratory related problems should seriously consult their health providers or doctors first before engaging in glass blowing. Also practitioners should periodically go for checkups to ascertain their health status.

It is evident from the literature review that not much works have been done by pervious researchers in the area of assessing the operations of glass blowing units be it State-owned or privately owned. Very little is even recorded on the tools and materials used. Manuals and hand books are also difficult to come by.

- ❖ Refer to apendix ‘A’ for full version of the article on safety rules by (OSHA)

These gaps the researcher would seek to address with this thesis and it could not have come handier.

CHAPTER THREE

METHODOLOGY

Overview

This chapter explains the research method employed in the collection and analysis of data for the purpose of this research work. The chapter deals with the Research Design, Population of the Study, Sample and Sampling Procedure, Instrumentation for Data Collection, Reliability and Validity of Instruments, Data Collection Procedure, and finally, Data Analysis Plan.

Research Design

Qualitative research method was employed to carry out this research work. According to Osuala (2005), "Qualitative research places stress on the validity of multiple meaning, structure and holistic analysis, as opposed to the criteria of reliability and statistical compartmentalisation of quantitative research''.

The researcher adopted qualitative research method precisely case study partly due to the seemingly limited information about glass blowing operations in the country and the need to collect very extensive data in order to conduct a more thorough research on the various stakeholders involved in glass blowing operation and their activities. In order to have an in-depth understanding of the entirety of the case being studied. Qualitative research method is the most recommended for this purpose.

The type of case study adopted was the multi-case studies approach. This is a collection of case studies that is based on the sampling logic of multiple subjects in one experiment. In reference to this particular research work, three Glassblowing units were studied; namely, Glassblowing Unit, Chemistry Department (KNUST), Glassblowing Unit, Chemistry Department (U.C.C) and the Glassblowing Unit Industrial Research Division (CSIR) Accra.

Strengths of Case Study

The major strength of a case study is its ability to generate an in depth and in breathe understanding of the subject matter being studied. However since the researcher has to research deeper into the dynamics of an individual or groups of individuals, or activities he/she ought to be trained and prepared in the planning or structuring of the case study to obtain the required data from the field to aid him in his final analysis.

It is said that the study of one case unit will not be appropriate for broader generalization; but its foremost advantage is that it helps in the formulization of a hypothesis which can later be tested through a more vigorous means. Also, in responds to this limitation posed by a case study that is the more reason why the researcher opted for the multi-case study approach.

Population of the Study

One of the foremost steps in determining a sample is by defining your population. Williman (2001) defines population as a collective term used to describe the total quantity of cases of the type, which is the subject of one study. He goes on to state that it could be objects, events and people.

Osuala (2005) explains population to be the means of identifying characteristics that members of the universe have in common and which will identify each unit as being a member of a particular group. In this research the target population was one hundred and seventy-five (175) respondents. The accessible population was one hundred and fifty-three (153).

This number was made up of professional or practising glassblowers, production unit coordinators, lecturers, technicians, students, supporting staff of glass blowing units, glass ware dealers, store keepers and science teachers of senior high schools drawn from Glassblowing Unit, Chemistry Department, University of Cape Coast (Cape Coast); Glassblowing Unit, Chemistry Department, Kwame Nkrumah University of Science and Technology (Kumasi) and Glassblowing Unit, Industrial Research Division-CSIR (Accra).

Sample and Sampling Procedure

Given the nature of the population the purposeful sampling method was used for this research. Agyedu, Donkor, Obeng (1999) explains that in purposive sampling the sample is chosen to suit the purpose of the study. Some elements of the population are intentionally selected based on the judgement of the researcher and nothing is left to chance. Purposeful sampling is recommended for qualitative research.

The sample size was one hundred and fifty three (153), this represent (87.4%) of the targeted population. Out of that number, four (4) were professionally trained glassblowers, three (3) Heads of Department, twenty three (23) laboratory technicians, one (1) cleaner, six (6) sciences teachers (S.H.S), two (2) facilitators, three (3) storekeepers, eight (8) glass ware dealers, three (3) customers and hundred (100) students.

The number of students sampled were eighty (80) laboratory technician students from U.C.C comprising forty six (46) level three hundred students and thirty four (34) level four hundred students representing seventy percent 80% of the student population. The other 20% were students who participated in a glass blowing workshop in KNUST. Refer to Table 3.1 to 3.3.

Table 3.1

Population of glass blowing Practitioners and Patronisers in U.C.C (Cape Coast Metropolis)

Number	Characteristics	Number of respondents
1.	Head of Department	1
2.	Glassblowers	2
3.	Technician (Glass blowing Unit)	1
4.	Laboratory Technicians	9
5.	Students	80
6.	Cleaner	1
7.	Science Teachers	3
8.	Laboratory Technicians (S.H.S)	3
9.	Glass ware Dealers	2
	Total	**102**

Table 3.2

Population of glass blowing Practitioners and Patronisers in C.S.I.R (Accra)

Number	Characteristics	Number of respondents
1.	Head of Department	1
2.	Glassblower	1
3.	Technician	1
4.	Costumers	3
	Total	**6**

Table 3.3

Population of glass blowing Practitioners and Patronisers in KNUST (Kumasi)

Number	Characteristics	Number of respondents
1.	Head of Department	1
2.	Facilitators	2
3.	Laboratory Technicians	9
4.	Storekeepers	3
5.	Students	20
6.	Science Teachers (S.H.S)	3
7.	Laboratory Technicians (S.H.S)	3
8.	Glass ware Dealers	3
	Total	**44**

The selection was not based on gender, although all the glassblowers interviewed were males. However, a considerable number of students interviewed particularly in U.C.C were females. The main criterion for selection was glass blowing practitioners and individuals who have a direct influence on the operation of glass blowing in the country.

Instruments for Data Collection

The instruments used for data collection include questionnaire, interview schedule and observation guide. The researcher employed a questionnaire to guide him to ask cogent and precise leading questions that would aid him to get more in-depth information out of his interaction with correspondents. The questionnaire was designed based on the SWOT analysis and analysed using S.P.S.S (Statistical Package for Social Scientist) software version 16.

The researcher conducted a critical evaluation of the establishments, because it was important to conduct analysis of the establishment and its environment as it was at that moment and how it might develop in the future. The analysis was executed at an internal level as well as an external level to identify all opportunities and threats of the external environment as well as the strengths and weaknesses of the organizations.

The SWOT analysis was the simplest way of conducting situational analysis in this research. It brought to light the strengths, weakness, opportunities and threats of the glass blowing units. This approach obviously resulted in an in-depth and in-breath knowledge of the outfit.

Questionnaire

There were two questionnaires in all. The first questionnaire constituted twenty one questions and targeted production unit coordinators, lecturers, technicians, students and supporting staff of glass blowing units. The questions were grouped under the following headings:

a) Background information about the respondent.

b) Knowledge about other operational glass blowing units.

c) Category of people who patronize the services of the unit.

d) What are the strength and weakness of the unit?

e) What are the threat and prospects of the unit?

f) What role the government can play to promote the art of glass blowing in Ghana.

The second questionnaire was also designed for the following category of people: Purchasing Officers, Glass ware dealers, Store keepers, Science Teachers, Laboratory Technicians, and Students. It followed a similar pattern as the one described above. The differences between the second and first questionnaires were that, the second questionnaire sought addition information like the level of interest in the art of glass blowing, assessment of glass blowing activities in the country, prospects of glass blowing in the country and the role government can play in the development of glass blowing in the country which were not included in the first one. (***Refer to apendix 'B' for sample of questionnaire***)

Interview

Interviews in qualitative research are usually not structured in the same way as in quantitative research. However, it often turns out to be open-ended or semi-structured, in the latter case revolving around a few central questions, (Leedy, 2002).

Unstructured interviews obviously, are more flexible and have a great potential of yielding more relevant information than the researcher planned to ask for. The chief disadvantage is that the researcher may get varying information from different people and may not be able to make comparison among the respondents.

The researcher chose the unstructured mode of interview and asked open-ended questions tackled under the following:

a) Historical background of the unit.
b) Source and types of raw materials used.
c) Types of tool and equipment used.
d) A brief biography of the present glass blower(s).
e) Strength and weakness of the unit.
f) Oportunities and threats faced by the unit.
g) Expected government interventions or assistance.

The researcher interviewed heads of Department, Professional Glassblowers, Technicians and Private Individuals who patronized the services of glass blowing units. The interviews were conducted in English at a pre-arranged time convenient to the interviewees. Generally, a section of interview lasted for as short as thirty (30) minutes to as long as two (2) hours based on the interest of the interviewee and the time at his or her disposal.

Observation

Observation in qualitative research is unstructured and free flowing. The researcher focuses his attention on one thing and moves to the other. The researcher may in the process chance on significantly important elements which may be of enormous benefit to the research work, which he may have had no clue about. (Schram, 2003)

The researcher conducted on the spot observation of all three glass blowing units. Critically observing and recording with a digital camera the tools, materials, equipment, production techniques and focusing more on aesthetic finishing, handling and packing. The general workshop space was not let out. Some of the key elements looked out for include: the size of the workshop, safety measures which are in place, ventilation, source of water and lighten among others.

Reliability and Validity of Instruments

Data collected for the purposes of this thesis are very dependable to a very large extent because it was subjected to triangulations. This is the use of more than one data collection methods in gathering data from various sources and individuals and subjecting these to vigorous scrutiny.

The sources of the data are very credible and the questionnaire used was subjected to pre-testing on similar small case scenario. All the necessary corrections were made before being administered on the field.

Data Collection

Library Research

The libraries consulted for the purposes of this research were Kwame Nkrumah University of Science and Technology (KNUST) library, Technology Consultancy Centre Library (T.C.C) and Building and Road Research Institute Library (B.R.R.I).

Administration of Questionnaire

Since the sample population was accessible and centralised the questionnaires were self administrated.

Collection of Primary and Secondary Data

Primary data was collected primarily, from the glass blowing units in U.C.C, K.N.U.S.T and C.S.I.R. Other sources also included storekeepers in the Department of Chemistry, Biochemistry, Pharmacy etc all in KNUST, glass door dealers in Kumasi and Melcom Trading Enterprise. Data was collected through interviews, discussions, self-administered questionnaire and on-the-spot observations.

Secondary data was collected from books, magazines; articles published and unpublished books as well as lecture notes. The internet was also extensively utilized.

Data Analysis Plan

Data gathered were painstakingly compiled, synthesised and analysed using descriptive statistics; interpretation and conclusions were drawn from it. A few imperative photographs for the purposes of further clarifications and evidence have been added in Chapter Four.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

Overview

This chapter is a careful analysis of the data gathered from questionnaire, interviews and on the spot observations made for the purposes of this research. The data was collated based on the following objectives: One, the identification and evaluation of operational glass blowing units. Two, the investigation and documentation of the materials, tools, equipments etc, which are used by these units. Three, the critical examination of the ways of improving the operations and aesthetic techniques of the units. Statistical tables, charts and plates were used to compile the data. The deduced findings have been interpreted using descriptive analysis.

Demographics Result

Questions one to seven of the questionnaire administered provided data which has been compiled into the demographical results.

Three glassblowing units in Ashanti, Central and Greater Accra regions were used for the purposes of this research (G.B.U. Chemistry Department, U.C.C, G.B.U, Chemistry Department KNUST, and G.B.U, Industrial Research Division-C.S.I.R, Accra). The total sample size for the research was 153 representing 100%. Out of this figure 75.0% were males, 16.7% females and 8.3% failed to disclose their sex.

Again, 79.1% of the sample has been associated with these units for a period between 1 to 3 years, whiles, 6.6% have been associated with the units between 4 to 6 years, also, 2.2% have been associated with the units between 10 to 12 years and 7.7% have had acquaintance with the units for a period of 16 years and more. These have been represented in a table: 4.1

Table 4.1.

A table showing the years of association with G.B.U

Years of association to Glassblowing Units	
Duration	Percentage %
1-3	79.1
4-6	6.6
10-12	2.2
16+	7.7
No Response	4.4
Total	100

As regards the level of education attained by respondents, 98.9% of the sample had attained education to the tertiary level with only 1.1% educated to the post secondary level. This comprises of 1.1% lecturers, 7.7% laboratory technicians, 85.7% students and 5.5% others (comprising facilitators, laboratory assistants, storekeepers etc). This has been represented in a form of a chart. (Refer to figure 4.1)

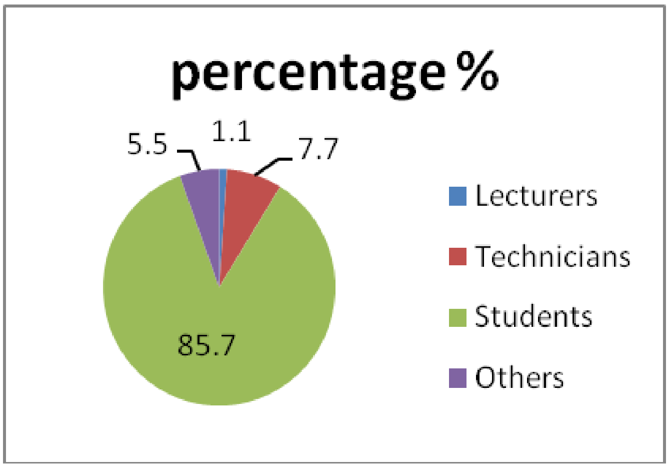


Figure 4.1 Professional Status of Respondents

In answer to the question whether the respondent is a professional glass blower or not, 8.8% of respondents were professional glassblowers, 91.2% were not glassblowers. The 8.8% quoted here for professional glassblowers is a little bit on the high side because from the interviews conducted with the professionally trained glassblowers the country has only four glassblowers and they know each other quite well. From a critical study of the questionnaire it becomes evident that some students who have received training in glass blowing saw themselves as professional glassblowers and did indicate to that effect.

Again from the practitioners, one requires between five to ten years of practical experience to qualify to be a professional glassblower. This view is buttressed by a lot of literature consulted including Wheeler (2008). Also, 45.1% of the sample received their training in Ghana whilst 2.2% received their training outside the country. In addition, 52.7% did not respond probably because they taught the question applied to only professional glassblowers.

Identification of Operational Glassblowing Units

Identification of operational glass bowing units was facilitated by respondents' answers to question '8' of the questionnaire. Question eight asked respondents' to list additional units they knew aside the ones provided. Armed with this list and through correspondence with a few interviewees, the researcher was able to identify aside C.S.I.R, U.C.C. and K.N.U.S.T Glass Blowing Units, four additional glass blowing units. These units were housed on the following campuses, University of Ghana, Ghana Atomic Energy Commission, Ghana Standard Board and Accra Polytechnic.

From the research conducted as to whether these glass blowing units were operational, it turned out that, out of the four additional units identified, it was only University of Ghana (U.G) that had an operational glass blowing workshop, built solely to carrying out repair works and simple glass ware fabrications. It was built purposely to be manned by one person with the sole purpose of servicing the University community.

A Brief Overview about the Operational Glassblowing Units

The brief overview was written based on interviews conducted and deduction from secondary data from the glass blowing units files.

Glassblowing Unit, Chemistry Department, KNUST, Kumasi

The Glassblowing Unit at the Chemistry Department, KNUST was part of the requirement that had to be met before the introduction of the chemistry programme in the University's curriculum. The unit was first manned by Mr Adjei a technician by profession who had received training in glass blowing in the Czech Republic. The rational for the operation of the unit was to repair damage glassware and design simple glass wares like capillary tubes for melting point determinations, simple dispensing droppers etc for both teaching and research purposes for the Chemistry Department and other departments in the University fraternity that may need the services of the unit.

The unit enjoyed tremendous patronage from the University community and was a great source of internally generated funds for the Department. The unit gradually came to a standstill when due to ill health the only glassblower of the unit went on an early retirement and the Department failed to attract a suitable replacement.

The glassblowing unit was dormant for a period of about seven years until the year 2005, when Professor J.H Ephraim[3] and Mr. M.K. Commeh[4] won a TALIF sponsorship to rejuvenate the unit. The objectives of the project included the rejuvenation and expansion of the unit to include a glass smelting unit, the supply of the University with the needed laboratory glass equipment and accessories, supply the region and the northern educational sector with laboratory glass ware, provide a fertile research ground for glass technology and gradually spearhead the introduction of glass blowing into the curricula of ceramic and chemistry programmes in the University.

This Glass blowing unit is still in its priming stages. It organises periodic glass blowing workshops for lecturers, technicians, students and the general public who sign up for their programmes. Most of the above stated objectives are yet to be realised. The unit is currently manned by two facilitators with oversight responsibility by Mr. Commeh and the Head of Chemistry Department.

(Refer to Plate. 4.1a and b)

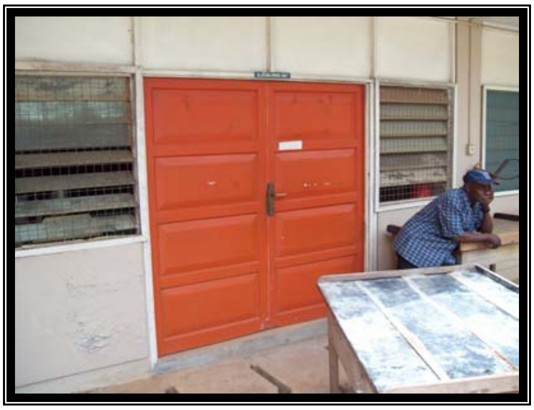


Plate 4.1a. Outside view G.B.U, KNUST

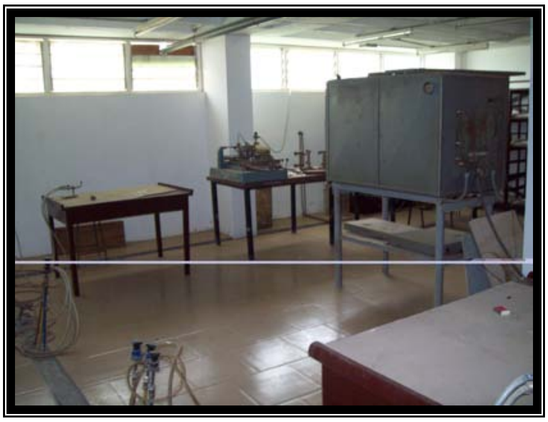


Plate 4.1b. Inside view G.B.U, KNUST

3. Prof. J.H Ephraim is the current V.C of Catholic University, Fiyapria Sunyani.

4. M.K Commeh is a research fellow at T.C.C, KNUST.

Glassblowing Unit, Chemistry Department, U.C.C., Cape Coast

The glass blowing unit, Chemistry Department, U.C.C, is the second glassblowing unit to be set-up in the country. It was set-up in 1965 but due to a few challenges the unit became fully operational in 1968. The rational for the establishment of the unit is to promote science education and research by Ghana's first president Dr Kwame Nkrumah. The unit was mandated to run a course in glass blowing for the Chemistry and allied Departments, offer repair services for damaged glass ware and accessories for the University, second cycle institutions, hospitals, industry etc in the catchment area, fabricate simple glass equipment for research in both postgraduate and other teaching activities and programmes.

Mr. Aning was the first glassblower of the unit. After him, the unit has successfully trained eight additional glassblowers, three of whom were sent for further studies outside the country. The unit has lived up to it mandate and has chopped many successes, it periodically organises glass blowing workshops for S.H.S science teachers and technicians. It also renders repair services and consultancy to establishments like, the University hospital, Aminsagari Ltd, Wemco Takoradi, Food research institute etc. Currently it runs a glass blowing course for laboratory technician students in the University. (Refer to plate 4.2a and b)

Plate 4.2a Outside view G.B.U, UCC **Plate 4.2b Inside view G.B.U, UCC**

Glassblowing Unit, Industrial Research Division, Council for Scientific and Industrial Research (C.S.I.R)

Glassblowing unit C.S.I.R was the first glass blowing unit to be established in Ghana. It was built as part of Dr. Nkrumah's dream of industrialising the Ghanaian economy through intensive research work. The unit was tasked to provide the glass ware needs of the council as well as carry out repair and consultancy services for private researchers and institutions. In addition, they were to carry out research on glass technology which may be utilised by both the government and private entrepreneurs wishing to enter the glass or ceramic industry.

The unit is by far the most popular unit owing to its regular advertisement in both the print and electronic media. They render repair services and consultancy to second cycle institutions, polytechnics, universities, hospitals, industries etc. The range of products rendered by the unit ranges from laboratory glassware to decorative pieces. The principal glassblower is Mr. Amo-Mensah, who is ably assisted by Mr. Amezado. (Refer to plate 4.3a and b)

Plate 4.3a The Building housing GBU,CSRI

Plate 4.3b Inside view GBU, CSRI

Evaluation of the Units

The units were evaluated based on the deductions from responses to questionnaire and interviews and also, from observations and secondary data obtained from numerous sources.

Situational Analysis, SWOT Analysis

A thorough evaluation of the glass blowing units was carried out. Just like any evaluation of any outfit or organisation is analysed in terms of its current environment and how it may develop in the future (An internal and external analysis were carried out) to identify all opportunities and threats of the external environment as well as the strengths and weaknesses which are essentially internal to the units and relate to matters concerning resources, programs and organization in key areas.

SWOT analysis provides an efficient way to evaluate the range of factors that influence the operations of the glass blowing units, and gave valuable insight as to the key areas that has to be enhanced or consolidated for expansion and improvement.

Strengths

The glassblowing units are endowed with resources and facilities which if well honed would form the basis for developing a comparative advantage.

Professional Competency

The units have well seasoned glassblowers who have matured with years of practical hands-on experience and gained remarkable knowledge in the art of glass blowing. An example can be made of Mr. Prah who is on record to be under utilised by the University authorities (U.C.C). This view was buttressed in the analysis of question ‘12’ of the questionnaire which called for the rating of the professional expertise of glassblowers in the units. The glassblowers were rated very high

(70 %+). This is against the backdrop that most of them have no opportunity for further studies or in service training.

Quality products and services

Majority of respondents (93%) interviewed were of the view that fabricated glass wares and repair services conducted by these units are of high standard and are comparable to any of its kind anywhere in the West African sub-region.

(Refer to Plate 4.4)

Plate 4.4 Display of some products and services rendered by GBU

Appropriate Infrastructure

The location of the units, working space, floor works, lighting, source of running water are all up to the recommended standards, (Barbour, 1978). In this category also the units were rated high from the analysis of the responses to the questionnaire. (Refer to Fig: 4.3)

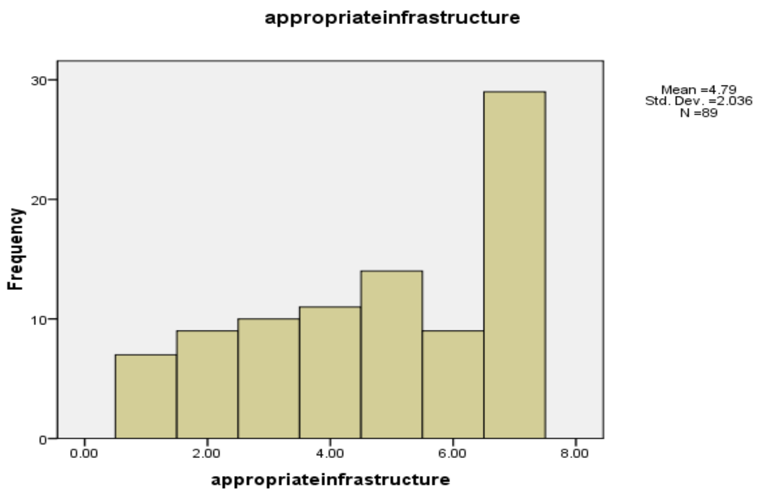


Fig 4.3 Ratings by respondents on state of infrastructure

Good Administrative Structure

Generally from the analysis of documented data at the units visited and personal observation made by the researcher, the units have a good laid down structure of organisation as is evident in the well defined roles specified for each senior or junior staff. A great sense of order and effective discharge of duty is maintained in the units.

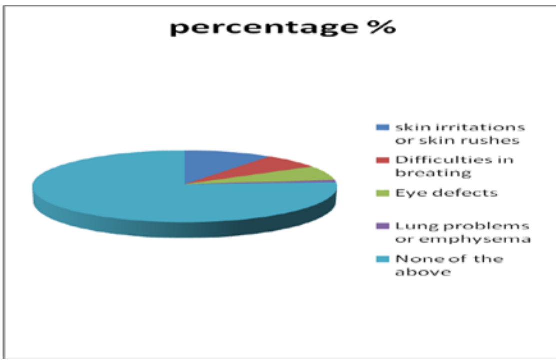
High Standard of Safety Precautionary Measures

The wearing of didymium spectacles and laboratory coats are strictly enforced by the units particularly during workshops. First aid boxes and fire extinguishers are strategically positioned for any unforeseen eventualities. Education on safety measures is also an integral component of their training programme. (Refer to Plate: 5a and b)

Plate 4.5a First aid box GBU, UCC **Plate 4.5b Participants in their lab coats**

National health insurance has also been well embraced by practitioners in the glass blowing industry. Out of the total sample of 100%, 79.1% have registered under the scheme whiles 8.8% were not registered and 12.1% did not disclose their NHIS status. These measures could probably account for the low risk levels of practitioners to most of the prevalent diseases associated with the profession.

The statistics derived from question ‘15’ of the questionnaire show that 75.8% do not have any of the prevalent diseases associated with glass blowing, 9.9% periodically experience skin rushes, 6.6% experience eye defects, again, 6.6% had difficulties in breathing and 1.1% experience lung problems. These statistics have been represented in a chart form below. (Refer to fig: 4.4a and b)



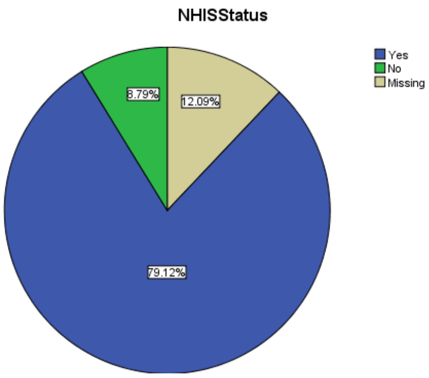


Figure 4.4a Chart on NHIS Status **Figure 4.4b Chart on disease prevalent in GB**

Good customer care and service delivery

The units were reported to be customer friendly, very reliable in meeting deadlines and prompt to honour invitation and calls. They were rated high by respondents ranking 70%+ in the Column for assessing the level of customer care and service delivery in question '12' of the questionnaire. (Refer to fig 4.5)

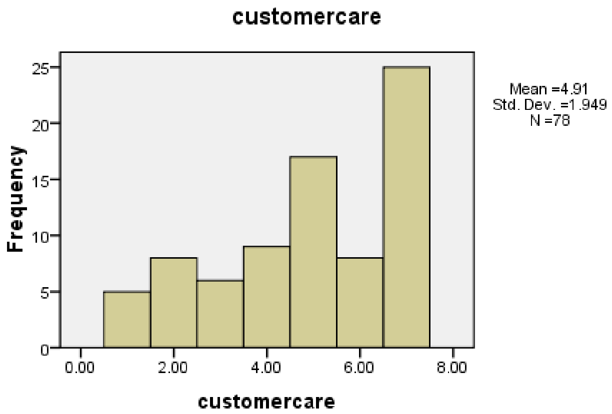


Fig 4.5 Rating of GBU on customer care and service delivery.

Weaknesses

These are conditions within the units that if not addressed could prevent the units from reaching their set objectives. These comprise the following:

Low publicity

Still on the interpretations of question '12' of the questionnaire and interaction with glass blowing practitioners and customers, one could reason that over the years, glass blowing units have failed to invest in publicity in both the print and electronic media. This shortcoming could probably be a contributing factor to the lack of awareness about the existence and operations of the units among the general public. The analysis of the questionnaire is represented below. (Refer to fig 4.6)

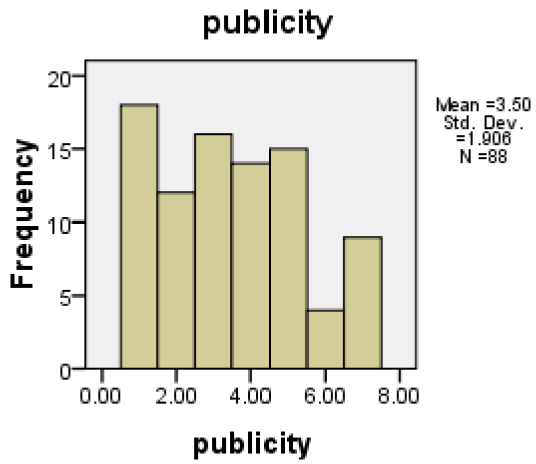


Fig 4.6. Ranking of publicity of GBU among the general public

Low patronage

The patronage of the services of glass blowing units is generally on the low side. These were attributed to a number of factors by interviewees, some of these factors are:

1. The imbibed Ghana culture of discarding broken glass ware. Literally Ghanaians throw away broken glass ware without considering the possibility of repair or even recycle. This culture in registered in their sub-consciousness to the extent that even laboratory technicians and lecturers in outfits where there are functional glass blowing units, they still find it very difficult to send damage glass ware for repairs even at no personal cost to themselves.
2. Bribery and corruption. It was alleged that some technicians, storekeepers etc are in league with glass ware dealers and suppliers and therefore prevent the sending of glass wares for repairs. They would wait till at the end of the year and go for invoices from their conspirators and forward it to procurement for new purchases to be made.

Lack of an Efficient Calibration Machine

It was observed by the researcher that with the exception of Industrial Research Division-C.S.I.R all the remaining visited glassblowing units lacked a calibration machine. This made reading on test tubes and other products produced by these units that require some form of measurement difficult to use. However, even the calibration machine at C.S.I.R is outdated, very cumbersome and tedious to use. (Refer to Plate: 4.6)

Plate 6. Calibration Machine Industrial research Division-C.S.R.I

Low commitment of management to glass blowing units

Contrary to the 50% score by management upon assessment by respondents via the questionnaire on the commitment of management to the units, glassblowers lamented the ordeal they go through before funds are made available for repair works on machinery and other administrative expenses. It was alleged that regardless of the high level of risk involved in the practise of their profession, glassblowers do not enjoy any preferential treatment, thus they are treated just like any other technicians.

Adding to the above, it was alleged that management as a result of the low remuneration given to glassblowers, fail to attract the required man power as a result they resort to assigning labourers and cleaners to the units to be trained as glassblowers. More often than not such individuals are not given to the stern mental and physical discipline of craftsmanship as is expected of a glassblower. It comes as no surprise to the professional glassblowers that these apprentices so to speak, abandon the profession for more ‘easier professions’.

Opportunities

These represent a pool of untapped or latent potentials or resources which could be exploited to the advantage of these units. These were identified by the researcher and from the answers derived from question ‘13’ of the questionnaire.

Teaching and Learning Innovation Fund (TALIF)

Teaching and Learning Innovation Fund (TALIF) presents a great leeway for funding of most of the projects run by these institution. If only they could draft convincing proposal that would assure the secretariat of the specific performance improvements and innovations that the proposal introduces, the secretariat would instinctively come to the assistance of these units.

Ghana Education Trust Fund (GETFUND)

Ghana Education Trust Fund (GETFUND) is also another promising avenue where funds could be secured to up-grade the standards of glass blowing units in the country and also fund most of their programmes. Finding a way of attracting the attention of the management of the fund to the role of the units in promoting quality tertiary education and learning activities through availability of glass wares and equipment for scientific research work in the country would be of enormous advantage to the unit.

Science Resource Centres

An effective collaboration between the units and science resource centres in senior high school would bring mutual benefit to both the unit and the science resource centres. Such collaboration has the potential of increasing the productivity level of the units and also securing a regular means of raising funds. On the other the hand, the centres would be cutting down on cost of glass wares the upshot of which would inevitably lead to the increase in the much sought after practical training in the senior high school level. Also the risk associated with travelling to Accra by heads of department and purchasing clerks to purchase glass wares would be eliminated.

Proximity to potential market

The educational or research environment in which the units are sited provides a readily accessible market for the units. The Chemistry Department KNUST spends averagely GH₵ 4000.00 on glass ware annually. Likewise the Biological Science and Pharmacy Departments also spends averagely between GH₵ 3000.00 to 3500.00 on glass ware for the same period. This money if channelled to the units would alleviate most of their current challenges.

Fairs and exhibitions

Glassblowing units could take advantage of fairs and exhibitions organised locally and on the national stage to showcase their products and services. These initiatives would not only boost the confidence and exposure of staff but could create opportunities for networking and attracting prospective customers.

Exploration of raw materials and development

According to Kesse (1985), the country stands tall comparatively in economic deposits of all the primary raw materials used in glass production (silica, lime or whiten and potassium/sodium feldspar) even when compared with the so called developed glass blowing nations.

A survey conducted by the geological survey department in October and November 1959 revealed that, with regards to silica deposits, there are four main areas where silica is found in commercial quantities in the country. These are, Aboso, Petepong, Asomasi and Kuranti. It was estimated that there were 34,390 cubic meters of sand at Aboso and 72,580 cubic meters at Petepong alone.

With regards to sodium and potassium feldspar, it was both found to be widespread in the pegmatites deposits in Ghana. Commercial quantities were found in Biriwa, Moree and Winneba. The feldspar at Winneba was found in pegmatites with or without spodumene. Closer analysis of the pegmatites at Mankwadzi revealed albite of sodium feldspar and potassium feldspar to be 245,000 and 85,500 tonnes respectively.

Lime or whiten, about 92% of the total deposits of whiten in the country can be traced to Bokpo and Mafi-Lado. Approximately there is 60,000 tonnes of shell which could be exploited profitably. These represent the bulk of raw materials that the units could partner prospective investors to exploit to their mutual advantage.

Monopoly

In developed countries the ratio of a factory to a population is one glass factory to between 0ne to two million people (Wikipedia 2008). If these figures are anything to go by it implies that Ghana should have had at least ten glass factories. Given the fact that the only glass factory in the country collapsed, the four glass blowing units enjoy total leverage of the glass industry in the country. The units have not taken full advantage of this fabulous monopoly they enjoy. Re-tailoring their products and services to meet the glass ware needs and services of tertiary institutions in the country alone has the potential to change the present state of glass blowing operation in the country. It will also generate employment and popularized the art of glass blowing among the citizenry.

Collaboration with professional bodies

Although from the interaction with practitioners and management of glass blowing units, it was said that the units organise workshops for science teachers and laboratory technicians, in the perspective of the researcher this goodwill established could be pushed a step further by partnering these professional bodies like Ghana Chemical Society, the Arts Council, Ghana National Association of Science Teachers (GNAST) etc so that as part of their annual conferences the units could organise workshops and symposiums to enlighten their members on the art of glass blowing and prospects in the country. Their usual one week spent is enough time to whip-up ones interest in glass blowing.

Aside the above mentioned bodies, the units could collaborate with other stake holders like, Ghana Investment Promotion Council (GIPC), Aid to Artisans, National Board for Small Scale Industries (NBSSI), Ghana Export Trade (GETRADE), Ghana Regional Appropriate Technology (GRATIS), Non-governmental Organisations and other donors for networking and capacity building.

Recycling

From observation made by the researcher at the store rooms of most of the departments in KNUST and UCC the stockpile of damaged glass ware at the stores is beyond once comprehension. If only these units are able to set-up a smelting unit to remould these glass wares into useful products, it would turn this redundant stock of glass wares into a gold mine.

The statistics according to a 2005 study by the U.S. EPA state that, the national recycling rate for glass containers in the U.S is just over 25 percent,. Americans recycle nearly 13 million glass jars and bottles every day. The glass container industry has annual revenue of $5.5 billion, with almost 50 manufacturing plants located throughout the country. A typical glass processing facility is estimated to be capable of recycle up to 20 tons of glass per hour.

Again, it is said that, glass containers produced today are 40 percent lighter than what it used to be 20 years ago, making them much easier to recycle. Every ton of glass that is recycled results in one ton of raw materials saved to process new glass, including: 1,300 pounds of sand, 410 pounds of soda ash and 380 pounds of limestone (www.Eearth911.com, 21/11/2008) .

Given these facts recycling and re-using glass wares would be the most beneficial way to reduce the waste in these stores rooms and the country's landfills as well. While obtaining a versatile, durable material that can be used in a variety of settings, from road surfaces and rain water drainage systems to reflective paint, terrazzo, jewellery, glass mosaic, fibre glass insulation and of course, decorative tiles in the home for walls and flooring. (Refer to Plate: 4.7a and b)

Plate 4.7a Recycled glass installation **Plate 4.7b Recycled glass terrazzo floors**

Glass art

Glass art is the use of glass as an artistic medium. Specific approaches include stained glass, glass etching, glass casting, glass fusing etc. From interviews conducted and interaction with the leadership of glass blowing units it became clear that the leadership in particular wants the units to be customer oriented, income generating and semi-autonomous entities. Again, none of the units is fully exploiting the potential in glass art apart from the art of blowing itself. Although they have the basic tool and some knowledge as to how glass art is done.

The following are some proposed glass art techniques that the units could exploit to enhance their aesthetic techniques and also diversify their current narrow market.

1. Glass etching

Glass etching is a technique of creating art on the surface of glass by aplying acidic, caustic, or abrasive substances. These chemicals for etching could be obtained on the market or better still; the units can easily prepare this chemical locally by neutralizing the waste of hydrofluoric acid resulting from the production of superphosphate fertilizer. It can also be generated by treating sodium hydroxide and sodium carbonate with hydrofluoric acid, followed by concentrating the resulting solutions, sometimes with the addition of alcohols to precipitate the sodium fluoride (NaF). The chemical equation is given below:

$$HF + NaOH \rightarrow NaF + H_2O$$

Using an excess of HF gives the bifluoride $NaHF_2$. Heating the latter releases HF and gives NaF.

$$HF + NaF \rightleftharpoons NaHF_2$$

The actual etching can be done in several ways: direct engraving (wheel engraving and etching) or indirect engraving (acid etching and sandblasting). In direct etching the chemical for etching could be mixed with any colouring oxide desired and aplied directly on the glass. The chemical is allowed to dry on the glass before it is placed in an annealing oven. The chemical would etch into the glass leaving all areas without the chemical bear. A pictorial explanation is given below. (Refer to plate 4. 8a, b and c)

Plate 4. 8a Painting with NaF Mixed with F_2O

Plate 4. 8b Annealing oven ready to receive the etched work

Plate 4.8c finished etched piece

Acid etching consists of plunging the cold glass into a bath of hydrofluoric acid. The decoration is affected by the corrosive action of the acid, while any surfaces protected by a painted on coat of bitumen resist the acid and remain transparent (Refer to Plate 4.9).

Plate 4.9 A picture of an acid etched glass (Plunging)

2. Glass Incising

This is the process of chiselling out pieces of glass from the surface of glass ware or plate to create a design in the surface of the glass. The units could in the initial stages, easily purchase mass produced glass wares and add value to it by using this method. This would make their products a little expensive than their mass produced substitute on the market; but the designs could be localised and customised to suit the preference of customers (Refer to Plate 4.10).

Plate 4.10 Glass incised products.

3. Glass cutting

Glass cutting is another technique for working cold glass by removing materials from a mass of glass. Glass cutting consists of creating motifs of a linear, geometric or prismatic nature, as well as facets, bevels, etc., in a glass object by carving out material with a grind stone or an iron wheel.

The cutting is facilitated by the addition of abrasive sand which is lubricated with water that flows steadily onto the surface of the cutting wheel. This technique is not beyond the capabilities of the units. At least U.C.C and Industrial Research Division (C.S.I.R.) have this iron cutting machine. (Refer to Plate 4.11a, band c)

Plate 4.11a Glass cutter (CSIR) **Plate 4. 11b Geometric decorative piece (glass cutting side view)**

Plate 4. 11c Geometric decorative (glass cutting 3/4 view)

4. Glass Moulding

The basic shapes of glass wares produced and worked on by Glassblowing Units visited were simple cones and cylinders that lacked creativity and aesthetic qualities. In addition to the basic shapes glass could be moulded into very aesthetically attractive decorative wares which will not only enhance the quality of their products but also contribute in the long term to lure prospective clients to the units. An illustration of how to use simple glass tubes to produce decorative piece (bird) is illustrated below by one of the facilitators of the glassblowing units KNUST:

Plate 4.12a Light up a bench burner

Plate 4.12b Rotate the glass tube and draw one end

Plate 4.12c Concentrate and rotate the flame along a particular path on the glass tube to indent it

Plate 4.12d Leave a gap between the indentation and heat the glass tube

Plate 4.13a Continue to rotate till the glass reaches it working temperature

Plate 4.13b Pull the tube away from the fire and draw

This constitutes the first section of the decorative piece. Put that aside and pick-up another tube to be used to fabricate the pedestal.

Plate 4.13c Rotate the glass and use a flaring tool to open up the opening of the tube

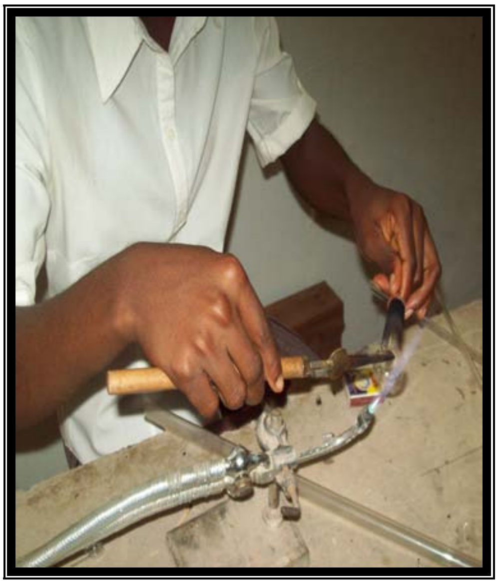


Plate 4.13d Intensify the heat and finish the base

Plate 4.14a Join the two sections and seal the seams with the flames

Plate 4.14b Pull it out of the fire and check for alignment

Plate 4.14c The piece after annealing

Plate 4.14d Decorative piece (Bird)

Threats

There are a number of factors, internal or external, that could hamper the glass blowing units from meeting their set objectives. Question '14' of the questionnaire required of respondents to identify the threats militating against the progress of glass blowing units. The following are the conclusions' obtained from their responses:

Aging personnel

Aging personnel was identified by respondents to be one of the greatest threat facing glass blowing units in the country. This view was also shared by V.R. Prof. D. K DoDoo, he stressed that aging personnel is the cause of the collapse of the glass blowing units in Ghana Standard Board and Ghana Atomic Energy Commission. Aging is inevitable to man and after years of training and experience the glassblowers retire leaving the units without suitable replacements.

Out of the four professional glassblowers in the country, one is already on retirement and has been on retirement for the past eight years or more. Two are over fifty years with the remaining one in his early thirties. If the remaining two also go on retirement too or suffer any serious health complication, it would have serious consequences on the art of glass blowing in the country. It may even lead to the total extinction of the art.

High cost of training personnel

The cost of training glassblowers according to Glass blowing units' management is exorbitantly high. Training in glass blowing in the country is limited to the elementary through to the intermediate levels. Further training in advance glass blowing and beyond would necessitate the sending of the aspirant outside the country to countries like Czech Republic, Italy, U.S etc. This move obviously came at a huge cost, stretching the budgets of the Departments beyond their elastic limits.

Unfavourable institutional administrative impart.

Certain unfavourable directives and decisions have the tendency to stifle the growth of glass blowing units. An example could be made of the abolition of glass blowing in the curriculum of chemistry student in U.C.C.

Lack of awareness about the prospects of glass blowing in the country

In response to question '19' of the questionnaire, the lack of awareness about the prospects of glass blowing in the country was identified to be the foremost threat facing the industry. Both interviewees and respondents hinged every challenge from the lack of funds to lack of opportunity for further studies to this challenge. They claimed all other challenges are subsumed to this major challenge. They stressed that; if the citizenry and government were aware of the prospects of the industry all the above bottlenecks' would be surpassed to revamp the sector. Below is a chart detailing analysis of responses by respondents. (Refer to fig: 4.7)

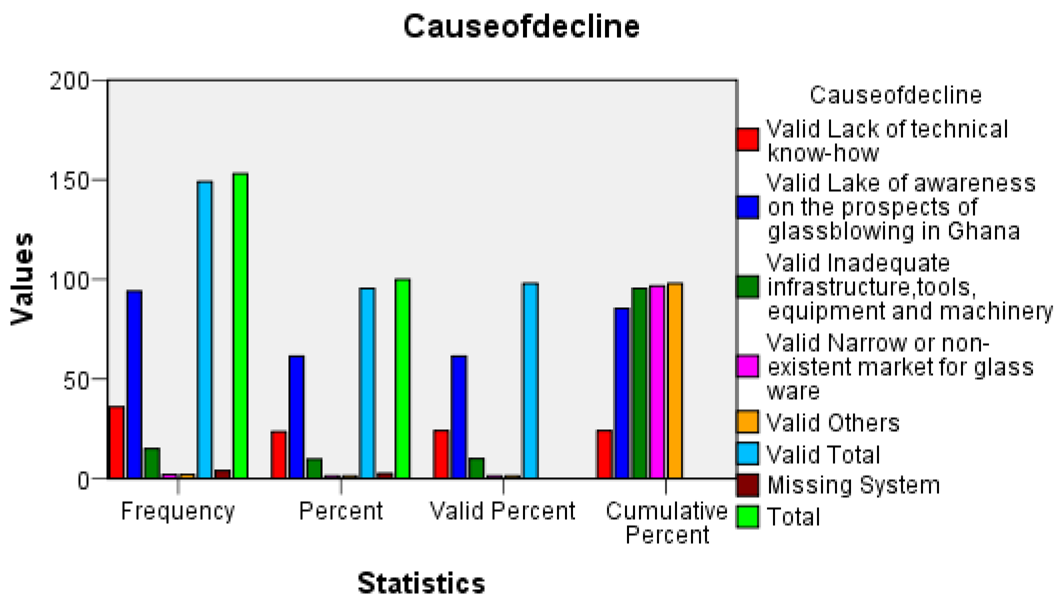


Fig 4.7. Respondents' assessment of major cause of decline in GBU

Investigation and Documentation of Tools, Materials, Equipments and Basic Techniques in Glass Blowing

Tools

The followings constitute the tools that were observed to be used by glassblowers in the units.

Didymium Lens

Didymium lens are used by glassblowers and visitors of the units to protect the eyes from glass debris and the hot flame. Unlike the ordinary lens it is chemically or mechanically toughened to protect the eyes especially from the damaging effect of the hot flame emanating from the burners. (Refer to plate 4.15)

Plate 4.15 Assorted Didymium Lens

Bench Burners

There were two kinds of bench burners in use at the units, surface-mix and pre-mix burners. A surface-mix burner uses a third component, compressed air, whiles pre-mix burners works perfectly well without compressed air. The intensity of heat produced by pre-mix burners is also higher than surface-mix burners. Surface mix burner appears to be the older of the two burners. (Refer to plate 4.15b and c)

Plate 4.15b. Surface-mix bench burner **Plate 4.15c. Pre-mix bench burner**

Carbon Rods and Shapers

These are used to shape hot glass because of their ability to withstand high temperature exposures. They are usually hand held tools which may be fashioned into rods, flats, tapers, custom forms etc. Flat paddles can be used in forming flat bottoms on glassware, an aid in reducing the outer diameters of tubing, or in forming an even taper (Refer to plate: 4.16a).

Graphite rods can be used to enlarge a hole blown in a tube, as a flaring tool, or to poke an indentation in the glass sidewall. These tools seemed indispensable to lampworking since all the blowers had them and used them very often in their work (Refer to plate; 4.16b).

Plate 4. 16a Graphite rods and shapers **Plate 4. 16b Carbon Shapers**

Graphite flaring tools

These are also hand held tools used for shaping the opening of glass wares and aid in the general fabrication of glass wares. (Refer to plate: 4.17a)

Plate 4. 17a. A display of some graphite flaring tools

Plate 4. 17b. Metal inside and outside callipers

Inside and Outside Callipers

Inside and outside callipers are tools used to measure the inner and outer diameter of glass ware. It is as well used to measure the thickness of glass tubing’s, rods etc. (Refer to plate: 4.17b)

Tungsten Carbide Knife

A diamond coated edge hand tool used to make a scratch on glass wall surface before applying pressure to break it (Refer to plate: 16a).

Plate 4. 18a Tungsten carbide knife **Plate 4.18b. Gas Lighter**

Gas lighter

The type of gas lighter commonly used in most units visited is similar to the ordinary gas lighters used in the homes. The lighters are used to ignite burners (Refer to plate: 4.18b).

Turn table

A turn table is a tool that services as a support for the glassblower to rest a long tubing or rod on, whiles manipulating tubing in the flame or outside the flame (Refer to plate 4. 19a).

Plate 4. 19a. In the picture are two different kinds of turn tables **Plate 4. 19b. Flask holder**

Flask holder

A flask holder is a three arm adjustable hand held tool use to gip rounded bottom glass ware for easy handing and manipulation in the flame and outside it (Refer to plate 4. 19b).

Materials

Soda-lime/Borosilicate Glass tubes and rods

A variety of glass tubes and rods constitute the main raw materials used by all the units. Soda- lime tubes and rods remain the mostly used glass ware. According to Mr. Amoahful, most glassblowers use glass rods and tubes of a diameter of about 7–8 mm, although pre-made stringers are available in 1–3 mm sizes, or rods of 15 mm or more.(Refer to Plate: 4.20a and b)

Plate 4. 20a. Assorted glass tubes

Plate 4. 20b. Soda-lime glass rods

Butane Gas or LPG

Liquefied petroleum gas the same type as used in the homes are used for glass blowing. The size of bottle used is dependent on the production capacity (Refer to plate: 4. 20ac).

Plate 4. 20c. Gas Cylinder (LPG) **Plate 4. 20d. Oxygen Cylinder**

Pure Oxygen

Pure oxygen is also indispensable in glass blowing. Fuel gas mixed with oxygen to generate a temperature hot enough to work glass. It enhances the combustion process and is obtained from a local supplier like Air Liquid GH Ltd. The oxygen is delivered to the units in cylinder bottles just like the home use L.P.G gas. The size also varies from 4.5 m^3/kgs to 7.5 m^3/kgs and slightly bigger. (Refer to plate 4. 20d)

Asbestos blanket

Asbestos fabric or blanket is used for blocking outlet on an apparatus before it is repaired (Refer to plate: 4. 21).

Plate 4. 21. Asbestos blanket

Glassblowing Bench

From the research conducted at the units the idea Glassblowers bench always comes with an asbestos top to withstand the heat emanating from the hot glass tubes and rods. Which if placed directly on the bear wooden tops of the blower's bench would catch fire, hence the need for the asbestos as a protective cover for the top of the bench (Refer to plate: 4. 22).

Plate 4. 22. Glass blowing bench

Paraffin oil or jell

Paraffin oil or jells are used in lubricating and removing stuck glass ware

Dilute hydrochloric acid

Dilute hydrochloric acids are frequently used to clean residue of chemicals stacked in glassware prior to their being worked on by the glassblower.

Corks

A fix size heat resistant stopper used to seal off air outlet before blowing. Without these corks blowing would be impossible since the air would leak out from the various outlets on the apparatus being repaired.

Equipments Used in Glass Blowing

Assorted equipments are used in glass blowing. Some equipment's are very simple while others are very complicated to operate.

Annealing oven/ lehr/kiln

An annealing oven or lehr is a furnace used to remove stresses in glass ware (Refer to plate: 4. 23a).

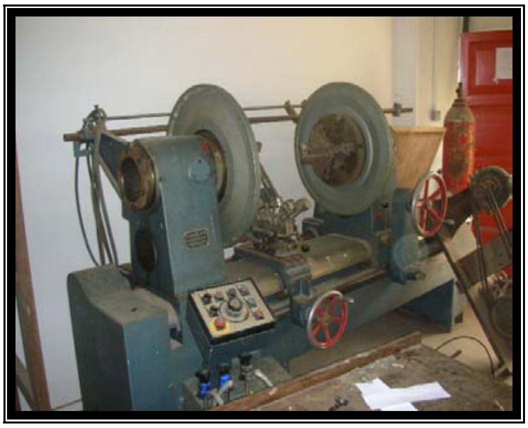


Plate 4. 23a. Annealing Oven **Plate 4. 23 b. Glass blowing Lethe burner**

Glass Blowing Lethe Burner

This machine aids in rotating glass tubes and rods which hitherto owing to the huge size of the glass made it impossible to rotate manually. The machine has a set of burners fixed at its base, beneath where the glass tube or rod would be fixed. This set of burners is movable enabling the blower to work on various portions of the glass without much difficulty (Refer to Plate: 4. 23b above).

Regulator

A single or double stage pressure control device installed in a gas manifold, gas delivery line or on a compressed gas cylinder.

Oxygen pressure regulator

An instrument fixed unto the oxygen cylinder to read the pressure of oxygen released from the bottle per a second (Refer to plate: 4. 24a).

Plate 4. 24a. Oxygen pressure regulator **Plate 4. 24b. Glass cut off wheel**

4.6.3e.Glass saw or cut off wheel

A machine used in cutting glass to the desired size and shape (Refer to plate: 4. 24b above).

Basic Techniques in Glass blowing

These comprise the basic techniques observed at the selected glass blowing units and deduction from interviews and interactions with glass blowing practitioners.

Type of Glass Blowing Technique Practised

Lampworking glass blowing or scientific glass blowing technique is the form of glass blowing technique adopted by all three glass blowing units visited. Lampworking is a form of glass blowing technique that employs the use of butane gas and oxygen fuelled burners and torches to melt tubes and rods of transparent and assorted coloured glasses. When the heat generated by the burner is able to transform the glass to it working temperature, the glass is formed by blowing and shaping it with assorted tools and very artistic hand manipulations.

Lampworking differs from offhand glass blowing in many ways (refer to plates below, for illustration on off-hand glass blowing and compare it with plates in page 103, lampworking glass blowing).

Plate 4.25a Drawing of glass from a glass furnace

Source www.glasscolour.com

Plate 4. 25b Blow to create a bubble in the glass

Source www.glasscolour.com

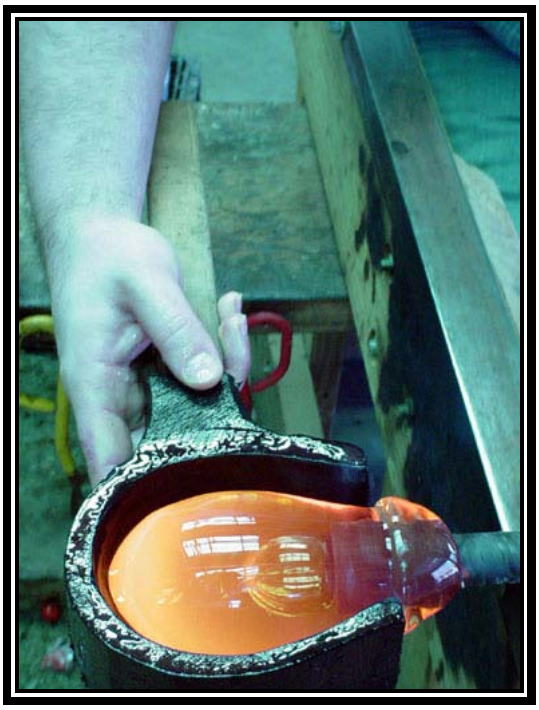


Plate 4. 26a An initial blow glass with a bubble
Source www.glasscolour.com

Plate 4. 26b Blocking to create a uniform shape
Source www.glasscolour.com

Plate 4. 26c Shape the glass with a jacking tool

Source www.glasscolour.com

Plate 4.26d The bottom of the glass is attached to a punty to aid in the defining opening

Source www.glasscolour.com

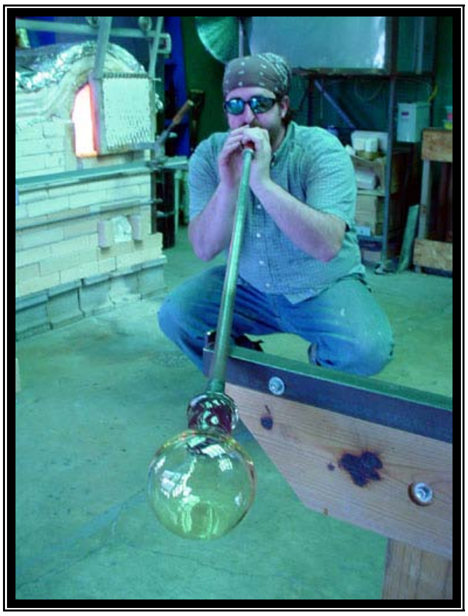


Plate 4.27a Reheating periodically

Source www.glasscolour.com

Plate 4. 27b Blowing to expand the shape and size of the glass to the desired shape

Source www.glasscolour.com

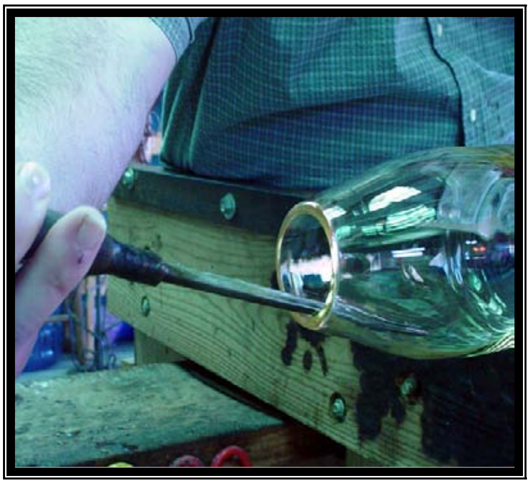


Plate 4.27c Defining the lip or rim of the glass

Source www.glasscolour.com

Plate 4. 27d Defining the base of the glass to render it stable on a flat surface

Source www.glasscolour.com

Due to the nature of lampworking, lamp-workers usually work with burners and hand held or stationary torches as opposed to melting tanks and glassblower chairs for offhand glass blowing. Only a small proportion of the glass can be heated and shaped at a time which allows for greater detail and precision. According to Mr. Amo-Mensah, previously lamp workers were limited by the size and weight of their creation. Now modern technologies provide hotter flames and the glass can also be rotated mechanically with machines like the lathes burner.

The wares thus made are first annealed with the aid of a burner using a soft flame or a yellowish flame to prevent cracking. Glass has to be preheated before and after it is introduced to intense heat. The yellowish flame produces soot which covers the entire portion where it was preheated.

It is only after annealing in an annealing lehr that all stress are released from the glass. The use of soot in annealing is only a temporary or precautionary measure taken before the wares are packed in an annealing lehr for a thorough annealing.

Once the glass is removed from the annealing lehr, a variety of cold working techniques can now be safely used to create many desired forms and shapes. These techniques may include etching, faceting, drilling, cutting, polishing, grinding, etc. These additional steps add tactile and visual textures without masking the vibrant colour or clarity of the glass.

Lampworking technique is suitable to these units because of the services they rendered. None of these units was set-up primarily to produce decorative or aesthetic products in which case offhand glass blowing would have been more appropriate technique.

Basic Steps in the Art of Glass Blowing

After careful observation of the practise of glass blowing by all the units visited the researcher attempt's to give a narration of the basic steps in the art of glass blowing.

Safety

Safety has been defined by Encarta®2008 as 'protection from, or being exposed to, the risk of harm or injury'. Safety as observed by the researcher during the field work appears to be very crucial in the practise of glass blowing; apparently because of the close proximity of the glassblower to naked fire. Accidents abound and one cannot afford to be reckless or lose focus for even a second. Burns and cuts are almost unavoidable more especially for beginners in the art of glass blowing.

From all units visited, it appears that common-sense and personal hygiene is keen in ensuring the safety of the blower and the studio. It is very imperative to keep the working area clean and free of excess and unused tools and materials which may obstruct ones path whiles blowing. When sharing a table with someone, the general advice is to try and keep to your half of the table and be conscious of the goings on in your immediate vicinity. Know the location of exits, fire alarms, telephone, fire extinguishers, safety and first-aid equipment, and gas shut-off valves.

In addition, always wear appropriate protective clothing and or equipment. Do not run away when the burner makes a 'puff sound' or catches fire. The first precaution according to Mr J. K Prah[3] is to identify where the sound is coming from, then close the valves on the burner and switch off the gas and oxygen regulators. Finally allow fresh air into the room by opening all windows and doors in the room and when you are sure that the gas or fumes has left the room then safely turn on the burner again.

Always inspect the entire work area, especially the gas supply system, to confirm safe working conditions. Maintain the caps of gas cylinders and oxygen on when not in use or when transporting the bottles. As much as practicable, do not work alone, be sure someone is close by to offer assistance if necessary. These were the safety measures adopted by all three glass blowing units. KNUST Glass Blowing Unit was the only one observed to have failed in providing appropriate first aid box and fire extinguishers.

Cutting Glass tubing/rods

Glass tubing and rods are usually sold in bulk. The length of a tube or rod may be four feet or more and with a diameter which varies from five millimetres (5mm) to one fifty millimetres (150mm) or even more. The size is agreeably cumbersome to handle in a hot flame and therefore it is cut down to a size manageable enough to work on in the flame. A scratch is made perpendicularly across the tubing on the surface of the tubing with a tungsten carbide knife or simply a glass cutter.

Glassblowers advise not to saw glass in an attempt to make cutting easier. Likewise do not make a long scratch on the tubing. A simple short deep cut on the tubing would produce a clean cut.

Apply a little water or saliva on the scratch with your fingers and turn the scratch away from your body. Place your two thumbs at both ends of the scratch such that the scratch would be in between your two thumbs. Place your arms by your side for support and then push your thumbs away from you. The glass tubing would break clean at the place you made the scratch.

Rotation

After learning how to cut glass the next important step is mastering the art of rotating tubing simultaneously with both hands. This skill according to Mr. Prah is the most difficult to master and is the hallmark of any great glassblower. To be able to manipulate glass to produce any glass work is dependent on the ability of the blower to rotate glass tubing. The products produced would indefinitely reflect his/her proficiency in rotating tubing.

To vividly describe the art of rotation from what the researcher observed this is how it is done; cut glass tubing to a working size and hold the tubing with both hands horizontally. Place your left hand under the tubing with your palm facing upwards. Place your thumb on the tubing for support, remove your right hand from beneath the tubing and place it on top of the tubing with the back of your palm facing upwards. With your left hand serving as a support use the thumb and finger tips of your right hand to serve as the pivot. Turn the glass tubing slowly, synchronising the rate of rotation of your right hand to that of the left hand. Do not be in a rush to increase the tempo but concentrate on rotating both hands simultaneously.

The positioning of the hands could be reversed if one is more comfortable working with the left hand rather than the right-hand. It may take days or even weeks of constant practise for one to become proficient in the art of rotation. More experience would be gained as one continues to develop his skills in the art of blowing through practise (Refer to Plate: 4. 28).

Plate 4. 28. Rotation inside the flame

One may also asses his ability in rotating tubing’s by practising with two pieces of tubing in each hand. He would then align each tube to one imaginary centre line and then afterwards, rotate the tubing in a synchronized manner always looking out for consistent alignment of both tubing. If this is achieved consistently one has at least gained a grip on tubing rotation. Rotation permeates through every activity in glass blowing; it is the principal technique in glass blowing.

Lighting Up

The following are the procedures taken before lighting up the burner(s) in a glass blowing studio, check to see if the gas and oxygen are in a safe operating mode. Then turn the gas regulator at 5 psi and the oxygen at 10 psi. At this gage level the pressure of both fuels is at equilibrium with each other and it also propels smooth flow of the fuels. Open the gas valve full turn to push out air trapped in the pipe line and then immediately close the valve. Repeat the same exercise to the oxygen supply.

After these, reopen the gas valve this time to approximately one fourth (¼) turn and light the burner with the flint lighter. Adjust the flame produced to about three fourth (3/4) long. This flame according to Mr. Prah, U.C.C, is called a pilot flame because you may leave the burner flame at this position when not in use but not unattended to. Mr. Prah reiterated that it is not uncommon to experience difficulty in lighting up a burner. The caution though is to be aware that anytime you experience difficulty in immediately lighting a burner beware of excessive gas build up in the burner. To avoid accident shut the gas valve off and allow a minute to elapse for the gas build up to dissipate. Then after light the burner (Refer to Plate 4. 29a and b).

Plate 4. 29a. Setting up oxygen regulator @ a safe operating mode (10 psi).

Plate 4. 29b. Lighting up a burner

Drawing

Drawing is the process of heating glass to its working temperature and pulling the glass tube apart so that the heated portion becomes stretched and thin. This process is achieved by first lighting the burner and adjusting the flame size to match the diameter of the tube. Insert the portion of the tubing you wish to draw in the flame and rotate.

Rotating outside the hot flame is a little different from when the tube is in the flame. When especially the glass reaches it working temperature, the tube would sag and manipulating the glass becomes a little difficult. When the tubing begins to sag pull the tubing out of the flame and pull apart while still rotating the tube to the thickness desired on till the glass cools down or solidifies (Refer to plate 4. 30a).

Plate 4. 30a. Drawing glass **Plate 4. 30b Compression outside the flame**

Compression

Compression just like in drawing tubing, the tubing is heated to its working temperature but here the heat is concentrated on a predetermined path around the tubing. Again, instead of drawing the glass apart, apply a little pressure on the tubing whiles still rotating the tube. If this is done properly a smooth ring would be created around the tubing. A number of these rings could be created on the tubing for a decoration or to serve as a stopper (Refer to Plate: 4.31a and b).

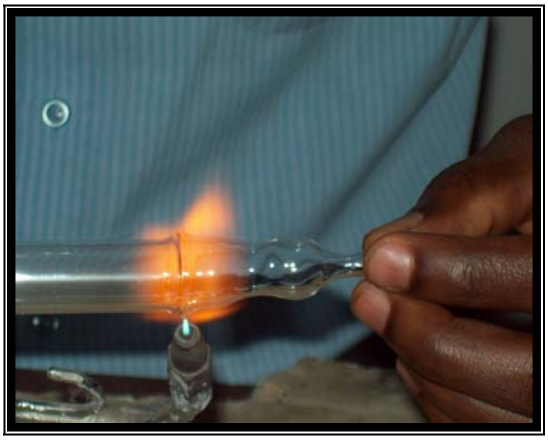


Plate 4. 31a Compressing glass tube **Plate 4. 31b An up-cose picture of the Compressing operation**

__Blowing__

Blowing of glass tubing into a blub is always a glassblowers way of alluring the attention of novice in the art of blowing. Mr Amo Mensah says he enjoys seeing the eyes of such people almost popping out of their sockets as they watch in amazement as he blows glass tubing into blubs. Glass tubing’s are converted into blubs by first cutting the tubing into a workable size. Light a burner and adjust the flame to the size of the tubing. Rotate the tubing and introduce the tubing into the hot flame.

Keep rotating the tubing until its reaches it working temperature. When the tubing is ready you would feel it within your hands. The tubing becomes red hot and begins to sag on its own weight (Refer to plate 4. 32a).

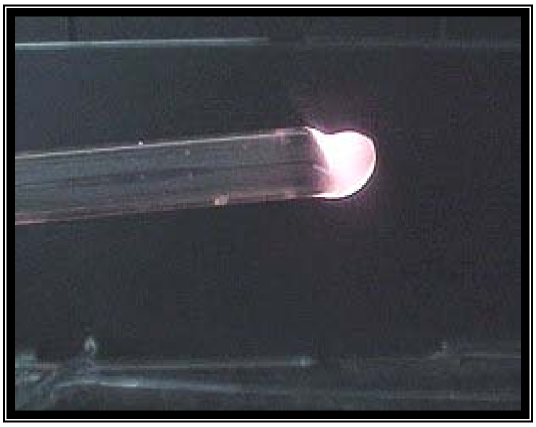


Plate 4. 32a. Glass tubing sagging under it’s own weight.

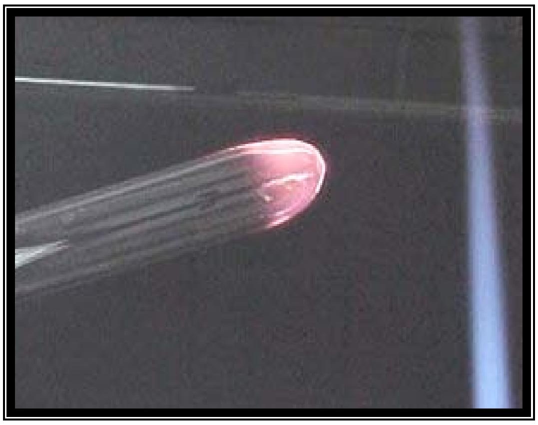


Plate 4. 32b. Tubing at its’ working Temperature

At this point remove the tubing from the flame and draw to its pulling point. Reintroduce the tubing into the flame and seal off one end of the tubing at the pulling point. While still rotating the tubing simultaneously, submerge the entire area of the tubing you wish to blow onto a blub into the hot flame and rotate the tubing homogeneously on till it reaches its working temperature (Refer to plate: 4. 32b).

Bring the tubing out of the flame but do not cease to rotate the tubing. cautiously but steadily put the other end of the tubing in your mouth and whiles still rotating the tubing in your mouth with your finger, blow air into the tubing. If the rotating of the tubing was synchronized well, the resultant blub would be perfectly round. If not the blub would protrude at one side (Refer to plate: 4. 33a, b and c).

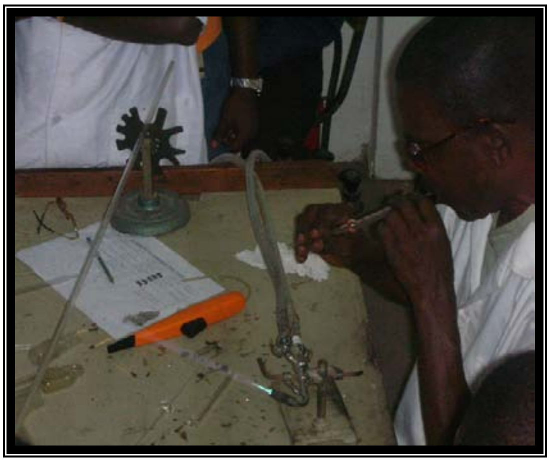


Plate 4. 33a A demonstration of blowing **Plate 4. 33b. A perfectly blown glass**

Plate 4. 33c. A protruding glass bulb resulting from poor rotation and excess pressure

Butt Seals

Butt sealing is the process of joining two or more glass sections together. This is only successfully done when the two glasses are composed of the same constituents or are the same glass type. Borosilicate glass for example cannot be joined to soda lime glass and vices versa. For the seal to be perfectly done it requires the mastering of the skill of rotating tubing/rods.

The following is the procedure for sealing glass tubing; preheat or fire polishing the two ends of the tubing to be sealed with a burner. Seal one end of the tubing with a cork or asbestos cloth. Adjust flame size to match with the diameter of the tubing in question. Rotate both tubing in the flame simultaneously. When both ends of the tubes are red hot bring them out side of the flame, and cease rotating for a while.

Being guided by the eyes push the ends of the tubes together; whiles ensuring that they fit very well to each other. Reintroduce the butted ends into the flame. This time adjusting the flame to a smaller size directed precisely on the seal and rotates the tube on the sealed axes. The sealed joint may be a little thicker than the actually wall thickness of the glass. This defect is corrected by drawing the tube apart a little immediately after butting them together or by blowing air into it to expand the tubing (Refer to plate 4. 34).

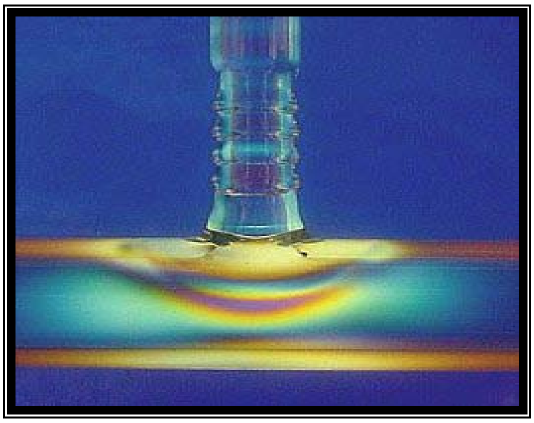


Plate 29. Butting seal or joining to pieces of glass together.

Fire polishing

Fire polishing the ends of glass tubing and rods aids in smoothing cracks which may be hidden from the naked eyes on the surface of tubing's or in the end wall, reducing the chance of fractures originating from this source. Fire polishing ends will also reduce cuts and abrasions to the blower or anything (corks, latex tubing, etc.) that may come in contact with the glass (Refer to plate: 4.35).

Plate 4. 35. Fire Polishing glass tube

Annealing

Whenever glass has been altered or shaped by exposure to a hot flame, stresses have definitely been introduced into the tubing. The glassware you make can have some of the stresses reduced by hand annealing. Stresses are not visible to the naked eye, so you have to use a little imagination in performing this step. If you have access to a polariscope, check out your seals before and after annealing. Unfortunately none of the units visited had asses to this equipment. The more complicated the seal is, the more likely to have stresses harmful to the final product and you.

Use a soft, bushy annealing flame to "brush" away the stress areas located in and around the area of your fire polish and other seals you will learn to make. Think of your flame as an artist’s paint brush. The strain (paint) needs to blend into the surrounding glass smoothly, with no jagged edges. The above listed steps forms the fundamental technique involved in the creation of any glass blowing piece.

Test of Hypothesis

It was hypothesised that the neglect of the development of the art of Glass Blowing and the steady decline in the activities of Glass Blowing Units in the country can be attributed to the lack of awareness of the prospects of glass blowing in the country. This hypothesis was tested using descriptive statistics.

Question ‘18’ of the questionnaire, asked whether the activities of glass blowing units in the country was on the decline? The options provided were, ‘Yes, No and No idea’. The following constitute the findings generated from the gathered data. Out of the total respondents of 153, constituting 100%; 68.1% said yes it was on the decline, 25.3% said no and 6.6 responded no idea (Refer to table: 4.2.below). It is obvious from the data generated that close to about 70% of respondent think that the activities of glass blowing units are on the decline. This finding indeed buttressed the SWOT analysis findings, which revealed that the productivity levels of the units were low and also, three of the hitherto operational glass blowing units had already folded up.

Table 4.2
The Decline State of Glassblowing Units

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	104	68.1	68.1	68.1
	No	39	25.3	25.3	93.4
	no idea	10	6.6	6.6	100.0
	Total	153	100.0	100.0	

The researcher sought to ascertain whether the neglect in the development of the art of glass blowing and the affirmed steady decline in the activities of glass blowing units in the country could be attributed solely to the lack of awareness of the prospects of glass blowing units in the country; these are the findings:

out of the total sample of 100%, 28.6% attributed the decline to lack of technical know-how, 46.2 also attributed the decline to lack of awareness on the prospects of glass blowing in the country. Again, 16.5% said the decline is the upshot of inadequate infrastructure, tools, and equipments, 2.2% also said the situation is so, because of narrow or non-existent market for glass ware, while still, 2.2% also attributed the decline to other factors such as the collapse of Aboso glass factory among others (Refer to table: 4.3).

Looking at the figures closely it can be said that, the decline in the activities of glass blowing units in the country is significantly influenced by the lack of awareness on the prospects of glass blowing in the country. However, this falls short of say that, the decline can be solely attributed to the lack of awareness on the prospects of glass blowing in the country. Since such a claim will not be backed by any statistically data and obviously not this data collected. The cause of decline is multifaceted and calls for a restating of the hypothesis.

Table 4.3

Cause of Decline

Questionnaire		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Lack of technical know-how	44	28.6	29.9	29.9
	Lack of awareness on the prospects of glassblowing in Ghana	71	46.2	48.3	78.2
	Inadequate infrastructure, tools, equipment and machinery	25	16.5	17.2	95.4

	Table 4.3 continue				
	Narrow or non-existent market for glass ware	3	2.2	2.3	97.7
	Others	3	2.2	2.3	100.0
	Total	146	95.6	100.0	
Missing	System	7	4.4		
Total		153	100.0		

Restated Hypothesis

The neglect of the development of the art of glass blowing and the steady decline in the activities of glass blowing units in the county warrants a thorough evaluation and recommendations made for improvement and expansion.

Summary

The development of the art of glass blowing in Ghana: prospects and challenges of selected glassblowing units is a more suitable title for this research work. The title itself contributes to knowledge for it is original and the first to be researched into by a candidate. Again, the researcher succeeded in gathering extensive data on the prospects of glassblowing units in the country such as abundant raw materials for glass production, proximity to potential market, glass recycle, glass art among others. Some of the challenges identified include; lack of awareness about the prospects of glass blowing in the country, aging personnel, high cost of training personnel, unfavourable institutional administrative impart etc.

The researcher conducted a thorough evaluation of the glass blowing units using the SWOT analysis, thereby highlighting the strengths, weaknesses, opportunities and threats facing the units.

The research also revealed that the challenges bedevilling the glassblowing units are multifaceted and needs to the tackled holistically and makes recommendations for improvement and expansion to save the units from going into extinction.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The qualitative research method was employed to carry out this research work. The researcher adopted the multiple case study approach to evaluate the operations of Glassblowing Units-Chemistry Department (KNUST), Glassblowing Unit-Chemistry Department (U.C.C) and Glassblowing Unit-Industrial Research Division (C.S.I.R.). The population consisted of glassblowers, administrators, junior staff, students and clients of the glassblowing units. The target population was 175. The accessible population was 153. The purposive sampling method was used to sample 153 respondents which constituted 87.4% of the targeted population. Questionnaire, interview schedule and observation guide were the main instruments used.

The research revealed some of the strengths of the units as having professionally glassblowers with years of hands-on training regardless of the numerous challenges. The country's glassblowers exhibit a high level of craftsmanship in the practise of the art of blowing and show a high level of understanding of the tools and materials used. Their products and services are also of high quality and comparable to any of its kind in the sub region

The glassblowers in the units however, appear to lack initiative and ingenuity in that, over the years they seem stuck to the production and repair of laboratory glass ware, even though they have some of the requisite tools, equipment and training to diversify the existing market. There seems to be no real urgency to take advantage of the current craze for glass products, be it souvenirs, decorative pieces, plaques, structural glass products, etc. The units are also faced with the challenge of aging personnel, lack of awareness of the prospects of the industry in Ghana among the citizenry and central government, etc.

Despite these challenges, the future is ever hopeful and bright as noonday; the units still enjoy total monopoly of the glass industry as far as repairs and constructions of new glass apparatus are concerned locally. There are a number of agencies both state owned or private institutions that they could fall on for assistance to improve upon their services and expand. Also, there is vast variety of economic deposits of raw materials awaiting exploration.

Conclusion

This research work provides in-depth and in-breadth knowledge on the operations of glass blowing units in Ghana. It reveals that there are as at the time of compiling this research work, three operational glass blowing units in the country with one glass blowing workshop on University of Ghana, (Legon) campus. This number is woefully inadequate, considering the size of the population. The causative factors that necessitated the establishment of glass blowing units nationwide still exist and are as relevant today as it was in times past. However, the glass blowing units in the country still possess the potential to sharpen skills development.

The tools, materials and equipment used by the glassblowing units are of standardised quality however, the purchase of annealing oven and calibration machines would be an added advantage.

The research further reveals that, this vision will forever remain a mirage if the gains of the units such as competent personnel with years of hands-on training, quality products and services, appropriate infrastructure, good administrative structure, good and reliable customer care service, etc are derailed.

In the same vein, drawbacks like low publicity, low patronage of the products and services of glass blowing units, inadequate financing of glass blowing units, low commitment of management to glass blowing units, high cost of training personnel, etc, must be curtailed. If these drawbacks are not addressed they could lead to the units being totally extinct in the country.

However, it identifies agencies like Ghana Education Trust Fund (GETFUND), Teaching and Learning Innovation Fund (TALIF), Inter-university Office in UK, Science Resource Centres (SHS), Ghana Investment and Promotions Council (GIPC), Aid to Artisans, etc that the units could collaborate with for assistance. Additionally, it also throws more light on the total leverage of monopoly enjoyed by the units in the West African Sub-region, vast stretch of untapped raw materials awaiting exploration and exploitation, the proximity to a potential market and the unexploited area of glass aesthetics that the units could capitalise on to gain comparative advantage.

Finally, it narrows down on four internal and external threats that could militate against the improvement and expansion of glass blowing operation in the country. These were identified as aging personnel, high cost of training personnel in overseas, unfavourable institutional administrative impart and lack of awareness about the prospects of glass blowing in the country. A pragmatic and holistic approach to addressing these bottlenecks would see the glass blowing units contributing their quota to national development.

Recommendations

Based on the evaluation and observations made through this research work on the activities of glass blowing units, the following recommendations should be considered:

1. The management in particular should take a second look at the rationale and objectives for setting up these units and refocus as well as expand their operations to be more customer-oriented and embrace glass art to make the units more productive and self sustaining.
2. Training in glass art should be an integral component in the curriculum of glassblowing units to make the profession more attractive and in the process diversify the current market. Special emphasis should be laid on glass etching, stained glass; glass casting and fusing.
3. Generally, the units should enhance the aesthetic qualities of locally produced glass wares by introducing colour and modifying their basic shapes to make them more aesthetically attractive.
4. Glass blowing should be included in the curriculum of ceramic and chemistry departments at the tertiary level to increase the market value of students and promote the development of employable skills in the glass industry.
5. The public institutions especially KNUST, should invest in staff development through higher education by assisting glassblowers to upgrade their skill to qualify to lecture in the Universities and Polytechnics and by so doing making the art more attractive to prospective students.
6. As a matter of priority interested students in glass blowing should be given incentive packages to understudy the current glassblowers since in less than five years, almost all of the current blowers would be on pension.

7. All effort should be made to secure calibration machines and other necessary equipment for the smooth operations of the local glass industry. This would facilitate the making of calibrated glass apparatus like, test tubes, burettes etc, locally thereby increasing the competiveness of the local products to imported glass ware.
8. Publicity on the operations of glassblowing units should be stepped-up in both the print and electronic media. In addition the units should also embark on road shows to broaden their market and attract the needed investment. The units should take advantage of fairs and exhibitions organised both locally and internationally to showcase the products and net-work with prospective customers and investors.
9. Given the essential resources of the units, it should spearhead research work in glass technology in the country and gather data for prospective investors.
10. Glassblowing units should draft proposal to stakeholders like TALIF and GETFUND to seek sponsorships to fund some of their projects and activities.
11. As the raw materials for glassblowing abound in Ghana, stringent effort should be put in the exploration and exploitation of these portentous raw materials to reduce importation of foreign raw materials to feed the glass blowing units and other promising up and coming glass establishments in the country.
12. The government and other developing partners of the nation should assist the units' to set-up smelting units. This would aid the remoulding of damage glass wares currently gathering dust in the respective store room of Universities. It would save the country foreign exchange and create jobs.

13. If due diligence is paid to the glass blowing units, they still have what it takes to raise the quality of tertiary level teaching and learning activities through availability of equipment for aesthetic and scientific research. Sharpening the relevance and skills content for the University and polytechnic education in the area of research development in glass technology and through the combined effect of these will enhance the man power needs of the country for industrial take-off.

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APENDIX ‘A’

Evidence of Glassmaking In Ancient Egypt Found

By Guy Gugliotta
Washington Post Staff Writer
Friday, June 17, 2005; Page A03

Scientists said yesterday that they have unearthed the first conclusive evidence of a glass factory in ancient Egypt, offering new insights into production techniques for a commodity so highly prized that nobles used it interchangeably with gemstones.

Analyzing glass and clay fragments at Qantir-Piramesses in the eastern Nile Delta, researchers described a two-step process in which factories melted crushed quartz to form "semifinished" glass, then re-melted and colored it to make glass "ingots" for shipment to artisans elsewhere. They melted the glass again and shaped it into inlays, ornaments and other objects.

"For years, there was no direct evidence of the production of glass," said archaeologist Thilo Rehren of University College London. "Somebody was making it, but the only thing we had were museums full of glass objects."

Rehren, reporting in this week's edition of the journal Science, said he first visited Qantir 12 years ago to examine artifacts at the ruins of an ancient industrial complex dated 1250 B.C.

"There were lots of bronze castings, but among all the debris we found a number of things that didn't fit," Rehren said in a telephone interview. "It took me a year or two to figure out that the unusual finds were related to glass."

But it was not until additional excavations at Qantir in 2003 that researchers were able to say that Egypt had a thriving glassmaking industry of its own instead of simply importing glass from Mesopotamia. The Qantir artifacts have allowed archaeologists for the first time to show in detail how glass was made in the ancient world.

"We have thought that people were actually making glass in earlier excavations, but it has been very hard to interpret some of the evidence," said Egyptologist Christine Lilyquist of New York's Metropolitan Museum of Art. "Qantir is a very important excavation."

Common glass is made mostly of silicon dioxide -- the same compound as quartz or sand -- that has been melted and cooled rapidly so the molecules remain amorphous instead of forming a crystal lattice. Other compounds give glass its color or other properties.

Lilyquist said the first true glass appeared in Mesopotamia between 1600 B.C. and 1550 B.C. Ancient Egyptian texts describe how a pharaoh brought home skilled glassworkers, along with buckets of glass ingots, after a Mesopotamian expedition in 1500 B.C.

"The mainstream opinion was that the Egyptians were importing it from Mesopotamia," Rehren said. "In Egypt, we had only evidence that they were making it into artistic objects."

Glass was highly prized, not because it was inherently expensive but because "not that many people knew how to do it," Lilyquist said. Artisans used it as a gemstone equivalent in gold jewelry and in making small bottles, beads and sculptures.

It is unclear when glass production began in Egypt. At Amarna, archaeologists have found finished glass and intact furnaces from the time of the pharaoh Akhenaten, about 1350 B.C., but there is debate about whether the furnaces were for glass production or glassworking.

"We have wires of glass that are used for making objects, and it's true that glassworking doesn't necessarily mean glassmaking," said Cardiff University archaeologist Paul T. Nicholson, a glass expert who works at Amarna. "But I think we actually do have the factory."

Qantir, the ancient capital of the pharaoh Ramses II about 60 miles northeast of Cairo, has no intact furnaces or kilns but is littered with about 1,100 fragments of ceramic vessels marked by heat and frequently encrusted with bits of glass.

Rehren outlined a two-phase process that began by loading crushed quartz powder into half-gallon ceramic beer jars and heating it to about 1,650 degrees Fahrenheit. The quartz was mixed with an equal amount of ash from desert plants rich in sodium carbonate, which lowers the melting temperature of quartz.

Rehren said the artisans then crushed the semifinished glass into a powder and leached it with water to remove salt and other impurities. Then they put it into a flowerpot-shaped crucible and heated it to 2,000 degrees Fahrenheit, probably with the aid of a bellows.

"On the second melting, the gas bubbles disappear and you can get the colors," Rehren said. Qantir appears to have specialized in red glass, made by adding coper oxide during the second melting in carefully controlled amounts and conditions. Once cooled, the ceramic was broken and chiped off, and the ingots were sent away.