DESIGN AND FABRICATION OF EMBOSSING DIES AND PUNCHES FOR MAKING

THREE DIMENSIONAL JEWELLERY ELEMENTS

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DECLARATION

I hereby declare that this submission is my own work towards the MFA and that to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the university, except where due acknowledgement has been made in text.

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HEAD OF DEPARTMENT

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ABSTRACT

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Many jewellery workshops in Ghana rely on traditional hand fabrication techniques including cuttlefish bone casting for making silver and gold jewellery. Jewellery items produced by these outfits are generally heavy and the methods of production are time consuming which tend to command rather high cost and therefore, high prices. Gold and silversmiths therefore need tools which could be used to produce thin walled jewellery at faster rate without compromising on their visual qualities.

In this regard, this research intends to use locally accessible materials, develop studio techniques which could be used by gold and silversmiths to convert their designs into embossing dies and punches suitable for mass production of light weight, three dimensional design elements for assemblage into jewellery pieces.

The study combined studio based research and descriptive research methods under the qualitative research. The target population for this study has been practising goldsmiths and silversmiths in the Ashanti region of Ghana. The accessible population for the study was made up of selected goldsmiths and silversmiths shops in and around Ashanti New Town and

Oforikrom. Purposive sampling was used in this study. The practical aspects of the study were carried out at the Metal Section of the Industrial Art Department, KNUST, Kumasi.

The research revealed that there are many designs and images that reflect Ghanaian culture which could be transformed into dies and punches to produce three dimensional jewellery elements. Therefore, Gold and silversmiths should use studio practice to fabricate basic tools such as dies and punches to increase the spectrum of jewellery designs produced.

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CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

A preliminary investigation conducted by the researcher indicated that gold and silversmiths in Ghana are accustomed to the traditional techniques of jewellery production such as lost wax casting, cuttlefish bone casting, piercing and forging. These techniques are sometimes time consuming and the weight of works which come out of them are difficult to control, especially in situations where many pieces of the same weight and sizes are desired. Admittedly, each traditional technique used by goldsmiths and silversmiths has its own direct influence on the character of the jewellery pieces which come out of it. For instance, the aesthetic qualities of a pierced work are different from that of lost wax casting. While cast works are heavy and look three dimensional, pierced works are flat and look two dimensional unless they are sometimes filed or slightly domed to give them the three dimensional effect which makes it difficult to standardise their weights. However, with the current high cost of materials especially precious metals coupled with the presence of machine mass produced fake imported jewellery into the Ghanaian market, there is the need for producers of jewellery to adapt innovative ways to enhance the patronage of their works if they want to be competitive in the business.

To stay competitive in the jewellery business, a jeweller should consider the method he or she employs. This is paramount because in the jewellery industry, the technique which is used to produce articles has a direct bearing on the cost of the finished product. The reason

is that the final cost of every finished art work such as precious metal jewellery, is determined by the cost of materials used and the production cost. The cost of materials such as gold, silver, and copper is determined by external forces (world market prices) which a jeweller has no control over. However, the jeweller has control over a technique of production which can be fast, efficient and can help control the weight of the material and achieve quality of works as well. In doing this a jeweller can bring the cost of his/her finished products down to an appreciable level to meet the demand of the masses and the pockets of prospective jewellery buyers. Some of these techniques which are considered as techniques of the industrial world are casting, electroforming, stamping and photographic processes.

Embossing which falls under stamping is what this study explores as the technique which can be employed by goldsmiths and silversmiths in the studio context to reduce production cost and thereby reduce the total end cost of their finished jewellery. According to Bawa (2004), due to the advantages of metal stamping, embossing is extensively used in the automobile, aeronautical and electrical engineering industries. Industrial products embossing include automobile bodies, shells, construction grinders, car and truck frames, furniture legs, beer cans and wheel rims.

Embossing is an act of stamping which is done by forming out an image in cameo or intaglio on metal sheet with the aid of dies and punches. This study adapts the industrial embossing technique in a studio context. It explores available materials and existing studio techniques as a means of creating dies and punches for local goldsmiths and silversmiths. This has been carried out through the use of innovative expression of concepts from

imagination, cultural background and local environment as the basis for the development and creation of the dies and punches. It has been necessary to expose the concept of dies and punches creation to the Ghanaian local goldsmiths and silversmiths with the understanding that their usage has the ability to reduce time needed in mass production of jewellery and their accompanying labour cost.

1.1 Statement of the Problem

Jewellery materials especially precious metals such as gold, platinum and silver are sold mainly by the weight; therefore if the precious metal weight of jewellery is high, the overall cost is also high. For this reason, many people are unable to afford precious metal jewellery because of very high market prices. However, the cost and for that matter the final unit price of jewellery, can be lowered by reducing the weight. This can be achieved by employing cost effective tooling technique in the production process such as the usage of dies and punches. This is significant because in the jewellery industry, the technique which is used to produce articles has a direct bearing on the cost of the finished product.

However, many jewellery workshops in Ghana rely on traditional hand fabrication techniques including piercing and cuttlefish bone casting for making silver and gold jewellery. Jewellery items produced by these outfits are generally heavy or flat and the methods of production are not mass production friendly. Reduction of the unit weight of precious metal jewellery through the use of dies and punches should result in the decrease of the unit price of jewellery. One way of reducing the unit weight is by making the

jewellery pieces thin walled and hollow while also ensuring good strength and high quality design.

In spite of the numerous benefits that can be derived from the use of dies and punches in jewellery production, a survey carried out by the researcher has revealed that currently gold and silversmiths and majority of contemporary Ghanaian jewellery producers are not employing this forming method because they do not have any knowledge about them. In this regard, there is need for research to explore locally accessible materials including tools and equipment, to develop methods at the studio level and produce samples of dies and punches to serve as a blue print to be used by Ghanaian gold and silversmiths. This is to enable them convert their designs into embossing dies and punches suitable for mass production of light weight, three dimensional design elements suitable for assembling into jewellery pieces.

1.2 Objectives of the Research

The objectives of this study are as follows:

1. To identify and document suitable methods and locally available materials /tools for the production of dies and punches that could be used by Ghanaian gold/silversmiths.
2. To design and fabricate embossing dies and punches suitable for mass production of quality light weight three dimensional design elements in Ghana.

3. To assemble some of the embossed design elements into jewellery pieces.

1.3 Research Questions

The following are the research questions used in the study:

1. Do Ghanaian gold/silversmiths in Kumasi use dies and punches for the production of jewellery?
2. How can dies and punches be made in the studio setting using locally available materials?
3. Can jewellery elements be assembled into jewellery pieces?

1.4 Significance of the Research

This study would be beneficial to Ghanaian gold/silversmiths, jewellery studio artists and learners of jewellery and metal smithing alike. Owing to the fact that the usage of dies and punches in jewellery production process can be used to reproduce the same design within a considerable period of time, adaptability of this industrial process in studio practice by goldsmiths and silversmiths in Ghana would ensure quality and light weight per unit jewellery pieces. The use of dies and punches would facilitate the production of lower unit weight jewellery pieces in studio environment which will eventually make the pieces less expensive or more affordable. This would attract jewellery buyers and eventually enhance the economic strength of goldsmiths and silversmiths in Ghana.

This embossing method with dies and punches would improve a studio based artist's ability to use little material (precious metals) to produce a considerable number of jewellery. This

could be used as an alternative method to casting and forging methods to reduce material content of jewellery pieces. Such a method would enable goldsmiths and silversmiths in Ghana to use reasonable quantity of precious metal for mass production and thereby reduce prices of their products.

The dies and punches could be used as teaching and learning aids for embossing techniques for jewellery elements during teaching sessions at the Metal Product section.

These would in totality encourage a jewellery based studio artist to develop alternative methods which can aid faster production in jewellery making.

1.5 Delimitation

This research is only limited to the development of studio techniques which could be used by Ghanaian gold and silversmiths to convert their designs or ideas into embossing dies and punches suitable for mass production of light weight, three dimensional design elements suitable for assembling into jewellery pieces.

1.6 Limitations

Ideally, jewellery pieces should have been produced from all the dies and punches but because of cost and time involved, sampled ones were used for the jewellery pieces. Another challenge had to do with the imperfect registration of some intricate images after casting especially with regards to organic shapes.

1.7 Definition of Terms

The following are the terms used in this study:

1. Shims: Thin sheets of metal usually lead which are put on metal sheet to assist in making images clear and sharp during stamping.
2. Die sinker: An artist who forms or shapes a depressed intaglio relief in a die block to be used for reproduction of cameo relief on metal sheet.
3. Boss: Raised images or effect created on metal sheet from dies or punch.
4. Fin: Thin projections which form around the embossed image.
5. Anvil die: Lower part of a two part stamping die which contains the design in low relief (female die).
6. Trussel: Upper part of a two part stamping die which contains the design in high relief (punch or male die).
7. Findings: Small jewellery elements which are used to link two or more sections of jewellery.
8. Piercing: It is a process of sawing metal using jeweller's saw and blade.
9. Fake jewellery: They are machine made imitated gold and silver costume jewellery usually imported and sold in Ghana.

10. Embossing is an act of stamping which is done by forming out an image in cameo or intaglio on metal sheet with the aid of dies and punches.

1.8 Abbreviations

The abbreviations used in this study are:

1. APA: American Psychology Association

2. CD: Compact Disc

3. DC: Design Concept

4. Fig. : Figures

5. KNUST: Kwame Nkrumah University of Science and Technology

6. POP: Plaster of Paris

7. Cm: Centimetres

8. Mm: Millimetres

1.9 Arrangement of the Rest of the Texts

Chapter two reviews literature related to the study; chapter three outlines and discusses the research methodology. Chapter four deals with the presentation and discussion of the findings from the study. Chapter five looks at the fabrication of the dies/ punches and the making of jewellery pieces from the embossed elements. Chapter six contains the test and

result of the dies and punches. The seventh chapter covers the main findings, summary, conclusion and recommendations.

CHAPTER TWO REVIEW OF SELECTED RELATED LITERATURE

2.0 Overview

To understand clearly the problem on hand, certain factors have been reviewed. These factors are:

i. Concept of design, ii. Concept of embossing

iii. Concept of Dies iv. Materials used for

die/punch manufacturing

v. Types of dies vi. Methods of

die/punch production vi. Usefulness

of Dies and Punches

2.1 Concept of Design

Design plays a key role in innovation in all fields of artistic study. In jewellery, design is not much different from other plastic arts such as sculpture and ceramics because in all fields of arts, planning precedes execution of the medium.

Amenuke et al (1991) consider design as a process or the result of a process. This means that design can be understood in two ways: (1) as a process and (2) as an end product. When a designer plans his work, he puts together certain qualities such as dot, line, shape and colour and it is the relationship of these qualities that the viewer sees. These qualities which according to Amenuke et al are sometimes called elements of design are the basic parts or qualities of any design.

Untracht (1985) also shares the same view with Amenuke et al on design states that design in reference to jewellery can be described as an intellectual or intuitive concept (both possibly acting simultaneously) in which purposeful planning or mental imagery governs

the manner in which materials are used and arranged into a relationship of shapes, forms, and surface treatments to create an integrated object.

According to Untracht, the form of material itself can suggest process because each form of metal embodies a natural range of possible treatments that inspires design. However, he admits that superimposing upon the basic concept a material's initial form and character related to process, are those considerations of composition and organisation termed formal design elements, possibly better called design components since by their use, an object is composed. Untracht adds that no matter how limited they may be used, or isolated for purposes of discussion, when creating a design, these elements and the above – mentioned considerations are dynamically interrelated in a highly flexible manner, in reality, one aspect can hardly be mentioned without involving another.

Untrcaht again explains that designing and creating a jewel is a reciprocal procedure of synthesizing the intangible into reality. This is accomplished essentially through a sequence of judgments, decision making and problem solving, all of which occur when fabricating materials into forms.

For him unless the design concept is the kind that can be conceived with mathematical precision in drawing and followed, without alteration, as graphically depicted, the designing process may not end there. When designing in jewellery, besides design components and the shape of the material that should highly be considered, other critical factor which need to be given ultimate attention is how the design will harmonize with the human body. This is based on the form a jewellery design takes and functional considerations of a design.

From the above submission, it can be deduced that in jewellery design, until final dimensions have been given to parts of a design and strictly followed, new ideas could be added in the course of fabricating the materials into jewellery forms.

Untracht(1985) opines that the size of a jewel that a person may choose to wear bears a direct relationship to the motives that the person may have for wearing the jewel. He agrees that in cases where large bulk is desired, weight can be reduced and bulk increased by fabricating hollow forms. He acknowledges that while weight tolerance may be an individual question involving personality difference, when using precious metals, it is also decidedly a question of economics. He re-echoes the views that the greater the weight, the higher the costs and the final price. Providing a solution to this problem, he adds that the control of weight lies, first of all, in the particular choice of materials, and thickness of parts of jewellery. He continues that of importance is the system of construction: solid, cast forms weigh considerably more than jewels fabricated from hollow low forms.

The writer agrees with views shared by the authors that design components and shapes of materials are undeniably factors which should be given necessary attention when designing in jewellery, but of equally important factors are the cost of material and how the end product will sell. This is one of the reasons why design of dies and punches to be used for fashioning out light weight jewellery is paramount in this study.

2.2 Concept of Embossing

Embossing is a method of creating raised shapes on metal surface. The raised shape created could be used either in intaglio or cameo depending on the purpose a metal artist wants to achieve with the shape. According to Muldoon (2008), metal embossing imparts lustre, radiance, intriguing dimension and texture to metal.

Rajput (2007) explains that embossing as an operation is used in making sunken figures on sheet metals with corresponding relief on the other side. The metal flow is in the direction of the applied force. The forces needed are much less than in the coining/stamping process.

Burto (1963) also states that the chief raw material required for embossing is soft sheet metal – brass, copper or aluminum between 0.005 and 0.010 inches thick. He narrates that normal sheet copper or brass must be annealed before it can be embossed and this is done by heating the metal until it glows red; then it is cooled in air or 'dunked' in water.

He continues that the actual embossing operation is extremely easy. It starts by clamping the annealed piece of sheet metal over the die and pounding it with the padded hammer. This forces the metal down into the die openings and reproduces the pattern in the die. According to Muldoon (2008), metal embossing is an art form that has been around for centuries. A variety of easy-to-use tools are used to push flat metal sheet from the back to create designs.

Untracht (1985) discusses embossing as an act of stamping to force out a shape in cameo or intaglio. This process, according to him is done with the aid of a stamping punch or die. When the resulting form is positive or in high relief, it is termed cameo (from the Italian cammeo "a gem carved in relief"). When the form is negative or concave, it is termed

intaglio (from the Italian intaglire, “to engrave, cut, or carve a design into a substance below its original surface”). In the case of sheet metal, these forms can be used with the positive or negative side uppermost. The shape formed can be relatively small- as when it is made with small, hand embossing punch-and the resulting boss is usually one of several such elements placed in an arrangement on still intact sheet.

The researcher agrees with the author on the above assertion that embossed shape can be used as a unit and this means that it can be added to other elements to make whole jewellery or an embossed shape could stand on its own as complete jewellery.

On the above distinction drawn between coining and embossing, it is apparent that the end product of the latter gives form to a blank whiles the former gives shape. Embossing on metal is achieved by exerting force and the forms created can be used with the positive or negative side up.

2.3 Concept of Dies

McCreight (1991) defines dies as rigid and reusable forms that give shape to work piece. He adds that they can be made in a range of materials and can have a lifespan from only a few to thousands of pieces. He continues that dies can be categorized by the amount of detail they impart and their strength. With the latter, he adds that it is important not only because it determines the lifespan of the die, but also controls the difficulty in making the

die in the first place. It is easier to cut a die of wood than of steel, but of course the steel tool will last longer.

A die means any structure which can give shape to a material such as metal or wood. A shape, according to Mittler and Ragans (1992), is an area clearly set off by visual elements of art. A shape may have an outline or boundary around it. Some shapes show up because of colour and others are set off purely by the space that surrounds them. There are two groups of shapes: geometric shapes and organic shapes. Geometric ones are those with precise shapes that look as if they were made with drawing instruments. Organic shapes are irregular or uneven and their outlines curve to make free form shapes and are often found in nature. The five basic geometric shapes are square, circle, triangle, rectangle and oval.

Distinguishing between shapes and forms, Mittler and Ragans (1992) explain that shapes are like forms but whereas shapes are two dimensional thus having length and width, forms are three dimensional and therefore have length, width and depth. They add that forms too are classified into either geometric forms or organic forms.

Though McCreight explains that dies could be made to generate shapes, dies could also be made to produce forms which would have length, width and depth and can be used as jewellery pieces.

Burto (1963) explains that at least half of the work in embossing the sheet of metal is fabricating the dies. Since die is simply a metal matrix which is harder than the sheet metal being embossed, the home craftsman has available, an almost limitless variety of ready-

made-dies-in the form of perforated or expended metal, hardware cloth, even ordinary wire screening.

Rajput (2007) states that the die set consists of a die and a punch with the desired contours, so that when the punch and the die meet, the clearance between them is the same as that of the sheet's thickness.

Codina (2007) explaining how steel dies and punches are developed and used at the industrial level, states that making a steel punch and die is the most common method used in the industry, since it offers greater durability and precision. Just the same, it is the most costly procedure requiring quite a large punch press and thus it requires expensive production to pay for itself. He continues that a preliminary evaluation of the production goals and cost is recommended before utilizing this method. He adds that a properly tempered steel punch has unmatched durability, though, and the quality of the embossed pieces produced is comparable to the original designs. He again narrates that a die could be created, from a block of steel appropriate to the type of relief the punch is intended to produce. He continues that once this steel is annealed and rendered ductile; it can be shaped with milling cutters, files and graves. It has to be as smooth and polished as possible – as if it were a piece of jewellery – so that metal piece stamped in the mould is easily released. Next, the soft steel is tempered; this is a process that has to be done in specialized shops, since it is more involved than merely tempering a chisel.

Codina (2007) again explains tempering as a heat treatment that gives steel adequate hardness and flexibility for hammering the punch into another piece of steel that actually

serves as the die. He continues that to do this, the punch is heated to about 900^{0c} and quenched in water or oil; since it's now excessively hard and subject to breakage, it has to be tempered. This involves heating it to a lower temperature for a certain amount of time to achieve the right balance between hardness and flexibility so as to enhance toughness. Once the punch is tempered, it is struck into another piece of steel, which serves as the die: it must be polished as required and tempered properly. The stamped die is used to fabricate the pieces.

Codina (2007) also explains that the steel punch is used only to make the original model; it has to be stored carefully for if the die is damaged in stamping, the punch will have to be struck into the die again. This implies that a well developed punch could be used to create dies for onward fabrication of metal pieces.

The submissions above from the authors show that dies and punches get longer lifespan from materials they are made from. Those made for industrial purposes are usually made using steel.

2.4 Materials Used for Dies and Punches

Different materials can be used to produce dies or punches to achieve a particular purpose. Davis (1995) discusses that materials for dies and punches fabrication range from plastics for low-quantity production of simple to moderate parts to the most wear- resistant (nitride) tool steels for making severely formed parts. Parts of even greater severity or those running in quantities larger than one million may require dies or inserts of cemented carbide.

Miller and Miller (2004) state that a good grade of tool steel is used for making punches and dies. The steel should be free of harmful impurities. Sometimes, the body of the die can be made of cast iron with inserted steel bushings to reduce the cost of material. They continue that the advantage of this type of construction is that an insert can be replaced when it becomes worn out. Soft steel that has been case hardened does not change its form as readily as tool steel, and any mint changes in form can be corrected readily because the interior is soft. Internal strains or stresses are set up in steel during the manufacturing process. In die making operations, these stresses must be relieved before the die is brought to its final size, else they will cause distortion. The presence of stresses cannot be determined in the steel beforehand, but the die maker can relieve the stresses in the steel by annealing after the die has been roughed out.

According to Sharma (1999), hot forging dies operate under very severe service conditions since the forging process is characterized by high interface pressure coupled with high temperatures; therefore, the tool and die materials are selected and manufactured with the greatest care. The materials used for making dies must be heat resistant, possess adequate strength of low wear rate and lend themselves well for machining with cutting tools. A compromise between hardness and ductility must be struck since the dies are exposed to thermal shock. Die blocks used for the production of forging dies are manufactured from high grade special tool steels.

Youssef et al (2011) state that another attractive feature of die making is the versatility in die making procedures using castable die materials, such as glass reinforced plastics(GRP), urethane, epoxy resin, ductile cast iron, kirksite (a zinc – based casting alloy) or concrete. A simple wood or styro-foam pattern can be used to manufacture such dies. For higher pressures and longer tool life, hardened steel dies are used.

Altan (2011) explains that steels are used mainly for hot dies due to their ability to retain their hardness at elevated temperatures with sufficient strength and toughness to withstand the stresses that are imposed during forging. There have also been some successful applications of other materials such as ceramics, carbides and super alloys though their application is limited due to design and cost of manufacturing. Selection of die material grade and subsequent treatment affects the mode of failure and rate of tool failure.

What the various writers have said above reveal an array of materials which can be used to manufacture dies and punches. These materials could be grouped into metallic and nonmetallic materials. Non metallic ones include plywood or hard wood, ceramics, plastics, cement carbide, nitrides, mesonite, carbides, glass reinforced plastics, urethane, epoxy resin and styro foam and hardware cloth. The metallic materials are steel, ductile cast iron, super alloy and kirksite (zinc-based casting alloy). Other materials such as plywood or hard wood, ceramics and cement can be obtained locally but it is apparently clear that majority of these materials can only be obtained by importation which makes it expensive to acquire.

Secondly, the materials mentioned above are mostly used for manufacturing industrial dies and punches. In the initial investigation conducted by the researcher, it was revealed that all the doming blocks used by gold and silversmiths are made in brass. Brass was selected over the other materials mentioned because of the following reasons: its availability in Ghana; its physical and mechanical properties which make it conducive to the making of dies and punches at the studio level. The selection of brass in this study for the making of dies and punches also stems from the fact that the available facilities support the casting of brass more than other materials such as steel.

According to Margot et al (1998) brass is an alloy from the mixture of copper and zinc. Cobb (2012) explains that brass is noted for its beauty and corrosion resistance. Margot et al reveal again that the colour of brass varies depending upon the amount of zinc in the mixture and whether or not other metals are added. Brass with relatively large amounts of zinc is yellow in colour; the addition of aluminum makes it a high golden colour; a small percentage of manganese produces a bronze and the addition of nickel results in metal called nickel silver. This means that even though copper and zinc are the chief metals which are alloyed to obtain brass, sometimes other small quantities of other metals are added to obtain a particular result. However, it is the amount of zinc content in a brass that determines its type.

Cobb (2012) contends that there are three types of brass, according to their crystalline structures. The alpha (α) brass, with up to 30% Zn, is the most ductile. The alpha – beta brass have 30-43.5% Zn; and Beta (β) brass include those from 43.5 – 50% Zn. The

hardness and strength increases with increasing the zinc content, while the cost of alloy decreases.

Historically, Cobb (2012) explains that artefacts consisting of copper with 23% Zn have been found dating at least to 1000 BC, but brass was not in common use until approximately a thousand years later, in the time of the Romans. It is one of the strangest stories in the history of metallurgy because zinc, one of the constituents of brass, was unknown and, in fact not even identified until 1526. Roman artisans became engaged in the process that they describe as the colouring of copper. Pieces of copper, along with powdered calamine and charcoal were packed in a clay crucible with a tight – fitting lid and baked in furnace for 24 hours at temperature much too low to melt the copper. The Romans called it "aurichalcum" which is translated as 'golden copper' we call it brass. The coloured copper was melted and made into ornaments, dress armor, utensils and sesterces (Roman coins). Unknown to the Romans was the fact that calamine actually was zinc carbonate which, in the furnace, vapourized the zinc that was absorbed by the copper to form a copper zinc alloy. The calamine brass process remained the preferred method of making brass for many years after the discovery and production of metallic zinc in the 18th centuary.

Brass became popular for church ornaments and for their figures in floors inscribed to commemorate the dead. One of the principal commercial uses of brass was for brass pins used for carding in wool processing.

Margot et al (1998) enumerating some properties of brass hint that it is a hard, durable, and utilitarian metal and it makes excellent casting, can be worked hot, and extruded.

These qualities of brass given by the authors above show that it could be sourced and used for the manufacture of dies and punches. The brass used in this study was obtained from scraps of automobile parts which were made robust to withstand pressure.

2.5 Types of Dies

Dies are grouped based on different functionalities.

Schwan et al (2002) state that dies are classified broadly as single operation dies and multi-operation dies. They explain that single operation dies are further classified into the following:

1. Cutting Dies: these dies are meant to cut sheet into blanks. The operation so performed is named as blanking operation.

2. Forming Dies: these dies are used to change the shapes of work piece material by deforming action. No cutting takes place in these dies. These dies are used to change the shape and size related configuration of metal blanks. Boljanovic (2005) explains that depending on the production, quality of pieces: high, medium or low stamping dies can be classified as classes A, B and C.

Class A Dies are used for high production only. With this class of dies, the best materials are used. All easily worn items or delicate sections are carefully designed for easy replacement. In this class, a combination of long die life, constant accuracy throughout the die life, and ease of maintenance are prime considerations regardless of tool cost. Class B Dies are applicable to medium production quantities and are designed to produce designated quantity only. Die cost as related to total production becomes an important consideration. Cheaper materials may be used provided they are capable of producing the

full quantities. Less consideration is given to the problem of ease of maintenance. Class C dies represent the cheapest usable tools that can be built. They are suitable for low-volume production of part.

Untracht (1985) groups dies as (1) stamping dies, (2) a two part disc-shearing die, (3) one part open intaglio die and (4)two part closed die. His grouping is as follows:

1. Stamping die is a device used to cut or shear a shape or blank of certain contour, and / or to impact a relief pattern to sheet metal. This is done by striking the die with a hammer, as in hand stamping, or by mechanical pressure.
2. A two part disc-shearing die is a more complicated die, consisting of a matrix that is used in conjunction with a shearing punch to shear away a blank from sheet metals.
3. One part open intaglio die is used for all open dies and that the metal is not restricted at its outer shape, but is permitted to flow in the direction of least resistance and freely enter the die cavity. To make a stamping of more than shallow depth from such die, place the die on an anvil and put the annealed sheet metal over the die intaglio, cover it with a shim and hammer it with convex faced hammer.
4. A two part closed die has a lower part called anvil or lower pile die and contains the design in intaglio. The upper or second hand held part is called a trussel and contains either the observed pattern in intaglio, or if a thin sheet of metal is being stamped, the same pattern in cameo matches that of the other half.

Boljanovic (2009) groups dies depending on how they are used in the following manner:

1. Blanking dies: a blanking die produces a blank by cutting the entire periphery in one simultaneous operation.
2. Cut-off-die: the basic operation of a cut – off die consists of severing strips into short lengths to produce blanks.
3. Punch die: a punching die punches holes in a work piece.
4. Compound Die: in a compound die holes are punched at the same station where the part is blanked, instead of at a previous station, as is done in a punch – and – blank die.
5. Bending die: a bending die deforms a portion of a flat blank to some angular position. The line of bend is straight along its entire length.

McCreight (1991) says that silhouette die is simply an outline shape cut from a tough material such as masonite, plywood or steel. He adds though that there are several families of dies but gives two basic types: conforming dies and non conforming dies. Conforming dies consist of two corresponding parts. They are generally held in a superstructure of some sort to guarantee that the parts line up when they are brought together. This die controls every aspect of the form and ensures exactly duplicated units time after time.

Nonconforming dies which are also called silhouette dies consist of rigid material pierced with an outline silhouette of a desired shape. The process is extremely versatile because the contour and depth of the image can be changed each time the die is used.

2.6 Methods of Die Production

Die production methods vary from stage to stage.

Sharma (1999) states that the most commonly used methods for manufacturing dies include: turning, machining or planing, milling and grinding. Turning is used for rough

finish using rotary machinery, whereas for rectangular and square die – blocks, the operations are done on a planer. Grinding is mainly used for finishing the surfaces. The impressions are cut in the die block by highly skilled men who use the milling machine, specially designed for sinking die. Cutters of various types are used in accordance with the shape of each section of the impression. But much of the accuracy of the die depends on hand work performed after it is sunk. The impressions are machined either by manual sinking after layout and/or by copy or patterns.

2.7 Jewellery

So long as human beings continue to exist, the uses of jewellery will go on unabated. Untracht (1985) explaining the motivations behind why people wear jewellery, states that it involves elemental and eternal human concerns and because jewellery is portable, intimate art that can be worn and constantly enjoyed, it is safe to assume that the use of jewellery will persist, in one form or another for as long as the human race survives.

Untracht continues that Jewellery is for men and women (and occasionally for animals), and that it must relate to the human anatomy; its scale or proportions must be concerned with dimensions.

He adds that the form a jewel takes is determined first of all by the place on the body or clothing where it will be worn, modified by thoughts connected with how it will be attached there, and whether it can be worn with relative comfort (though the latter is sometimes

scarified for other considerations). Such concerns may dictate whether the design is basically conceived of as being frontal, cylindrical, or three – dimensional.

Untracht explains further that the three forms a jewellery piece can take are:

i. Frontal conceived forms: in frontally conceived forms, the jewel is intended to be best displayed from its front side, which by implication means it has a back side. The latter is ordinarily flat, or its points of contact with the body are in a flat plane in a direction parallel to the body. The front side or the portion seen may take any dimension from flat to projections at right angles to the body plane. Included in this category are brooches, clips, pendants, medals etc.

ii. Cylindrical Forms: the total form of these concepts is cylindrical, conical, or curved in relation to similarly shaped parts of the anatomy on which they are placed. The work may not be seen as a total in actual use on the body, but initially the design is conceived as a total unit encompassing the basic form. Such forms may include frontal or even back elements. Ornaments in this class may be worn on the head, neck, arm, wrist, fingers, waist, leg, ankle, and toes. Head ornaments include crowns, tiaras, chaplets, fillets, and forehead ornament; neck ornaments include necklaces, chokers, chains, pendant on chains, etc.; arm ornaments include bracelets, bangles, watchbands, and upper arm bracelets; fingers hold rings; waist ornaments include belts and girdles; ankles support anklets; and toes hold toe rings.

iii. Dimensional jewels: these are conceived of in the round, and are worn on parts of the body or in ways that allow the form to be seen from all, or at least several, sides. Such jewels may include hanging earrings, hair ornaments, brooches, pendants suspended from

chains, any other suspended, moving, or spring mounted and therefore turns completely around.

Talking about functional considerations in jewellery concept, Untracht again states that the size, weight, and shape of jewel as well as its position on the body or costume, may determine the system used to hold it to clothing and secured it from loss. These general considerations also have to be kept in mind when creating the jewellery design.

Jewellery findings, the metal parts used to attach jewel parts to each other and to the body or clothing, are of course related to this subject area.

The weight that different people can tolerate in any single piece of jewellery varies considerably. Some persons will submit to wearing very heavy jewels and will not mind any possible discomfort, while others will insist on extreme lightness.

In this study, the elements which will result from the usage of the punches and dies will include jewellery elements which could be assembled to form jewels such as necklace or choker, bracelet, and earring.

2.8 Stamping

According to Codina (2007), in ancient times artisans realised that cast tools and arms became more durable when they were forged or beaten; these cold forging and stamping processes are very old. The minting of coins as valuable objects originated with stamping, which was also frequently used as an ornamental technique as early as the second century

B.C. He describes stamping as consisting of imprinting and shaping metal by exerting pressure with a harder and more resistant tool.

Mohammed (2011) explains that the stamping of sheet metals can be defined as the process of changing the shape of the sheet metal blank into a useful shape in the plastic deformation state, using a die and a mechanical press; stamping is considered a net shaping process. However, he adds that the stamping engineering efforts are not limited to production engineering (i.e. the stamping process) but also include the development of the required tooling (i.e. stamping engineering).

Untracht (1985) explains stamping as a process in which a tool or die is forcibly struck into sheet metal for one of three purposes; impressing, blanking or embossing. He explains impressing as the act of making a mark by pressure. He says further that in impression stamping, a pattern is made on flat sheet metal with a stamping punch that bears a linear figure at its working end in comparatively sharp, projection that leaves an impression on surface of the metal when struck with a hammer. Improvised punches can be used for the same effect.

The pattern is imparted directly to the metal surface by striking the punch with a handheld hammer while the metal rests on a supporting surface. The impression punch is called a single-blow punch because the pattern is normally made by striking the punch with a single blow of the hammer, which is the unifying concept behind this diversified group. Pattern punches can be subdivided into two groups: those for decorative purposes such as an impression punch that imprints a decorative figure, and those that impress a normally non-decorative figure on metal such as a trademark, quality mark, letter, number, or a stamp

with some other figure used for identification or other purpose. For blanking Untracht (1985) explains it as the act of stamping out a flat shape of special contour, or a three-dimensional form, called a blank, by the use of sharp-edged blanking punch, alone or in conjunction with a blanking die. The larger or more dimensional the blank is, the more likely it is that greater mechanical force must be applied to produce the blank.

Loney (2009) states that stamping is the process of imparting a design into metal using chasing tools or stamping tools. She explains that the design end of stamping tool is placed on the metal while a hammer strikes the other end of the tool.

Szumera (2003) explains that metal stamping process is actually divided into five different and distinct types and that those that are used for production at industrial level include the following: swaging or coining, bend or multiple bend forming, draw forming, deep forming and blanking or fine forming.

Swaging or coining is the reduction of the original thickness by applying a certain force to it. The method is used to produce coins, kitchen utensils such as spoons and knives. Szumera explains that bending is a type of metal forming which shapes metal in angular or radial forms. Brackets, switch boxes, stapler machine components, and appliance components are examples of items which are made with this method.

Draw forming is a process that stretches material into various shapes. The shapes are usually round, oval, or rectangular where depth of the part does not exceed its diameter. The metal starts out as a flat blank and is laid over a die opening. A force must be applied to the blank in order to restrict the flow of metal to prevent it from wrinkling. This

technique is used to produce ash trays, bottle caps and lids, ceiling fan housings and door trimming parts.

Deep draw forming is basically the same as draw forming except that the metal is drawn to a greater depth. A part can be considered deep drawn if the depth exceeds the diameter of the part. This type of metal forming is usually done in stages or reductions. Deep draw applications may also require special types of machines such as hydraulic or double – action presses. In the process annealing may also be required to stress the metal in before relief subsequent forming can be done. Typical deep drawn items include fire extinguishers, canisters, soda cans, containers and oil filters.

Blanking is usually considered the easiest type of stamping because it involves only a cutting process. Blanking operations can be accomplished using conventional dies. They can be single operation, compound, or progressive. Fine blanking is a cutting process that produces a straight edge with no evidence of metal break. This usually requires a special fine blanking press. A straight edge can be produced in a conventional die and press, employing a shearing operation. Examples of blanks are keys, washers and spacers. Fine blanks are used to produce small gears that require straight edges for engagement.

Codina (2007) also explains that stamping is commonly used in manufacturing process since most of the daily objects are made using some production process based on stamping and die stamping. He admits that contemporary stamping with complex dies has evolved tremendously and that presently the technology is associated more closely with industrial engineering than with handicrafts. He adds that with the use of older production methods

and taking advantage of the resources and products that are available and affordable in today's market, one can produce very attractive, interesting shapes and decorative features at a reasonable cost.

This is very important since it will facilitate mass production of jewellery pieces and ensure that the cost of the items can be afforded by customers.

Codina again reveals that stamping is commonly used, especially in mass production of jewellery, since this process produces a very fine thickness of metal that is also very strong and durable. Given the great number of pieces that can be made, the result is vast savings in production cost. He adds further that making a steel punch and die is the most common method used in the industry, since it offers greater durability and precision. However he was quick to add that it is the most costly procedure, requiring quite a large punch press and thus it requires extensive production to pay for itself.

Bawa (2004) gives the following as advantages of metal stamping:

(i) Weights of fabricated parts are less;

(ii) Production rate is high;

(iii) Parts that are produced are very accurate in size;

(iv) Strength of components is well controlled; and

(v) Cost of labour is low.

Considering the production usefulness of metal stamping as against its cost in terms of tooling, adapting the method in studio practice and using simple technology which can cost less but achieve the same results will go a long way in reducing the cost of producing

jewellery items. Bawa confirms that due to its advantages, metal stamping is extensively used in producing automobile, aeronautical, electrical engineering and other industrial components. He adds further that variety of products include automobile bodies, shells, construction grinders, car and truck frames, furniture legs, beer cans and wheel rims.

CHAPTER THREE

METHODOLOGY

3.0 Overview

This chapter discusses the methodology of the research. It comprises the research design, library research and population for the study. It also includes the sampling technique, data collecting tools, primary and secondary data, data collecting procedures and data analysis plan.

3.1 Research Design

In this project work, qualitative research design was employed. Strauss and Corbin as quoted by Marshal (2010) explain qualitative research as any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification. Qualitative research was used to identify practising jewellers, their understanding of the cost of precious metals such as silver, the techniques used for producing jewellery and their effects on pricing the finished products.

Borg and Gall (1989) state that qualitative research method is largely subjective and that it relies heavily on the investigative skill of observation and interpretation to provide valid information. This research method investigates the why and how of decision making. Therefore, smaller but focused samples are more often needed, rather than large samples. The researcher selected qualitative method because it provides the means whereby professionals' attitude towards the use of dies and punches can be observed and evaluated.

The descriptive and experimental methods of research have been employed in the qualitative design.

Ndagi (1997) expatiates that descriptive research is concerned with the collection of data for the purposes of describing and interpreting existing conditions, prevailing practices, beliefs, attitudes and on-going processes. Significantly, in the course of describing and interpreting the collected data, the central motive is to discover meaning. Descriptive research was therefore used to describe and interpret in detail the current techniques used in jewellery production.

The experimental method used in this sense does not mean scientific enquiry of quantitative research but rather, art studio based experiment and description. Niedderer and Roworth-Stokes, (2007) reveal that the role of practice within research in particular regarding its use is for the purpose of generating and communicating experiential knowledge. Candy (2006) also adds that practice based research is an original investigation undertaken in order to gain new knowledge partly by means of practice and the outcomes of the practice. Marshall (2010) explains that the goal during the studio based research process is to achieve synergy of words and art so that the entire arts enquiry (i.e., the praxis and exegesis) together through synthesis and evaluation is more than the sum of its parts.

In this study, the studio based research design was used to discover concepts, ideas, and themes and involved the design and production of the dies, punches, embossed jewellery elements and jewellery pieces.

Marshall states that the purpose of aesthetic-action research is to "*learn from our experience, and apply that learning to bringing about change".* Aesthetic – action research

was used to interpret, analyse and document the intuitive experience which enabled the researcher to apply some processes in creating the embossing dies and punches and how they could be used. It was also used to articulate the rich descriptions of die sets, the embossed elements and the jewellery which resulted from the die sets.

3.2 Facilities Available for the Study

In the course of carrying out this project, various libraries were visited to obtain relevant secondary data for the research. The libraries visited included:

i. Kwame Nkrumah University of Science and Technology main library;

ii. College of Art library – KNUST iii. Department of General Art and

Art Education library and iv. University of Cape Coast main library.

In addition to the libraries, the internet also served a great deal as a source for data collection. In addition, the following facilities were used in the course of embarking on this study:

i. Metal Product Studios, KNUST ii. Mechanical

Engineering Work Shop, KNUST iii. Ceramics

Studio, KNUST and iv. Kumasi Magazine

As already alluded to, visits to the various libraries and the use of the internet afforded the researcher the opportunity to collect a lot of information both from published and unpublished sources for this research.

3.3 Population for the Study

A population is the group of people or objects of which the results of the study are intended to apply. Salkind (1991) outlines that given the constraint of limited research funds that almost all scientists live with, the next best strategy is to take a portion of a larger group of participants and do the research with smaller group. In this context, the larger group is referred to as a population and the smaller group selected from a population is referred to as a sample. The target population for this study was practising jewellers or gold/silversmiths of Ghana. The area of study was the Ashanti region of Ghana. However, due to the vast nature of the region, the area of study was limited to Kumasi, the capital town of the Ashanti region, where most jewellery or goldsmiths or silversmith shops are found. Table 3.1 shows the population segmentation. The accessible population for the study was made up of selected jewellery shops in and around Ashanti New Town and Asafo.

Table 3.1: Population Segmentation

Segments in the population	Units in population

Area of study	Ashanti region
Accessible population	Selected gold/silversmiths from Ashanti New Town and Asafo, jewellery products and some selected tools.

3.4 Sampling

Frankel and Wallen (1996) explain that sample in research study refers to any group from which information is obtained. Sampling is the process of selecting these groups or individuals. Owing to the nature of the study and population, purposive sampling method was used. The researcher handpicked practitioners from different jewellery or goldsmith shops from Ashanti New Town and Asafo areas of Kumasi. Frankel and Wallen again add that purposive sampling researchers do not study whoever is available but use their judgment to select a sample they believe based on prior information which will provide the data needed.

This sampling technique was relevant to the study because of the fact that practising jewellers are those who are on the field, and are going to benefit immensely from this study. This cohort was to confirm their production cost and prices and their appreciation of the uses of punches and dies. Twelve (12) jewellery shops in Kumasi were visited.

Five (5) family owned jewellery shops were selected and the available jewellers interviewed. Seven (7) jewellery shops which were owned by individuals were also visited and owners interviewed. The works of these twelve shops were also carefully observed. Table 3.2 shows the distribution of jewellery shops visited. **Table 3.2: Sampled Jewellery Shops Visited**

Groups interviewed	Frequency
Jewellery shops owned by families	5
Jewellery shops owned by individuals	7
Total sample size	12

3.5 Data Collection Instruments Used for the Study

The data collecting instruments used in this research were interview and observation. According to Tuckman (1994) observation gives a researcher an advantage of directness. This is because it makes it possible to study behaviour as it occurs and the researcher does not have to ask people the behaviour and actions of others. Observation was used to collect data whiles the jewellers were working or had finished working.

An interview is a face to face interpersonal role situation in which an interviewer asks interviewees questions designed to elicit answers pertinent to the research. In this study, the interview method was used because the education background of the jewellers or goldsmiths was uncertain. Interview was used to collect data concerning the understanding of the current techniques used in the production of jewellery at the shops or studios as well as the practitioners' knowledge about the uses of dies and punches in this respect.

3.6 Primary and Secondary Sources of Data

Primary data were collected from practitioners of jewellery and jewellery works. Secondary data were also obtained from published books, unpublished thesis, articles and the world wide web.

3.7 Data Collection Procedure

The collection of both primary and secondary data for this research spans from about one and half years. It begun early in January 2012 when the researcher started to gather information from different sources such as published books, articles and unpublished books. Here, mention should be made of the internet which also served as an important source of information for this research.

By the mid of February 2013, final interview schedule and observational check list for the study had been printed out. Direct interviews were carried out in Asafo and Ashanti New Town in Kumasi because of the concentration of gold and silversmith shops in those areas. Both interview and observation were carried out extensively at the workshops and studios where sometimes work was in progress. This gave the researcher the opportunity to establish cordial relationship with the respondents. The respondents included practising goldsmiths and jewellers who have taught before. The interview was conducted in Twi which of course allowed free flow of ideas. Though the exercise was costly and difficult, it provided the needed results. Direct interviews were carried out at the respondent's homes, work places and offices of respondents; and they provided useful ideas and

information within the duration of thirty 30-40 minutes. Recording of the interviews were done in writing.

The researcher also made keen observation on certain objects and behaviour which were deemed useful for the study. The tools of the jewellers such as punches and dies, their methods of production and the finished jewellery products were observed. In some cases, photographs were taken with a digital camera where allowed. This was done immediately after the interview.

CHAPTER FOUR

PRESENTATION, DISCUSSION AND INTERPRETATION OF THE FINDINGS

4.0 Overview

The chapter deals with the presentation, discussion and interpretation of the findings which emanated from the data collected from field work.

The primary data collected were obtained from local goldsmiths and silversmiths using observation and interview. The study was conducted at the Asafo and Ashanti New Town in Kumasi in the Ashanti region. The presentation and discussion of the data have been done under four main headings. These are:

1. Cost of precious metals in Jewellery Production.

2. Handling of orders by goldsmiths in Kumasi.

3. Works and methods of production by gold and silversmiths in Kumasi.

4. Gold and silversmiths knowledge of dies and punches in Kumasi.

4.1 Cost of Precious Metals and Jewellery Production

The rising cost of precious metals lately is impacting on jewellery production in Ghana. All respondents interviewed agree that the current prices of precious metals such as gold (Au) and silver (Ag) negatively affect the costing of jewellery production. Ten (10) of the respondents, representing fifty percent (50%) explained that the high cost of gold and silver do make customers feel cheated when the price of finished jewellery is mentioned to them. The customers were now resorting to ordering low carat gold jewellery such as nine

(9) carat gold articles and sometimes they even ordered for brass jewellery articles as substitutes for gold wares. Figure 1 shows a goldsmiths working on brass instead of gold.

Fig. 1: A goldsmith working on brass rings

This has made it difficult for customers to patronise jewellery products and has brought about a reduction in the number of customers who visit their jewellery shops. For example, formerly, it was possible to have ten (10) customers ordering for works but now, you hardly get two (2) customers a day. The respondents explained that only few customers who were abreast with the current trends of prices of gold and silver did not complain but the rest complained that the prices of the works they ordered were expensive. They asked for reduction in prices and if they did not get it, they left and did not return. All the respondents agreed that the cost of precious metals was also affecting the profit margins of goldsmiths. Four (4) of the respondents representing (20%) believed that the type of work decided the costing and that if the weight of the work was heavy, it automatically made it cost high. Six (6) of the respondents representing (30%) argued that the difficulty to come by precious metals lately was contributing extensively to the expensive nature of jewellery made from precious metals. They added that their inability to produce and display works was due to inaccessibility and high cost of raw materials. Agya Osei Frama (personal communication,

15th March, 2012 Ashanti New Town, Kumasi) who has worked in the jewellery business for sixty five (65) years stated that "it was easy to buy silver and gold coins in the early days for making jewellery but it is not the same today". Again, in another personal conversation with Kwodwo Addo, he also added that formerly precious metals such as gold and silver could be bought from the banks but currently, there are no legal spots to purchase the materials for jewellery production.

4.2 Handling of Orders by Goldsmiths

Handling of orders from clients by goldsmiths did not vary so much. Ninety (90%) percent of the respondents interviewed were of the view that they handled both small and large orders depending on the nature of the works that a client commissioned them to do.

The works they produced were mainly done by using piercing and fabrication methods. However, they sometimes employed casting method as well. Ten percent (10%) of the respondents were of the view that they usually assessed the method which was suitable and used it to execute orders. Figures 2a and 2b show pierced jewellery works at a jeweller's shop.

(a) (b)

Fig. 2a & 2b: Pierced jewellery works

4.3 Works and Methods of Production by Gold and Silversmiths

At all the goldsmith shops visited, it was observed that almost all jewellers employed the same methods in producing their works. These methods included casting, fabrication and piercing. Due to the similar methods of production, the jewellery pieces produced tended to be similar and included assorted rings, chains, pendants, and earrings as well as bracelets and anklets.

4.4 Gold and Silversmiths knowledge of Dies and Punches in Kumasi

Out of the twelve goldsmiths shops visited, doming blocks and doming punches were observed at eight (8) shops. However, all the twenty goldsmiths interviewed revealed that they have been using metal dooming blocks and punches. Those who did not have metal doming punches and doming blocks at their shops explained that when it became necessary, they borrowed them from their friends or colleague goldsmiths and use them.

Figure 3a and 3b shows metal punches and dooming blocks found at the goldsmiths or jewellery shops. All the metal punches and dooming blocks found at these goldsmiths shops were the same in design. They were all foreign made and could be used only for stamping letters and making domes. The doming punches were fabricated using steel and the dooming blocks made of brass. The focus of this study however is the making of embossing dies and punches (die making) which is different from simple doming blocks

and metal punches as shown in figures 3a and 3b that are well known to Ghanaian gold and silversmiths especially those in Kumasi.

(a) (b)

Fig. 3a & 3b: Samples of doming blocks and metal Punches used by the goldsmiths

(a) (b) Fig. 4a & 4b: Letter Punches used by the Goldsmiths

Figure 4a and 4b show letter punches used by goldsmith in Kumasi. All the interviewees admitted that they only use doming blocks and metal punches to create “balls” and “half balls” which are used for pendants, earrings and chains. It should be added that there were stamped hollow jewellery works at some few workshops visited but the goldsmiths admitted that they were imported and used as elements for jewellery sets. Figure 5a &5b show the back and front parts of imported embossed elements

(a) back part (b) front part

Fig. 5a &5b back and front parts of imported embossed elements in silver

Table 4.1: Number of Years the Respondents have been in the Jewellery Business

Years	Frequency	Percentage
5-10	12	60%
15-20	0	0%
25-30	7	35%
35-40	0	0%
45-50	0	0%
55-60	0	0%
65-70	1	5%
Total	20	100%

Table 4.1 shows the number of respondents interviewed and the number of years they have worked as gold/silversmiths.

Their experience in the field of gold/silversmithing enabled the researcher elicit their understanding on dies and punches.

6. Table 4.2 Distribution of Responses from gold/silversmiths on the uses of Dies and Punches in Kumasi.

Items	Yes%	No%
I know about dies and punches	100%	0%
I have used dies and punches in jewellery production before	100%	0%
Dies and punches reduce cost of production and increase profit margin	100%	0%
Dies and punches can be used for making three dimensional works	90%	10%
Uses of dies and punches can help standardize weight of jewellery	90%	10%
I want to know how to fabricate my own dies and punches	100%	0%

Table 4.2 shows gold and silversmiths knowledge about dies and punches. This gave the researcher insight into how they perceived dies and punches in the production of jewellery elements.

4.5 Interpretation of the Data

The distributions on the number of years the respondents have been in the jewellery production show that majority of the practitioners have been in the jewellery business for a considerable number of years (See table 4.1). It was observed that majority of the practitioners are youthful. Sixty percent (60%) have had five to ten years (5-10) experience, thirty five percent (35%) have had twenty five to thirty years experience and five (5%) had practiced over sixty five (65) years.

If fifty percent (50%) of the goldsmiths lamented that because of the current high prices of precious metals makes customers feel cheated and because of this high patronage of jewellery made from precious metals is going down, majority of respondents agree that

high cost of precious metals inevitably affects the price of finished jewellery. This is also making customers prefer purchasing cheap "fake jewellery" which is mostly imported into the country to those locally made jewellery with precious metals. That is why one of the goldsmiths stated that "Formerly, it was possible to have ten (10) customers ordering for works a day but now you hardly get two (2) customers a day".

If thirty percent (30%) of the goldsmiths argue that it is difficult to obtain gold and silver to buy for their jewellery production, then it could be deduced that lack of specific legal places for goldsmiths to easily purchase gold and silver metals is also contributing to the high cost of jewellery production.

If twenty percent (20%) of the respondents think that the type of work and its weight affect the pricing of the works, then goldsmiths could be made to understand that a change in the method of production such as embossing can reduce the heaviness of jewellery products and still maintain the integrity of the forms. However, if casting, fabrication and piercing are the main methods used by goldsmiths for producing jewellery works, then it becomes obvious that dies and punches are not often used. They however admitted that they used punches and doming blocks for making works which involves the making of 'balls' and 'half balls' which are used for pendants, earrings and chains.

Also, it could be said that if doming block and punches used by the goldsmiths are all imported as observed, then it could be established that it demonstrated limited creative abilities of the goldsmiths as it showed they were unable to use their own ideas to create dies to emboss jewellery elements for their jewellery production. They merely rely solely

on already made ideas in the form of doming blocks and punches to create some of their jewellery.

Though ninety percent (90%) of the goldsmiths claimed they were aware of dies and punches (as shown in table 4.2) and could be used for mass jewellery production; to create three dimensional works; and could be used to standardize the weight of works in mass production, it was observed that the ones they referred to as dies and punches are actually doming blocks with their doming punches. Gold and silversmith were not familiar with dies and punches created with one's own symbols or images which could be used to emboss jewellery products with less weight and in big quantities in a short possible time. This in house ability could eventually lead to maximisation of profits with minimum materials. Hence, all the goldsmiths interviewed indicated they would be glad to learn how they could fabricate their own dies and punches for jewellery production.

The ownership of imported doming blocks and metal punches by the goldsmiths buttressed the fact that 'balls' and 'semi balls' which they used for pendants and earrings were the only major three dimensional works produced using doming blocks and dome punches. This means that the goldsmiths had little knowledge about dies and punches fabrication and how they could be used to emboss designs of Ghanaian origin. Ninety percent (90%) of the respondents confirmed using mainly fabrication, piercing and casting methods for making the jewellery ordered by clients. This reflects why almost all the works they produced were either flat or heavy in nature. Figure 6 shows samples of jewellery for sale at a shop.

Three main reasons account for the high cost of jewellery made from precious metals according to the goldsmiths and silversmiths. First, high cost of raw material such as gold and silver; second, lack of designated legal posts for selling gold and silver and third, method of production which results in heavy jewellery pieces.

Fig. 6: Showcased jewellery pieces at a shop

4.6 Findings from the Field The research found out that:

1. Goldsmiths were not able to explore their own ideas using embossing methods because they relied solely on imported dome blocks and metal punches which could only produce domes and half dome forms.

2. Steel and brass are the metals used for the manufacture of the existing dies and punches found in workshops with some having lasted for over thirty years.
3. Jewellers mostly used dies and punches for making domes and half dome elements for onward use as pendant, earrings and necklace.

4. Most of the jewellers learned the jewellery profession through apprenticeship system.

5. Lack of designated legal centres for goldsmiths to purchase raw materials such as gold and silver also contributes to the high prices of jewellery.
6. Goldsmiths used similar imported doming blocks and punches and therefore tended to have the same designs.

The jewellery profession is still serving as a source of employment for a lot of people in Kumasi. This is evident in the data collected which shows that majority of the respondents (sixty percent) have spent between five and ten years in the trade. It means that the jewellery profession is still attractive to people. Since the learning of the profession is based on traditional family apprenticeship system, elders pass on the knowledge to the young family members and this in a way perpetuate the jewellery practice in the family. This is the reason accounting for the numerous goldsmiths and silversmiths learning the trade in the apprenticeship system.

Directly or indirectly, all respondents agree that the cost of precious material (metals) inevitably affect the price of jewellery. Goldsmiths in practice are aware that the quantity of materials one uses for a work determines its cost. This in effect also affects patronage of jewellery wares. For the respondents, it is only when the material is cheap that precious jewellery products can also become affordable. Makers of jewellery do not have control over the market cost of gold, silver and other precious metals. However, they complained of low patronage because they have not taken full advantage of modern methodologies such as the use of dies and punches which can help them produce jewellery of high quality and form in less weight which will command lower prices and thereby attract more

customers. The jewellery business thrives when jewellers produce wares of high quality at prices that meet the needs of customers in terms of affordability.

Execution of orders has also followed a tradition. Both large orders and small orders were worked on using piercing, casting or fabrication methods. The result is that their works were flat and light weight or in the round and heavy in weight. Though the goldsmiths claimed to have in-depth knowledge about the uses and benefits of dies and punches such as using less material to produce three dimensional works; standardising weight of jewellery; reducing cost of production and increasing profit margin, they did not use them because most of them dd not have technical know how to design and fabricate their own dies and punches for production of jewellery of their own designs.

CHAPTER FIVE

PRODUCTION OF DIES/PUNCHES AND JEWELLERY PIECES FROM EMBOSSED ELEMENTS

5.0 Overview

The chapter discusses the procedures used in generating ideas for the dies and punches. It also explains the methodology employed to create the dies and punches within a studio environment. The chapter further explains how selected samples from the finished dies and punches have been used in mass production of jewellery elements. It provides an orderly procedure which could be followed to use the dies and the punches. It also covers the method used by the researcher to assemble the embossed elements into jewellery pieces. The discussion starts with idea development through to the tools and materials used in this project.

5.1 Idea Development

Idea development in this study was started with the sourcing of ideas. Variety of sources was relied on to generate shapes and forms for creating dies and punches. The first source of idea emanated from the idea of how Ghanaian traditional symbols (Adinkra) could be used to develop dies and punches since such symbols are the most commonly used images by gold and silversmiths. The second source of ideas came from the manipulation of natural objects from one's environment into dies and punches. Another challenge which served as a third source of idea was the use of geometric shapes to create a die and punch.

5.1.1 Adinkra Symbols Selected and their Connotations

Though a lot of the Adinkrah symbols were used in the course of the experimentation, few were finally selected based on their popular uses. These symbols include: 1. Gye Nyame (Except God)

Fig. 7: Gye Nyame (Except God)

In Ghana, this symbol connotes the omnipotence and immortality of God. It is used in recognition of God as the source of life and to promote spirituality through righteousness. Figure 7 shows Gye Nyame symbol silhouette.

2. Ako-ben (war horn)

Fig. 8: Ako-ben (war horn)

It is a symbol of war. It is a significant version of the war horn which symbolises the call to war. Figure 8 shows Ako-ben (war horn) in silhouette.

3. Biribi wo soro (There is something in heaven)

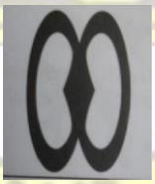


Fig. 9: Biribi wo soro (There is something in heaven)

It is a symbol which signifies hope. The symbol represents the belief that God's goodness and man's reliance on him for sustenance. Figure 9 shows Biribi wo soro (There is something in heaven) in silhouette.

4. Kra Pa (Good fortune and Sanctity)

Fig. 10: Kra Pa (Good fortune and Sanctity)

It is a symbol which is used to ward off negativity. Kra pa is a symbol of sanctity and good fortune. Figure 10 shows Kra pa (Good fortune and Sanctity) in silhouette. 5. Konsonkonson (link or chain)

Fig. 11: Konsonkonson (link or chain)

Ghanaians are linked in both life and death. Those who share common blood relations never break apart. This symbol reflects unity and responsibility. It is a symbol of human relation. See figure 11 for Konsonkonson (link or chain) symbol in silhouette.

7. Ntesie Mate Masie (I have heard and kept it)

Fig. 12: Ntesie Mate Masie (I have heard and kept it)

It is not prudent to engage in gossiping, rumour mongering and eavesdropping as they do not show maturity and wisdom. Figure 12 shows Ntesie Mate Masie (I have heard and

kept it) in silhouette.

5.1.2 Ideas Developed from Geometric Shapes

The first idea was from a circle which is labelled number one. After going through five developmental stages, the final one was made silhouette. The second idea was sourced from a triangle. After going through the development, the final image was also silhouetted. The third image in silhouette too originated from a triangle. Figure 13 shows three different stages in developing images from triangles and circles.

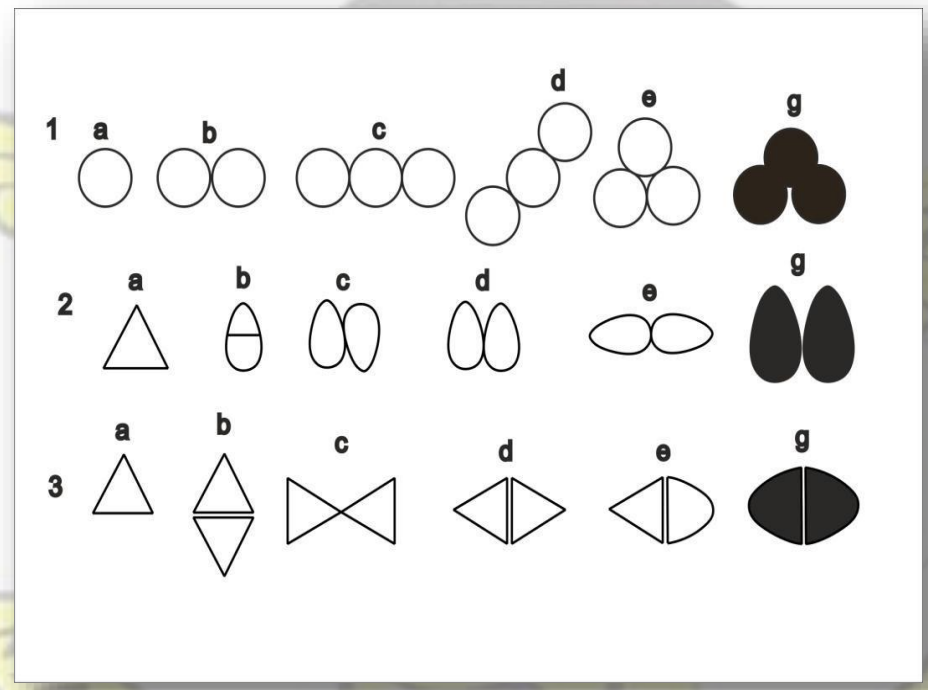


Fig. 13: Images from circles and triangles.

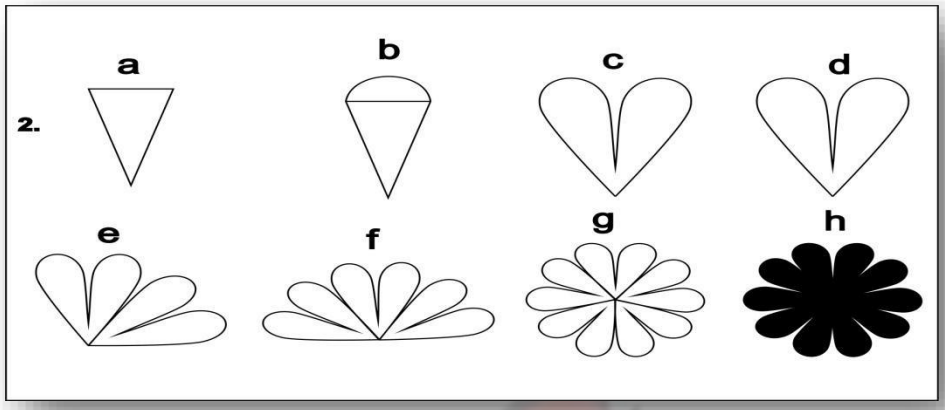


Fig. 14: An image developed from a triangle and a semi circle.

The next image was developed from a triangle and a semi circle. The development of the idea was carried out through eight stages and the final design was silhouetted. Figure 14 shows the various developmental stages which the researcher went through before obtaining the desired image. The third idea was also started with a screw. The development of the idea went through eight stages before the desired image was obtained and the final developed shape was made silhouette. Figure 15 shows the various units in the developmental stages of the image from a screw.

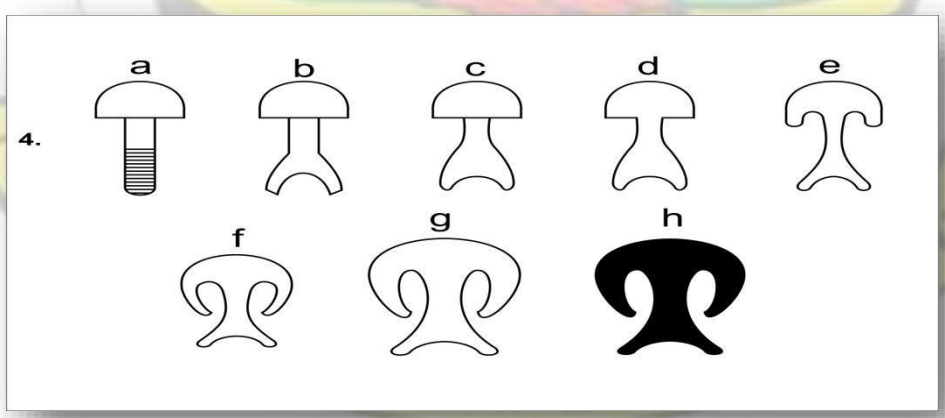


Fig. 15: An image developed from a Screw.

5.1.3 Ideas from Organic Shapes

To establish how an organic material could be used for making of a die and punch, two shells were selected due to their aesthetic appeal. The first one is called prickly cockle shell (Acanthocardia echinata) and pointed snail (cochlicella acuta). Figure 16a shows prickly cockle and 16b shows pointed snail shell.

(a)

Fig. 16a: Prickly Cockle shell

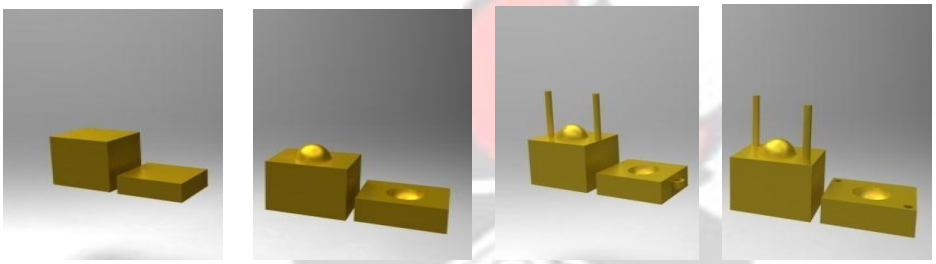
(b)

Fig.16b: Pointed snail shell

5.2 Designing of the Dies and Punches (Form and Configuration)

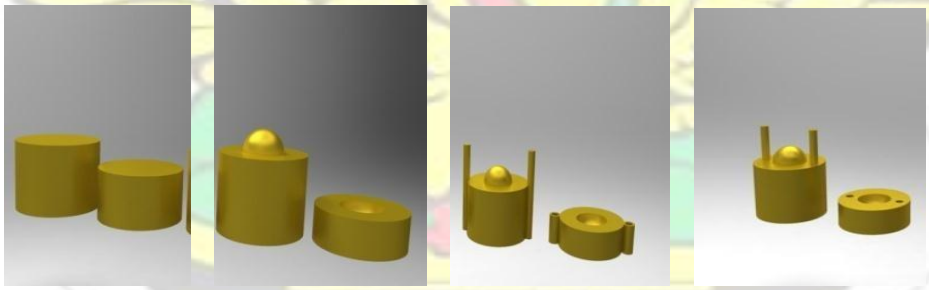
The design of the dies and punches in different configurations were done in pencil and finished using the rhino software on a computer. Four design concepts inspired by geometric forms were created and developed. The four design concepts (DC) were labelled DC 1, DC 2, DC 3 and DC 4 respectively. The first design was started from rectangles and developed into two rectangular forms; one for the die and the other for the punch. In the

second step, the image was developed in high relief as a punch and sunk in the cubic form as a die. See figure 17 for the stages in designing of the die/punch with rectangular forms. The next stage was done with the attachment of two pilots on the punch and two corresponding external holes on the die. The last development was made by repeating the punch but altering the key in this mechanism. With this, the two holes to hold the two pilot pins were created inside the die at the two opposite ends.



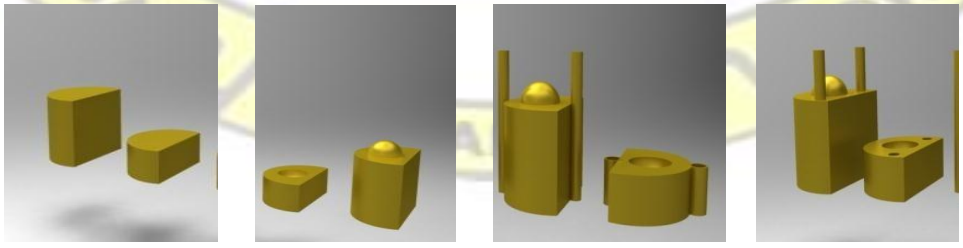
Stage 1 stage 2 stage 3 stage 4

Fig. 17: DC 1 Design stages from rectangular forms



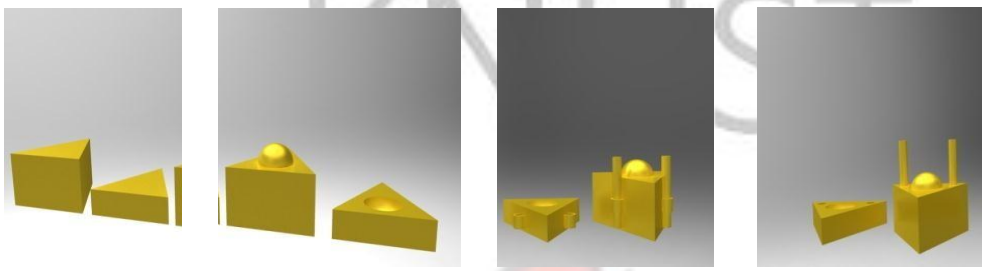
Stage 1 stage 2 stage 3 stage 4

Fig. 18: DC 2 Design stages from cylindrical forms



Stage 1 stage 2 stage 3 stage 4

Fig. 19: DC 3 Design stages from semi cylindrical forms



Stage 1 stage 2 stage 3 stage 4

Fig.20: DC 4 Design stages from Triangular forms

The designing process was continued with other geometric forms such as cylindrical forms, semi cylindrical forms and triangular forms. See figure 18, 19 and 20 for the rest of the designing stages from other geometric shapes. In the designing of dies/punches for this study, two operating systems were considered and used by the researcher: externally keying mechanism and internally keying mechanism. With the externally keying mechanism, pilot pins and their corresponding holes have been designed to be an added part to a die and the punch. The internally keying mechanism has been made to have both the pilot pins and its holes as integral part of both the die and punch.

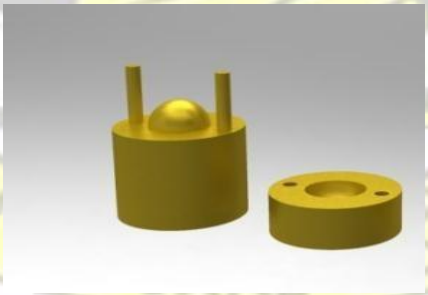


Fig. 21: DC 2 Selected Die/punch set Design

However, DC 2 which was made from cylindrical forms was selected for execution because of the following reasons: it was appealing to the researcher. It had a wide space to contain images with varied parts and also, the two pilot pins could stand firm on it. Figure 21 shows the selected die/punch design set with pilot pins and two holes for keying. Also, the designer chose the die/punch set in figure 21 because the pilot pins and holes are inbuilt; it made them stronger than the ones which would have been attached to punches and dies externally. More importantly too, the selected design was supported by available facilities thus casting facilities.

a. Rationale for Choosing Sandcasting Method for this Project

Sand casting generally means pouring molten metal into a refractory mould of sand with a cavity of the shape and form to be made, and allowing it to solidify. When solidified, the desired metal object is taken out from the refractory mould by breaking the mould apart. (Rao 2001)

In sand casting, molten material flows into any small sections in the mould cavity and intricate shapes can be made with the casting process. It is possible to cast practically any material be it ferrous or non ferrous. Further, the necessary tools required for casting moulds are very simple and inexpensive. As a result, for trial, production or production of a small lot, it is an ideal method. (Rao 2001)

Adu-Boachie (2004) states that the choice of any casting technique is influenced by factors such as ready availability of tools and equipment involved in that particular casting technology, the size of the die being designed and flow of the alloy (metal being used) at the casting temperature. He reveals also that cuttle fish bone casting, lost wax casting and local sand casting are all classified as gravity pour casting techniques, meaning the flow of the molten metal in these techniques is by simple gravity and not aided by any pushing or pulling force. The implication is that they work efficiently when the metal involved can flow smoothly at its casting temperature and for this reason recommends sand casting for die production.

The motivation to use sand casting process for the production of the punches and the dies stem from the fact that it is adequately supported by local facilities. Tools, materials and studio setting in Ghana provide comparative advantage for the production of punches and dies in affordable way as compared to other casting methods such as centrifugal casting, permanent mould casting, cuttle fish casting, die casting and lost wax casting. The local gold/silversmiths who are the ultimate beneficiaries of this study are more familiar with sand casting and lost wax casting and this will serve as an incentive for them to easily adapt the method of die/punch fabrication in their production line.

b. Rationale for selecting Brass as a material for the Project

There are different materials which were identified locally and can be used as materials for fabricating dies and punches. Examples of these materials are pvc plastics, steel, cast iron, and expoxy resin. Other materials are concrete, wood and brass. Each of these materials

has its own qualities and makes its selection for making embossing dies/punches suitable for pecuiliar purposes. For example, it is easy to make dies from wood but their life span can not be compared with those fabricated from steels. Though the above mentioned materials could be sourced locally, brass (scrap brass from automobiles' parts) was selected as a material because of the following reasoning:

i. Brass is easy to source as scraps.

ii. Casting it is supported by local studio technology.

iii. It is resilient and hard enough to ensure fairly long life of dies and punches; and iv. Brass is able to withstand rusting.

5.3 Fabrication Processes

The fabrication processes used in this study begun with the identification of tools and materials.

5.3.1 Tools and Materials Used in the Project

1. Hacksaw and blades: They were used to cut galvanised pipes and metal plate.
2. Galvanized Pipes: It was used as flask to cast lead patterns for the dies and punches.
3. Files: They were used to file unwanted metal from the edges of the elements.
4. Bench vice: It was used to hold metal pieces especially during the carving of the dies and punches.

5. Gas torch: It was used for annealing and soldering of metal and jewellery pieces respectively.
6. Bees wax: It was used for making wax models
7. Leather hard clay: It was used to test the depth of the engraved images and for pressing images that were used to make models.
8. Steel figure: It was used as a base for the flask during pattern casting.
9. Brass: It was used for making model dies.
10. Copper Sheet: It was used for embossing the jewellery elements.
11. Scrap plastics: They were used to create models during the experimentation stages.
12. POP: It was used during the experimentation stages.
13. Lead: It was used to create patterns for the casting of the dies and punches.
14. Sand: This was the material used to cast the dies and the punches.
15. Clay: This was mixed with wax, pop and used for models during the experimentation stages
16. Guillotine: It was used to cut copper sheet.
17. Drill Press: It was used to drill holes through the dies and the punches.
18. Scratch brush: It was used to clean metal sheet after annealing and pickling.
19. Jeweller's Saw and Blades: They were used together to pierce out the bosses from metal sheet.
20. Hammer: It was used during the embossing of the jewellery elements.
21. Flexible Shaft: It was used to engrave some areas of the dies and punches.
22. Engraving Tools: They were used to engrave the model dies and also used in finishing the cast punches and dies.

23. Wooden bat: It was red wood which was placed on the dies before stamping was carried out.

In considering the methodology to employ in the fabrication of the dies and punches, two thoughts came to mind: the first one was to use a thick scrap metal to create a die and use it to create a pattern which could be used subsequently to cast the male counterpart (punch). The conviction was that it would enable the researcher to test and see off hand the depth of the dies and the punches.

5.3.2 Experiment 1: Producing Wax Punch Model from an Engraved Image

i. Apparatus used: 3.5cm wide galvanised pipe, metal scriber, soldering torch, 5mm brass, carving tools, hacksaw, grinding machine, scrub brush, pickle solution, beeswax, bench vice, leather hard clay, white glue, flexible shaft and running tap.

The first experiment was to test whether or not an engraved image could be used to produce the opposite part to serve as a punch.

The objective of this experiment was to find out how a design on paper could be transformed into embossing dies.

ii. Processes involved in the experiment:

1. A brass plate, five millimetres (5mm) thick was selected.
2. A galvanized pipe with a circumference of 3.5cm was used as the size for the dies and served as a measure for the circles; a metal scriber was used to mark the inner circumference of the pipe on a brass plate.

3.The brass plate circle was marked and cut with a hacksaw. The hacksaw was used instead of jeweller's saw because of the brass's thickness of five (5) millimetres.

4. The brass metal plate was then cut into a cube form before it was rounded into a sphere using a grinding machine.

5. The piece was annealed, pickled and scrub brushed under running water.

6. The designs or images were cut and pasted on the brass metal plate using white glue and allowed to dry.

7. The piece was first fixed in a bench vice and with carving tools; the image was sunk by removing the intaglio portions bit by bit;

8. Having got the shape, a flexible shaft machine was used to sink deep the image; in the course of sinking the die, the appearance of the image was evaluated at intervals by pressing leather hard clay into the depression. Figure 22 shows sunk image on brass plate of 5mm thickness. This ensured that the desired appearance of the relief as it should appear on the metal was achieved. It enabled the sinker to make alterations where necessary. Figure 23 shows a high relief impression on leather hard clay.

Fig. 22: Sunk image as die model.

Fig. 23: High relief impression

9. Needle files were used to obtain some needed details. Figure 23 shows a relief image on leather hard clay.

The next step was to cast the engraved image in wax to establish how the sunk image could be turned into the male part (punch). The process is as follows:

1. The sunken image in brass was positioned on a metal plate and the flask positioned on it.
2. The space between the flask and the metal plate was sealed with leather hard clay;
3. The inner wall of the flask was oiled
4. Molten bee wax was poured into the flask to produce the replica of the image;
5. After two hours, the wax got solidified and the image was removed. See figure 24 for the cast wax in a flask.

Fig. 24: Cast wax image in a flask.

The researcher observed from the result that it was possible to sink an image on a metal plate and use it to create the opposite in wax which could be used to produce the male die. With this conviction, the researcher was set on the procedure and began to produce the dies. The procedure used in 5.3.2 experiment one: producing wax punch with an engraved image except that the galvanized pipe used as a measure for the circumference of the dies was 5cm which was bigger in size than that of the first one which measured

3.5cm. The process was as follows:

Fig. 25: Brass plate

Fig. 26: Cutting of brass figure into squares

1. A brass plate, five millimetres (5mm) thick was selected again and areas on the brass plate which were marked with circles were cut with a hacksaw. See figure 25 for the brass plate.
2. The brass plate was then cut into squares. The brass squares were then rounded into discs using a grinding machine. See figures 27a, 27b and 27c.

a b c

Fig. 27a: Brass squares, 27b: Grinding & 27c: Finished blank samples

3. All the pieces were annealed, pickled and scratch brushed under running water. Figure 28 shows the annealing of the brass pieces.

Fig. 28: Annealing process Fig. 29: Designs pasted on brass blanks

4. The designs on paper were cut and pasted on the metal blanks using white glue and left to dry. See figure 29 for the pasted designs on brass blanks.

5. Each piece was fixed in a bench vice and using carving tools, each image was sunk by removing the intaglio portions bit by bit. See figures 30 &31 for the die sinking process.

Fig. 30: Sinking of the dies models Fig. 31: Sinking of Nkonsonkonson symbol.

6. Having initially cut the design using improvised cutting tool, a flexible shaft machine was used to cut further in order to define the sections more accurately and in the course of sinking the die, the appearance of each image was evaluated at intervals by pressing leather hard clay into the depression. See figure 32a&32b for the sunk die model and the high relief boss in clay. This ensured that the desired appearance of the relief as it

should appear on the metal was achieved. It enabled the sinker to make alterations where necessary.


a b

Fig. 32a: Sunk die model and fig.32b: boss in clay.

7. Based on the designs, two holes were drilled at both ends for the key in mechanism.

This method was used to create dies model using ideas sourced from the Adinkra symbols and designs made from the geometric shapes.

5.3.3 Experiment 2: Producing Wax Punch and Die Models from Natural Objects

i. Apparatus used: 5mm galvanised flask, seashell, steel figure, Milo beverage container, leather hard clay, foam and soldering torch.

This experiment is in two parts. The first part of the experiment was to establish how both natural objects and artificial objects could be turned into a punch. The second part of the experiment was to establish how both natural objects and artificial objects could be turned into a die. A prickly cockle shell was used in this exercise because of its aesthetic appearance.

ii. Processes involved in the experiment: First Part

1. The prickly cockle shell was washed, cleaned, dried and lightly powdered with talcum.
2. A casting flask was one third filled with leather hard clay and the top neatly smoothed with foam. Figure 33 shows the casting flask with clay and the prickly cockle shell beside it.

Fig. 33: Casting flask and prickly cockle shell

3. The prickly cockle shell was pressed downward convex side down into the clay to register the image.
4. Molten bee wax was poured into the flask to produce the replica of the prickly cockle.
5. The wax was allowed to cool and solidify.
6. The replica wax was removed from the flask. Figure 34 shows prickly cockle shell model in high relief and the shell (real prickly cockle shell).

Fig. 34: Prickly cockle shell model in high relief

iii. Processes involved in the experiment: Second Part

1. The seashell was washed again, dried and lightly powdered with talcum.
2. It was placed on a flat steel plate with the concave part facing upward;
3. Metal flask was positioned on it and leather hard clay was used to seal the space at the base between the flask and the plate.
4. Molten bees wax was poured into the casting flask and dried.
5. It was then removed from the casting flask. Figure 35a, b & c show the stages in the casting process: (a) cast molten wax; (b) solid wax model in the casting flask and (c) cast solid wax model of the prickly cockle shell model in intaglio.

a: molten wax b: solid wax in flask c: cast wax

Fig. 35a, b & c: Shell model in Intaglio

Table 5.1: Results from Experiment 1&2 conducted

Materials	Methodology	Observable findings
Brass	Carving and engraving	It resulted in a clear strong model die from brass.
Bee wax	Casting	It provided a replicable wax pattern for the punch from an already made model die.
Natural object, leather hard clay & Wax	Casting	It is possible to create both die and punch models from found objects.

Though there are different methods which could be used to produce dies and punches as already alluded to, sand casting was opted for because it is supported by locally available materials and facilities. However the challenge was that the bee wax could not be used as a material for creating patterns for sand casting since it sticks to some of the sand particles when pressed into it. The researcher decided to experiment further with other available materials.

The table below shows materials used for further experiment, methods used and the outcomes from the result.

Table 5.2: Result of Experiment from other materials

Materials	Methodology	Observable findings
1. POP & wax (mixture)	Molten wax mixed with POP and cast (1part POP to 3parts wax)	It was strong but brittle. Figure 36 shows the die and Pattern cast in wax and POP mixture.
2. Wax, clay & POP	Molten wax, clay powder and POP mixed and cast (1part wax, 1part clay and 3part POP)	Dries fast, smooth and glossy surface but sticks to the dies. See figures 37 and 38 for the cast piece from wax, clay and POP.
3. Clay & POP	2 parts leather hard clay and 1 part POP were mixed uniformly.	It does not dry fast and the images did not register well. See figure 39 for the cast piece from clay and POP mixture.
4. Lead	It was melted and cast	The surface was not smooth but the outcome was heavy and presentable. Figure 40 shows a cast piece from lead.

5. Brass	It was melted and cast	There were a lot of defects on the image. It was difficult to remove it from the model die after casting. See figure 41.
6. Scrap plastics (#2) high density polyethylene	It was cut into small pieces, melted and cast.	It melted quickly and flowed well when pouring. It shrunk which made it fit well into the die. The outcome was brittle, stiff and made it difficult to work on defeats. See figure 42a & b.

Fig.36: Die and pattern cast in wax and POP mixture

Fig.37: Die and parttern cast in wax, POP and clay

Fig. 38: Die and cast parttern in wax, clay and POP

Fig. 39: Pattern cast in clay and POP

Fig. 40: Cast pattern in lead

Fig. 41: Cast brass and die

a

b

Fig. 42a & b: Patterns cast from scrap plastics

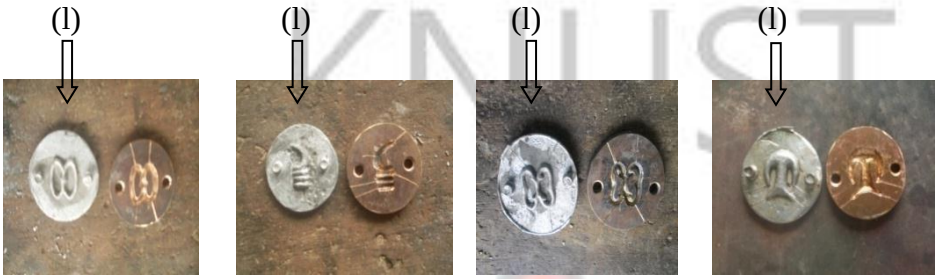
From results obtained from the experiment conducted, the researcher concluded that lead would be used for making the patterns for onward casting because of three reasons:

1. Lead has low melting point (327.5^{o}c) which makes it easy to melt and cast.
2. Though the cast pattern sample came with some defects, they were easily corrected.
3. The weight of the material made it easier to press the image in the sand mould.

5.3.4 Production of Patterns for Dies and Matching Punches

This process is in two parts: the first process of making punch patterns was done after selecting some dies bearing Adinkra symbols which are commonly used by jewellers and other designs developed by the researcher. As already alluded to in table 5.2, number 4, the process was repeated to produce patterns from the carved designs. Figure 43a-g shows the

engraved dies and their corresponding lead patterns. All the lead patterns are labelled letter l with arrows pointing to the lead patterns.



a b c

d

e f g

Fig. 43a, b, c, d, e, f &g : Samples of lead patterns and Die models

The second process of making punch patterns using natural objects and images developed in brass (as found from the second experiment) is as follows:

1. The found objects were washed, cleaned and dried.
2. Leather hard clay was wedged and kneaded and the top neatly flattened.

3. A casting flask was used to cut the clay and metal rods were pressed into both sides for the keys.
4. Each object was pressed downwards into the clay in between the keys to register the image.
5. The clay moulds were allowed to dry thoroughly for two weeks before they were used to cast the patterns.
6. Vents were created on each dried clay mould using a triangular needle file.

The following figures (44-48) show the result from the clay moulds and the cast lead patterns.

a : Pointed snail shell b: clay mould c: lead pattern

Fig. 44: (a) Natural object, (b) clay mould and (c) cast lead pattern 7

a : Brass Design b:clay mould c: lead pattern Fig. 45: (a) Brass design, (b) clay mould and (c) cast lead pattern 8

a: Brass design b: clay mould c: lead pattern

Fig. 46: (a) Brass design, (b) clay mould and (c) cast lead pattern 9

a : Brass design b: clay mould c: lead pattern

Fig. 47: (a) Brass design, (b) clay mould and (c) cast lead pattern 10

a: Prickly cockle shell b: clay mould c: lead pattern

Fig. 48: (a) Prickly cockle shell, (b) Clay mould and (c) cast lead pattern 11

5.4 Production of the Brass Punches and Dies

Tools and Materials Used: wheel barrow, head pan, clay, sand, spade, wooden mould (drag and cope), tea spoon and spade. The rest includes ramming wood, plastic pipes, lead

patterns, tongs, crucible, furnace, blower and scrap brass. The lead patterns produced in the previous process were used as patterns in this process.

The processes involved were carried out in two segments. The first segment was the fabrication of punches and the second part covered the production of matching dies. The following were the processes used to produce the punches:

1. A wheel barrow of sand and two head pan of sieved clay were mixed uniformly with water. Figure 49 shows the prepared sand.

Fig. 49: Prepared sand.

Fig. 50: Sieving of sand on mould surface

2. The drag was formed by ramming sand into a wooden flask with a wooden bat till it was full. To achieve a smooth surface cast, the surface to be pressed with the pattern was covered with fine sieved sand. Figure 50 shows the covering of the mould surface with fine sieved sand.
3. Six patterns were carefully pressed into the sand mould and rammed with two wooden bats. The patterns were covered with sand again and rammed in order to obtain the details of images (Figures 51 & 52).

Fig. 51: Pressing and ramming processes. Fig. 52: The finishing of the first mould

4. Each pattern was given a two inch plastic pipe for the purposes of creating sprues and the cope was positioned on the drag. Parting sand was then sprinkled evenly on the surface of the mould (Figure 53).

Fig. 53:Application of parting sand. Fig. 54: Ramming of the cope with sand.

5. The cope was carefully filled with sand and rammed using wood (See figure 54).
6. A tea spoon was used to scoop the sand from the pipes and a metal rod was used to tap the inner part of each pipe to loosen it before it was removed (Figure 55a and 55b).

a: Removal of sand b: Removal of pipes

Fig. 55a & b: Removal of the sand and pipes from the mould

7. The cope was detached from the drag and the patterns were carefully removed from the drag. Figure 56 shows the prepared sand mould after the patterns had been removed and corrections had been made.

Fig. 56: Prepared sand moulds

8. The moulds were allowed to warm up while the brass was being melted in a furnace. Occasionally, iron sheets were heated and placed on the moulds to warm them up until the molten metal was poured into the individual cavities. Figures 58, 59 & 60 show the pouring of the molten metal into the sand mould, the retrieval of cast pieces and cast pieces respectively.

Fig. 58: Pouring of the molten metal. Fig. 59: Removal of the cast pieces

Fig. 60: Cast items

9. The excess brass from cast piece was cut off using hacksaw. The surfaces were ground, filed and sanded.

10. Carving tools were used to refine the images on the punches, after which bits on a flexible shaft were employed to sharpen the contours of the images (Figures 61a,b &c).

The outcome from the sand cast pieces confirms Bhandari (2010) assertion that cast components have rough surface finish and therefore require additional machining and finishing which may increase cost.

a b c

Fig. 61: Stages in finishing the punch

5.4.1 Second Segment: Production of the Lead Dies

The second segment involved the use of lead to cast the matching patterns. The matching patterns were cast one at a time. The process was carried out as follows:

1. Each brass punch was positioned on a metal sheet and encased with a galvanised pipe (flask). The outer space around the punch was filled with leather hard clay. Figure 62a shows a punch on a metal sheet. The gap between the metal sheet and the flask was also sealed with clay (Figure 62b).

a

b

Fig. 62: Preparation stage in the casting process

2. The flask and the brass punch were heated and this ensured that when the molten metal was poured, it flowed well into all parts of the image;
3. The lead was melted (slag swept from the surface with a piece of wood) and poured into the flask (Figure 63a, b & c).

a: lead melting b: casting lead c: cast lead pattern Fig. 63a, b & c: Stages in the casting of the pattern

4. After pouring of the molten lead, the casting was allowed for about thirty minutes to solidify and cool down before it was immersed in water to remove the clay between the punch and the flask.
5. The cast part together with the punch was removed from the flask and oil was applied between the punch and the pattern to facilitate parting of the two parts.

a: Parting process b: Cast lead

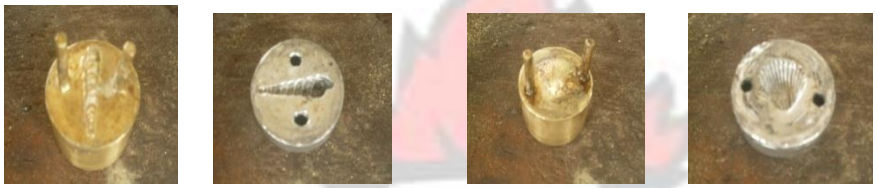
Fig. 64a & b: Parting the brass punch from the cast lead die

6. The lead die was carefully and gradually parted from the punch using a flat chisel, wooden tool and a hammer. Figures 64a & b show the parting process which was accomplished in a bench vice and the liberated lead die respectively.
7. The rest of the lead dies were produced using the same method. See figure 65 for the rest of the lead dies. All the brass punches are labelled p and the lead dies with

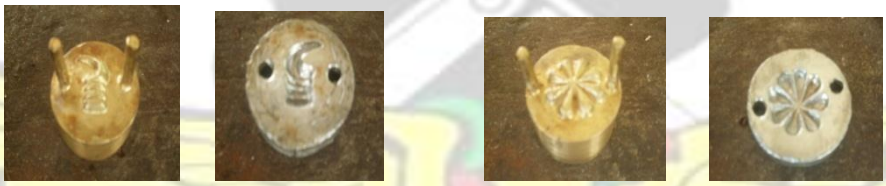
letter l.

Other Punches and their corresponding lead dies

p l p l



p l p l



p l p l

p l p l

p l p l

P l p l

Fig. 65: Other punches and their lead dies

5.4.2 Second Segment: Casting of the Matching Brass Dies

The tools, materials and process used to cast the male parts or the punches as stated on page 78 were used to produce the matching dies for the punches. It was begun with the preparation of the sand, casting of the matching dies and finishing.

1. The composition used for the mould was a wheel barrow of sand and two head pan of sieved clay which was mixed uniformly with water (Figure 66).

Fig. 66: Prepared sand

Fig. 67: Sieving of sand

2. The drag was formed by ramming sand into a wooden flask with a ramming wood until it was full. To achieve a smooth surfaced cast, the surface of the lead patterns to be pressed with was covered with sieved sand (Figure 67).

3. Four lead dies were carefully pressed into the mould and were rammed using two wooden bats. The patterns were covered with fine sand again and rammed in order to capture details of the images well (Figure 68).

Fig. 68: Pressed lead dies in the drag

4. Each lead die was given a one inch plastic pipe which was used to create a sprue and the cope was positioned on the drag. After that, parting sand was sprinkled evenly on the surface of the drag. Figure 69 shows the pipes on the lead dies. The pipes were later removed to create sprues.

Fig. 69: Pipes on lead dies

Fig. 70: Prepared sand moulds

5. The cope was detached from the drag and the patterns were carefully extracted from the drag. After that, some corrections were made on the mould. One mould was discarded because the image did not register well. Figure 70 shows the prepared cope and drag.

6. The same process was used to develop the rest of the moulds as shown in figure 71..

Fig. 71: Some prepared moulds

7. The moulds were left to dry as the brass was being melted in the furnace. Iron sheets were heated and placed on the moulds to warm them up until the molten metal was ready to be poured into the individual sprues. Figures 72a, b & c. show the pouring of molten metal into the mould, removal of the cast pieces from the mould, and the cast dies themselves respectively.

Fig. 72a, b, c a: Casting b: Removal of cast Dies c: Cast Brass Dies

8. The excess brass from cast piece was cut off with hacksaw. The surfaces were ground, filed and sanded (Figure 73).

Fig. 73: Finished Brass Dies Fig. 74: Refining an intaglio image with a flexible shaft

9. Again, carving tools were used to refine the intaglio images; followed by a flexible shaft bits which were employed to sharpen the contours of the images. Figure 74 shows the use of the flexible shaft to clean up the intaglio images.
10. In the course of refining the images, aluminium foil was pressed in to check for the integrity of the images.
11. Fourteen punches and dies were started with but two of them were discarded because the impressions were not accurately reproduced.

5.4.3 Aligning the Dies to the Punches

Aligning each die to a respective punch was not realised because the pilot pins on the punches were not straight enough to align with the holes in the matching dies. The researcher thought of machining the pilot pins but ignored it because it would have reduced their strength. Consequently, the cast pilot pins were removed with hacksaw. After that each set was carefully aligned through reshaping by engraving and filing. Each die was placed on a punch and when they fitted pefectly without any gap between them, they were marked with two vertical lines at one side and three lines at the opposite side to serve as keying mechanism. This was done to facilitate accurate matching of dies and punches.

To determine the working clearance of the dies and punches, thus thickness of metal sheet suitable for the embossing of the images, 1mm thick copper sheet was cut into four pieces. The pieces were annealed, pickled and scratch brushed to remove the fire scales from the

surfaces. Three of pieces were milled into 0.5mm, 0.25mm and 0.125mm thickness respectively. A set of die and punch was selected and sheets of the various thicknesses were embossed in it.

Metal sheets of the following thickness 0.125mm and 0.25mm resulted in a boss showing crevices but the one with 0.5mm thickness produced a clean strong boss. A repeat embossing with the 0.5mm sheet confirmed that the 0.5mm sheet metal thickness was suitable for the creation of the final jewellery elements.

5.4.4 Testing the Dies and Punches on a Metal Sheet

Testing of the dies and punches was conducted in two phases: preliminary test and final test. The preliminary test was done using series of marks on punches and dies as keying system. In the final test however, the researcher employed pilot pins mechanism. The process of testing the embossing dies and punches was carried out as follows:

1. The die and punch were fitted together on an anvil. Two vertical lines were made on one side of the die set and three lines on the opposite side;
2. The annealed metal sheet was placed on the punch and also marked with two and three marks respectively to correspond with those on the die and the punch; figure 75 shows the die/punch set for trial embossing.

Fig. 75: Die and Punch used for Testing

Fig. 76: Testing Embossing Process

3. A piece of red wood was placed on the die and hammered twice to capture the preliminary outline of the boss as shown in fig. 76.

4. The metal sheet was removed, annealed and allowed to cool down.

5. The metal sheet was again placed on the punch, aligned with the die and hammered while the wooden bat was on it to achieve perfect sandwich of the copper sheet between the die and the punch. Apart from the red wood serving as a 'clamp', it was used to protect the brass die/punch from being moved by the hammer blows.

6. The process of annealing and embossing continued until the punch, the metal and the die fit together perfectly.

7. The same process was used to produce all the twelve sample dies and punches (Figure 77).

Fig. 77: The samples of the embossed elements

Observation from the First Phase Test in Embossing Process

It was observed during the trial process that though the dies and the punches were able to produce the bosses as expected, it was realised that during mass production, it would be difficult to produce them at a faster rate. This is because the blank sheet sometimes got shifted during embossing and resulted in deformed bosses. It became prudent to introduce more permanent keying mechanism to replace the malformed one removed earlier on.

5.4.5 Provision of the Keying Mechanism for the Die/punch Sets

Two holes initially created on the die patterns served as a guide for the creation of the keying mechanism. With 5.5mm drill bit, a drill press was used to drill two holes through these initial holes in the dies. Figure 78 shows the drilling of the holes in a die with a drill press.

Fig. 78: Drilling the holes through a die

In order to maintain a perfect alignment between each die and punch, each drilled die was firmly placed on its corresponding punch and drilled through as shown in figure 79.

Fig. 79: Drilling holes through a die and a punch

Fig. 80: Fixing the 5mm metal pins

A 5mm smooth iron rod was fixed into the holes depending on the height of each die punch set (Figure 80) shows the fixing of the 5mm metal pilot pin into the die/punch set.

The same process was used to key all the die/punch sets with appropriate metal rods. To enhance quick production, each die /punch set was given a master plate to be used for marking and drilling holes to be held by the pilot pins. Figure 81 shows an embossed metal element with pilot pins.

Though the testing with the pilot pins mechanism produced the needed result, two important problems were identified again. These were:

Fig. 81: Embossed Element with pilot pins

1. The location of the right position of the blank sheet after annealing
2. The repositioning of the die after annealing the blank sheet for another embossing.

Owing to this, the researcher decided to drill on top of each die and its corresponding punch to assist the user to position a die on a punch without any difficulty. Figure 82 shows the drilled dots on a die and its corresponding punch.

Fig. 82: Drilled dots on a Die and its corresponding punch

To ensure the correct orientation of the blank sheet for embossing, one end of a blank was punched to correspond with the marks on both the punch and the die. This provision eliminated the problem of wrong orientation of the blank in between the punch and die prior to hammering.

5.4.6 Testing the dies and punches using Metal cans from the environment In order to expand on the uses of the die/punch sets, some metal cans found in our environment was also tested. Figures 83a-f show the outcomes of the test.

a

The body of a milk tin unannealed

b

The base of a milk tin (base) annealed

c

Can coke annealed

d

Milk tin unannealed

e

Perfume can

f

Perfume can

Fig. 83a, b, c, d, e & f: embossed images from tins and cans

Test carried out on some selected tins and cans such as milk, Milo, and can coke tins showed impressive results. Figures 83a, b, c, d, e & f show the embossed images from tins and cans. However, due to the thinness of the tins coupled with the high relief nature of the tools (dies and punches) all the bosses created had an undercut or two on them. It was observed that if a die set with reasonable low reliefs are made, they could be used to emboss images from these cans and tins which could be assembled into art. When this is done, it would go a long way to improve sanitation and ensure good health because those cans and tins which stay in our environment collect rain water and breed mosquitoes could be put into good use.

5.5 Production of the Jewellery Elements

The production of the embossed jewellery elements followed the same processes as described in the testing process. A strip of copper sheet of 1mm thickness was cut and milled into blanks. Each metal blank covered the surface of the punch and this ensured that when it was embossed, there was enough fins around the embossed element.

Three dies and their punches were selected randomly as samples and used to produce the jewellery elements. They were “Biribi wo soro” die/punch set, “Kra pa” die/punch set and “Ahoɔfɛ ntua ka” die/punch set. The following were the processes used to produce the jewellery elements:

1. Strips of copper measuring 5.5cm in width were cut with guillotine and milled in a milling machine (Figure 84).

Fig. 84:Milled copper sheets

Fig. 85: Marking for drilling

2. The master plate was used to mark the positions of the pilot pins for drilling. Figure 85 shows the marking for drilling process.

3. The metal blanks were drilled with a 6mm drill bit (Figure 86).

Fig. 86: Drilled blank

Fig. 87: 1st Embossing process

4. The annealed metal blank was placed on the punch, the die aligned on it and

Stamped. Figure 87 shows the result of first embossing process.

5. After embossing all the prepared metal blanks for the symbol, they were annealed again (Figure 88).

Fig. 88: Annealing

6. The annealed pieces were allowed to cool slightly and they were embossed the second time after pickling and rensing (Figure 89).

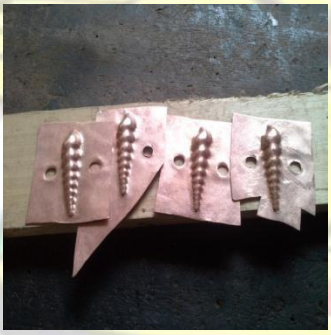
Fig. 89: 2nd Embossing after annealing

7. The pieces were annealed again and stamped the third time.

8. The pieces were pickled to remove the surface oxides (Figure 90).

Fig. 90: Pickled embossed elements

9. The process was reapeated using other selected die and punch sets to produce the other jewellery elements (Figures 91a & 91b).



a b Fig. 91a & 91b: Some embossed elements

10. The embossed jewellery elements were pierced to separate the bosses from the fins (Figure 92).

Fig. 92: Piercing

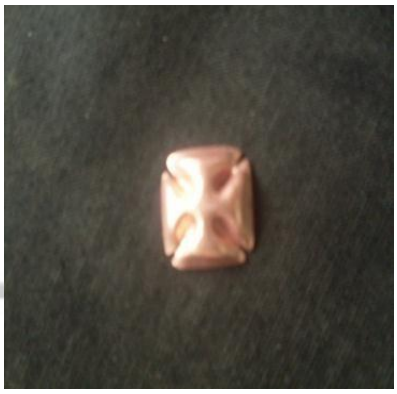


Fig. 93: A sample peirced boss

11. The edges of each element were filed to the desired form. Figure 93 shows a sample of peirced boss with the edges filed.

5.5.1 Assembling the Jewellery Pieces from the Elements

The following were the processes that the researcher used to assemble the embossed pieces into jewellery items.

1. Copper wires were drawn and used to link the elements to one another through soldering.
2. The first jewellery made from the embossed elements was a necklace. It was made by linking four “Kra Pa” and five “Nyame Biribi Wo Soro” symbols with rings in rectangular forms. This was linked with a chain. Figure 94 shows the assembled Necklace from “Kra Pa and Biribi Wo Soro” symbols.

Fig. 94: A necklace from Kra pa and “Biribi wo soro” symbols

3. The pair of earrings made for the necklace was also made by linking one “Kra pa” and one “Biribi Wo Soro” symbols together. Figure 95 shows the pair of earrings made from the “Kra pa” and “Biribi Wo Soro” symbols. Figure 96 shows assembled pair of earrings and a necklace from “Kra Pa” and “Biribi Wo Soro” symbols.

Fig.95: Earrings from Kra Pa and Biribi Wo Soro symbols

4. A bangle was also made from one embossed “Biribi Wo Soro” symbol to make the set complete (Figure 97).

Fig.96: Assembled jewellery on display

Fig.97: Bungle

5. The assembled jewellery from Kra Pa and Biribi Wo Soro symbols was finished by using oxidation.

6. Two of the elements embossed using the "Ahoɔfƹ Ntua Ka" symbols were made into a beautiful pair of earrings (Figure 98a). "Ahoɔfƹ Ntua Ka" literally means "beauty does not pay a debt".

a b

Fig.98a & 98b: Earrings and necklace from Ahoɔfƹ Ntua Ka

8. The necklace was made by linking eleven of the "Ahoɔfƹ Ntua Ka" symbols to a chain (Figure 98b).

9. The jewellery set made from "AhoɔfƐ Ntua Ka" elements was finished by electroplating.

The jewellery generated from the embossing dies and punches can be used by anyone for different reasons. When worn, they show their three dimensional forms and are aesthetically pleasing. They appear bulky but because they were embossed from thin metal sheets, they weigh less and feel light on a human body.

This chapter started with the identification of tools and materials needed for the production of the dies and punches. Ideas for the images on the dies/punches were sourced from Adinkra ideographs, geometric shapes as well as organic forms. The final forms of the dies/punches were developed from cylindrical geometric shapes. Series of experiments were carried out to come up with a suitable procedure for the production of dies and punches. Three main directions were established based on the design ideas.

(i) An image was created in intaglio on thick brass; it was used as mould to cast a lead pattern and this lead was further used to develop dies/punches set.

(ii) An image was created in three dimensional form; it was used to make a clay mould; a lead pattern was made from of it and used to develop dies/punches set.

(iii) A natural object was used to create a clay mould; a lead pattern was cast from it and used to develop die/punch.

The developed dies/punches were tested on copper sheets, cans and tins. Some of the embossed units were assembled into jewellery articles.

CHAPTER SIX

RESULTS AND EVALUATION OF DIE/PUNCH AND JEWELLERY SETS

6.0 Overview

The chapter is twofold. The first part presents and evaluates the final die/punch sets. Evaluation of the die/punch sets considers both the intrinsic and extrinsic qualities with reference to their efficiency in the production of jewellery elements and its potential benefits to Ghanaian gold and silversmiths. It also showcases the qualities of each individual die set. The second section appreciates jewellery articles generated from the research. Appreciation of the jewellery articles focuses on aesthetic qualities resulting from impressions, parts, colour and discusses how the jewellery pieces look when on display and when worn.

6.1 Result and Evaluation of Die/Punch Sets

Part one of the project resulted in creating a set of twelve die/punch sets. Each die set consists of a die, a punch, two pilot pins and a master plate. The master plate is used to develop blanks for stamping. The main dies and punches were made from brass. Each set has two 5mm iron pilot pins. The average diameter of a die and a punch is between 4cm and 5.2cm with the average height between 5.4cm and 5.2cm. Figure 99 shows twelve die sets with their iron pilot pins.

Fig.99: Die/punch sets

The punch is about twice as thick as the die. At both sides of a punch are two holes in which the iron pilot pins are held. The two iron pilot pins have been made to be removed in the course of work to speed up easy removal of embossed images. Each punch goes with its corresponding die. It has two drilled holes, one on either side of the design in low relief (intaglio) form. The master plate is also made from brass. Figure 103 shows the master plates.

Fig. 100: Master plates

The dominance form of the die/punch sets is seen in the roundness of the elements: the die is in a circular shape, the punch in a circular shape, master plates is in circular shape and the iron props are also in circular shape. This gives all the elements harmony in all the die sets in terms of form.

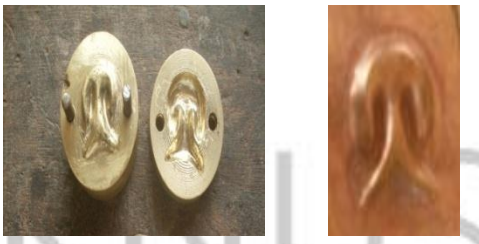
The working efficiency of the die/punch sets comes from the collective workings of all the parts. Brass was used because it is resilient, tough and this will give the die set fairly long life. The surfaces of the die sets are rough and make it easy for handling when working with them. The sets will be able to withstand rusting and this is going to prolong their life span. The surfaces of the die set can be cleaned easily after use because of the material it is made of. As a tool, die sets were used to emboss samples and numerous jewellery elements and they did not show any sign of wearing. This attests to the resilient nature of the tool and the brass in particular. The test runs using the die sets show that they are suitable for ensuring material economy in jewellery production as because they can be used for mass production of jewellery elements using less labour and time. The embossed jewellery elements were done on 0.05mm thick metal sheet and some of the embossing could produce depths of about 5mm. This depth is an indication of the degree of three dimensionality of the elements produced with the die sets. Work pieces produced from the die sets are hollow, light weight yet bulky. It means that with little material, a goldsmith can emboss jewellery elements with three dimensional forms using their sheets. This supports Bawa's assertions that one of the advantages of metal stamping is that weight of fabricated parts are low.

The use of the die sets reveal that it is efficient in reducing effort and production time needed for mass production of jewellery elements by gold/silversmiths. When metal sheet is milled to the required thickness, made into blanks and annealed, numerous copies of jewellery elements could be stamped within a short possible time. With this the die sets can help the user produce a lot at lower cost using less labour. It does take little time to align die and punch together when using them in embossing processes. During embossing, a user needs to use hammering method to register desired impression on a metal sheet. It shows how studio friendly and less effort needed to put the die sets into use. It is also an indication that the die set does not need any expensive mechanical means to operate. The die/punch sets produce quality embossed pieces. This is evident in the samples of jewellery elements which were produced from them. It is because metal sheets used are standardized for embossing and give even thickness. The tools enhance production of the same thickness and sizes of embossed elements which do not change because the same die/punch set are used for numerous copies. Embossed pieces produced from the die sets have sharp, clean contours and smooth surfaces due to the smooth die/punch surface and proper working clearance between the die, punch and pilot pins.

The sharp boss outline makes it easy to remove fins around the embossed elements.

The embossing die/punch set and the embossed image in figures 101a & b is titled ‘Papaye’ Good action. It was developed from a bolt. Bolts and nuts are helpful materials used in several ways to get things secured. The symbol ‘papaye’ depicts morally good action which is needed in society and therefore should be encouraged by all and sundry.

The die shows the design in intalio while the punch portrays the design in cammeo.



a

b

Fig. 101a & b: Papaye Die/punch set and embossed piece

The embossed impression in figures 101b shows an arc at the top joined at the middle with a vertical body which gracefully splits into two parts; one to the left and the other to the right. It shows that one half of the parts is a facsimile of the other resulting in a symmetrical arrangement. The relief embossed from this set came out successfully. The embossing die set can be used to produce several copies to be used as jewellery elements. The second embossing die/punch set and its embossed impression as shown in figures 105a &b is titled "Ako-ben". It has been designed and developed from Adinkra symbol "Ako-ben" (war horn). Literally, it is a symbol of war. The symbol is significant because socially it means being prepared to perform duty.

a

b

Fig.102a &b: Ako-ben Die/punch and embossed piece

The embossed impression is a horn-like form which sits on top of three horizontal stacked ovals. The image as seen on the punch is in a high relief (cameo) and in a low relief (intaglio) on the die. The die and punch show the 'reflected' images and the two parts align with each other perfectly. The sample bosses obtained from the die set have been successfully produced and therefore the punch/die set can be used for mass production.

Another interesting die/punch set with its embossed image is the one titled "Ahoɔfɛ ntua ka" (Figures 103a & b). The title literally means "beauty does not pay a debt". The implication here is that beauty is not in itself enough, but must be accompanied by good character. This is one Ghanaian moral value used to encourage children, especially girls, to develop upright and decent character. The "Ahoɔfɛ ntua ka" design is from a natural source. It is from a sea snail shell found at the seashore. With its flesh inside it, human beings and birds alike eat it; when dead without the content, the shell lies beautifully on the beach without anybody paying attention to it, hence the title of the set.

a b

Fig. 103a & b: Ahoɔfɛ ntua ka Die/punch set and embossed piece

The motif which was picked and used directly from the environment shows how beautiful nature is. The image as shown in 103b shows nine segments on it with the biggest being the head. The joints between the segments from wavy diagonal lines as the segments

gradually reduce in size from the head to the tail. The image obtained from the "AhoɔfƐ ntua ka" die/punch set was successful and demonstrates that the die/punch set can be used for mass production.

The next die/punch set and its embossed impression in figures 104a & b is titled "Konsonkonson" (link or chain). It has been developed from the Adinkra symbol. The symbol can be said to imply that as people, Ghanaians are linked in both life and death.

a b

Fig.104a & b: Konsonkonson Die/punch and embossed piece

The message here is that those who share common blood relations never break apart. This is a symbol which reflects unity and responsibility and epitomises human relation. The symbol which is believed to have been created from a handcuff shows two sides put together. The body as shown in figure 104b shows raised image like a butterfly without a body. Each of the halves gives lower impression at both sides of the raised middle body. At the top, the impression at the middle splits to the left and right in simple arcs at both ends. The body bends sharply at both sides, curve out and join at the base to the middle body. The parts of the embossing die/punch set show symmetric organisation. It can be used to produce several copies of the same jewellery elements.

The next die/punch set and the embossed impression in figure 105a & b is titled Kra Pa (Good fortune and Sanctity). The design is an Adinkra symbol Kra pa and connotes sanctity

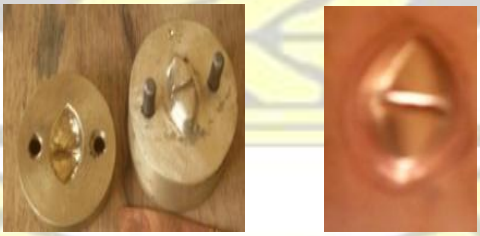
and good fortune. It is a symbol which is used to ward off negativity. The embossed design as shown in 108b shows four axe forms joined together symmetrically. The edges of all the four axes project outwardly. Perhaps that is why it is a symbol used to ward off negativity.

a b

Fig. 105: kra pa Die/punch and embossed piece

The design on the punch is in high relief (cameo) and in intaglio on the die. Both parts align with each other perfectly in use. The embossed pieces from the die/punch set were successful without any kinks or folds and can therefore be used for mass production.

The design in figure 106a &b is embossing die/punch set and impression dubbed 'perper' (justice). It is derived from per meaning exact or equal. Thus, socially, 'perper' means 'Two equals' as it were in a balance;this further means a man must be fair and just in whatever dealings he has with his fellow man. It is a traditional value which teaches one to eschew injustice and embrace justice.



a b

Fig.106a & b: Perper Die/punch set and embossed piece

The embossed image is actually two images in one: it shows two curves which start from the top and meet at the base in high relief. They are only seen as two equal forms due to a low relief line at the middle. Though it was devloped from two triangles, its two sides one curved to enhance its looks and also to avoid undercuts during embossing.

The embossing die/punch and its impression in figure 107 is titled Ntesie Mate Masie (I have heard and kept it). It is an Adinkra symbol. The symbol means what one hears, one should be able to keep it; in other words, one should be able to keep secrets. Hence it is not prudent to engage in gossiping, rumour mongering and eavesdropping as they do not show a sign of maturity and wisdom.

The embossed design from this die/punch set (Figure 107 b) shows an interesting image. The centre has kite-like shape in low relief. This kite-like shape is the result of four combined circles in high relief, each with a raised dot pointing downwards.


a


b

Fig. 107a & b:Ntesie mate masie die/punch and Embossed piece

The overall form of the boss is three dimensional and buttresses the fact that the die/punch set is ready for mass production of jewellery elements. It is a successfully finished die/punch set which can be used for mass production.

The embossing die/punch and the embossed image (Figure 108) titled “Akokoduru” (Bravery) which literally means ‘heavy chest,’ has been developed from geometric shapes: triangles and semi circles. Its title represents a Ghanaian traditional value. The design implies that one should show bravery in the face of threats, menace or war. It is also used to describe moral courage.

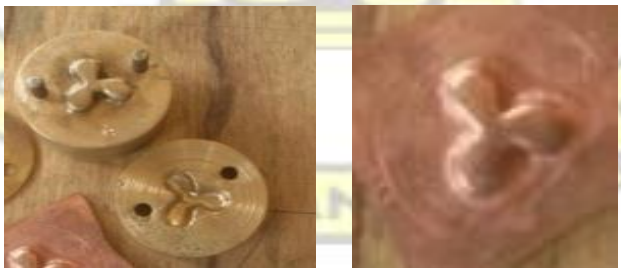
a

b

Fig.108a & b: Akokoduro Die/punch and embossed piece

The embossed design from this die set (Figure 108b) shows radial arrangement. At its centre is a circle in high relief. From this circle radiate eight tear drop forms in a circular manner giving the total configuration of the image its roundness. The overall effect is three dimensional yet again confirming that the finished die/punch set can effectively be used for mass production.

The embossing die/punch set and the embossed work piece (Figure 109a & b) is titled “Enyimnyam”(Splendour of face).



a

b

Fig. 109a & b: Enyimnyam Die/punch and embossed piece

The design was developed from geometric shapes: three circles. It represents Ghanaian indigenous value which by the design represents the countenance of God shining upon the individual who wears it.

The embossed design from this die/punch set (Figure 109b) shows three circles joined together. At the centre, the boss shows one round form which serves as the body, and other two circular forms which are attached to each other like wings to the middle one. This makes each circular form points in a different direction. The main body of the boss shows a three dimensional effect. It is a successful finished die/punch set which can also be used for mass production.

"Gye Nyame" is the name of the image on the die/punch set and the embossed work piece shown in figure 110a & b. It is an Adinkra symbol; it is the symbol that has been used to develop this die/punch set. Literally, the Gye Nyame" means only God.

It is a symbol of omnipotence and immortality of God. This symbol is used in recognition of God as the source of life and to promote spirituality through righteousness. The design resulting from the embossing as in figure 110b represents the original "Gye Nyame" symbol but now made in high relief.

a b

Fig.110a & b: Gye Nyame Die/punch set and embossed piece

The image has an undulating body. On the right top side, a horn like form is attached to the body. At the left bottom is another horn like form which is attached to the body and balances the one at the opposite side. This embossing die/punch set can also be used to produce several copies.

"Odo" (Love) is the title of the image on the embossing die/punch set and the impression shown in the figure 111 a & b. Ackah (1988) states that there is a saying in Akan that, "odo ye owu", meaning 'love is death'. This is often used to refer to love between man and woman and suggests that it is only death that can separate people who really love one another.

The image on the embossed piece as shown in 111b shows two oval forms with a low relief line at the middle. Its body shows togetherness. The wider part of the two oval forms are seen at one side and the narrow sides also at one side. The oval forms represent a wife and a husband and shows that though they are two, they are one because of love.

The embossing die / punch set can be used to reproduce several ones.

a b

Fig. 111a & b: Odo Die/punch and embossed piece

The image on the die/punch set as shown with it embossed work piece in figure112a & b is “Biribi wo soro” (There is something in heaven). It is an Adinkra symbol. It is a symbol which signifies hope. The symbol represents a belief of God’s goodness and man’s reliance on him for sustenance.

a

b

Fig. 112a &b: Biribi wo soro Die/punch set and embossed piece

The design resulting from the embossment as shown in 112b represents the original “Biribi wo soro” symbol but in high relief. It has two low relief sides surrounded by a curved high relief form. The two low relief areas are held by the high relief form at the centre. At the centre of the middle body is a kite like shape where pointed ends are seen in the two opposite low relief areas. The embossing die/punch set can be used to reproduce several bosses.

The adaption and use of die/punch by local gold/silversmiths could be done because the technology needed to produce the die/punch sets is ably supported by local studio methods which makes it economical but gives quality three dimensional jewellery elements outcomes. It is clear that the jewellery elements produced weigh less as it would have weighed when produced with the traditional techniques being employed by Ghanaian goldsmiths and silversmiths.

6.2 Results and Aesthetics of the Jewellery Sets

This segment of the project resulted in creating a set of strong and magnificent jewellery sets from some selected die/punch sets. The first jewellery set titled 'Expectations' comprises a bangle, a pair of earrings and a necklace made from "Kra pa" and "Biribi wo soro" (There is something in heaven) Adinkra symbols respectively.

Fig. 113: Bangle

Each "Biribi wo soro" element measures 2.6 by 2.3cm and each "Kra pa" element measures 2.5 by 2.5cm.

The bangle has inner circumference of 17.5cm and weighs 35.5g. It has two semi domed ends soldered to two rectangular rods. The two rods are soldered together and curved in a circular manner with an opening between the two semi domed ends (Figure 113). At the centre and on the two rods is attached a "Biribi wo soro" embossed element with one of the rectangular rods curved in semi circular shape on back of the embossed element. This creates an opening which balances the opening between the two domed ends of the bangle. Arrangement of the parts of both bangle and earrings forms a symmetrical whole. Figure 114 shows a model wearing the "expectations" jewellery set. Each earring measures 6.5cm

long and weighs 8.9g. The earring has been made by linking a “Kra pa” and “Biribi wo soro” elements with three jump rings.

Each embossed element has a jump ring soldered to it and the two rings are linked with a third rectangular ring at the middle. The pair of earring has a pin attached to the stud part and a chain connects this to the hanging component enabling the earring to dangle as and when the wearer is in motion. This interesting effect is also seen in the way the elements in the necklace have been organised.

Fig. 114**:** Expectations set on a model

The “Kra pa” and “Biribi wo soro” necklace is composed by linking chains and embossed jewellery elements. It measures 40cm by 11cm and weighs 50.6g. The necklace looks bold and bulky but is light in weight. The necklace rests comfortably around the neck and chest when worn. The embossed elements are organised in a triangular form. The body of the necklace is in three parts: a chain on the left and right sides with the organised embossed elements at the centre. The embossed “Biribi wo soro” element is repeated four times at the top. The first and the fourth are linked with chains from both left and right sides respectively. This is followed by three embossed “Kra pa” repeat elements; two embossed “Biribi wo soro” elements and one embossed “Kra pa” element in a rhythmic fashion. Each

embossed element is linked to another with three jump rings except the last two "Biribi wo soro" embossed elements which are linked with five jump rings. At the left end of the chain is a round rod finding soldered to a jump ring; followed by flattened thick rectangular rings, each going over the other with two semi circular rings soldered and hooked onto other rectangular rings. This has been repeated six times. The chain elements at the opposite side are the same as those on the left, but the chain elements are in a repeat of five with a finding which is a rod in the form of '8' linking it to the main chain.

This jewellery set is made of copper and has been oxidised and lacquered (Figure 115). The jewellery set has smooth surface. Its dark brown colour reveals reddish colours through the dark brownish surface. The embossed elements in the set present different layers of reliefs which show three dimensional effects. The jewellery set is gorgeous and bold. The elements in the necklace have been organised in a formal manner using a triangular and symmetrical balance.

Fig. 115: Expectations set

The jewellery set shows creativity and elegance and could be worn with both dark and light coloured dresses to achieve either harmony with dark dresses or contrast with light dresses. Though each segment of the set could be worn separately from each other, when worn together, it portrays togetherness and belongingness.

The second jewellery set titled "Ahoɔfƹ ntua ka" has been made by linking embossed elements from "Ahoɔfƹ ntua ka" (Beauty does not pay a debt) elements. It is made up of a pair of earrings and a necklace. Figure 116 shows a model wearing "Ahoɔfƹ ntua ka" jewellery set. The necklace when stretched, measures 40 by 5.3cm and weighs 56.1g. Each earring also measures 8cm long and weighes 5.0g. As already alluded to in the appreciation of the "Ahoɔfƹ ntua ka" die/punch, the motif which was picked and used directly from the environment shows how beautiful nature is. The motif shows eight segments with the biggest being the head. Each segment is carefully attached to the other by a curvy diagonal line as the segments gradually reduce in size from the head to the tail.

Each earring has an "Ahoɔfƹ ntua ka" embossed element soldered to a round ring at the top. This is linked to a rectangular ring; followed by a round ring which is attached to a finding which helps the earring to dangle at any time. The finding is a round thick wire which has been twisted in a flamingo like form with a granus at the end and soldered at the back to the body of the finding. This makes the earrings stand out and hang on the ears easily. The necklace shows a repeat of eleven embossed "Ahoɔfƹ ntua ka" (Beauty does not pay debt) elements linked to a chain.

Each embossed element is linked to the chain with three jump rings. The chain is composed of thirty one major rings in the form of number ‘8’ and are linked by thirty flatened rectagular auxilary rings which give a sense of repitition and orderliness. Both ends have findings which enable a wearer to hook and unhook the two ends of the necklace.

Fig. 116: Model wearing Ahoɔfƹ ntua ka

When the jewellery set is worn, the necklace relaxes around the neck and the embossed elements give three dimensional outlook. The jewellery set is electroplated in gold and has smooth surface (Figure 117). The necklace, when worn together with its earrings, show uniqueness, glamour and exquisiteness.

Fig. 120: Ahoɔfƹ ntua ka set in gold

In all, twelve different embossing die/punch sets were produced and used to emboss a variety of elements. Some of these embossed elements were selected and assembled into different jewellery pieces. This embossing method can be employed by Ghanaian goldsmiths and silversmiths to meet customer orders which demand mass production. The next chapter focuses on summary, main findings, conclusions and recommendations made from the study.

CHAPTER SEVEN

SUMMARY, MAIN FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

7.0 Overview

This chapter discusses the main findings obtained from the study. It also contains the summary of the study, conclusions and recommendations.

The study sought to identify suitable methods and locally available tools/ materials for the production of dies and punches; design and fabricate embossing dies and punches suitable for producing light weight three dimensional design elements; and assemble the design elements into jewellery pieces of low unit weight. In view of this local gold and silversmiths were interviewed for necessary data regarding the study.

7.1 Summary

The creation of the embossing dies and punches has been achieved through exploration of different methods. The design methods were based on three areas: ideas which were conceived and developed into shapes: shapes which were found directly in the researcher's environment and those from Ghanaian cultural symbols. This has brought variation in the shapes found on the dies. All the dies and their corresponding punches were tested to ensure their functionality. More importantly, three dimensional work pieces were made using the dies and punches and the embossed pieces served as elements for assembling into jewellery sets.

The main objective of this study was to explore studio based methodology as well as available materials for the production of dies and punches. The dies and punches were meant for the creation of embossed three dimensional designs. The ultimate aim was to develop techniques which could be used to create dies and punches for embossing jewellery elements at the studio level in shorter production time.

This research started with the collection of relevant data for the review of related literature. In order to assess the understanding of goldsmiths and silversmiths regarding the use of dies and punches and the kind of material they were made of, it became necessary to visit jewellery shops to seek for first hand information. The exercise was documented in texts, tables and visuals. Interviews and observation were the research instruments used by the researcher to collect the necessary information from the respondents. Brass was the main material used in this study. Sand casting and embossing were the major methods utilised in the project.

7.2 Main Findings

The main findings obtained from the study are as followings:

1. Gold and silversmiths do not explore their design ideas using embossing methods as they do not have enough knowledge on how to create dies and punches for that purpose.
2. Local gold and silversmiths mostly produce domed and semi domed elements for pendants, earrings and necklaces because they only rely on doming blocks and metal punches.
3. Local studio technology supports the use of brass for making dies and punches. 4. Already existing designs such as Adinkrah symbols can be made into dies and punches.
5. It is possible to use sand casting to produce dies and punches at the studio level.
6. Images produced from the dies and punches are three dimensional in form.
7. The punches and dies can be used to emboss images on sheet metal from Milo, milk and coke cans.

The data gathered from the field research were of paramount importance in that it gave the researcher insight into materials available for making dies and punches as well as the kind of works gold and silversmiths produce. With these experiences, the researcher was well

informed to make the right decisions regarding designing and the choice of materials for the project.

7.3 Conclusion

The study, 'Design and Production of Embossing Dies and Punches for making Three Dimensional Jewellery Elements' has yielded a lots of insight worth learning from.

1. There are many designs and images that reflect Ghanaian culture which could be transformed into dies and punches to produce three dimensional jewellery elements.
2. The concept of die-forming has not been explored much in the Ghanaian jewellery industry.
3. Brass as a chief material in this study is readily available locally. Its hardness, resistance to corrosion (under normal condition) and its workability in studio make it a material of choice.
4. At the studio level, dies and punches could be used for mass production of jewellery elements within a fairly long possible time.
5. Ghanaian gold and silversmiths and students need to turn their attention to lesser used jewellery methods of production such as embossing which starts with the development of one's own ideas into designs, then into dies and punches and finally use these tools for production.

6. Prices of precious metals for jewellery is a major factor in pricing jewellery products but adaptation of appropriate methods such as the making and usage of dies and punches in the studio practice would contribute to the reduction of the overall cost of the end products.
7. Apart from the traditional jewellery metals, embossed elements could be created from tins and cans found in our environment as waste.

To conclude, it is evident from the foregoing that designs from cultural symbols, natural sources and self-generated ideas can be transformed into dies and punches at the studio level for downstream production of light weight three dimensional jewellery elements to save time and reduce product cost.

7.4 Recommendations

From the main findings and conclusions emanating from the study, the following recommendations have been made for consideration:

1. Gold and silversmiths should use studio practice to fabricate basic tools such as dies and punches to increase the spectrum of jewellery designs produced.
2. Brass should be used by local goldsmiths to produce their dies/punches not only because it is fairly durable but also it is locally accessible and can be worked by local studio level technology.
3. Young jewellers especially students should be encouraged to explore ideas from their environment as design inspiration for die and punch production.

4. Local gold and silversmiths should adapt this study to enable them cut production cost by using dies/punches to broaden the production technology base.
5. The creation and use of dies and punches should be encouraged in the jewellery sector for the mass production of three dimensional jewellery.
6. Local gold and silversmiths should be trained to make their own dies and punches.
7. Punches with very low relief and their corresponding dies could be made to emboss cheap jewellery elements from discarded tins and cans found in our environment.

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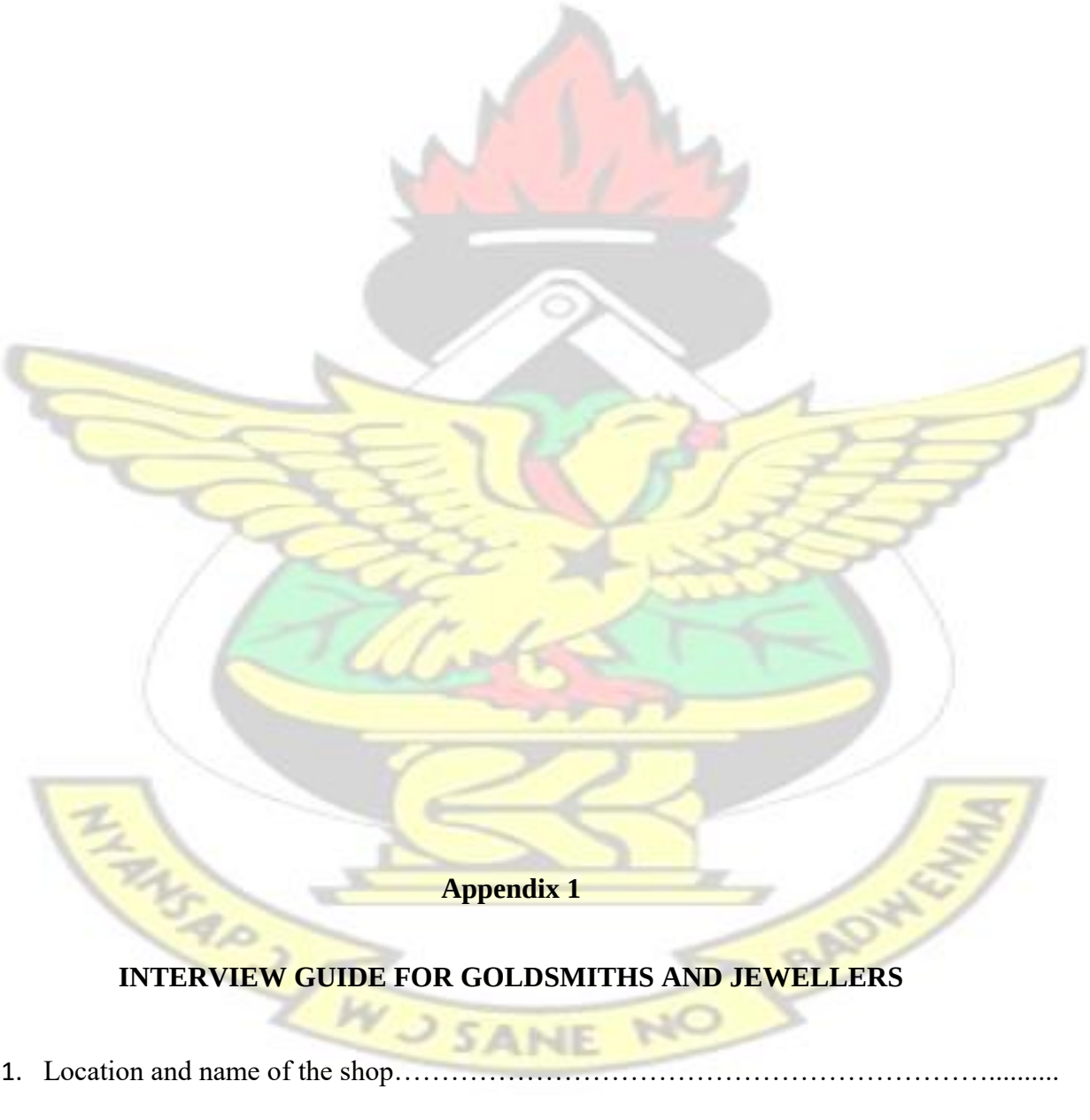

Appendix 1

INTERVIEW GUIDE FOR GOLDSMITHS AND JEWELLERS

1. Location and name of the shop…….....

2. For how long have been in the goldsmith trade? ……..

3. How did you learn the trade?

   Apprenticehip …… Gifted ……. School

4. How did you learn it? .....

5. Does the current price of precious metals (gold and silver) affect the costing of your finished produce? Yes……. No…….

6. Please explain your answer……

   ……

   ……

7. What are the reactions from your customers when you tell them the cost of your work or the work they want to buy from you?

   .....

   .....

   .....

8. What kind of works do you produce?

   ……

   ……

   .....

   ……

   ……

   ……

9. What methods do you use to fabricate your works?

   Casting…… Piercing…….. Forging…… Filigree…….

Others……

……

10. Do you produce hollow works?

.....

.....

.....

11. Please explain your answer……

……

……

12. Do you use punches and dies?

.....

.....

13. What works do you use them for?

.....

.....

.....

.....

Appendix 2

OBSERVATIONAL CHECK LIST

1. Location and name of the shop……
2. Size of the shop small scale …….. Medium scale……large scale……
3. Works Found Method of Production

4. Rings
5. Chains
6. Pendants
7. Earrings
8. Bracelets
9. Anklets
10. Others……

    ……

    ……

    ……...

11. Punches Yes……. No…….
12. What materials are they made of?
13. Iron
14. Steel
15. Brass
16. Wood
17. Others……

    ……

    ……

    ……

18. Punches made of foreign materials? Yes …… No …….
19. Punches made of local materials? Yes …… No …….
20. Dies

21. What materials are they made of?

22. Iron

23. Steel

24. Brass

25. Wood

26. Plastic

27. Others……

……

……

28. Are they made of foreign materials? Yes……. No……..

29. Are they made of local materials? Yes…… No …… 30.

General observation……..