Challenging the Aesthetics and Functionality of Metals in Contemporary Blacksmithing

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Declaration

I, Justin Lucas & 212423967, hereby declare that the treatise/ dissertation/ thesis for *Master of Technology: Fine Art to be awarded* is my own work and that it has not previously been submitted for assessment or completion of any postgraduate qualification to another University or for another qualification.

Justin Lucas

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Abstract

A forge allows the creation of both utilitarian craftwork and artworks. It is difficult to find blacksmiths who are willing to pass on their knowledge, particularly in South Africa where the art of blacksmithing is practised by a small number of individuals who rely on their labour for an income. This dissertation documents the building of a forge and what is needed to practise the art of blacksmithing, sourcing of the materials, and the application of blacksmithing to make pleasing artefacts. The document includes the processes of forge tool-making, providing an avenue for future students to fabricate tools and use the processes for art-making as well as list of suppliers and list of blacksmiths in South Africa.

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Chapter 1 : Introduction

1.1 Purpose

The purpose of this study is to research the art and craft of blacksmithing in South Africa with the intention of building a forge at the Nelson Mandela University in order to create aesthetically pleasing artefacts and to determine the viability of blacksmithing as a career.

1.2 Rationale

1.2.1 Background

There was a time when every village had a blacksmith with the skill to craft hinges, horse shoes, agricultural tools and weapons. It took thousands of years to develop the art of blacksmithing, which became an important tool in man's cultural development and subsequent civilization (Appalachian Blacksmiths Association 2015).

Iron is an abundant material found in the earth's crust while natural coal is used in the working of iron. The physical properties of iron offer so much more than copper or bronze as it is stronger, and does not break or crack on impact. It has many uses, especially in construction and for making weapons. Blacksmithing was born at the start of the Iron Age with the Hittites, who made their home in an area that was known as Anatolia (Ares 2004). Iron metallurgy spread rapidly from the Near East, carried from Cyprus to the Aegean by the Greeks, and then to Sicily, Italy, and onwards by means of the trading undertaken by the Phoenicians (Ares 2004).

According to Drury (1986) there are three types of iron, namely are cast iron, wrought iron and the contemporary material, milled, or mild steel, as it is commonly known. Wrought iron is the oldest of the irons and was initially used for making hardware such as nails or door hinges, weapons and agriculture. With the development of forging skills, wrought iron became ornamental and was used to decorate building doors and railings. By the 11th century wrought iron was being formed into scrolls used as hinges for church doors, for example, as well as flat patterns. It became so popular that decorative ironwork served as a protective barrier around tombs and monuments.

In the early 18th century wrought iron decorations became an art form in their own right after many commissions had been undertaken for important patrons such as Louis XIV. The popularity of the art form developed to the extent that artists would produce catalogues of designs for wrought-iron work (Drury 1986).

1.2.2 Personal triggers

I have always been fascinated with the history of the Greeks, the Medieval period, and those early civilizations who made use of the sword as a primary weapon. Films such as *Troy*, *Gladiator*, *Kingdom of Heaven*, and *A Knight's Tale* encouraged my interest in and desire to read about the history of their weapons and armour. As a young boy I made wooden swords in my father’s workshop and played make-believe battles so intense that I named my swords. As I discovered more about other cultures and their weapons, I fell in love with a weapon of precision and flawless craftsmanship known as the katana.

My love for antique weaponry has continued today, together with the desire for decoration. To me, if a weapon or object is used in the service of man, why not have it look flawless in appearance?

In my B.Tech year I created a series of Corinthian helmets modelled on those worn by the soldiers of Greece. Each of these helmets represented the various gods of Greece and was decorated in its own unique manner. The helmets were made of plaster of Paris, not steel, and my mentor suggested that I explore the art of blacksmithing. I started to watch videos about blacksmiths and how today the tradition of sword-making, plate body armour and many more artefacts is continuing through the art of blacksmithing. I was inspired to build my own forge (both stationary and portable) in order to create artworks and artefacts of my own and perhaps even use blacksmithing as a tool to further my career.

1.2.3 Previous research

Jean Tijou, born in France around the 17th century, was a master blacksmith who made flamboyant ironworks for the Hampton Court Palace gardens in England and at St Paul’s Cathedral (Drury 1986). King William and Queen Mary were his patrons from whom he received the title, England’s Best Wrought-iron Designer, according to Dyer (1917). Tijou was especially?specifically ? an ironwork designer and one of his most popular works is the Privy Garden screen, at Hampton Court. He also designed the ironwork for St Paul’s, where he was employed for twenty years (Dyer 1917). Tijou’s work was not limited to royalty and the important buildings of England; it can also be observed surrounding private mansions and country estates. Not much information is available on Jean Tijou; no one knows much of his previous works in France or in Holland, or even the source of his training (Dyer 1917).

Figure 1

The iron screen by Jean Tijou at the end of the Privy Garden at Hampton Court Palace (Baty 2010)

Julio González was born in Barcelona. At the age of 15, González started an apprentice-ship as a goldsmith with his brother, and in the evenings he studied drawing at the Barcelona University of Art. González then moved to Paris with his family. There he met artists such as Picasso, and many more, after which he made the decision to become a painter. González eventually abandoned painting and took up blacksmithing in order to make a living from it. He started to focus on metal sculpture, and also trained to weld, a skill that would help him in his future work. His first sculpture was constructed out of wrought iron, from which he made human figures. Picasso in fact learned his metal-working from González, who, influenced in turn by Picasso's work, produced more abstract, and also massive, sculptural pieces (Art Directory n. d.).

David Smith’s career is impressive, as is the intensity of his sculpture. He is known as a metal sculptor in the contemporary arts although he was trained in the art of painting (at the Art Students League (1927–32). He taught himself how to sculpt, inspired by the post-Cubist sculpture of Pablo Picasso and Julio González. Smith wished to learn more about the potential of cast bronze and aluminium, of forged iron, of ceramic art and, to a limited extent, stone carving (Wilkin 1984). Known exclusively as a sculptor of welded metal, he loved working in isolation – at his studio at Bolton Landing. His sculpture was inspired by Picasso’s iron artworks, and so in 1933 his interest in working with forged iron began (Hunter 1957). Smith was a pioneer of constructed open-metal forms and welded free-standing sculpture. From his work one discerns that he is aware of current aesthetic concerns, and it can be said that his sculptures respond to the wars, concerns or regional conflicts of the time within which each piece was constructed (Wilkin 1984).

Figure 2

Cubi XII (1963), stainless steel, David Smith (Arts Inventories catalogue 2016)

Kashief Booley is a local blacksmith in South Africa whose smithy is located in the small village of Prince Albert in the Karoo. "The minute I first saw a blacksmith at work, I was fascinated. Fire and human creativity are powerful elements. And metal is a comfortable medium for me. I love designing and working with it," Booley is quoted in *Karoo Space* (2017, p.1). Kashief's work includes chandeliers, chairs, tables, gates, grates, wine racks, bed frames, lanterns, butcher’s racks, burglar bars, door handles - in fact anything a blacksmith could imagine (Karoo Space 2017).

Figure 3

Kashief Booley (Karoo Keepsake 2 2017)

Conrad Hicks is a recognised South African artist/blacksmith renowned for hand-forging metal sculptures and architectural works. His smithy is located in Cape Town, occupying an old Art Deco cinema known as The Bijou in Observatory. He studied art at the Cape Technikon, finishing in 1986. At his forge Hicks has developed and refined his own methods which do not involve any welding as he believes this devalues the work. True to blacksmithing and traditional joining, he believes that the integrity of the artwork resides in the application of traditional materials and processes (Hicks 2013).

Figure 4

Chaise Muse, copper and stainless steel, Conrad Hicks (Southern Guild 2017)

Figure 5

Fallow Deer Buck, Wyre Forest, Gloucestershire (2012) (Freedman 2016)

David Freedman is a British artist and blacksmith, who first smelled burning coke from the Mark Cross Forge in Sussex. Freedman started his own forge in Cheshire, where he was raised (Freedman 2016). He always said that one should give back to that from which you have taken, that is, the landscape (Freedman 2016). Forging for over 20 years, Freedman made sculptures for private as well as public spaces, for galleries, parks and museums. His work is well known across the UK (Freedman 2016).

These artists all used blacksmithing processes as a means to creativity. It is the art of blacksmithing that I wish to master in order to be able to produce aesthetic blacksmithing products and artefacts.

1.3 Problem statement

Today the skills of the blacksmith (smithy) and his forge have been replaced by off-the-shelf cast metal, or even plastic products. Every conceivable item is available to the craftsman/handyman/decorator. Yet there has been a reaction to the dying out of manmade, hand-crafted products, and hobbyist artists and craftsmen are returning in ever increasing numbers to the practice of blacksmithing. Generally in South Africa, however, blacksmiths are few and far between.

So the problem is both of a dying old trade and its associated skills and equipment, and identifying a suitable smithy who is willing to train interns while transferring skills and knowledge. The problem is further compounded by a lack of major resources (money, materials) and information (books and videos).

1.4 Research question

How does one become a blacksmith, then learn to apply this trade to produce both the functional and the aesthetic object in order to produce a sustainable livelihood?

1.4.1 Main questions

- How does one start to become a blacksmith in South Africa?
- Where does one source the information, tools, equipment and training that the apprentice blacksmith needs?
- How does one build a forge?
- What tools are needed in a blacksmith's forge?
- What materials does one use and how are they sourced?
- Can one make a living from practising as a blacksmith?
- What artefacts would one make?

- Where would one find a market?
- Can weaponry be considered to have aesthetic qualities?
- What would be a sustainable bread-and-butter line?

1.5 Objective

The overarching objective of this study is to create a working forge within which I can make artworks using blacksmithing methods. It is also a way of introducing blacksmithing as a subject within the Fine Art and Sculpture departments. This will enable students to learn about the role of metal in sculpture, and the skills required to make a career as an artist.

Knowledge of forge
Knowledge of materials
Knowledge of equipment/tools
Knowledge of skills and application
Knowledge of practice mentors

Metal Stock

Commissions

Designs

Functional artefacts
Doors + Hinges + Hooks + Railings + Knives
Props+ Farriers + Tools + Lighting

Aesthetic artefacts
Sculptures + Weaponry

Markets

1.6 Theoretical framework

1.6.1 History

Looking at how ironwork techniques began, Ross (2002) believes that the technology of iron forging and smelting is known to have been used among the Nok people in Nigeria from around the sixth century BCE. Iron technology was a fundamental necessity for the growth of the centralized kingdoms in the western Sudan as well as along the Guinea coast of West Africa (Ross 2002).

The Kingdom of Dahomey (today southern Benin) was very well known for its artworks. The Dahomean kings maintained royal artisan guilds that specialized in both the metal and textile arts (Blier 1988). It is known that the large metal sculptures were not cast but instead were carved out of wood and covered by metal sheets fixed in place using hammers (Blier 1988). Prisoners of war were forced to work as blacksmiths, and some were of royal blood, according to Blier (1988). Dahomey's art was mostly created through the form of assemblage, meaning that it was made up of separate parts (Blier 1988).

Blacksmithing played a significant role in the creation of weapons, and much more so in the three great empires of the savannah lands of western Sudan (McNaughton 2015). Smiths learned the art of creating guns from the Moroccans, who invaded the Sudan in 1591 CE, and today it is still commonplace for hunters to purchase guns from a smithy (McNaughton 2015).

An excavation of the west and east Transvaal led by R.J. Manson and T.M. Evers in 1971 uncovered clay-floor huts the floors of which were scattered with iron tools, well-preserved agricultural seeds and animal remains, along with some pottery (Mason 1973). These excavation sites also led to the discovery of metal-smelting furnaces (Mason 1973). Two types of furnaces exist in South Africa, divided into classes: Class 1 is a bowl furnace, a hole that is dug in the ground and which has a low rim above ground; whereas a Class 2 furnace features a super-structure, on which is a [1]tuyere inlet. Some Class 2 furnaces have up to three tuyere inlets (Friede & Steel 1985).

We already know that blacksmithing as a trade started with the Iron Age after the first person became aware of iron-rich rocks and observed that when these were heated to a certain point, a molten liquid would ooze from the stone. But it took man three thousand years to understand the properties of metallurgy (Appalachian Blacksmiths Association 2002). The Hittites are the first people known to have melted iron ore and worked with wrought iron around 1500 BCE (Appalachian Blacksmiths Association 2002).

Once charcoal had been discovered, with its properties of burning at a very high temperature so that it extracted quality iron ore, this method was put to use in a small furnace constructed out of clay and called a bloomery. With the help of manually operated bellows, air was forced into the furnace to get the charcoal to burn at high temperatures. Iron ore was placed on the charcoal and after hours of waiting, a fist-size piece of bloom or a porous mass of iron and slag was produced. By hammering the bloom into desired shapes, the blacksmiths were able to make tools and weapons. It was a very specific skill: a striker would hammer the iron into a rectangular bar, which would then be folded and hammered again, and this continued several times in order to get rid of the impurities (Appalachian Blacksmiths Association 2002). The skill of a blacksmith became very important as iron started to play a central role in daily human life. As many new skills were being developed and many taught, so more uses for iron became relevant (Jones 2011).

In the thirteenth century, the bloomeries were increased in size and the bellows ran on water power. This also meant bigger bellows and the use of trip or tilt hammers to hammer larger blooms. The blacksmith became so advanced in his trade that eventually he was producing weapons, armour and tools. Specialists started calling themselves armour-ers, bladesmiths and swordsmiths instead of simply smith (Jones 2011). One

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[1] Tuyere is the nozzle through which the air flows which is then forced into a smelter or a forge (Dictionary.com 2016).

needs to understand that blacksmiths were very much involved in the "military-industrial complex" (Appalachian Blacksmiths Association 2002, p.8).

A significant advance in blacksmithing and metalworking was the blast furnace according to Jones *et al.* (2011, p.6), with "the first one being set up in Newbridge Sussex in 1496, and [it] was to supersede the bloomery completely". Cast iron was produced in large amounts, but in the beginning there were limited uses for it other than the casting of cannons and cannon balls. In 1543 It was recorded in Sussex that cast iron was so plentiful that, most of it was made into wrought iron. By 1700 the Industrial Revolution had begun and both cast iron and wrought iron were used to build machinery. This marked the end for the hardworking labourer as machines were faster and more productive. By 1975, wrought iron had become outdated and was no longer being produced as it was far more expensive to produce than steel.

1.6.2 Materials

The material that blacksmiths originally used was wrought iron as it was easy to come by, very strong and not that expensive. Today blacksmiths use mild steel - it is the wrought iron of today. Although wrought iron is still obtainable, there is little call for it because of the technological advances in steel-making. Blacksmiths go to scrapyards to find steel to forge, commonly from scrap vehicles or scrap from construction sites. It is important for a blacksmith to know which materials to use as different steels a unique way of being handled in a forge.

Metals are known for the shine they give off when polished. However, before the buffing process, most ferric metal colours appear grey, greyish and white, while the non-ferrous metals, such as copper and gold, are red and yellow respectively (Ares 2006). It possesses two qualities that help with manipulation: malleability and ductility. There are two groups of metals known to us ferrous metal, in which iron is present, as can be seen in the following examples according to Ares *et al.* (2006, p.16): "carbon steel (iron and carbon), stainless steel (iron, chromium, nickel, manganese, and silicon), grey iron

(iron, carbon, and silicon), and white iron (iron, carbon, and manganese)". The metals that do not contain any iron at all are known as nonferrous metals. These metals (or alloys) are copper, brass, bronze, aluminium, and zinc (Ares 2006). Improvements, such as strength and hardness, have been made to metal properties by combining them to make the alloys (Ares 2006).

Wrought iron is produced from pig iron in a special hearth and use a technique known as the puddling process. It is more expensive than mild steel (Rural Development Commission 1997). "Commercial wrought iron contains approximately 0.4 per cent carbon and 0.2 per cent slag which, during the process of manufacture, is hammered or squeezed throughout the mass of the metal, producing the well-known fibrous structure which makes wrought iron so easily recogniz-able when broken across the grain" (Rural Development Commission 1997, p.24). Wrought iron has two very important qualities: it can be drawn out (ductility) and it can be hammered into shapes (malleability). This is due to wrought iron's low carbon content (Rural Development Commission 1997). Wrought iron was once used in all types of con-struction work but today, metal with properties of ductility and resistance to corrosion is more sought after than high tensile strength. Wrought iron today is mostly used for ornamental works. The texture of wrought iron improves with careful forging, and as it is worked, it can be formed into intricate, delicate and graceful shapes far more easily than mild steel (Rural Development commission 1997).

Cast iron differs from wrought iron in that it is heated to a liquid state so that it can be poured into a mould. This is usually a sand mould, using a special sand mixed with a small amount of clay to assist with holding its shape in the precasting phase. Cast iron is easily identified because of its rough surface caused by the sand texture of the mould. A great deal of ironwork, such as window grilles, doors and other ornamental pieces, is cast at a foundry and not a blacksmith's workshop. Wrought iron, as opposed to cast iron, can be heated and beaten forever. Cast iron contains more carbon so when it cools down it crystallizes and becomes brittle and thus fragile (Appalachian Blacksmiths Association 2002, p.9).

Mild steel has less ductility and is not as malleable as wrought iron: However it has far greater strength in terms of its tensile quality. These properties are very important to forging. Mild steel can be easily forged and welded using a more limited range of temperatures than wrought iron. It contains 0.2-0.3 per cent of carbon so it cannot be hardened or tempered. Its structure shows as granular when cracked (Rural Development Com-mission 1997).

Medium carbon steel is harder and stronger than mild steel. It is easy to forge but difficult to weld. It contains 0.5-0.6 per cent carbon so it cannot be tempered and will not hold a cutting edge; however it can be hardened to a point (Rural Development Commission, 1997).

High carbon steel is well known for making cutting tools such as cold steel chisels which have carbon levels of 0.875 per cent. Steel with carbon levels of 0.75 per cent is used for hammer heads, hot sets, punches or drifts (Rural Development Commission 1997). The carbon levels of this steel range from 0.75-1.5 per cent, making it possible to harden it to a high degree and it can be tempered to hold a cutting edge (Rural Development Commission 1997). If high carbon steel is worked in the forge a great deal of care must be taken because of the narrow range of forging and the heat treatment temperatures - it can oxidize very easily or burn to the point that it can’t be repaired (Rural Development Commission 1997). Carbon steel's properties and characteristics are defined by its carbon levels. The most common steel used is that with a carbon level lower than 1.7 per cent. Carbon percentages higher than this classify the metal as cast iron (Ares 2006).

Damascus steel is an ultra high carbon steel with carbon levels of 1.0-2.1 per cent. The understanding we have of this steel is that it has outstanding properties and can be obtained with [2]hypereutectoid steels (Sherby & Wadsworth 2001). When wrought iron is worked in its heated stage, its hardness rises by a factor of two, making it stronger than copper or bronze. Before it is worked, it is already the same strength as treated bronze (Sherby & Wadsworth 2001). Damascus, being an ultra high carbon steel, already surpasses all metals in strength, even in its softest state, but when it is heat-treated it attains a very high hardness level, making it five times stronger than wrought iron (Sherby & Wadsworth 2001). Damascus steel has been around longer than most people think. The Persians created swords from ingots so old that legend tells of how the steel was developed in Atlantis, the Lost Continent, and from there was conveyed to India (Sherby & Wadsworth 2001). The steel was traded in an ingot form known as wootz. It was widely traded and got its name from the market places in Damascus, a trading centre known to thrive around the seventeenth to the eighteenth centuries. Alexander the Great was given a sword belonging to the Indian king, Porus, as a sign of respect, as well as a chest full of wootz ingots after Alexander had defeated him (Sherby & Wadsworth 2001).

1.6.3 Introduction to the tools and processes of blacksmithing

The forge is the heart of the blacksmith workshop. It is not difficult to build a forge from salvaged materials and most people invent their own layouts to suit themselves. According to Weygers *et al.* (1974, p.10) "the basin holds in its centre a sufficient mound of glowing coal in which to heat the steel". The bellows control the air flow to generate more or less heat. The device used to generate air flow can be a hand-cranked centrifugal fan or one that is operated by an electric motor controlled by an on-and-off switch. Some people have used a hairdryer that can be altered for the job. Many blacksmiths prefer the hand-crank blower as it will automatically stop when cranking ceases. Electrically operated machines should have a switch to stop air flow so the fire can lie dormant when the blacksmith is forging (Weygers 1974).

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[2] (Of an alloy) having more of the alloying element than the eutectoid composition (Dictionary.com 2016).

The shop should be arranged in a way that the blacksmith himself need only take one step in order to reach whichever tool he wants, for example, hammers, tongs, and the water trough and dipper. The forge should be located in the darkest area of the workshop so that the colour of the steel can be judged accurately.

The fire of the forge is very difficult to maintain as a clean-burning and effective heating tool, a skill that must be acquired. On a daily basis, remnants of coke as well as ash are left behind. According to Weygers *et al.* (1974, p.11) "…smoke and yellow flames indicate the burning of unwanted elements that are not pure carbon. When coal is heated it becomes coke, and like charcoal when lit, it gives off a blue flame and makes a clean fire." When the fire is smoking, it is dirty and not suitable for forging. Slag will form as the fire burns and it will lump together and plug up the holes of the air flow, causing the heat to decrease (Weygers, 1974). When designing a forge one must have a built-in ash pit with an easy-release door in order to empty the ash into a different container. In starting the fire, use is made of coke left from the previous fire together with a handful of wood chips, and a stack of fresh coal is kept close by. If the lumps are big, they must be broken down to pea-sized pieces. Where the coal is stacked close to the fire, water should be sprinkled over it so that the fire will not spread to the waiting/nearby coal (Weygers 1974).

The anvil is an expensive item. Second-hand anvils can be sourced but generally they are neglected. They are also rare as the mechanized industry has made/rendered blacksmithing an outdated profession. What can be used in place of an anvil is a section of a large-gauge rail from a railroad, which can be formed into an anvil. The anvil must be secured with bolts or spikes to a wooden block or a tree stump. The height of the anvil is also very important to consider. When working on it the anvil, including the height of the wooden blocks, should just touch the knuckles of one’s hand when one’s arm is dangling freely. This so that the hammer blow can hit the steel at a full arm's length. When the steel is struck, the anvil must not move at all (Weygers 1974).

The blacksmith vice or post vice, although very rare to find today, can nevertheless still be ordered from the modern hardware store. A normal machinist bench vise is just as good but must be the heaviest available (at least 15 kg), in order to beable to handle the blows of a hammer (Weygers 1974).

Blacksmith hammers are available in stores and have been improved by modern metallurgy. The cross peen hammer is known to be the most useful. One end is the cross peen used for drawing out, the other side is a flat or octagonal face with rounded edges which must be struck obliquely, not parallel, to the face of the anvil so no deep marking is left on the steel. Blacksmiths use a variety of hammers in different sizes and weights. According to Weygers *et al.* (1974, p.14). "…the flat and cross peen, and the flat and ball peen are the all-round blacksmith hammers. Sizes of 1, 2, 3 and 4 pounds are preferred." With more experience, specially shaped hammers will be bought or made later on. Sledgehammers are the heaviest of the hammers but are comfortably replaced by the mechanical hammer (Weygers 1974).

Tongs are the ‘"hands’" of the blacksmith. Many can be seen in museums in multiple designs made for almost every forge job, making it easier for the smith to work. The jaws come in a multitude of designs to hold the different shapes of the steel as well as for easy holding of the piece forms. Vice grip pliers are self-locking and are very useful and welcome in a blacksmith's shop. They can hold a wide range of shapes and sizes more easily than some tongs, and are highly recommended by Weygers.

Cutoff hardies, hot chisels, top and bottom swages of various sizes, top and bottom fullers, heading plates, hot punches, and forming dies all are useful and often necessary auxiliary tools.

Quenching liquids are used to cool down the steel as well as temper it. A bucket of water (about 20 litres) should always be available and should be deep enough to quench a long bar of hot steel with ease. The container of oil (also about 20 litres) needs to be large enough as well, with a hinging lid that can be closed if a fire starts.

The oil-quenching container should be kept far from flammable material. It should either be stationed outdoors or in an area of the shop far from everything else, or there should at least be a wall between the forge and the oil container. Wooden floors should be covered with steel sheets. Stone floors and walls provide the ideal workplace (Weygers 1974).

The swage block, in the form of a rectangular block made out of cast iron, has different half-round sizes and V-shaped notches on all sides plus various holes of different sizes on the face of the block. The swage block is mounted on a stand at an appropriate height to provide one with access to all the edges or the face (Appalachian Blacksmiths Associ-ation 2002).

Chisels are the blacksmith's cutting tools. There are two types, namely hot chisels and cold chisels, the names indicating what they are used for. These tools are used with brute force, wedging their way into metal and taking it apart. A smith would make his own chisels from steel but today these can be purchased from hardware stores. Metal in its cold state is hard, which is why cold steel chisels are blunter and are tempered to be harder than hot chisels. Hot steel chisels have a sharper edge because the metal they cut is heated and very yielding. They are tempered differently to cold steel chisels. Hot chisels receive more attention for they have to be regularly re-tempered owing to the damage the working edge suffers. Smiths regularly cool the chisels in the slack tub in order to protect the temper. It is known that the appropriate chisel should be used under the correct circumstance; cold chisels lose temper when used on hot metal, hot chisels break very easily on cold stock (Light 2016).

In modern-day blacksmithing, electrical machinery is used to help make a job quicker and easier. A drill press is designed to make exact perforations. Rotational bits can be lowered into the steel by means of a lever in a straight, accurate motion (Ares 2006). Power shears are an extremely powerful tool used to cut metal plate as well as rods and tee sections. The lever with the shears increases the force that is applied to it. There are also electrical shears that work with small tempered blades, which will cut in straight as well in curves into sheet metal up to 2.5 mm thick (Ares 2006).

Hand saws are obviously manually operated. These have a flexible saw blade with teeth held together by a steel frame that has mastery over its tension. Electrically operated jigsaws are mostly used to cut holes, and use a much thinner blade. Grinders are very useful when it comes to cutting and abrasive work. They use discs that have a high speed (from 6,000 to 10,000 revolutions per minute) and can wear out easily (Ares 2006).

A plasma cutter cuts steel using an electrical arc between the torch and the steel. The machine can be adjusted to control the current, mostly from 10 to 60 amperes. The cutting torch uses oxygen and acetylene and is a most effective rough cutting tool.

Welding machines play a major role in modern blacksmithing, the most common being, the inverter welder. According to Ares *et al* (2006, p.45) "it converts the available current into an ideal welding current". It can be set to regulate the intensity of the current. The inverter welder works with a metal base cable and a torch cable connected to the welder (Ares 2006). The TIG welding machine was originally made for joining difficult metals such as stainless steel, but over the years it has become useful for any metal. It is connected to a cylinder of argon gas that creates a neutral atmosphere for the electric arc (Ares 2006). Ares *et al* (2006, p.44) say of the MIG welder, "…this is a constant power rectifier, a generator that supplies the current necessary for melting the filler metal wire without producing great variations in the length of the electric arc". MIG welders are known to be the most comfortable arc-welding machines as they are very easy to use. Known as semiauto-matic welding, the spool wire is automatically fed out into the welding gun.

Files are used at the end of a project to finish the work: this is all done with brute force. These files have three working stages. Firstly, the roughing stage uses a coarse file that takes off much of the steel but leaves file marks. The second, medium stage removes the marks from the previous filing, and the third polishing stage finishes off the surface (Ares 2006). Machines such as thr orbital sanders and belt sanders help to speed up the process when it comes to polishing.

1.6.4 Intent

My intent for this year is to construct a working forge and make sculptures of a decorative nature out of steel. I planned to do so utilizing various blacksmithing techniques. I wished to attempt to create antique pieces of work such as swords, armour, and also use the style of inlaying metal into other pieces of work. In addition, I want to design pieces that could be used in interior design. In this manner I will learn the processes of blacksmithing itself.

1.6.5 Creating blacksmith objects

The objects created by the process of blacksmithing will depend entirely on the blacksmithing knowledge and skills acquired through research, practice and application. Primary skills will produce tools and basic objects and decoration. Improved skills will allow an attempt at creating masks, larger objects, the challenges of bending, forming, joining and presentation. It is intended that the artefacts produced will include knives, tongs, tools, hanging or suspended artwork, and decorative scrollwork. Experimentation with a variety of metals and steels will add depth to the output.

1.7 Research design and methodology

This study makes use of practice-based or practice led research strategy, which is aided by qualitative research design as well as purposive sampling. The study adopts a con-structivist, interpretist world view. Essentially this is action research and rich, thick data is generated through a recorded and reflective approach to the making (artwork), analysing and reflecting on process, object and outcome.

1.7.1 Philosophical world view

The aim of this research is to contribute to the understanding and learning of new skills and in the process, creating artefacts. This research is practice-based (Candy 2006), but also practice-led as the research is technologically focused, essentially to record data which provides the guidelines to follow for guaranteed results in the use of blacksmithing and steel as a medium. This constructivist approach to research is a focused investigation and analysis of both theoretical and process data using reflective journals in order to demonstrate and understand the ways of blacksmithing and the techniques it can offer an artist (Biggs 2000).

Candy states (2011) that in the making, reflecting, and evaluating of an artefact in practice-based research it is essential to do, gain experience, and give feedback on the artefact that was made. The creative art in this research is motivated by emotion and a concern for the subject on a personal level, as well as the fact that the research not only functions on the basis of explicit knowledge but also on experiential learning and understanding through the handling of materials. It makes use of more of the senses: accumulating information via material thinking, and feeling via physical handling (Barrett 2007). When using the constructivist method in blacksmithing, one starts to understand the material and its capabilities. By gaining the experience of creating the artefacts, one takes action to improve and evolve as an artist.

In practice-led research the artefact also plays an important role in gaining understanding, but the aim is directed more at evolution into newer practices (Candy 2011). Reflection will lead to better understanding and will contribute towards new knowledge, which can then be utilized in planning further investigation. Reflection in practice can essentially be used as a type of preventative measure to eliminate the repetition of mistakes.

1.7.2 Research strategy

Malins states ‘"practice’" can be defined as "…the development and making of creative work as an explicit intentional method for specific research purposes and data generation" (Gray & Malins 2004). This is why a practice-based or practice-led research strategy is applied to show the research findings. This research document requires the researcher to engage with the medium by means of active interaction which will result in learning through experimentation, reflection and adaptation (Gray & Malins 2004).

1.7.3 Research design

This research is a qualitative investigation which includes a practical approach through material practice in a true environment, with reflection on the processes and creative output. According to Creswell (2009, p.176-77), qualitative research contains specific characteristics that define the type of research the researcher has to adhere to in order to gain the benefit of the research data. When the researcher is working, it should be in the natural environment, in this case that of an artist: more accurately, in the space of a blacksmith, since his processes and skills are being investigated. Qualitative research relies on observation and interpretation (meaning making) through the use of multiple data sources, namely theoretical documents, process journals, and personal reflection journals to accurately document any new findings (Creswell 2009). The researcher is an agent who analyses, evaluates and interprets the processes that take place during the making of creative artefacts, using multiple data sources as references in order to prove their soundness (Gray & Malins 2004).

One key element for which process-based research is known is critical reflection on the discoveries made during the actual process, which can be analysed to aid the researcher to understand the medium and how to manipulate these results to the researcher's thinking (Baxter & Babbie, 2004). One should bear in mind that blacksmithing is a very old profession and that most of the techniques have remained the same over hundreds of years. The up-to-date research that is available today is often online and hard to verify, so the use of seasoned theoretical data is still valid in the process of blacksmithing.

1.7.4 Methods of sampling and data-gathering

The sampling method used to produce accurate data that serves as a reference for blacksmithing techniques in the making of creative artefacts includes going to sources such as documents, field notes, and information from experienced practitioners. Purposive sampling suggests that focused research questions are applied to the available data, and the research results can then be used as reference material for the visual artist (Candy 2006). Sampling as in crating examples of specific materials.

Primary sources: Books, online journals and articles, YouTube

These sources were used to provide technical information on the background and history of forging and highlight the potential of forging methods for visual artists.

Secondary sources: Books, artist's and craftsmen's websites, social media

These sources were investigated to provide visual examples of past and contemporary forged artefacts in order to inform and encourage new works and the possible combination of mediums or material to create works that demonstrate the collaborative potential of forged artefacts with other forms of visual art.

1.7.5 Methods of data analysis (data types)

Sources consist of multiple data types build a stronger case in the attempt to validate the research findings. Process-based research is the way the researcher explores interacting with the work to formulate an interpretation for process work and work books, personal reflective journals, and theoretical documents in order to finally present detailed in-depth documentation accompanied by high-quality creative artefacts (Gray & Malins). The data types used for this research were the following:

- Visual journals
- Process journals and observational notes
- Theoretical document analysis
- Three-dimensional models (maquettes)
- Creative artefacts

1.7.6 Quality control (validating data)

Qualitative research is known as the method of reliability owing to the fact that a set formula is used to capture data to ensure the presentation of accurate, in-depth information (Creswell 2009). The research consists of a triangulation of data to validate any find-ings. By studying the theoretical process of the blacksmith and applying it to the practice work while documenting the outcome validates whether it is working or whether this can be improved. Experimentation can lead to new findings and techniques, and these will be documented in various journals. Inevitably this will contribute to the construction of an artistic artefact.

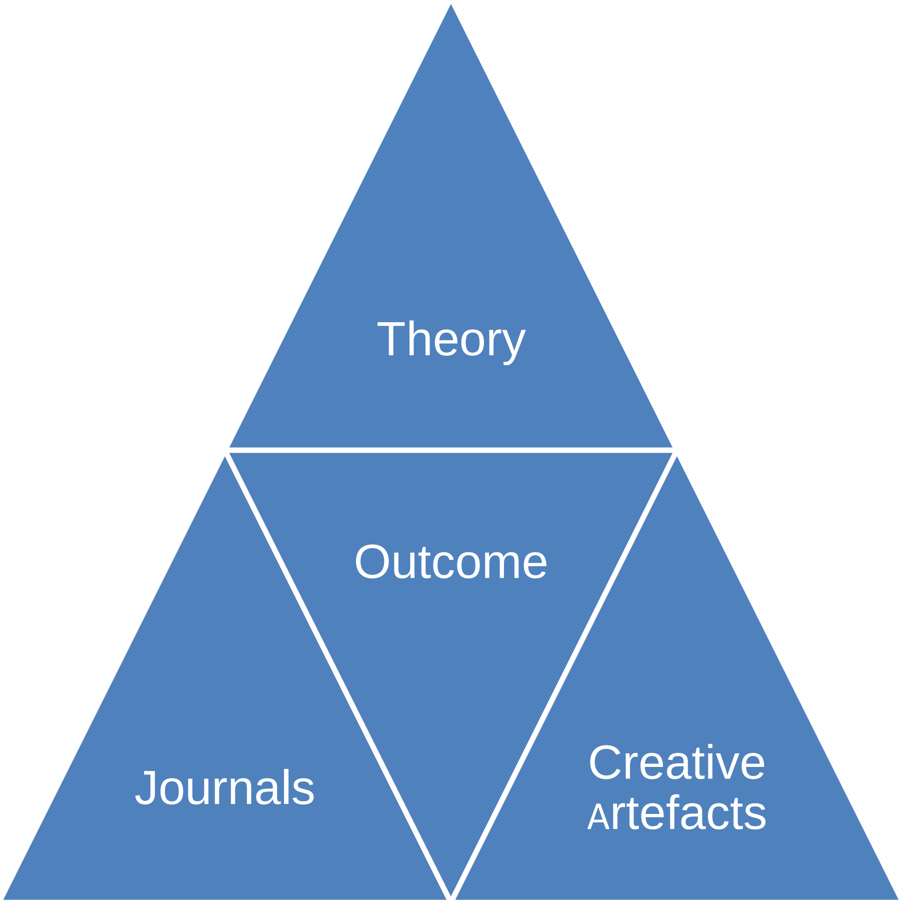

Figure 6: Data triangulation

1.8 Ethical consideration

Research was conducted under the guidelines and in accordance with the Code of Ethics for research at the Nelson Mandela University. In this instance the research was generated by the practical application of the researcher. No animals or children were involved in the research. No ethical clearance was required for this research.

Chapter 2 : Blacksmithing: History to Modern Day

2.1.1 History of blacksmithing

Blacksmithing evolved to suit the environment and the materials found in each geographic location. Each community would have had its particular needs, thus the focus of the blacksmith would have grown. Ridgway (2016) refers to the commonality of tools in the form of smelter, forge, an anvil of some description and, similarly, hammers. Iron eventually came to be the only choice for smiths, this being a new material that required higher temperatures of the forge. Therefore the smith had to evolve his forge and his tools. The advantages of iron smelting led to the improvement of society of its agricultural and warfare capabilities, and blacksmiths were the primary source of all the tools necessary for the surrounding traders (Ridgway 2016).

No period was richer than that of the Middle Ages (1000-1453), according to Richardson (1891), with the art form thriving in England, France, Italy, and most especially Germany. They competed eagerly with one another while producing exceptional wonders of art. It was during this period that blacksmithing techniques were thoroughly understood, and with the hammer in the hand of a skilled smith, this particular art was brought to perfection in form and workmanship.

In current times, blacksmithing has become something of a revived hobby, so much so that television reality documentaries such as *Forged in Fire* are very popular. In this show blacksmiths demonstrate how to forge steel into iconic weapons. The show is a competition where smiths compete by pushing their skills and knowledge of blacksmithing within a nearly impossible time frame. Four smiths go into the smithy and with each challenge placed before them, they are eliminated when they cannot deliver to the standards of the judges. When the last two are standing, they are instructed to create an iconic historical weapon in their home forges with enough time to do so. They are judged on quality, handling, and strength of the weapon, and after going through this trial one is left standing as the victor (Corus Entertainment 2018).

The popular YouTube channel *Man at Arms* hosted by *Baltimore Knife and Sword* is an example of practising blacksmiths making a living today. Blacksmiths take challenges from their social media fans who ask them to forge a unique weapon or a fictional piece that is well known in modern-day pop culture. In accepting the challenge, each blacksmith shows the step-by-step progress of the item in a video documentary that lasts for around 18-20 minutes.

Baltimore Knife and Sword is managed by brothers Matt and Kerry Stagmer who strive together to construct masterful metal works. Inside the smithy with its stifling heat, swords are being hammered, the rapier handles are being wrapped with leather, and armour is forged and pieced together with jewellery complementing a wearable steel outfit that once was fashionable in Medieval times. According to Bishop (2002) their works are sold to collectors and theatre troupes but their work can be found mostly at Renaissance festivals. To a blacksmith, the beauty of his work is always second to its function, especially when it comes to swords and armour. Kerry Stagmer is praised by many and Jim Frank, a festival fight choreographer, has said, "We have two broad swords of his that are eight years old. That’s the kind of work he does. It lasts forever" (Bishop 2002).

2.1.2 Blacksmithing in Africa

It is 3000 years later and the trade of blacksmithing still continues in Africa, with evidence from Nair (2017). In Bamako, the capital of Mali, is a blacksmith in the Médine district who works seven days a week making a profit of R94.80 a day. He makes use of recycled materials that consist of everyday objects, such as pots, buckets, or car parts, down to the smallest nut and uses a furnace dug into the ground to melt the iron - a direct descendant of the past 1000 years of practice. Mali blacksmiths are highly respected in the community, to the extent that when conflict arises the blacksmith is asked to settle the dispute and help the two parties come to an agreement (Nair, 2017).

In Benin, home to the former kingdom of Dahomey which was historically known for its blacksmithing artefacts (Dark 1973), the knowledge of iron was well advanced, while in neighbouring countries the best smiths were coppersmiths working in brass. In the blacksmithing world of Benin and Nigeria, advancements in technology and economic orientation have seen many improvements in the trade. Blacksmiths have been incorpor-ating nonferrous metals such as brass, aluminium, and lead into their products, not just iron. The reason for this is the scrap market, while iron and steel stockists are very easy sources for blacksmiths, and especially the utilization of salvaged steel in blacksmithing, which is a modern phenomenon (Emeriewen & Kalilu 2015).

In the traditional Benin smithy one would see forge and bellows, anvil, and hammers with tongs and files. Today modern smiths have furnaces powered by batteries, with some power tools, hand-held tools and machines. As tongs are the extended hand of a smith, pliers have been added but the pliers merely supplement the tongs, they do not replace them (Emeriewen & Kalilu 2015).

In Niger, a certain blacksmith makes a living by forging swords and knives as well as fixing old worn-out tools. This blacksmith, working out of his straw shelter, makes R588.86 per day which may not seem much but most of the population's annual income is as much as R4,239 in South African rand (Monbleau 2013). Blacksmithing was once of great importance in the daily activities of a civilization until the Industrial Revolution caused this to dwindle. However the skills were kept alive for many years by small organizations (Monbleau 2013).

2.1.3 Blacksmithing in South Africa

Paul Mikula, Conrad Hicks and Kashief Booley are among contemporary of the practising blacksmiths in South Africa: some very well known, others known to their community and private collectors. Knibbs (2017) states that artist and master blacksmith Paul Mikula represented South Africa in Belgium with an artwork he forged in his smithy. His skills were much praised and he was invited to create panels to commemorate an anniversary of World War One.

South Africa has blacksmiths as well as bladesmiths. At Heavin Forge, which is also a knifemaking school and is owned by Kevin and Heather Harvey, Kevin has been creating knives from the age of twelve while Heather is a certified farrier and blacksmith after having completed her studies at Montana State University in the United States of America (Heavin Forge info n.d.).

2.1.4 Blacksmithing in Port Elizabeth

In 1822 a list of the inhabitants of Port Elizabeth was drawn up (Figure 7) in order to formalise the establishment of the town. Thanks to civil authority, records have been constructed of the people and the new or exciting events that took place around Port Elizabeth. The first P.E. blacksmith was a Malay man with the name Fortuin. This is accurate evidence of blacksmithing having been practised in Port Elizabeth in the 1800s, which most likely continued well into the 1900s (McCleland 2017).

No proof exists of anyone currently practising blacksmithing in Port Elizabeth; however knifemakers exist aplenty. Deon Nel, a maker of tools, jigs and dies, had an obsession with handmade knives. He took a course in this trade to pursue a career as a full-time knifemaker, winning numerous awards for his skills. He also became a member of the Knifemakers Guild of Southern Africa, K.G.S.A. (Cape Knifemakers Guild 2008).

The closet blacksmith to be found near Port Elizabeth is Fanie Moller in Plettenberg Bay. His shop or smithy is called Amano Design and his work can be seen at his restaurant, around South Africa, and in some foreign countries. The exotic doors that are his speciality and which he is known for express his love for combining blacksmithing with woodworking. As Amano Design is against the destruction of forests, the projects that are created are from reclaimed wood, made to such quality that they will last forever (Amano Designs 2018).

Name	Occupation	Miscellaneous
Evatt, Francis	Commandant	Fort Frederick
Evatt, Henry		Francis Evatt's son
Creaig	Commissary	
Carn	Commissary's clerk	
Nicholl	Merchant	
Chabeau	Merchant	
Welsford	Retailer	
Green, Benja	Welsford's clerk	
Hunt	Retail, hotel	Ordinary at 2 o'clock (sic)
Frames	Storeman, boatkeeper	
McPhail	Mason	
Board	Carpenter	
Fortuin	Blacksmith	A Malay man
Hitje, Nicolaa	Red Lion Hotel	
Dunn	Postmaster	
Dunn, Gambol		Postmaster's son
Burchell	Apothecary	
Hartman	Field Cornet	
Dissel	Mason	
Griffin, Thom	Shoemaker	
Brown	Shoemaker	
Gurney	Boatman with crew	
Smith	Boatman with crew	
Kacheloven	Butcher	
Younger, Joh	Surgeon	
Younger, Thomas		Surgeon's brother
Mollineaux	Harpoonier	
James Read	Harpoonier's crew	
de Mell, Joe	Harpoonier's crew	
Hubbard, Joe	Harpoonier's crew	
Kane	Sawyer	
Le Harpe		
Minto	Garrison surgeon	
Hawkins, Griffin		Visitor (sic)

Figure 7

Port Elizabeth headcount (McCleland 2017)

2.2.1 Blacksmiths visited

I was fortunate to spend time in active blacksmith shops with experienced blacksmiths. These were Fanie Moller, owner of Amano Designs in Plettenberg Bay, and John McQaude, owner of The Village Blacksmith in Knysna.

Figure 8

The Village Blacksmith forge

John McQuade is a very experienced blacksmith, with 50 years of knowledge to be exact, and very traditional in his way of forging. Figure 8 shows his forge with the tools and jigs in the background hanging on their racks. He still uses coal as his fuel to heat his metal, the type of forge being a side blast forge that is at least 50 years old. John says that although his forge is old, it still burns as hot as the day he started it up for the first time (1,200 degrees Celsius). Wood can be seen in Figure 8; this is what he uses to kindle his forge, building a small fire out of chopped wood. When the fire is going, he stacks his coal neatly around it and on top of the fire, then starts his blower to rage his fire which leads to the coal blazing and becoming hotter.

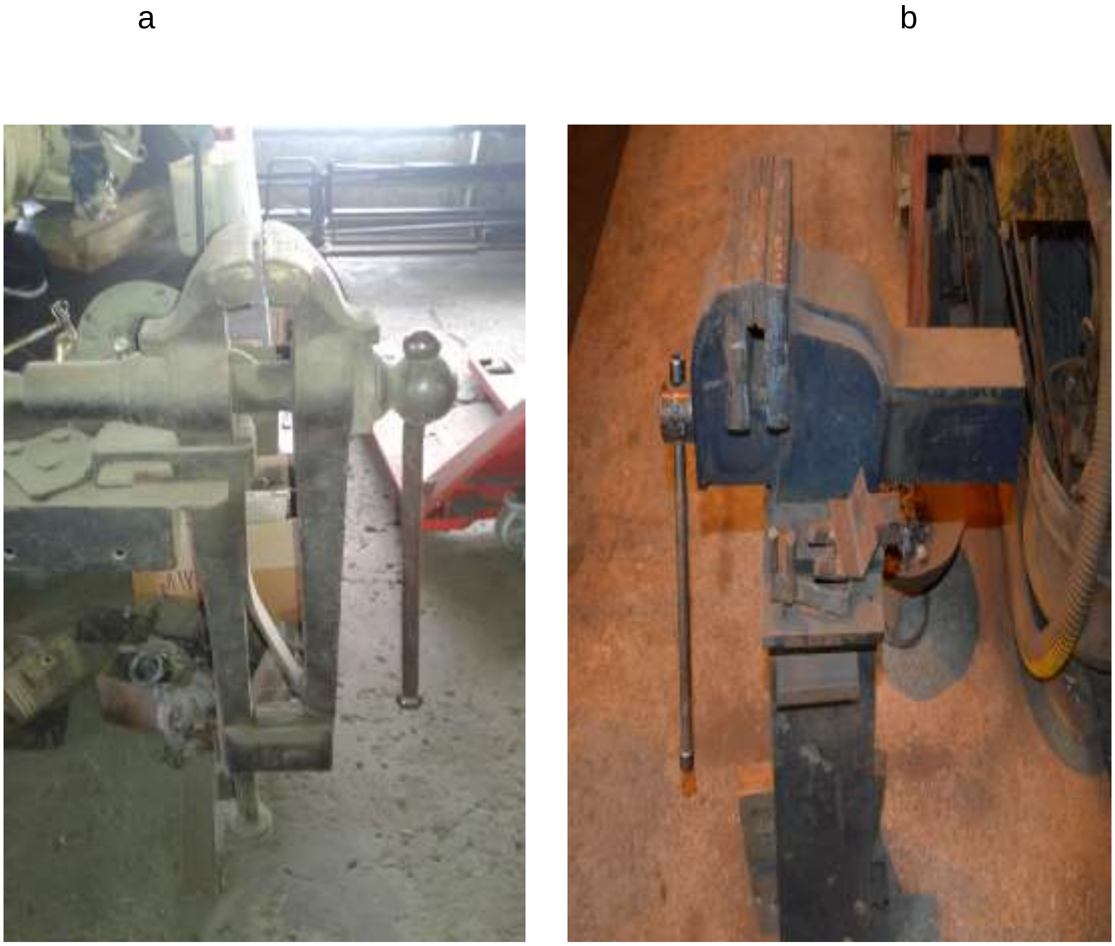

Figure 9

Vises

John makes use of traditional tools as well as those that are very commonly found today. Figure 9 shows a post vice (a) and an engineer’s vice or bench vice (b). They are different from each other in design but they serve the same function when it comes to holding an object. The post vice is secured to the steelwork bench with bolts to keep it in one place, as vices are generally used for the bending of steel and some hammering. The engineer's vice is given its own base in an open location in the shop to make it easier to work with large objects and to ensure adequate space when one needs the room in order to shape or hammer a large piece of work.

Figure 10

Tools

John is very organized. Each tool has a place and it is returned to its place, after use. In Figure 10 on the wall are all of his measuring equipment: rulers, vernier caliper, string, and compass. Right underneath are his tongs and some of the hammers that are the most commonly used are found right next to his forge.

Figure 11 is a rack that is covered with C-clamps and plier tools. These are very new to the blacksmithing world but are most popular in the shops of blacksmiths today.

Figure 11

C-clamps and pliers

Figure 12

Village Blacksmith anvil

The anvil is resting on an old stump with two U-shaped mild steel rods that are sharpened at the ends and hammered over the anvil's feet to wedge into the stump. This is to ensure the anvil is permanently fastened to the stump as seen in Figure 12. The stump is also fastened to the concrete floor with brackets as the anvil must always be stationary. This is a safety feature in a blacksmith's shop. If anvils are not secured to a base, they will move and can fall and injure the user.

Figure 13

Amano Designs propane forge

The propane forge that is used by Fanie Moller in figure 13 is very modern and extremely popular among blacksmiths today. In Fanie's shop you will see not one, but four propane forges, each constructed to handle specific sizes of metal to be heated. Fanie prefers these propane forges over coal forges as they are easier to use, comfortable to transport and much cleaner. His shop is open to the public, however he does advise that, when in the shop, visitors should stay a safe distance from the propane forges as they are very fragile and very dangerous.

Figure 14

Amano Designs coal forge

Fanie is very up to date with modern blacksmithing but he does resort to traditional methods as seen in figure 14, one of the coal forges used to heat the metal that the propane forge cannot. He normally uses the coal forge for heating sheet metal, with the open space around the fire pot making this the easier method. The coal forge is always the last resort, mostly because the burning of coal creates smoke which is very bad for one’s health.

Figure 15

Pneumatic hammer

Big hammers make a notable difference when one is working with a 40 mm square steel bar: they make it faster and easier to shape the steel. The hammer seen in figure 15 is Fanie’s very old 75 kg [3]pneumatic hammer that he uses when he is busy with large projects. The hammer is a significant asset to the shop as most of the projects he undertakes are big ones that require this kind of machinery. This 1.5 ton pneumatic hammer is the largest hammer in the shop. It was built on its own foundation to secure it to the floor as well as to absorb the vibrations the hammer gives off when it hits the anvil that is secured to its frame.

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[3] Pneumatic is a machine containing or operated by air or gas under pressure (Dictionary.com 2018).

Figure 16

Hammers and tongs

Many different hammers are seen in figure 16. Some are heavy, some are light, they have either rounded or flat-shaped heads. Each hammer has a different function. The different tongs are each made for a specific job and a great variety is to be found in Fanie’s smithy. Because of the different stock shapes, Fanie has specific tongs for each shape to ensure a comfortable and a stationary grip. This is to safeguard the blacksmith's hands and feet. The tongs serve as extended hands to grip the hot metal, and the metal should be secure. If not, it will bounce when striking it with the hammer. There are other hardy tools on these racks made for shaping large stock and to shape it to longer and smaller stock.

Figure 17

Anvil with steel base

More than one anvil is to be found in Fanie’s shop. The one in figure 17 is the biggest in his possession. Most of them are secondhand - very old but in working condition. Fanie’s two biggest anvils are used for shaping steel in its roughest form, while one of his smallest anvils is used for straightening steel. The anvil face has very little damage to it; care is taken that it does not deform as only steel heated to a bright white colour is placed on it, and it is tapped gently with a flat hammer to achieve a straight and levelled form.

Figure 18

John McQaude artefacts

Work created by John McQuade is of the highest quality. It can be seen in showrooms and galleries in both South Africa and foreign countries. In figure 18 a candle holder in the middle of the picture was commissioned for a castle in Scotland. Many were made, each priced at R28,000.00. John says that making an artefact like this takes long hours and hard work and should be sold for what it is worth. Blacksmithing is a skill that not only drains energy but also takes a toll on the human body. It is hard and difficult work.

Figure 19

Fanie Moller artefact

Fanie is mostly interested in large projects when it comes to commissions or personal projects. Well known for his doors, railings, gates, and chandeliers, his work is unique, one-of-a-kind. His work is always extremely heavy. Fanie loves to work with thick pieces of steel - no hollowed tubes or pipes, as he explains that the thick steel shows the hard work that goes into making such exceptional artefacts.

Chapter 3 : Construction of Forge and Tools Required

3.1 Actual Work

Figure 20

Coal forge

What is a forge? It is an open hearth that smiths use to contain their fire. Many sizes and shapes of forges were and are still constructed, but all coal forges are made up of the same components. Most forges today are similar to ones used thousands of years ago (Sims 2006). The forge is set at a convenient height that allows enough space for the airflow inlet system underneath the hearth (Blandford 1988). The chimney is directly above the forge and not too far from the fire but close enough to exhaust the smoke. The chimney has its own set of guidelines as to how it should function in conjunction with the forge, which will be explained later in this research on page 60.

In South Africa it is very difficult not to mention that it is very expensive to find or import a forge and tools. There are alternative ways to go about making a forge that would aid in the making of tools and artefacts. A visit to a local scrapyard can help in the construction of a forge.

Figure 21

Brake drum

The brake drum as seen in Figure 21 is a cheap and effective alternative to the cast iron fire pot. This is easily acquired and not at all expensive. It makes an excellent fire pot as the material that a brake drum is made of is designed to handle high temperatures and is very durable. The forge will be built around the size of the brake drum that has been acquired; they come in different sizes so it is essential to buy this item first.

Figure 22

Steel plate

The steel plate (mild steel) should be a minimum of 5 mm thick with a size of 60.96 cm x 76.20 cm. Using a permanent marker, the circumference of the brake drum is drawn on the steel plate (see Figure 22), keeping in mind that the brake drum has a rim that can rest on the steel plate. The hole should not be cut so big that it exceeds the rim. The plate can be cut with the use of a plasma cutter and be finished with a grinder on the edges.

Figure 23

Cut steel plate

Figure 24

Reinforcing

Reinforcing is required for the hearth of the forge to make sure the steel sheet does not move when the forge is ablaze. Steel moves when it gets too hot. Angle iron, square tubing, or round tubing (as seen in figure 24) of any suitable thickness can be used for the purpose of reinforcing. Four holes should be drilled at the corners of the frame, preferably with a bench drill press (see figures 25a and 25b). This will be used to join the frame and the hearth with 8 mm threaded rod, washers and nuts.

Figure 25a

Bolts and nuts

Figure 25b

Reinforcing frame with fire pot

The frame should be constructed according to the size of the hearth of the forge, and built so that it will assist in carrying the weight of the brake drum or fire pot. The use of an arc, MIG or TIG welder is necessary to weld the pipes to form a whole.

Figure 26

Hearth

According to Sims (2009) the fire pot and chimney are being supported by the structure of the hearth, therefore it should be constructed with enough space on it to carry extra coal and the tong racks.

The hearth and frame are connected by bolts (not welded), then coated with a paint that can be applied with a brush. This paint, which is available at hardware stores, is made to withstand very high temperatures and also protects against rust.

Figure 27

Flat bar

The flat bar is welded to the sides of the hearth, acting like a wall to prevent the coal from falling off. In figure 27, a piece has been cut off the flat bar. This is where the steel rests level over the fire pot. There should be no obstacles around the steel while it is heating up. Figure 28 shows the correct way to place metal stock over the fire pot.

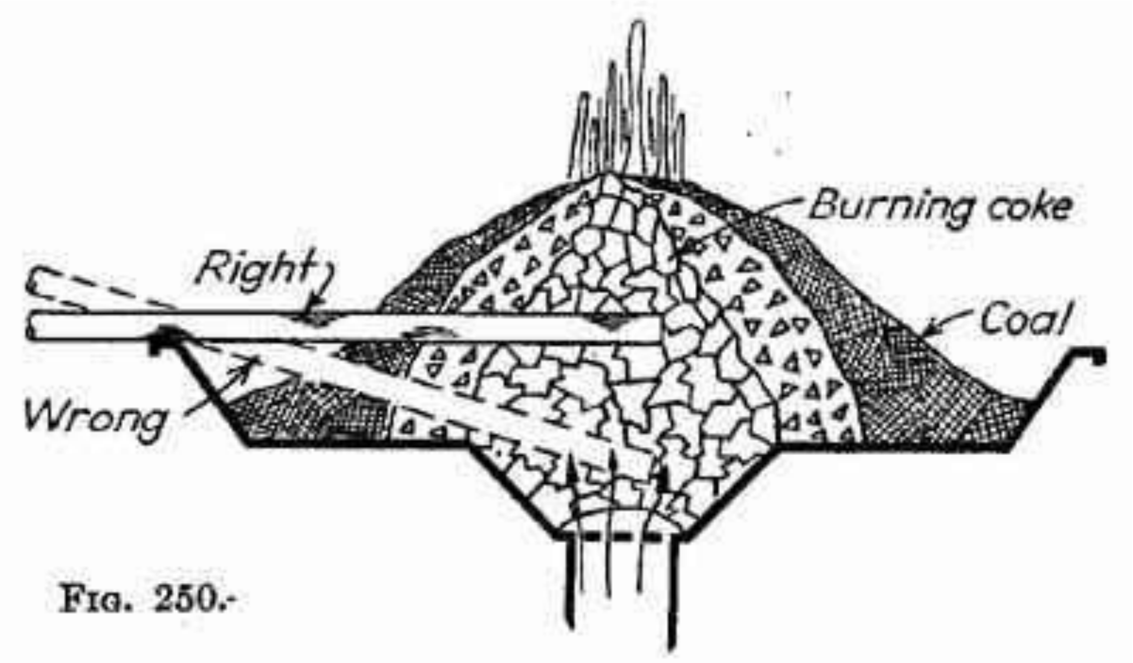

Figure 28

Fire pot the correct way (Jones 2018)

Figure 29

Forge walls

Figure 29 shows a white surface on the hearth where old kiln shelves have been laid down to protect the steel surface of the hearth. It is not necessary to do this in a forge, although some smiths do use fire bricks, but in fact others do not recommend it. This really comes down to one's personal choice.

Figure 30

Legs

The height of the forge will be different for every blacksmith. However, one needs to provide enough space for the air inlet to the fire pot. The coal forge legs in Figure 30 are one metre tall; the reason for this is that the height has been personalised for the researcher. The legs should be reinforced – there should be no wobbling of the hearth or legs; the forge must be as stationary as possible, but at the same time easy to access.

Figure 31

Welded pipe

The pipes to the brake drum can be welded (as seen in Figure 31) with the use of an arc welder. This was welded using a 3 mm welding rod to give it a thick weld, adding steel offcuts to ensure a good seal. No air should be allowed to escape underneath the brake drum or fire pot. As seen in Figure 32, the connecting process can also be done by welding the pipe to the steel plate, which is customised with holes and a bench drill is used to fit nuts and bolts to the fire pot.

Figure 32

Fire pot bolted pipe (Blacksmithing for Beginners 2015)

Figure 33

Centrifugal blower

The centrifugal blower is the air supply that is used to heat the coal. It is electrically powered, very reliable, and can be purchased in Port Elizabeth at Howden Donkin Fans. Some back-yard blacksmiths use hair dryers for air flow but these are not the most reliable. The one in Figure 33 is strong enough to get coal burning to a point that the steel will melt away if one is not paying attention.

Figure 34

Ash dump

When working with coal, a waste material that blacksmiths call clinkers forms in the fire pot. Clinkers and ash fall down the air pipe, filling it with waste material that needs to be removed. In Figure 34 an old petrol-drum screw cap provides easy access and prevents the air from escaping at the bottom. An easy and cheap way to build the ash dump is to use a plasma cutter to cut away the screw cap from the drum, leaving enough metal around the edge to be able to join the cap with the air pipe.

3.2 Building a Chimney

Figure 35

Forge chimney

Forge chimneys are designed in a specific way to make it more comfortable to work in the smithy. *Chimney Building* (2011) explains the theory of forge chimney designs as follows:

> Chimneys draw more than just the smoke from the fire, a fact most often overlooked by many chimney builders. Ambient air surrounding the fire will be

> drawn towards the fire and flows into the chimney with the smoke. The higher or farther a hood or chimney opening is from the fire, the more ambient air that will displace smoke as it rises to the chimney. The cooler ambient air will be heavier than the smoke and will slow the movement of smoke in the chimney. If the fire is located too far from the chimney or hood, then the amount of ambient air moving over the fire becomes so great that some or all of the smoke will be forced into the smithy.

Figure 35 shows the top of the chimney built for the coal forge. It is 1.2 metres higher than the highest point of the roof as this is mandatory for the placing of the chimney on a rooftop. This is to prevent smoke being pushed back down the chimney (*Chimney Building* 2011).

Figure 36

Welding the flue

The [4]flue was constructed from two 90-degree-bend mild steel sheets, three metres in length, and welded with a TIG welder using argon gas to make a square flue of 20 centimetres. A coating of heat-resistant paint was applied to the surface of the steel to ensure that no rust formed to destroy the flue.

In Figure 37 the flat bar is welded around the flue so that the chimney can rest securely on the roof.

Figure 37

Welded flat bar

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[4] Flue is a duct for smoke or waste gases that are made by fire or any fuel-burning installations (Dictionary.com 2018).

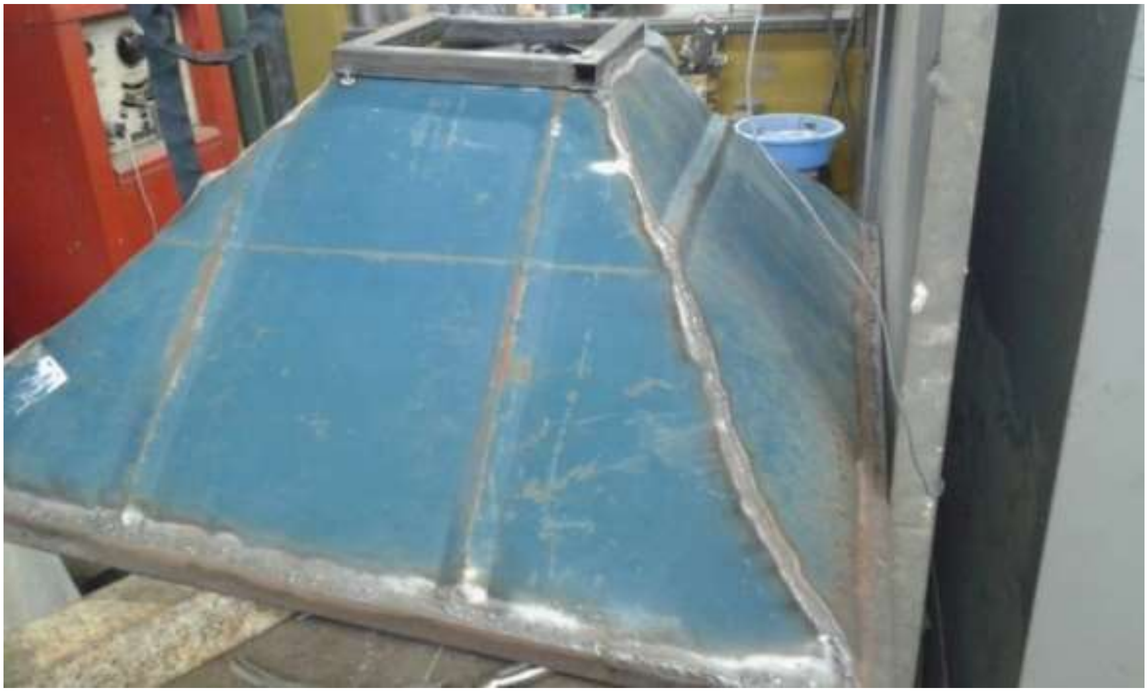

Figure 38

Chimney hood

The hood was made from old steel drums and square tubing. It measures 1 metre x 0.8 metre (the opening that is over the fire) with a small opening at the top of 20 x 20 centimetres, which will connect to the flue seen in figure 37. According to *Chimney Building* (2011, p.1) "large conventional hoods should be kept low to the fire. This will help smoke enter the hood and reduce the amount of ambient air displacing smoke entering chimney".

Figure 39

Welding chimney cap to angle iron

In Figure 37 the top of the flue has four pieces of angle iron measuring 20 cm in length, which is the same as the width of the flue – this can be greater but not less. The cap is placed on and welded to the angle iron to achieve a secure attachment, while ensuring that it is welded to the lowest edge of the chimney cap (*Chimney Building* 2011).

Figure 40

Chimney cap

The chimney cap is made out of the same material as the hood of the chimney. I used the bottom of the steel drum, following the rim as a guide for the plasma cutter and achieving a perfect circle for the cap. Once the circle was cut, the centre was determined as the point to cut to from the edge, using an angle grinder. Then the two cut edges that were once connected were forced together to overlap, turning the circle into a cap. To hold it, the overlapping edges were clamped together to ensure an easy and safe weld with the TIG welder.

Figure 41

Working chimney

The chimney should be tested before using coal. A normal wood fire was built under the hood to determine whether the smoke travelled up into the flue and was not being forced out into the smithy. The hood was chained to the roof beams to distribute weight equally.

3.3 Iron

I work mostly with mild steel and sometimes I incorporate bronze or copper. According to Sims (2006), mild steel is what modern blacksmiths use today. It is often referred to as soft steel, machine steel, or blacksmith iron. Mild steel is made from pig iron, undergoing a process in which the carbon is practically all removed. It cannot be hardened through a quenching process in water because of the low carbon content (less than 25%). Hammering mild steel cold is possible but only to a certain point. In a forge its limits can be pushed very far and it has excellent properties for forge welding.

Carbon steel's carbon content ranges from 0.10 to 2.10 per cent. The carbon content, even when differences are small, has a significant effect on the quality of the steel. When the carbon content is at 0.40 to 0.45 per cent, then the steel is at optimum strength. When steel with a high carbon content is used by a blacksmith, this is normally for tooling purposes (Sims 2006).

Mild or low carbon steel	0.10 to 0.25 per cent
Medium carbon steel	0.20 to 0.45 per cent
High carbon steel	0.45 to 0.95 per cent
Very high carbon steel	0.95 to 2.10 per cent

Steel found at scrapyards is always very challenging as one does not know what type of steel that is. It is a good idea to start collecting pieces of steel and store them in the smithy, as these can be used in future projects. Old tools are obviously of high carbon steel and can be reworked into new tools. Leaf springs or coil springs are excellent material for tools (Blandford 1980).

3.4 Tools

3.4.1 Four basic hammers

A variety of hammers are available for a smithy but four basic hammers styles are required, according to Sims (2006). They are the following:

Cross peen This has a large-diameter square face with a peen opposite to the square running perpendicular to the axis of the hammer handle. It generally weighs from 1½ to 4 lb (0.7 to 1.8 kg).

Ball peen The ball peen has a face that is smaller, rounded, and flatter, with a weight much lighter than that of the cross peen. It is easy to identify this hammer by its ball peen shaped head. It is commonly used to give a hammered look to the surface of steel. It weighs from 4 oz to 2½ lb (113 g to 1.1 kg).

Straight peen This is basically the same as the cross peen hammer but with one difference: its peen runs parallel to the handle of the hammer. It weighs from 1½ to 4 lb (0.7 to 1.8 kg).

Sledgehammer This hammer looks almost the same as the cross peen but weighs much more, and it has two faces and no peen. The average sledgehammer weighs between 5 and 10 lb (2.3 to 4.5 kg).

Figure 42

Cross peen

Figure 43

Ball peen

Figure 44

Straight Peen

Figure 45

Sledgehammer

3.4.2 Tongs

The great advantage a blacksmith has in his or her field is that he or she can make most of his or her own tools. The most iconic tool is the tong, which a blacksmith uses to hold steel that is removed from the forge. Smiths will normally work with longer pieces of steel in order to avoid touching the heated area, however small pieces of steel are also forged and these require tongs. Modern wrenches have locking mechanisms that serve as hand vices; these are second only to traditional blacksmith tongs. The tongs are long pliers, at least 45 cm in length, with some longer depending on the hearth size. The longer the handles, the tighter the grip on the jaws of the tongs. This is achieved through leverage (Blandford 1980).

Sims (2006) states that when starting to work with tongs, a coordinated effort is required, so one should start with tongs that do not have long arms as they are lighter and easier to handle. The following six types of tongs are used on a daily basis in a smithy:

Needle nose or scroll tongs are used to refine small curves.

Small jaw tongs hold square and round stock ¼ in (0.5 cm) or less.

Small wolf jaw tongs hold round or square stock ¼ to ½ in (0.5 to 1 cm).

Large wolf jaw tongs hold round or square stock ½ to 5/8 in (1 to 1.5 cm).

Flat jaw tongs hold discs and plate.

Open jaw tongs hold stock that is flat and already has a forged tip.

Most tongs hold metal stock parallel whereas wolf jaw tongs can hold material in both a parallel and perpendicular manner (Sims 2006).

Figure 46

Needle nose or scroll tongs (Pieh Tool Company 2018)

Figure 47

Small jaw tongs

Figure 48

Wolf jaw tongs (Kayne and Son 2016)

Figure 49

Flat jaw tongs

Figure 50

Open jaw tongs

3.4.3 Anvils

An anvil is the most important tool used by a blacksmith. Unfortunately these are very hard to find in South Africa. Although new anvils are being made today, according to Blandford (1980) fully cast steel anvils are being produced in favour of iron anvils which were often left with a misshaped surface from the pressure of the hammer. Buying a new anvil of approximately 125 kg will cost approximately R24,000.00 (2018). The best way to judge a used anvil is from the ringing sound it makes when struck by a hammer: it should be clear and sharp as opposed to dull. If the sound is dull, the anvil is defective (Lillico 1991).

Figure 51

Anvil

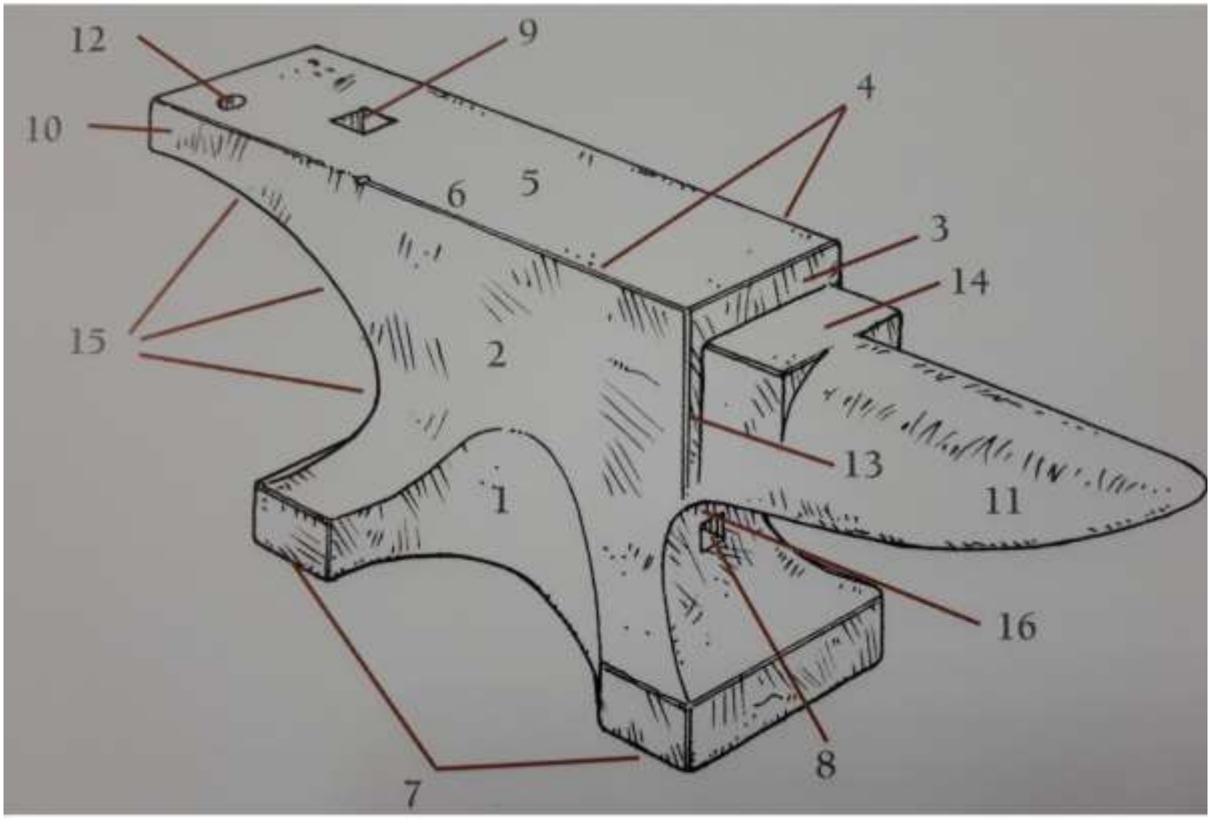

Figure 52

Anvil anatomy (Sims 2006)

The anatomy of an anvil, seen in Figure 52, according to Sims (2006):

1. **Base** All parts from the waist down.
2. **Body** The area of the anvil from the waist up, including the face, heel, and horn.
3. **Drop** The space from the face to the table.
4. **Edge** The perimeter of the face.
5. **Face** The main part of the anvil that is parallel to the floor. Most of the forging work will be performed on this area of the anvil.
6. **Face plate** A hardened steel plate welded to the face of the anvil. Unusually ¼ in to ¾ in (0.5 to 2 cm) thick.

7. **Feet / legs** The four corners of the base that project outwards.
8. **Handling hole** Rounded or square holes located in the waist of the anvil.
9. **Hardy or hardie hole** A squared, shaped hole located on the tail of the anvil; used to secure anvil tools such as swages and chisels.
10. **Heel or tail** An overhanging projection that extends from the face of the anvil, opposite from the horn. The top of the heel is part of the face, and it provides a location for the hardy and pritchel holes.
11. **Horn or beak** A fairly soft and somewhat cone-shaped projection that extends near the table.
12. **Pritchel hole** A round-shaped hole located on the tail of the anvil; used primarily for punch work.
13. **Shoulders** Area above the waist and below the face.
14. **Table or chipping block** The rectangular surface located between the horn and the face of the anvil, usually stepped down from the face.
15. **Throat** The area between the horn and the feet and the heel and feet.
16. **Waist** The area located between the body and the base.

3.4.4 Hardies

Most commonly a hardy tool is a chisel that fits into the hardy hole on the anvil, which the blacksmith uses to cut heated steel or cold steel. Two cutting hardies are made and each tempered to serve its purpose, either hot cut or cold cut (Lillico 1997). By placing the steel over the cut-off tool and using a hammer, the steel can be cut off flush. A hardy is a bottom tool but it has a mate, the top tool, which assists in doing the same job. The top tool can be integrated with a handle as these tools are struck with a hammer, not used as a hammer (Andrews 1977).

Figure 53

Hot cut hardy

Figure 54

The hardy tools mate

3.4.5 Vises

A vice is a tool that grips an object with clamping jaws to enable the worker to use two hands instead of one, or to deal with the large amount of friction from filing or chiselling. The blacksmith relies so much on his vices that they are located on a workbench close to the forge. If steel is to be worked cold, the vice is the centre of this action. The post vice, or blacksmith vice, as seen in Figure 55 was previously the most common vice to be found in a blacksmith's shop.

In more modern shops the bench vice is now the most commonly used, followed by the post vice, which is more durable since the leg provides stability as the pressure is applied to the floor (Sims 2006).

According to Weygers (1997) the bench vice should be bolted to the workbench. It should not weigh less than 11.3 kg: the heavier the better, as they are larger and have wider jaws in order to hold big objects.

Figure 55

Post vise

Figure 56

Bench vise

Figure 57

Bending fork

The bending fork is designed as a hardy tool to bend stock. It is mostly used to bend material into hooks at the end of long rods. The material is pressed against one rod and then bent around the other (Richardson 1891).

At Amano Design bending forks can be found welded to the sides of the working benches all over the shop.

3.4.6 Modern tools

Modern blacksmiths are able to make use of power tools to assist in their work or to facilitate the process.

Figure 58

Drill press

According to Weygers (1997) the drill press has fallen into the category of the most important tools needed by a blacksmith. The press is bolted to the surface of the table while making it possible for the swivel function to adjust it to any position. It is designed for drilling steel, wood, and many other materials, but it is also useful for routing, filing, rasping, and grinding.

Figure 59

Handheld grinders

Over time a blacksmith will develop a collection of grinders in different sizes as they save a great deal of time in the cleaning of ironwork. Within a set of grinders, each one will have brush cups and different discs for grits, cutting and grinding to prevent wasting time when a disc on a particular grinder has to be replaced (Sims 2006).

Figure 60

Plasma cutter

The plasma cutter makes use of electricity and compressed air from a compressor to cut metal. It is equipped with a gun which is used to cut as it is drawn across the metal. This machine is very dangerous to a person’s health as it releases gases and particulate matter (Sims 2006).

Figure 61

Welder

The most common welder in a blacksmith's shop is the wire welder, or MIG welder, as seen in Figure 61. It is easy to use and requires very little cleaning up after finishing with welding on steel. Because MIG welders are expensive, it is best to start out with an arc welder or a stick welder. Today most arc welders can also be used as a TIG welder. They are very affordable, easy to find, and much more portable than other welders (Sims 2006).

Figure 62

Propane forge

The propane or gas forge, as seen in Figure 62, according to Sims (2006) has many benefits or advantages over a coal forge. It can be constructed to fit any shape of metal, produce longer-lasting heat on stock, and its fuel source can be propane or natural gas. This is a much cleaner way of doing blacksmithing than coal forging, with the added benefit of not burning stock when heating several pieces at the same time.

However, although the propane forge is an excellent tool for a blacksmith, it does not have all the pleasures of blacksmithing, according to Sims (2006):

> With so many advantages offered with the gas forge, why is the coal forge still around? First of all, there is nothing that connects you with this craft more than fire. A coal fire can be made anywhere and the intensity of the heat makes forge welding, upsetting, and punch/drifting easier to execute. A coal fire represents the history of the craft.

Figure 63

Jigs

Chapter 4 : Artefacts and Products

4.1 Artefacts

Figure 64

Polynesian mask

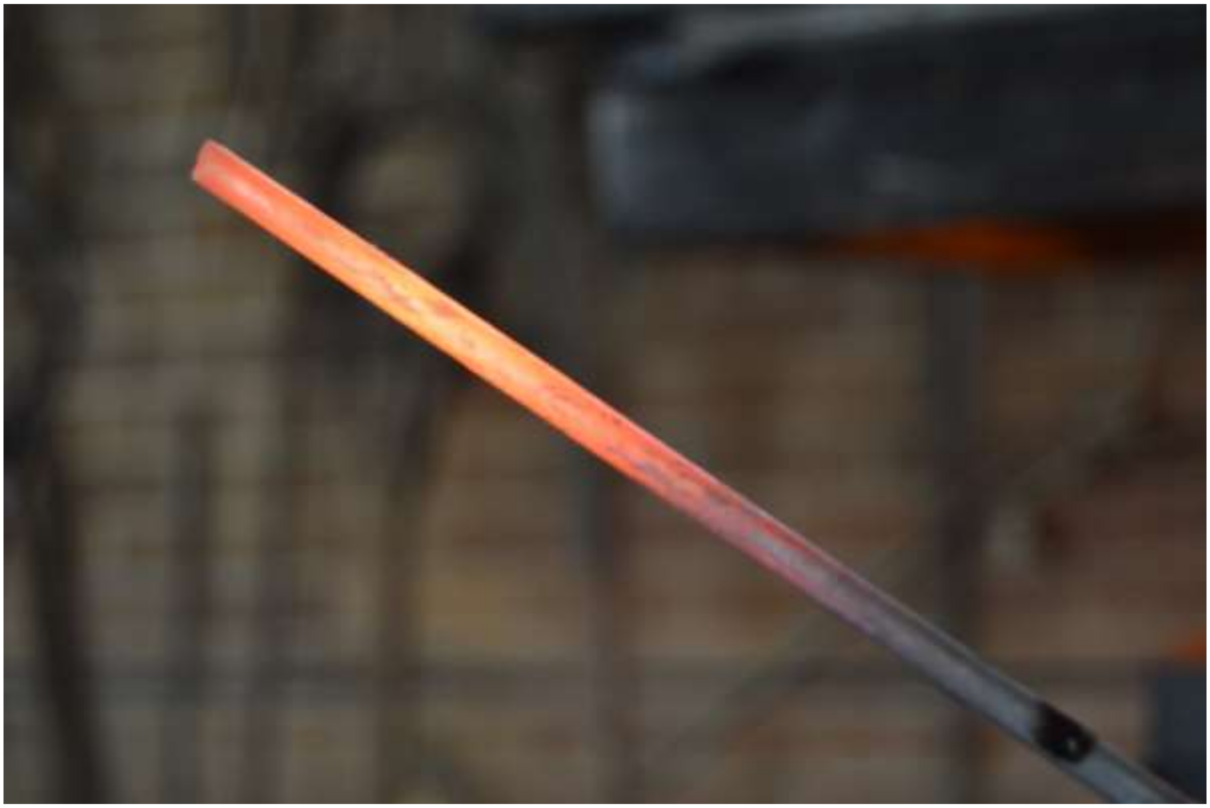

Figure 65

Material for Polynesian mask

This particular piece is made from mild steel flat bar and round stock. The stock was not too big in width or in thickness − the end product had to be considered as steel is a heavy material. The process for making the Polynesian mask is that normally used for making "to scale" sculpture. A drawing was made, and scaled up to a suitable size. The drawing was broken down into its simplest elements. These were eventually transferred into steel through a variety of forging methods.

Figure 66

Hammering shapes

A template was used to form each piece and to ensure the opposite sides were similar to each other as this was forged without the use of jigs. The eyes were cut slightly with an angle grinder and hammered and drawn out. The anvil's horn was use to shape the curved edges. Scrolling tongs were used to scroll the nose of the mask: this is the easiest way to scroll small pieces of steel.

Figure 68

Shaping curves

Figure 68

Cutting a pattern

After making up the flat steel sheet, the forehead was cut out with a plasma cutter and the edges were smoothed with files and an angle grinder using a flap disc. The forehead was heated in the forge to the point where it could be shaped over the horn of the anvil to give it a three-dimensional look. In Figure 69 hardened clay former under the pieces of steel was used to create a three-dimensional whole. Then they then connected together with small nails using a welder. The mask was made to be displayed in an exterior location so it had to be treated with a solution in order to withstand the weather conditions. This was done with steel primer and black paint, as well as a clear coat spray to make sure no rust would form on the surface of the artefact.

Figure 69

Clay and steel

Figure 70

Steel heating and shaping

Once again, all pre-making planning was done by drawing the intended object, and then sizing and shaping the various pieces until these were ready to be joined.

Figure 71

Turtle sculpture

Figure 72

The frame

The frame is built from 6 mm round stock or bar to reinforce the whole structure of the artefact. The forge was used to heat the round stock to make it easy to bend in the shape of a turtle body. To connect the round stock it was welded together with an arc welder. Some of the textured steel was also welded to the frame before more layers were added over the first set.

Figure 73

Textured steel

In Figure 73 the steel flat bar was heated to a forging temperature of 1,000 degrees Celsius in order to create texture with an old hammer that was cut with an angle grinder. The textured steel was cut into equal pieces with a cutoff saw, as seen in Figure 75.

Figure 74

Hammer pattern

Figure 75

The equally cut steel pieces were stacked one beneath the other so as to be able to weld them together, at the same time hiding the welding marks. The pieces were welded to the frame of the turtle (Figure 76), continuing to weld pieces until they covered at least three-quarters of the shell.

Figure 76

Figure 77

Top of turtle shell

The top of the turtle shell (Figure 76) was 3 mm mild steel square plate. A plasma cutter was used to cut the shape of the shell and by heating it in the forge as seen in Figure 78. The pattern was hammered into the steel with a cross peen hammer, as well as using an old round 40 mm steel ring. The pieces were placed in the hollow area while heated, then the ball peen was used to hammer in the centre of the steel to make the pieces round. The edges were first cleaned with a grinder and a grinding disc, and then with a flap disc to smooth the edges so as to be able to touch them with the naked hand without injury.

Figure 78

Plasma cutting

The design was drawn on the steel plates with some soapstone (steel stone scribes) that can be found in hardware stores. A Tipp-ex pen can also be used. It is much more convenient for its ability to handle high heat and it will not burn off.

Figure 79

Propane forge heating steel plates

Figure 80

Side view curved shell

When the three top parts of the turtle shell had been completed, they were welded to the frame. As more forged pieces were permanently joined to the frame, the weight was becoming uncomfortable to hold, so use was made of a traditional blacksmith’s vice, or a post vice, to hold the weight (Figure 81).

Figure 81

Post vise assistance

Figure 82

Turtle scrolls

I took the textured pieces to the second shell plate and at the end of the turtle I made some traditional scrolling out of 10 mm square bar. The square bar was forged by hand without jigs - a very traditional way using anvil and hammer. The sharp ends of the scrolls were made with the use of a crimping tool that blacksmiths make to achieve a specific shape

Figure 83

The pillars

The turtle is designed to hang free rather than to be mounted, so pillars were made to be welded to the reinforced frame for a permanent join (which can be seen in Figure 84). They were made from square bar, flattened at one end which is then scrolled so that the whole bar is twisted with the help of an adjustable wrench and a bench vice that grips the bar to get it to twist. Holes were drilled at the top with an 8 mm drill bit for the chain links to connect to the artefact.

Figure 84

Pillars on frame

Figure 85

Collars on the sides

The collars were made by flattening both ends of the square bar and by wrapping them around the stock so that an even-angled edge could be formed. They were made off-centre to show natural form in the artefact. This was achieved by scrolling the collar using a hammer and anvil horn as can be seen in Figure 86. These pieces were also permanently welded to the frame but really only serve as decorative pieces on the artefact.

Figure 86

Figure 87

Turtle fins

The fins were made from flat mild steel bar, 70 mm in width, and its thickness was around 10 mm. This level of thickness required more than human strength to manipulate or move the steel, so use was made of a 20 kg electric power hammer to shape the fins of the turtle. I started to shape the end of the fins first, as seen in Figure 88, and worked my way to the middle. The reason for following this method is that the heat diminishes quickly from the steel when struck. By working the metal efficiently, the steel was heated in sections, making it faster to shape the metal and not waste fuel from the forge. The one side of the fin was drawn out to a narrower thickness, the opposite was rounded with lite hammer taps and left at its current thickness.

Figure 88

Fin shaping

Figure 89

Figure 90

Fins joined to frame

The heavy fins had to be joined to the frame with the use of an arc welder, as seen in Figure 90. The fins were welded to more than just one part of the frame to ensure a secure fit. All the support was made from 6 mm round bar or stock. This is a very convenient material as no heat is required to bend this thickness of steel, just a bending fork fastened in a vice. The material is also very easy to source and is not expensive.

Figure 91

Belly

The belly of the turtle started as a U-shaped frame that would serve as part of the artefact. Since the frame is 8 mm thick, it needed to be heated in the forge in order to ensure that the bend would be the same as the small 6 mm frame for the shell. These two frames would eventually be joined permanently by welding them together with the arc welder. The belly frame was first bent into its desired shape and then holes were drilled with a 6 mm drill bit to connect the copper belly plate to the frame with the use of traditional rivets.

Figure 92

Rivets before

Figure 93

Rivets after

Rivets are made by heating a round stock and upsetting one side to make it thicker than the original stock size - a sort of bolt with a hammered semi-half-sphere head. There are jigs that can assist to make rivets in a very easy way; these are normally used to make big rivets. Small rivets, such as the one in Figure 93, are made from 6 mm round stock, and because they are so small, it is not necessary to heat them in order to upset them: they can be upset using cold forging by hammering them with a ball point peen hammer.

Figure 94

Cold forging a rivet

To cold forge a rivet, a piece of steel is required to hold the artefact that is being riveted 2 cm above the anvil's face. When hammering of the 6 mm round stock commences, it begins to upset at the top as well as at the bottom but the top upsets more because of the direct hammer blows.

Figure 95

Copper belly

The bottom frame is connected to the copper sheet with cold forged rivets. The copper was cut out with special tin shears which, when they cut the copper, make the edges blunt. The bottom half was made before connecting the two parts together in order to texturize the copper to make it look similar to the actual belly of a sea turtle.

Figure 96

Frame for copper texture

For the texturing of the copper sheet connected to the second frame, extra reinforcement had to be built over the existing one in order to make the copper resemble the texture of a turtle's belly. The pattern looks like square sections, or blocks, stacked beside each other.

A ball point peen hammer was used (Figure 97) to deliver blows to the copper sheet which, with the reinforcement, produced the effect of the copper lifting in some areas.

Figure 97

Figure 98

Figure 99

Neck collar

The collar above the neck of the turtle, as seen in Figure 99, is made from 8 mm square bar. Heated in the forge at around 1,000 degrees Celsius, the bar was placed into a vice and clamped to one side. Using a wrench it was twisted three times to give the rolled, twisted effect. When the twisting was done it was heated again to hammer and draw it out to form a point, then used the anvil horn was used to give a natural curve to the forged steel point.

Figure 100

Back fins

The back fins were made from flat bar that was 4 mm thick, but it needed to be prepared with some angle grinder cutting before being heated in forge. A cut was made down the middle of the bar to split the bar's point, then it was heated in the forge. Once it had heated to the right temperature, I started to draw out the points to make thin points. For the back end of the fin, the power hammer was used to narrow the steel and draw it out so that it was not too thick when I had to drill through it. The separated points were scrolled using the anvil horn and face by starting with the curve over the horn, then hammering the back side of the scroll. This starts to scroll itself naturally with each blow. To achieve the scrolling moving outwards, scrolling tongs were used to pull the scrolled steel.

Figure 101

Riveting back fins

As seen in Figure 101, holes were drilled in the fins as well as in the hammered 8 mm square stock with the tapped end that was forged. The square bar was heated and hammered, then bent over the fins to take the same shape so that this could be joined easily and permanently with rivets, as seen in Figure 102.

Figure 102

Figure 103

The stand

The stand, which holds the turtle so it can hover above the ground, was forged out of 40 mm square bar. The 75 kg pneumatic hammer had to be used to draw out the 40 mm to an end point of 10 mm. In Figure 104 the thickness is evident compared with my hand.

Figure 104

Hand comparison

To heat metal to this kind of thickness, a propane forge was used that is equipped with four burners and one centrifugal blower to achieve a very high heat. The 40 mm square bar had to be pre-heated for around 40 minutes to ensure the bar was heated to the core (Figure 105). If this is not done only the surface of the material is heated and the core is immoveable, which can break the pneumatic hammer and cause harm to the person wielding it. Note that the steel was preheated so that the whole piece was hot, even if its colour did not indicate this during forging. Generally more than one pair of gloves is required as the gloves become too hot from the steel and will burn one's hands.

Figure 105

Preheating

While working with such a large piece, a tong specifically made for this kind of work had to be used. This was a normal open jaw tong, but it was made bigger than usual to hold steel thicknesses of 6 mm to 12 mm, as seen in Figure 106.

Figure 106

Big tongs

Figure 107

Pneumatic hammering

The steel piece measured 1.4 metres long, making it easy to start off hammering with the pneumatic. However, as the steel started to draw out, it was harder to operate the hammer with the foot as the operating lever is at the bottom of the machine. The steel was forged to around 2 metres, but a piece of this length needs assistance from someone driving the hammer while you hold the material, as can be seen in Figure 107.

Figure 108

Twisting the bar

The stand was slightly twisted to give it a curve from the start to the end. This required a post vice and two adjustable, as well as portable, stands. The steel was heated twice and adjusted twice with an adjustable wrench, because as one works one's way down the steel it becomes thinner and the adjusting wrench eases the grip each time. When it came to scrolling such a piece, a bending fork was used as it was too big to hammer it. It was clamped to the table at the end and the fork was used to bend it until a flowing scroll was formed. The table made it easier to maintain and prevent it from going off-centre.

In Figure 103, once the stand had been curved and scrolled. It was clamped into a bench vice. As can be seen, some fishing wire weighted with two big flat washers hung from the hook of the scroll. This is to determine the centre of gravity and to ensure that the turtle floated exactly in the middle of the stand. The stand had a plough disc, which I received from a farmer, and welded at its base. However, still more leverage was needed to ensure that the stand would not fall.

Figure 109

Legs

The legs that were welded onto the stand were made from 25 mm square bar. Jigs were used as it is very difficult to make two pieces of material exactly the same. Again, this thickness of steel cannot be manipulated by hammering with a handheld hammer, but a 20 kg electric hammer made this possible. This is how the feet of the legs were drawn out and a jig facilitated the making of the scrolls.

Figure 110

Chain

The chain was made from 8 mm square bar and 6 mm round bar. The square bar was cut into equal pieces and an 8 mm drill bit used to drill out the holes for the links.

Figure 111

Coil rolling

When it came to making the links for the chain, circles had to be made with the 6 mm round bar, but making them individually was too time consuming. Therefore the 6 mm round bar was cut to 1.5 metres, and rolled around the 12 mm round bar to form a coiled spring. Then the bar with the coils was clamped in the vice and use was made of a grinder and cutting disc to separate the coil into individual circles.

Figure 112

Forge hook

The hook was forged out of a piece of 10 mm square bar that was drawn out at both ends. The scrolling was done with the use of the anvil horn and bending fork.

4.2 Blacksmith Products

Tongs

Figure 113

Flat bar measurements

Flat bar steel was used to make most of my tongs, ensuring that the width of the bar is a minimum of 40 mm and the thickness 4 mm. The minimum thickness is sufficient for making small tongs. To make bigger tongs, approximately the same width, or wider, and much thicker steel was used, depending on the size of the tongs to be forged. Figure 113 shows that, markings have been made on the steel to indicate where the hole for the rivet should be and how far from the rivet hole I should strike with the hammer. When forging with this steel, the stock is kept at 1 metre in length to eliminate the necessity to use of tongs.

Figure 114

Z-shape

In Figure 114 the steel starts to take on a shape that resembles the letter Z, achieved by striking the metal outside of the rivet hole area. To the right side the jaw that holds the square bar will be formed and the left side will be drawn out to form the handle of the tongs. In Figure 115, using an adjustable wrench the jaw of the tongs is twisted through 90 degrees to ensure the jaws line up correctly for holding stock.

Figure 115

Figure 116

The jaw has to go through several stages of forging before it takes on the final shape, as seen in Figure 116. The jaw is drawn out to a desired length which later will be formed by a jig to ensure both sides are equal. I left enough steel at the tip to form the mouth that grips onto the stock. In Figure 117, the final shape is formed by the jig which provides the form for the mouth of the square tong and helps line up the two pieces.

Figure 117

Figure 118

A small cut in the mouth of the tongs was made with the angle grinder as this assists in holding the square bar. When the steel is heated to forging temperature, the square bar is gripped with the tongs and a suitably heavy hammer used to strike the mouth holding the square stock to form a diamond-shape, as can be seen in Figure 120.

Figure 119

Rivet

For making a rivet a steel bar is necessary, similar to the one in Figure 119, that has a hole drilled through it to the size of the rivet being made. A 10 mm round bar was heated in the forge to a bright white colour, then placed into the drilled hole in the bar, or rivet maker. About 20 mm of the round bar stuck out and this was hammered with a ball peen hammer to form a mushroom shape. Once the mushroom had formed, the rivet was heated again and placed it in the drilled hole of the tong. This was repeated for the opposite arm, so that the two tong pieces are joined together, as seen in Figure 121.

Figure 120

Figure 121

4.3 Collaboration with a blacksmith

I was fortunate to be asked by Fanie Moller to help him construct the head of a horse in profile for one of his clients. The request was to make the head out of copper and fuse the artefact with the client's existing gate. Different tools were used to form the copper I learned that copper can be cold forged because its strength is second to that of mild steel.

Figure 122

Copper horse

Figure 123

Preparations

We began by measuring the gate to determine the size for the face so that it would fit exactly into the gate frame. After the measurements, we drew the shape of the horse head and neck, then cut out the silhouette to redraw this onto copper sheets, as seen in Figure 124.

Figure 124

The copper sheets were 0.7 mm in thickness, strong enough to work as a functioning piece and easy enough to cut with tin shears. The face was kept as one piece so that less welding was needed when putting it all together. The size made difficult to maintain under the pneumatic planishing hammer as the face was quite large and the machine is normally used to work small sheets of steel. I was taught that the machine can only be used for short periods at a time as the small anvils become heated from the hammering and they can break off if overworked.

Figure 125

Planishing hammer tools

The tools in Figure 125 are used for shaping and texturing the copper. They are made of K600 which is a tool steel that can handle a great deal of stress. However, these are specifically designed to handle sheet metal of not more than 1 mm in thickness.

Figure 126

Working with planishing hammer

In Figure 126 the hammer was used to slightly round the shapes of the horse to give it a three-dimensional appearance. The hammering caused the copper to go through a hardening state which in this case was not a problem as it was beneficial to the gate's weather-handling properties. The hardened state can also be countered if the piece needed to be shaped a second time: applying some heat with a gas torch softens the material again.

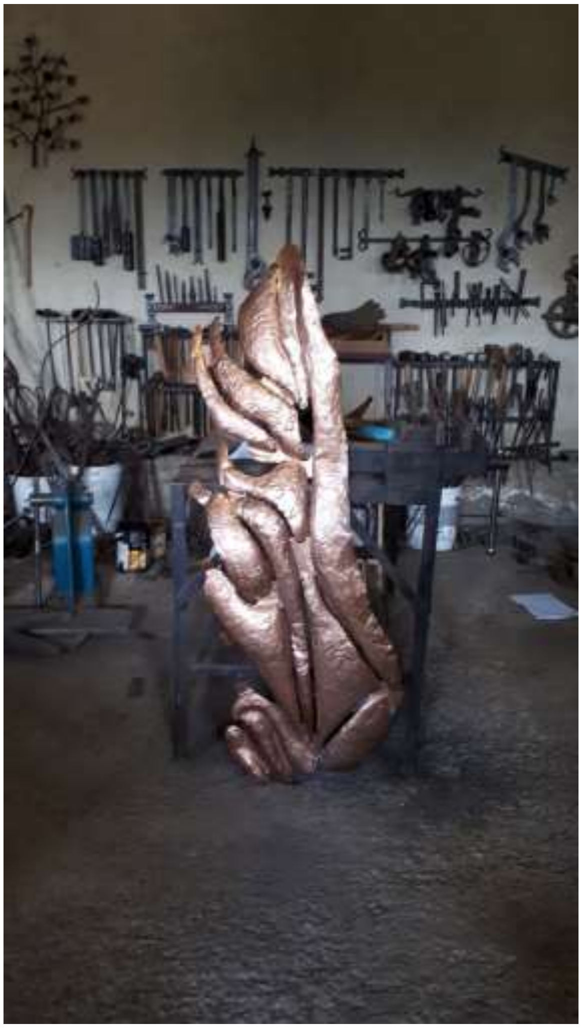

Figure 127

The face was hammered out in the areas that were marked out in black marker. After that had been completed, the narrow strips in between the hammered areas were cut out, as seen in Figure 127.

The areas that were left in the piece to hold it together had to be hammered down with the use of old stone chisels which had to be reformed in the forge and hardened to achieve the desired function. The style was copied from chasing tools that artists use to form copper in pitch bowls.

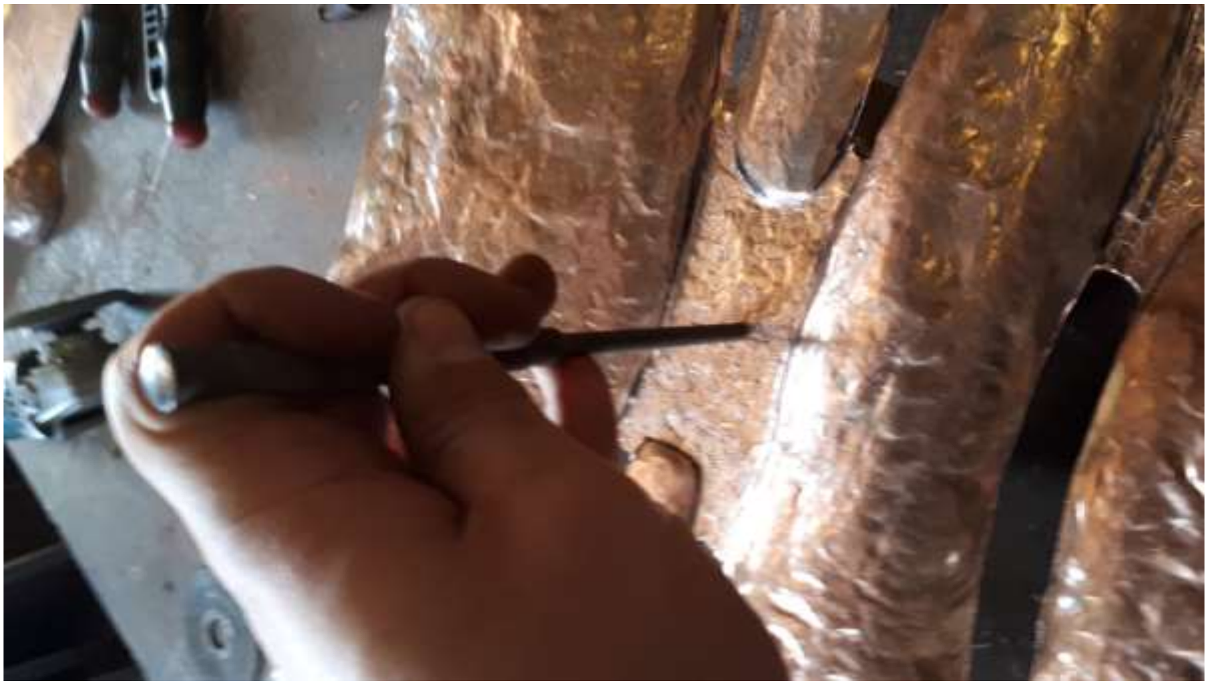

Figure 128

Chisels and copper

Figure 129

Copper to copper

Figure 129 shows a copper- to- copper welding rod with an oxygen and acetylene torch to weld the pieces together. Because the pieces were kept very big, it was not difficult to connect them all together with small tags that were left on most of the pieces: the welding affected only one side while its opposite side remained solid.

To connect the whole piece to the gate, copper brackets were made that were welded to the artefact which was clamped permanently on the gate. The gate had already been galvanized, making it impossible to weld copper to it.

Figure 130

Horse on gate

In Figure 130 the welding marks are clearly visible as the heat stains the copper. It can be easily removed with some sugar water or by spraying water mixed with pool acid, then washing with water and Scotch-Brite pads. While doing this suitable protection was worn, namely surgical gloves, masks and face shields. Figure 122 shows the gate finished and mounted for the client in the position for which it was requested for.

This project was a very useful lesson for me in the blacksmithing world. I was not only taught how to work with copper, the order in which the process works, and how to handle large projects, but also how to prepare in terms of financial planning and acquiring the materials.

Chapter 5 : Conclusion

The purpose of this study is to research the art and craft of blacksmithing in South Africa with the intention of building a forge at the Port Elizabeth Art School in order to introduce blacksmithing as a subject in the Fine Art and Sculpture Department. The aim is to create aesthetically pleasing artefacts and also to determine the viability of blacksmithing as a career.

In order to make the first start in the blacksmith trade, one requires a source for very high temperatures to experiment with this craft. The first step, therefore, is to build a fully functioning coal forge. By gathering information from different sources such as books, articles, and the use of the Internet I was able to acquire the knowledge to build this forge. The coal forge is the easiest and most affordable to build, and is much safer when one is building one for the very first time. If coal is not available, the alternative heat source would be a gas forge that uses propane. Unfortunately the knowledge to build one is not freely available and it is complex to build. A company by the name of Drakon Forge in Pretoria makes gas forges but they are expensive. For my coal forge, I built the hearth using a brake drum seated into a steel plate as the fire pot, then forged supporting legs, and constructed a chimney, flue and hood.

The only problem with the coal forge is finding its fuel source - anthracite coal. Fortunately, this coal is available in Port Elizabeth. The fire pots for coal forges are normally custom-made cast iron pots but the brake drum provides an alternative.

The next challenge is the making of blacksmith's tools. A blacksmith makes all of his or her own tools, from tongs to hammers, but in most cases conventional tongs, like hammers, are easy to come by at hardware stores. Jigs and drifts are items one would not find in stores as these are are handmade by the blacksmith. Even the tools for the forge, such as the poker, that can be hammered on the anvil when the steel had been heated by the forge fire. Personally, I focused on making my own tongs and jigs as well as cold forged rivets. The first tool I made was a pair of flat jaw tongs to hold my short pieces of stock, but as I learned about the different shapes and sizes of steel that were available, I realized I needed a great variety of tongs and tools.

The material of the blacksmith is mainly steel. Of the different types of steel I researched - wrought and cast iron, mild steel, medium carbon and high carbon steel, Damascus steel - I work mainly in mild steel, sometimes incorporating bronze or copper. I also learned to work purely with copper while assisting a professional blacksmith create a large decorative artwork for a farm gate. Material is freely available as there are many steel suppliers locally. However one needs to understand the material before trying to make something. For example, when making aesthetically pleasing artefacts, normal mild steel is a highly suitable material, but when it comes to hammers for functional pieces, one needs to know that metals containing 0.45 per cent carbon are ideal for that kind of use. Knowledge of one’s material is very important as it can make or break the work if it is not suitable for that specific function.

Through practical work I learned the skills of bending, forming, joining and final finishing and presentation. Starting with simpler blacksmithing techniques, I acquired forging skills first by making basic tools (tongs, jigs, rivets), then moved on to more complex work, for example, building the Polynesian mask. This involved angle-grinding, hammering and shaping on an anvil, using scrolling tongs, and a plasma cutter. Finally, the suspended turtle was the most challenging piece. It required skills such as frame-building, forging at extremely high temperatures, welding, texturing steel, twisting and scrolling, using a post vice, working with a propane forge, and machines such as the arc welder and electric power hammer. I also learned how to use old machines to forge large pieces of steel that cannot be formed by human strength alone.

I have succeeded in building a working forge, thus introducing blacksmithing as a process for use by visual artists at the Art School. I have also learned to use the materials in order to create a selection of artefacts, which are not only art pieces but also consist of functional craft pieces. They are the following:

Polynesian mask

Turtle sculpture suspended on a stand

Copper horse profiles for a pair of farm gates (assistant to Fanie Moller)

Further areas of research are the following

- South Africa steel suppliers and steel specialist
- Specialist steel makers
- Establishing a fraternity of personnel Blacksmiths and then resourcing material and equipment in South Africa
- Text book for South Africa Blacksmithing

I close with Googerty's view on blacksmithing (Weygers 1997):

> Every man has an inborn love for the beautiful. Primitive man at first fashioned his utensils for purely utilitarian purposes, but as he became accustomed to their uses he became also dissatisfied with their rude appearance, and the spirit of decoration took possession of him. This is manifested in his early pottery and weapons of warfare. Through successive ages that instinctive love for decoration has manifested itself in all mankind.

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