KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,

KUMASI- GHANA.

METAL VEHICLE IDENTIFICATION TAG WITH ACCESS CONTROL CHIP FOR KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

By

OBED PERSIE APPIAH-KUBI

(B.A. INTEGRATED RURAL ART AND INDUSTRY)

A Thesis submitted to the Department of Integrated Rural Art and Industry in the

Faculty of Art

College of Art and Built Environment,

in partial fulfilment of the requirement for the degree of

MASTER OF PHILOSOPHY

FEBRUARY 2019

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DECLARATION

I hereby declare that this research is my own work towards the award of the Master of Philosophy Degree in Integrated Art and that to the best of my knowledge, it contains no materials previously published by another person nor any material which has been accepted for the award of any other degree except where due acknowledgement has been made.

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ABSTRACT

In Ghana and across the globe, professionals like lecturers, lawyers, medical doctors, the security forces, but to mention a few, have different and unique vehicle identification tags that give them recognition in the society. Vehicle identification tags for KNUST, UG and UCC staffs are printed on polyvinyl chloride material which are not easily recognizable at a distance and fade within limited time. In KNUST and UG, these tags have been electronically improved to allow or deny entry into their campus via vehicular access control system. To improve distance visibility, this study aimed at producing a metal relief vehicle identification tag with an access control chip for KNUST. To achieve this aim, this study sought to; analyse the existing access control system in UG and KNUST, design an improved access control and employ local metal technology in the design of a vehicle identification tag to respond to vehicular access control system. In this regard, the research adopted the action, advocacy, descriptive and experimental research designs in the investigation, analyses and composition of the concepts. The research came up with two designs of the metal relief vehicle identification tag with an access control chip for Kwame Nkrumah University of Science and Technology for easy visibility and to respond to the access control systems. The samples were made through lost wax casting in brass: a traditional casting process among metal founders in Ghana. To demonstrate the concept, a simulation model was executed to present the mode of operation of the concept as it will work in reality. In conclusion, two contributions were made in regards to the designing of the system to respond to the metal relief identification tag. The introduction of the display screen and the introduction of traffic indicator all to prompt both the user of the vehicle's tag and the security. This it to provide good information regarding validity, the status of the user and also the state of the access control system.

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CHAPTER ONE

INTRODUCTION

1.1 Overview

Chapter one outlines the general information on the background to the research, problem statement, aim of the study, the objectives of the study, questions for which the researcher is looking for answers, as well as the importance of the study.

1.2 Background to the study

It is prestigious to be recognised in the society by one's profession with a unique vehicle identification tag having the details in design the kind of profession one practice in the society. In Ghana and across the globe, professionals like lecturers, lawyers, medical doctors, the security forces, just to mention a few, have different and unique vehicle identification tags that give them recognition in the society.

Vehicle sticker as called by many people comes in many forms or categories all with the aim of promoting an organization, person, or a product. The categories of vehicle stickers are; religious, political, patriotic, profession and trade, landscape, commercial, secular, humorous, to mention but a few. Vehicle identification tags or stickers for KNUST, UG and UCC staffs are mostly printed on polyvinyl chloride material which are not easily recognizable at a distance and fade within limited time. In KNUST and UG, these tags have been electronically improved to allow or deny entry into their campus via vehicular access control system.

Despite the nice sticker design, it is not visible from a distance. Hence a motivation for the researcher to produce a sample metal relief vehicle identification tag with an access control chip which has more visible at a distance for Kwame Nkrumah University of Science and Technology to respond to an access control system.

1.3 Statement of the problem

Vehicle identification tags or stickers are mostly printed on polyvinyl chloride material which are not easily recognizable at a distance. They fade within limited time and make the reading of the identification tag or sticker content difficult by other people.

Scientific research and exploration in metal has proven the amazing works metal in a well-treated and finished state could be as an alternate material for the usual PVC printed stickers, thus providing durability and promoting proper recognition from a distance. This scientific proof according to Gayle *et al* (1992), made known that metals can withstand the harshest conditions including chemical spills, outdoor exposure and temperatures up to 1200°F.

1.4 Aim of the Study

The research aimed at producing metal relief vehicle identifications tag with an access control chip for KNUST not only to identify staffs, but also to respond to a vehicular access control system. This is envisioned as an improvement on the access control system.

1.5 Objectives of the study

In order to achieve the aim of this study, the following objectives were considered;

1. To analyse the existing access control system for vehicles in University of Ghana.
2. To design an improved access control model based on the finding in objective one.
3. To employ local metal technology in the design of vehicle identifications tag that will respond to a vehicular access control system.

1.6 Research Questions

Three research questions were considered. These are:

1. What is the nature of the vehicular access control systems in the University of Ghana?
2. What other components can be adopted to improve on the existing vehicular access control systems?
3. How can the existing tags be improved with the use of local metal technologies?

1.7 Delimitation

The researcher's site of study was the University of Ghana (Legon) in the Greater Accra Region of Ghana. The researcher limited himself to any similar model of the Kwame Nkrumah University of Science and Technology vehicular access control system. On the choice of material, the researcher limited himself to brass metal because of its local availability, ability to withstand and perform better under the harshest temperature and its visibility from a distance.

The most appropriate technique employed was casting. A selected number of staff at the University of Ghana, some students who use vehicles, some commercial drivers who use the E-Card for entry access were visited for interviews and observations on the trend of vehicular access control systems in the university campuses in Ghana.

Inadequate funds limited the researcher to produce a table model representation of a vehicular electronic access control system to respond to the local metal technology vehicle identifications tag.

1.8 Importance of the study

1. The study is expected to make the work of inspectors of these vehicle identification stickers easier through distance visibility.

Usually in restricted areas in campuses, security personnel at post check for vehicles bearing the institution's identification tag before the user of a particular vehicle can be permitted to access the barrier. Because most vehicle identification tags are printed on polyvinyl chloride (PVC) material, the security personnel at post at times struggle to recognize the PVC tag on the vehicle from a distance. This metal identification tag because of the material used can be recognised well from a distance even before it gets to the barrier.

2. The metal relief identification can contain access control or security chip because of its volume.

Another important feature of the metal identification tag is its ability to contain an access control chip. The metal identification tag will be designed not to be heavy in weight but a light weight tag of 0.3cm to contain an access control chip.

3. It is also expected to project the image of KNUST by way of branding.

Institution identification tags on vehicles serves as a way of branding to the institution and to the vehicle. The metal vehicle identification tag aside its ability to last longer, its visibility from a distance, will serve as a good branding to KNUST and will help project the image of KNUST high.

4. Lastly, the work will produce a more lasting effect unlike the existing PVC stickers that deteriorates faster with time.

Metal vehicle identification tags has the tendency to withstand and perform better under the harshest temperature as compared to polyvinyl chloride vehicle identification stickers that deteriorates faster with time.

1.9 Definition of terms and Abbreviations.

Electronic Tag: Electronic tags or chips are devices in a storage which is monitored by attaching another electronic device to detect the presence of an object by communicating while the object is in storage or is being moved.

***Emblem*:** It is a symbolic object as a distinctive badge of a nation, organisation or a family. Emblem can also be defined as anything serving as a symbol of a particular quality or concept.

Identification: It is simply the act of recognizing something or someone.

Relief: It is a sculptural technique where the sculpted elements remain attached to a solid background of the same material.

Sticker: Any sticky label or notice generally with a message printed or illustrated, intended to be attached on a surface of an object.

Vehicular: It's an adjective used when talking about something that has to do with car or truck.

ABBREVIATIONS:

DVLA: Drivers and vehicle license agency

GHz: Gigahertz

HF: High Frequency

KHz: Kilohertz

LF: Low Frequency

MHz: Megahertz

NFC: Near-field Communication

PVC: Polyvinyl chloride

RFID: Radio frequency identification

UHF: Ultra-High Frequency

1.10 Arrangement or Organization of the rest of text

Subsequent chapters are in the following order. Chapter two which follows the chapter one carries relevant data reviewed for the purposes of this study which encompasses detailed review of selected related literature that are relevant to the study to give the researcher an insight on what others have done on the proposed research or similar. This is followed by chapter three which outlines the research methodology and the research design outlining the strategies forming the roadmap for the execution of the study. The final chapter deals with calculated budget and time schedule of activities.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview

This chapter contains every essential information on the topic, **'Metal Vehicle Identifications Tag with an Access Control Chip for Kwame Nkrumah University of Science And Technology'.**

2.2 Introduction

Many studies have been conducted by many researchers concerning the topics to be reviewed and the works that others have done in relation to this study. Though all these conducted studies are aimed at explaining the topic better, most of these sources end up either contradicting or agreeing to each other in their explanation and result. This is relevant to the researcher because it will enable him the chance for certain argument to be laid forth.

The sub topics below were selected for review to further subject the research topic to the necessary scrutiny to ascertain its feasibility and viability;

- Methods of branding automobiles
- Types of metals for relief vehicle identifications
- Techniques and processes used in the production of a metal relief vehicle identifications
- Finishing given to the metal relief vehicle identifications
- Adhesion behind metal stickers
- Forms or shapes of vehicles as a surface for fixing the metal sticker
- Electronic tags
  - -Types, classification, function, advantages and disadvantages of electronic tags
  - -Other forms of Electronic tags
- Types of Radio frequency identification reader and how access control systems operates

2.3 Methods of Branding Automobiles

In understanding branding well, brand is an ancient Norse word “Brandr” which means to burn. According to Davis (2009), brand is considerably more than a symbol, sign, emblem or a name, as it embodies the full nature and personality of an establishment. It is the boundary amid an establishment and its consumers or customers.

A brand can again be defined by Schmidt (2005), as any distinctive symbol, design, word, sign or a blend of these, to create an image that identifies an artefact or a company and distinguishes it from its competitors.

The researcher after reading and understanding the meaning of brand, also defined brand as any simple but distinct design, logo or a letter that easily distinguishes a product or company from others for the purposes of recognition in the society. However, brands are generally secure from usage by the public by acquiring a service mark or a feature or from an accredited organisation, generally an administration agency.

Schmidt (2005), defines branding as the representation of your organization as a personality. Branding is who you are that differentiates you. Experts in advertising do branding not specifically for recognition, nonetheless to establish a good reputes by way of setting standards as a benchmark for companies to endeavour to uphold or outshine. As a way to build a significant establishment asset, which is a decent repute. Whether an establishment has no status, or less astral reputation, branding can aid in changing that.

Plate 2.1: Shows a 3D metal spider car sticker on a vehicle
(Source: *www.market14.com*)

Plate 2.2: Shows an air force chrome metal emblem badge on a vehicle
(Source: *www.collectionfast.org*)

Plate 2.3: Shows camouflage vinyl wrapped around a vehicle

(Source: *www.aliexpress.com*)

Plate 2.4: Shows a 3D evil umbrella emblem badge on a corner of a car door
(Source: *www.aliexpress.com*)

Plate 2.5: Shows a grand chrome metal hood logo of jeep fixed to the bonnet of a vehicle
(Source: *www.dhgate.com*)

The numbered plates 2.1- 2.5 above shows vehicle branding by different branding materials.

Vehicle branding is important since it brings about innovation, increased security, high visibility, and increased night-time safety since a good graphical or impression branding mirrors illumination during the nights and makes a branded automobile appear resembling a lighted commercial moving across the road, therefore averting the chance of accident.

Branding according to Perry (2013) and Wong (2005) branding comes in these methods or ways;

1. Magnetic Car signs or branding
2. Vinyl Graphics or branding
3. Metal impression branding

2.3.1 Magnetic Car Signs or Branding

With this method of automobile branding, a designed logo, letters or emblem of a company or an individual customised is produced from either metal or plastic for the purpose of sticking onto a vehicle by a magnetic force.

Plate 2.6: Shows magnetic badges of some countries stuck to the bonnet of a vehicle
(Source*: www.ebay.com*)

Plate 2.7: Shows magnetic badges of Coca-Cola
(Source*: www.alibaba.com*)

Looking at the above design, the back of the sticker has a magnet or magnetic linen stacked for it sticking to be possible for it intended purpose.

2.3.2 Vinyl Graphics or Branding

Vinyl graphics or branding is also considered as one of the methods of branding automobiles. The vinyl style of branding is usually a design of logo, an abstract, picture or letters printed on a PVC material or photo paper intended to be stacked onto a surface. The method of this branding approach can either be the transfer type of design or a normal wrap of designed vinyl material on a vehicle that does not require any transferring of the design. In simple terms, Vinyl branding on vehicles is seen to be a design in either two or three layers so people often mistake it to be a decal.

(Sources*: www.ebay.com)*

(Source*: www.stickeryou.com*)

Plate 2.7 and 2.8: Shows vinyl sticker design being transferred onto a vehicle surface.

Looking at the above vinyl style of branding, the sticker design is transferred onto a surface for attraction purpose and advertisement.

Vinyl as a material for automobile branding may be designed customised and used by an individual or by an institution to aid them advertise a specific product to the public through indicating the products the institution is marketing or advertising in the vinyl design to be wrapped on a vehicle. This style or method of vehicle branding is very common in the society nowadays due to the competitive markets. A vehicle either four wheel or three wheel is wrapped with the vinyl design and then wrapped on either the whole body of the vehicle or half wrapping.

This style of branding is mostly done during promotions of company's products as it is common in Ghana. The product and the name of that company is designed and printed on a vinyl material for easy advertisement.

Plate 2.10: Shows a customised vinyl designed material wrapped around a vehicle
(Source: *www.ebay.com*)

Plate 2.11: Shows an advertisement on vinyl material wrapped on a van

(Source: *www.alibaba.com*)

2.3.4 Metal Impression Branding

The metal impression branding unlike the other methods, make use of a designed logo, emblem, any abstract or letters representing a company or institution in metal and with the help of any reliable adhesive material, fixed on the surface of an automobile. The metal identification for branding can be fixed from the bumper to the corner of a vehicle's windscreen. Metals that can be used for this branding method include brass, aluminium, zinc, lead, copper, nickel, iron, silver, stainless steel etc. when treated very well to withstand high temperatures and for the purpose of visibility is given a good finish to be able to recognise from afar.

Plate 2.12: Shows a 3D metal jaguar emblem on a vehicle's bonnet
(Source: *www.solidrop.net*)

Plate 2.13: Shows a 3D metal bonnet shield emblem for old Regal Excelle
(Source: *www.dhgate.com*)

Plate 2.14: Shows Air Jordan jump man car metal badge on a vehicle's booth.
(Source: *www.ajavenue.com*)

Plate 2.15: Shows a 3D metal front hood ford car bonnet badged.
(Source: *www.dhgate.com*)

The above numbered plates 2.12-2.15 indicates metal impression branding on vehicles

2.3.5 Removing Metal Emblems or Designs (Brand) From Vehicles

Today most emblems or designs for metal impression branding are attached on vehicles using a strong adhesive. This strong adhesive used despite its bonding strength can be detached from the vehicle body together with the emblem or design fixed as a brand on the vehicle.

Modern branding on vehicle is done in such a way that the branding (design for advertisement or recognition purposes) can be detached or changed due to the dynamic nature of the world or the changes of moment to suit present innovations and creativity.

Like plastic stickers on vehicles can be removed without any left stains on the surface pasted on, so can metal stickers on vehicles be done, whether the metal sticker is glued to the bumper, the doors or even to the windscreen.

Removing emblems or designs as brands on vehicles can be done using three main procedures according to wikiHow logo (2017)

The procedures are below;

1. Loosening the adhesive
2. Removing the metal emblem or the design
3. Cleaning and waxing the surface

2.3.5.1 Loosening the Adhesive

In loosening the adhesive, the first thing to do is to determine how the logo or the sticker was attached to the vehicle. This will enable the one removing the sticker to know which procedure will be ideal for separating the sticker from the vehicle. Some stickers are attached to vehicle bodies by the use of strong adhesive or by mechanic bond.

After determining how the sticker was attached to the vehicle, the next necessary action or step is to use hot water to soften the adhesive, using hot water on adhesives will reduce it sticking strength.

The next necessary action after using hot water to soften the adhesive is to spray adhesive remover onto the adhesive. Adhesive remover is a liquid or paste substance that when sprayed or smeared on a surface removes glue remains or for preparing surfaces preceding to use of adhesive. Adhesive removers can be applied on surfaces to clean weighty oils, tar, silicones, grease and paraffinic materials like Cosmoline. Adhesive removers are categorised into three main types; solvent-based removers,

citrus-based removers and soy-based removers. The ingredient meant for each kind differs and they each have their strengths in terms of the substances and materials they work on.

Plate 2.16: Shows solvent-based adhesive remover
(Source: *www.amazon.com*)

Plate 2.17: Shows a citrus-based adhesive remover
(Source: *www.honda-tech.com*)

Plate 2.18: Shows a soy-based adhesive remover.
(Source: *www.products.franmar.com*)

Plate 2.19: Shows a solvent-based adhesive remover being sprayed onto an adhered impression
(Source: *www.wikihow.com*)

The last step under loosening the adhesive for easy removal of the sticker from a vehicle is to use blow dryer or a heat gun to warm the adhesive down. Here the dryer is set to the hottest temperature and then pointed directly to the edge of the sticker, logo or emblem and sweep it back and forth along the length. Keep the blow dryer on the sticker for some few minutes until it begins to get tacky. During the process, you can check the strength of the adhesive by running a fingernail along the edge of the sticker,

if you can press your fingernail into the adhesive then it is warm enough for easy remover of the sticker.

Plate 2.20: Shows a blow dryer (Source: *www.vecteezy.com*)

Plate 2.21: Shows a blow dryer heated and pointed on an adhered impression to warm the adhesive behind it (Source*: wikihowlogo.com*)

2.3.5.2 Removing the Metal Emblem or the Design

A flat tip edged tool like a hard identification card or a plastic putty knife can be used to help remove the sticker or the design from the surface of a vehicle once the adhesive has been loosen.

For easy peeling off, try to slide the identification card behind the sticker or design and continue to work it through the softened adhesive until it is loose enough to remove. Continue the process by spraying adhesive remover onto the surface of the vehicle since there will certainly be residue of the adhesive on the surface. Pull the sticker or emblem off of the car, and let the adhesive cool and roll your hand and fingers over the remaining adhesive to loosen it from the car's surface.

Plate 2.22: Shows a plastic putty knife tilted behind the impression for easy peeling.
(Source: *wikihowlogo.com*)

2.3.5.3 Cleaning and Waxing the Surface

After the removal of the sticker from the vehicle body, wash the area with water and automotive soap and once done rinse the area again. After washing the area completely, allow it to dry or you may speed the process by rubbing a towel to dry it faster but be sure there are no moisture left on the surface else the area will take longer to wax.

The next necessary action after washing the area is to wax the area. The reason for waxing the area in the process of removing metal stickers on vehicle is that, the surface or the paint will still look shiny and protected from the elements in the adhesive remover.

In waxing the area where the sticker was, the vehicle should be under shade since sunlight can dry wax too quick to paint but the process needs gradual drying of the wax on the surface of the vehicle. Use the supplied wax applicator foam or sponge to apply wax to the area the sticker used to be. Ensure you cover any part of the paint or the surface of the vehicle that the adhesive remover was sprayed onto or may have dripped on. You may choose to wax the entire portion of the car to ensure the wax cover is uniform, and you don't need to apply too much wax, just a light coat.

Gradual wax drying on vehicle under shade will take anywhere thirty minutes to some few hours to dry completely. Touch the surface area with your finger periodically to

check the dryness of the wax, if the wax rubs off easily under a single finger, the wax is dry. Buff the wax off with a chamois towel and ensure there is no left waxy residue on the surface of the vehicle.

Plate 2.23: Shows chamois towel being used to clean the area where the impression was after the removing.
(Source: *wikihowlogo.com*)

2.4 Types of Metals for Relief Identification

According to Gayle, *et al* (1992), metal has the ability to withstand the adverse conditions including chemical spills, open-air exposure and altitude up to 1200°F.

Metal stickers as many call it, are known for their security and durability and for offering readability as far as distance is concerned and often prevent intentional removal for theft or unauthorized asset transfer (Nicole, 2016).

Metals like aluminum, nickel, iron, silver, copper, lead, magnesium, zinc, stainless steel can all be used for the production of a relief identifications provided one can treat their surfaces to withstand the environment. Gayle *et al*, (1992) attests that despite the ability of stainless steel to be used for metal relief identifications, it will remain durable after exposure in harsh environment once made from 316 or 304 stainless steel type.

Platinum metals, brass and bronze can also be used for metal relief identifications wherever corrosion resistant and strength is vital for decorative purposes.

2.4.1 Examples of Metal relief identifications.

Plate 2.24: Shows a metal relief identification for US coast guards
(Source: *www.dhgate.com*)

Plate 2.25: Shows a metal relief emblem badge for China army
(Source: *www.alibaba.com*)

Plate 2.26: Shows a metal relief Aladdin eagle emblem sticker
(Source: *www.dhgate.com*)

2.5 Techniques and Processes Used in the Production of a metal relief identification with access control chip for KNUST.

Stickers are produced for the purpose of sticking to an object with a precise information about an organization or identifying an institution.

There are several metal forming techniques that can be used in the production of a relief metal stickers. The following are some of the techniques or processes through which a metal relief identification can be produced;

2.5.1 Casting

Casting is one of the oldest manufacturing processes. It is the first step in making most metal products. Casting according to Campbell, (2003) is the process of creating metal or alloy constituent parts of preferred form by pouring the liquefied metal or alloy into a prepared mold (of that shape) and then letting the metal or alloy to cool and harden. Again Kelvin (2009), also defines casting as a manufacturing procedure usually used for bulk production in which materials in a liquefied state is poured into a mold where they harden. Chakrabarti (2005), also defines casting as the manufacturing method in which a molten metal is injected or poured into a mold to form an object of the desired shape.

In conclusion based on the above definition of casting, The researcher defines casting as an engineering procedure in which molten metal is dispensed into a mould which contains a hollow cavity of the desired shape of the work one intend to produce made of sand, metal or ceramic, and then allowed to solidify to form geometrically complex parts.

In metal relief identification production, casting can be considered as on the major techniques or processes one can employ since major metals can be cast.

Steps in casting

- With a prototype of desired work, create a mould cavity
- With a good furnace, melt the metal.
- Pour the molten metal into the cavity and leave to harden.
- Break the cavity, pick and trim the end product to the desired shape.

2.5.1.2 Images of metal cast identifications

Plate 2.27: Shows a cast metal identification for Italy department of Justice
(Source: *www.cornerstonesign.com*)

Plate 2.28: Shows a cast metal horse
(Source: *www.pinterest.com*)

2.5.2 Printing

Another technique of producing a metal relief identification is printing. Many people have narrowed their understanding in printing to be done basically on paper, wood, ceramic or fabric only. Colours or printing paste has the ability to stick to other materials like metal serving as a support for the printing to be done on.

Printing according to the Cambridge dictionary (2016) is the activity or business of producing writing or images on paper or any other material with the help of a machine. Merriam- Webster also defines printing as the process of producing books, magazines

etc. by using machinery. It can also be the transfer of an inked image unto another surface.

A piece of metal is 3 Dimensional object, so relating it to the context of the study, this technique is possible to be used because a sheet metal when treated properly has the ability to hold ink and can be adhere unto another surface as a sticker.

A typical example of printing technique that can be used to achieve this project or study is flexography and other printing techniques that can also be used to achieve the same purpose as far as this study is concerned.

2.5.2.1 Images of printed metal pieces

Plate 2.29: Shows sample printing on metal for identification
(Source: *www.norcorp.com*)

Plate 2.30: Shows a printed metal identification for Harmony Public Schools
(Source: *www.labellab.com*)

2.5.3 Etching

Etching according to Elizabeth (2016), etching comes from a German word meaning to eat. Etching known to the French ‘Gravure’ and to the Italians ‘Acquaforte’ is the art of producing an image from a metal plate into which an image or text is created through the process of eating away of bare metal surface in an acidic solution.

Apart from metal, etching can be done on other hard materials like glass. In acid metal etching, apply a resistant usually masking tape or wax coat unto the metal one intends to create the design on. Since the plate is covered with wax or masking tape, the one working on the process will need to scratch off the ground with a pointed etching needle

exposing that area to pick the acid for the eating away of the portion to produce the design. Dip the metal into an etchant and allow it to eats the exposed portions of the metal, leaving behind the metal plate with sunken lines. The end product is cleaned and in some cases ink is applied to the affected surface area.

Below is an etching work done by Daniel Hopfer, the first person who is believed to have applied the technique to printmaking.

Plate 2.31: Shows 'The Soldier and his Wife" etched piece by Daniel Hopfer, the first man believed to have applied the etching method.
(Source: *www.mutualart.com*)

Plate 2.32: Shows an etched metal Identification
(Source: *www.wikihow.com*)

Plate 2.33: Shows a laser etched printing labels in New Delhi, India
(Source: *www.pinterest.com*)

2.5.3.1 Process of etching

- Get any metal plate, cover it with wax to serve as a resistant or cover it with masking tape.
- Draw with a needle onto the wax coated or masked metal plate to create a design.
- Prepare an acid solution (etchant) for the process.
- Dip the metal plate into the etchant after creating a design on it.
- Submerged in etchant, the uncovered will erode after some period of time.

The depth of etch is controlled by the amount of time the etchant is allowed to eat into the metal. The longer in etchant, the deeper the line and the darker it will print

In order to obtain a print, a viscous greasy ink is pushed into the etched grooves, then the surface is wiped clean with muslin, leaving only the etched areas retaining ink.

2.5.4 Engraving

Most people usually confuse themselves with engraving and etching although the result can be same but different processes. The difference here is engraving makes use of tools and it involves the physical removing of the metal part with a sharp pointed tool whereas etching makes use of a strong acid that eats or bites into the metal to create a dent in the metal sheet. Engraving is clearly different from etching, which no one should be confused of. Meek (1973) defines engraving as the art of cutting grooves into a surface of wood, stone, or metal or a print made from a cut surface to create a design. Engraving processes can be entirely mechanised produced dependent on the specific element to be inscribed or done manually with device assist.

Engraving in metal can be done by manually or by the use of machine entirely. In manual engraving, burin, an identified device in a chisel form is used and it comes in many sizes, it use depends on the kind of design one intend to create on the metal plate.

Plate 2.34: Shows a burin being used to engrave a metal plate
(Source: *www.embeddedtronics.com*)

Plate 2.35: Shows an engraving machine being used to engrave a metal plate.
(Source: *www.signplus.com.au*)

Plate 2.36: Shows mechanised engraving of Ferrari on a plate
(Source: *www.ebay.com*)

Plate 2.37: Shows mechanised engraving of John Smith on metal plates
(Source: *www.fastframeencino.com*)

2.5.4.1 Process of engraving

- Choose the material (any suitable metal) for the printing plate
- Scratch or inscribe the design on the desired metal plate with any burin that will suit the inscription

Below is an image of set of burin for engraving:

Plate 2.38: Shows engraving tools.
(Source: *www.pinterest.com*)

- Smear ink into the inscribed plate.
- Carefully clean the excess ink on the plate leaving ink held in the engraved lines.

2.5.5 Chasing

Chasing is from a noun ‘chase’, which alludes to indentation. It comes from a French word ‘chasser’ explicating to drive out, or to chase around an images on metal surface to obtain a relief final design.

The Archaeology wordsmith (2017) defines chasing as a method of decorating metalwork by engraving on the outside of the raised surface. Chasing is the line beautification applied to the face of repousse work with a tracer. Chasing is used largely to refer to any hammered or punched decorations on metal.

The procedures of repousse and chasing make use of the manipulability of metal, creating forms by degrees. Through hammering the metal from the front to raise and push

without eliminating any of the design on the metal surface. Chasing is the reverse of repousse whereby the metal is controlled from the behind to give a higher relief.

Plate 2.39: Shows a chased metal piece
(Source: *www.pintereset.com*)

Plate 2.40: Shows a chased metal artefact.
(Source: *www.alamy.com*)

2.5.5.1 Example of chased work.

Looking critically at the figure above, the relief design on the metal was derived by hitting with tools to raise or push aside the metal without eliminating any form from the metal surface.

Plate 2.41: Shows a chased face In brass metal
(Source: *www.nancylthamilton.com*)

Plate 2.42: Shows a chased running beast on a metal plate
(Source: *www.pinterest.com*)

2.5.5.2 Process of chasing

- Trace design on a metal sheet
- Anneal the metal after tracing
- Place the annealed metal sheet in a wax pitch
- With your tools, punch and anneal intermittently to avoid tearing in the metal.
- Turn the metal when desired shape is achieved and apply the repousse method to push out the designs on the metal to obtain a raised design surface.

2.5.6 Piercing

Booker's INC (2017) defines metal piercing as a process of creating holes, slots and notches with tight tolerance within sheet metal or metal component. This provides a clean cut and high output rates often making it a more productive method than drilling or using a laser.

Plate 2.43: Shows pierced metal designs
(Source: *www.melissamuir.com*)

Plate 2.44: Shows pierced metal design
(Source: *www.pinterest.com*)

Plate 2.45: Shows pierced bird as pendant
(Source: *www.pike.com.au*)

2.5.6.1 Process of piercing

- Create a design on a piece of paper and stick it onto a desired metal sheet.
- With the help of center punch, drill a hole around the design for easy cutting.
- Fix a jewellers' blade into the saw frame and insert it through the drilled metal sheet.

- Once the blade is inserted into the drilled hole in the metal and tightened, pierce out the design out.
- After piercing out the design out, file and sand the edges of design to obtain a smooth round edges.

2.5.7 Embossing

Britannica (2017) defines embossing as the art of raising decoration or pattern in relief from the reverse side. Embossing can be produced on metals such as brass, aluminium, steel, zinc and so on by some pre-determined forms and shapes.

2.5.7.1 Processes involved in embossing metal

The metal sheet embossing operation is commonly accomplished with a combination of heat and pressure on the sheet metal, depending on the type of embossing required. Theoretically, with any of these procedures, the metal thickness is changed in its composition. Metal sheet is drawn through the male and female roller dies, producing a pattern or design on the metal sheet. Depending on the roller dies used, different patterns can be produced on the metal sheet. The pressure and a combination of heat actually "irons" while raising the level of the image higher than the substrate to make it smooth. The term "impressing" refers to an image lowered into the surface of a material, in distinction to an image *raised* out of the surface of a material. In most of the pressure embossing operation machines, the upper roll blocks are stationary, while the bottom roll blocks are movable. The pressure with which the bottom roll is raised is referred to as the tonnage capacity. Embossing machines are generally sized to give 2 inches (5 cm) of strip clearance on each side of an engraved embossing roll. Many embossing machines are custom-manufactured, so there are no industry-standard widths. It is not uncommon to find embossing machines in operation producing patterns less than 6 inches (15 cm)

wide all the way up to machines producing patterns 70 inches (180 cm) wide or more. Stamping, repousse etc. are also metal techniques that one can use to produce a three dimensional vehicle identification stickers

2.6 Finishing Given To the 3d Metal Stickers

Metal finishing is defined as the process of changing an object's surface, for the purpose of improving its appearance and or durability.

The English oxford dictionary then defines finishing in metal to a layperson's understanding as the final detail completion and enhancing or beautifying a piece of work. Finishing processes are employed on a piece of metal work to enhance its look, bond, solderabilty, in order to control the surface friction of the metal.

However, with regards to finishing given to 3 dimensional (3D) metal stickers, surface finishing processes can be characterised by how they affect the work piece:

- Removing or Reshaping Finishing
- Adding or Altering Finishing

The following are some of the finishing technique one can employ in enhancing the surface beauty of a metal work; grinding, sanding, painting, enamelling, buffing, electro plating, burnishing, powder coating, blanding, pickling, galvanising, plasma spraying, electro polishing and so on.

Any of these finishing technique when employed well will give a good surface finishing of metal, hence preventing further any surface disorder.

2.7 Adhesion behind Metal Stickers

Pocius (2002), explains adhesion to be the forces or mechanisms that keep or joins each substrates together. Shrikant (2010), defined adhesion as the attraction process between

dissimilar surfaces that cling to one another. IUPAC (2016) also defines adhesion as the process of attachment of a substance to the surface of another surface.

There are five adhesion mechanisms according to Shrikant (2010), these mechanisms are specific to a particular material scenario. The mechanisms include:

1. Mechanical adhesion
2. Chemical adhesion/ Chemisorption theory
3. Dispersive adhesion/ Physical absorption or Physisorption theory
4. Electrostatic adhesion
5. Diffusive adhesion

2.7.1 Mechanical adhesion theory

With the mechanical adhesion theory, Shrikant (2010) explains that the adhesion materials fill the pores of the surfaces and holds the surfaces together by interlocking.

This mechanism of adhesion enables the adhesion material to flow and fill the micro cavities on the substrate for the adhesive to harden then the substrates are held together mechanically. The adhesive must not necessarily wet the substrate but also the right to show the properties to penetrate the pores and openings in a reasonable time.

Since the adhesive must flow and fill the micro cavities, the surface of the substrate shouldn't be smooth, it should consist of a maze of peaks and valleys to enable the adhesion to be possible. Again in order for this mechanism of adhesion to function properly, aside the penetration of the adhesive, it must also displace the trapped air at the interface, and lock on mechanically to the substrate.

Mechanical theory of adhesion generally suggests that roughening of surfaces is beneficial because;

1. It gives teeth to the substrate for easy mechanical interlocking.
2. Increases the total effective area over which the forces of adhesion can develop.

2.7.2 Dispersive adhesion/ Physical absorption or Physisorption theory

Dispersive or dispersion adhesion also known as Physical absorption or Physisorption theory of adhesion results from the molecular contact between two materials and the surface forces that develop, usually designated as secondary or van der walls forces. Shrikant, (2010)

In this adhesion theory, adhesives should make intimate molecular contact with the substrate surfaces. The establishment of continuous contact between an adhesive and the adherent, referred to as wetting can be determined by contact angle measurement. Complete spontaneous wetting takes place when adhesive uniformly spreads over a substrate to form a thin sheet or when contact angle is 0^{o}. This continuous contact between the adhesive and the adherent becomes favorable when the substrate surface tension is high and the surface tension of the wetting liquid (adhesive) is low.

As a matter of fact, low energy polymers wet high energy substrates such as metal and glass. Reversely, substrates with low surface energies will not be wet by other materials.

2.7.3 Electrostatic adhesion

According to Shrikant, (2010) the electrostatic theory of adhesion originated in the proposal that if two metals are placed in contact, electrons will be transferred from one to other so forming an electrical double layer, giving a force of electrostatic attraction. However, some insulators seem difficult to apply this adhesion theory since they are polymers.

2.7.4 Chemical adhesion or Chemisorption theory

The chemical theory of adhesion brings about the formation of ironic, covalent or hydrogen bonds across the interface.

2.7.5 Diffusive adhesion

With this theory of adhesion, some materials may combine to form a single entity at the end or joint by diffusion, and this is possible when the molecules of both materials are mobile and soluble in each other.

Shrikant, (2010) stated that this theory of mechanism is effective with polymer chains where one end of the molecule diffuses into the other material. When polymer granular are pressed together and heated, atom diffuses from one particle to the next and this joins the particle into one. The diffusion theory characterizes the adhesion of polymeric materials to the inter penetration of chains at the interface. It is required that both the adhesive and adherend are polymers, which are capable of movement and are mutually compactible and miscible.

The limits or boundaries affecting this process of adhesion are contact time, temperature, molecular weight of polymers and physical form either solid or liquid.

This theory is generally only applicable in bonding like rubbery polymers, as may occur when surfaces are coated with contact adhesives are pressed together, and the solvent-welding of thermoplastics.

2.8 Forms or Shapes of Vehicles as a Surface for Fixing the Metal Sticker.

Vehicles are grouped into numerous categories, by the body shape and the level of construction as distinct by number of doors and roof treatment either convertible, sedan, hatchback or fastback. Due to the fact that vehicles have many forms or shapes, the ability to fix a sticker in a form of crown like that of benz on its surafce will vary from one vehicle to another. Below are some forms or shapes of vehicle that will serve as a support for fixing metal sticker

Plate 2.46: Shows suzuki car

(Source: *www.carwale.com*)

Plate 2.47: Shows toyota highlander

(Source: *www.cars.usnews.com*)

Plate 2.48: Shows BMW vehicle
(Source: *www.pexels.com*)

Plate 2.49: Shows Kia Sportage vehicle
(Source: *www.90scars.wikia.com*)

Plate 2.50: Shows an Audi vehicle.
(Source: *www.ph.priceprice.com*)

Plate 2.51: Shows a daewoo mini car
(Source: *www.pexels.com*)

Plate 2.52: Shows a jeep
(Source: *www.ranker.com*)

The plates numbered 2.46-2.52 above, Shows different front shapes of vehicle as a support for fixing a metal relief identification.

2.9 Electronic Tags

Electronic tags or chips according to Rouse,(2010) are devices in a storage which is monitored by attaching another electronic device to detect the presence of an object by communicating while the object is in storage or is being moved by a vehicle.

It is simply defined as a device in a storage or moving vehicle which is monitored by another communicating device.

Electronic tags have processor, a readable memory for holding an identification number connected to the processor, and an antenna connected to the processor for radiofrequency broadcasting of the identification number (Domdouzis *et al*, 2007). There is a power supply that powers the antenna to broadcast the identification number. Interestingly, each electronic tag or chip as popularly called has a unique identifier differentiating a particular group of users (Woolley and Minoa, 1998).

2.9.1 Types of Electronic Tags

The nature of the application of the electronic tag or chip will determine the type of system that is most suitable (Tomka, 2002). Electronic tags may be passive, semi passive or active in nature (Lou *et al.*, 2011; Bouet, 2008)

Active tags hold an internal power source that constantly air their own signal, they are known to have a much longer read range as compared to passive tagging systems. They are normally applicable for beacons to track precisely the real-time whereabouts of properties in high speed environments. Passive tag systems use tags without internal power source but rather are powered by an electromagnetic energy transferred from a radio frequency identification devices (RFID) reader. Semi passive tags are similar to passive tags but the difference between them is that, semi passive tags are embedded in internal battery that continuously powers their internal circuitry (Bouet, 2008). Passive radio frequency identification tags are useful for applications such as automated access

control, race timing, supply chain management, file tracking, and more (Tesoriero *et al.*, 2008)

2.9.2 Images of Electronic Tags

Passive Electronic Tags;

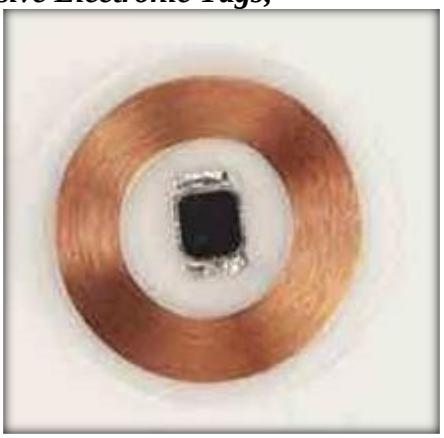

Plate 2.53: Shows a passive tag
(Source: *www.stockoverflow.com*)

Plate 2.54: Shows a passive tag
(Source: www.telsor.com.au)

Plate 2.55: Shows a passive tag
(Source: *www.pinterest.com*)

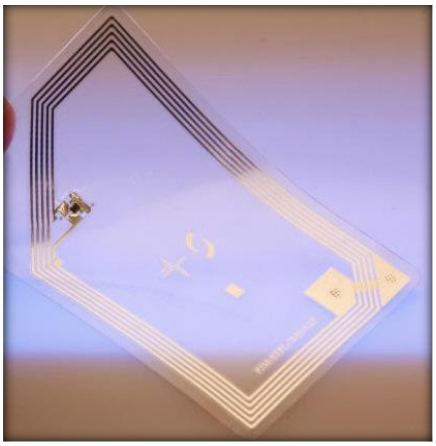

Plate 2.56: Shows a passive tag
(Source: *www.aliexpress.com*)

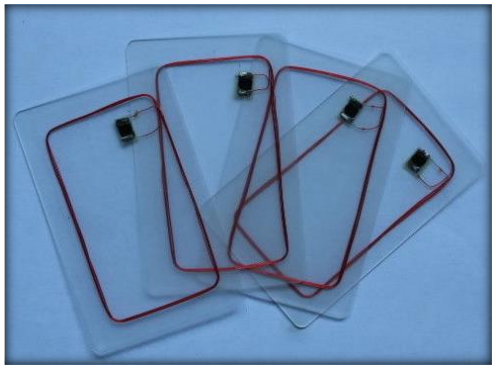

Plate 2.57: Shows a passive tag
(Source: *www.promageurope.com*)

2.9.3 Active Electronic Tags

Plate 2.56: Shows an Active electronic tag opened to see the components (Source: *www.learn.sparkfun.com*)

Plate 2.57: Shows an Active electronic tag (Source: *www.learn.sparkfun.com*)

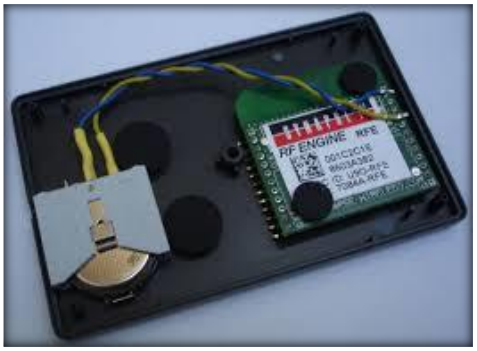

Plate 2.60: Shows an Active electronic tag Opened to see the components (Sources: *www.promageurope.com*)

Plate 2.61: Shows an Active electronic tag (Sources: *www.promageurope.com*)

2.9.4 Differences Between Active And Passive Electronic Tags

ATTRIBUTE	**ACTIVE ELEC. TAGS**	**PASSIVE ELEC. TAGS**
Power source	Internal battery	Draws power from reader
Typical lifespan	10 years maximum	Unlimited lifespan
Typical capability	Read/Write	Read only
Read range	1-100 meters	1-10 meters
Size	Large enough to accommodate the battery. Usually bulky.	As small as a microchip and as large as a paperback book.
Typical memory size	1 Mbyte	32-128 bits
Weight	Heavier than passive tags	Less than active tags
Advantages	-Reads long distances -Highest data bandwidth -Able to initiate communication. -Tags must be replaced when battery dies.	-longer lasting, tag lifespan doesn't depend on battery. -Tags are inexpensive -Small tag size accomodates range of assets and is easy to conceal. -Tags are more resistant to physical damage or harsh environments.
Disadvantages	-Tags are costly -Cannot function without a battery -The tags are large in size, not suitable for smaller assets.	-Communication depends on the antenna size and shape -Read range is limited -Difficulty reading through metal or liquid.

Table 2.1: Shows the differnces between an Active and a Passive electronic tags

2.9.5 Classification Of Electronic Tags

Radio Frequency Identification (RFID) tags are grouped into three categories based on the range of the radio frequencies they use to communicate data, (Roberti, 2009). The category include; low frequency (LF) , high frequency (HF) , or ultra-high frequency (UHF), and the way the tag communicates with the reader as active or passive (Huang, 2009; Lou *et al.*, 2011). Generally speaking, the lower the frequency of the radio frequency identification system, the shorter the read range and slow.

2.9.5.1 Low Frequency RFID

Frequency in this context refers to the size of the radio waves used to communicate between system components. Low frequency RFID systems operate in the 30 KHz to 300 KHz range, and have a read range of up to 10 cm (Ward *et al*, 2006). They have a shorter read range and slower data read rate than other technologies, and they perform better in the presence of metal objects or in liquids (Alamin *et al.*, 2012). Low Frequency tags are best used in access control, livestock tracking, and other applications where a short read rang is acceptable (Roberts, 2006).

2.9.5.2 High Frequency RFID

Unlike the low frequency systems, the high Frequency systems operate in the 3 MHz to 30 MHz range and provide reading distances of 10 cm to 1m (Rao, Nikitin and Lam, 2005). This system's common applications include electronic ticketing, electronic payment or transaction and data transfer. Other types of smart card and proximity card payment and security systems also use High Frequency technology system. (Qing and Chen, 2007)

2.9.5.3 Ultra-High Frequency RFID

The Ultra-High Frequency systems have a frequency range of 300 MHz to 3 GHz, they offer read ranges up to 12 m, and have faster rates of data transfer. The frequency band differs and are limited to the signal the radio frequency identification provides depending on the area of operation and application (Yang *et al.*, 2007). They are much more sensitive to interference from metals, liquids, and electromagnetic signals as compared to low frequency systems, ultra-high frequency tags are commonly used in retail inventory tracking, pharmaceutical anti-counterfeiting, and other applications where large volumes of tags are required (Rao *et al.*, 2005).

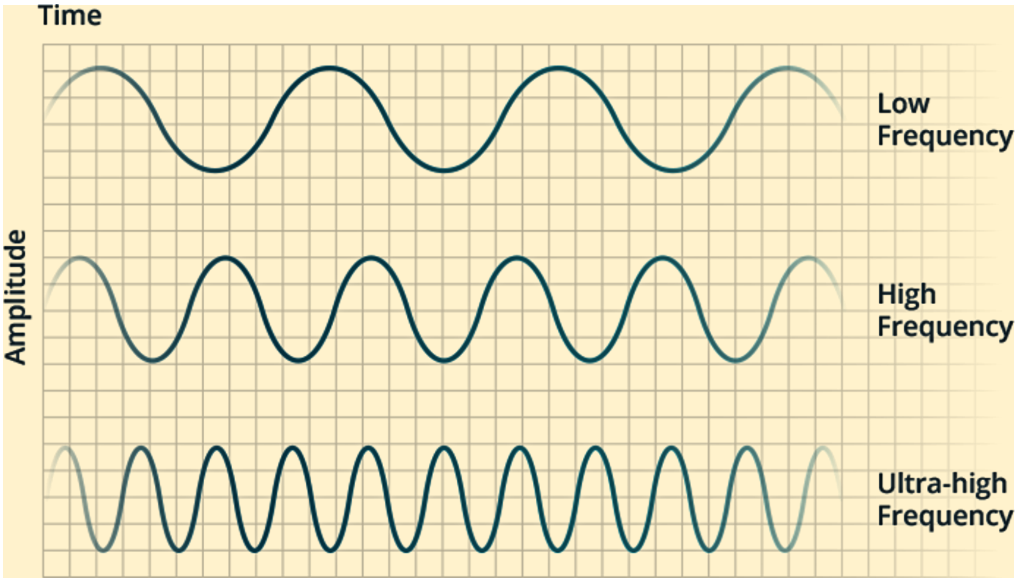

Figure 2.1: Shows the low, high and ultra-high frequency waves.
(Source: *www.impinj.com*)

2.9.6 Other Forms of Electronic Tags

According to Woolley and Minoa(1998), there are four other forms of electronic tags. They include;

1. Electronic Article Surveillance Tags (EAS)
2. Radio Frequency Identification devices (RFID)
3. Smart Cards (Contactless)
4. Intelligent Tags

2.9.6.1 Electronic Article Surveillance Tags (EAS)

Electronic Article Surveillance (EAS) is the simplest device among electronic tags, they are passive and greatly have integrated circuits. It has the ability to sense the existence or absence of a transponder in a reader zone. They are used for theft prevention commonly used in libraries and most often, in retail stores (Dressen, 2008; Lim *et al.*, 2009). These forms of tags are usually fixed on items found in the libraries like the books, items in a retail shop. The most common are pins through the item, labels attached to the item's tags, and wire loops attached to the item. In each of these systems, all items are tagged with an EAS security tag upon being received in the store and must be deactivated upon purchase. Electronic Article Surveillance-enabled stores have gate readers at the entry or exit points that generate a field around the area to detect Electronic Article Surveillance transponders that have not been deactivated.

Plate 2.62: Shows an electronic article surveillance (EAS) Tags
(Source: *www.emenotec.com*)

2.9.6.2 Radio Frequency Identification Devices (RFID) Tags

Rouse (2010) defines Radio frequency identification devices tagging is an identification system that uses small radio frequency identification devices for identification and tracking purposes. RFID may be active, passive or semi passive (Bouet, 2008). There are three main parts make up in a passive radio frequency identification system- an RFID reader or interrogator, an RFID antenna and an RFID tags. Unlike active RFID tags, passive tags have two main components-tag's antenna and the microchip or integrated circuit for data collection, processing, and transmission.

RFID tags that contain their own power source are known as active tags, those without a power source are known as passive tags another type of tag is semi passive, this type of tag is just similar to passive tags but the difference is that, they have an internal battery that constantly powers their internal circuitry (Bouet, 2008). Passive tags are briefly activated by the radio frequency scan of the reader. The electrical current is small enough for transmission of an identification number. Active tags have more memory and can be read at greater ranges.

The tags don't get dirty, fall off or require an unobstructed line-of-sight between the tag and the reader. Radio frequency identification uses electromagnetic fields to automatically identify and track tags attached to objects as these tags contain electronically-stored information. The functions of the RFID tagging system include internal control of fixed assets, internal control of expensed assets and theft prevention (Peris-lopez *et al.*, 2002).

Plate 2.63: Shows an active RFID tags (Sources: *www.promageurope.com*)

Plate 2.64: Shows a passive RFID tags (Source: *www.telsor.com.au*)

2.9.6.3 Smart Cards (Contactless)

A contactless smart card is a contactless credential whose dimensions are credit-card size. Its embedded integrated circuits can store data and communicate with a terminal via near-field communication (Blythe, 2004).

There are two broad varieties of contactless smart cards; memory chips which contains non-volatile memory storage components and perhaps some specific security logic and a

microprocessor chip which, adding to memory engages a processor controlled by a card operating system (Blythe, 2004). Contactless smart cards contain read-only radio frequency identification called card serial numbers (CSN) or unique identification, and a re-writeable smart card microchip that can be transcribed via radio waves (Jones *et al.*, 2005).

Plate 2.63: Shows a contactless smart card
(Sources: *www.indiamart.com*)

Plate 2.66: Shows a contactless smart card
(Source: *www.accraconnet.com*)

Plate 2.67: Shows a sample of Ghana card which is an example of a contactless smart card.
(Source: *www.pulse.ng*)

2.9.6.4 Intelligent Tags

Intelligent tags are tiny chips with a built-in radio transmitter and receiver, to send and receive data. Intelligent tags are attached as labels, integrated into, or written onto any packaging material to offer improved possibilities to critically monitor products' quality

and give more detailed information through supply chain by sending signal (Dainelli, 2009).

Plate 2.68: Shows an Intelligent tag
(Source: *www.lamons.com*)

Plate 2.69: Shows an intelligent tag fixed behind an iPhone.
(Source: *www.amazon.com*)

Plate 2.70: Shows an image example of intelligent tag
(Sources: *www.shopbomp.com*)

2.10 Types of Radio Frequency Identification Devices (RFID) Readers

Radio frequency identification reader is a device that wirelessly communicates data between itself and a radio frequency identification tag to identify and track individual objects (Casden, 2004). Radio waves are used to transfer data from the tag to the reader. There are many radio frequency identification readers that communicates with electronic tags for easy transfer of data. The following are some image examples of the readers.

Plate 2.71: Shows an image example of RFID reader
(Source: *www.perfectrfid.com*)

Plate 2.72: Shows an image example RFID reader
(Source: *www.rfidshop.com*)

Plate 2.73: Shows another image example of RFID reader
(Source: *www.aliexpress.com*)

Plate 2.74: Shows an image example of RFID reader
(Source: *www.rfid4ustore.com*)

Plate 2.75: Shows an image example of an RFID reader
(Source: *www.oprfid.com*)

Plate 2.76: Shows another RFID

(Source: *www.rfidtagsfactory.com*)

2.10.1 Images of Electronic Automatic Gated Barrier

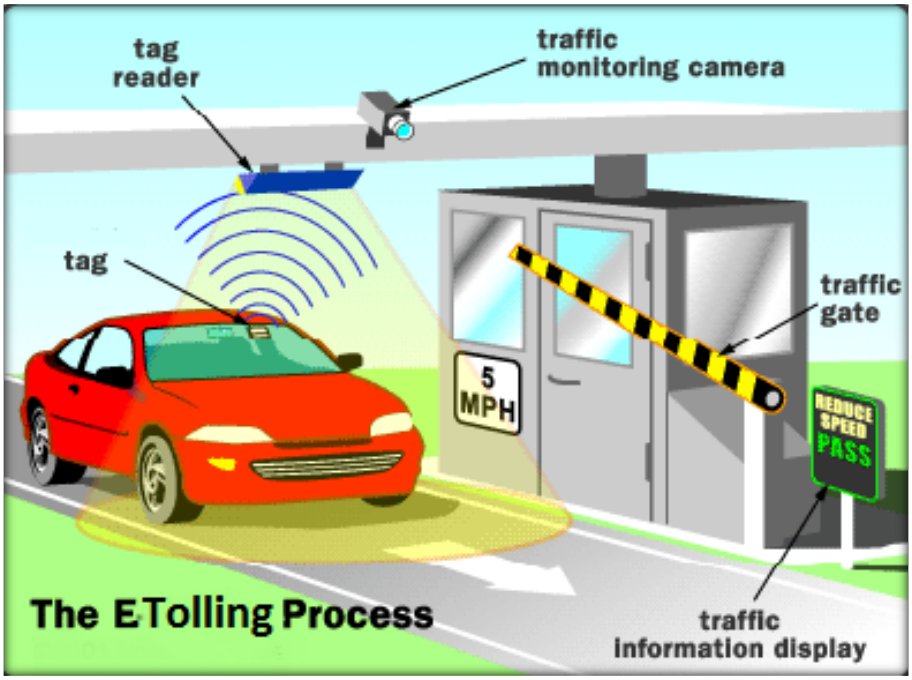

Plate 2.77: Shows an image example of electronic access control system.
(Source: *www.quora.com*)

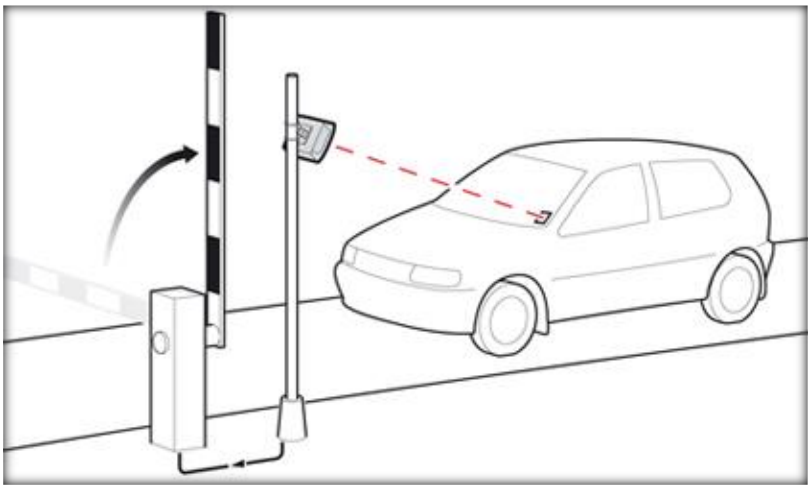

Plate 2.78: Shows another example of electronic automated gate system.
(Source: *www.altimaglobal.com*)

2.10.2 How Access Control System Operates.

A credential or tag (in this case metal sticker with an embedded chip) is presented to a reader or sensor, the reader authenticates and sends the credential's information or signal to a control panel. The control panel compares the credential's information to an access control list, displays it on a screen to either grants or denies the presented request and sends a transaction log to a database for the bar to open or remain blocked. A reader can read at an angle of 90°C or 120°C to pick signal from an approaching tag (Casden, 2004).

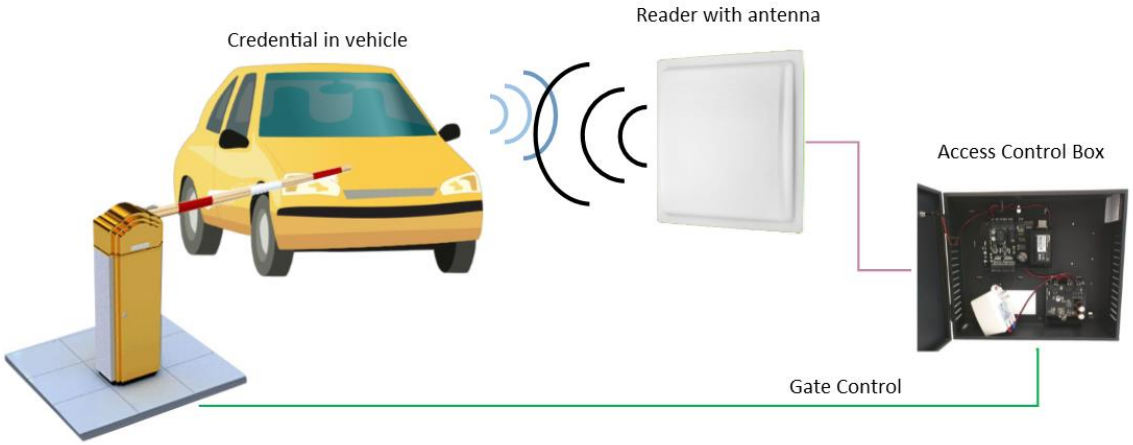

Figure 2.2: Is an image showing how the access control system operates.
(Source: www.kintronics.com)

CHAPTER THREE

METHODOLOGY

3.1 Overview

The main purpose of this study is to produce a sample metal relief vehicle identification with an access control chip for Kwame Nkrumah University of Science And Technology to respond to an electronic barrier. This chapter contains research design, population for the study, sampling design, data collection instrument; the data analysis which analyse the research questions in achieving the purpose of the study and the processes the research employed in the practical demonstration of the system designed.

3.2 Research Methods

The research is pragmatic in nature. In this regards, the qualitative research method was largely employed in the research with a little quantitative research support. The qualitative method was employed to seek information on how local metal technology can be employed in the designing of vehicular identifications that can respond to access control system and the need to analyse the UG vehicular access control system. The quantitative method was used when collecting information on what inspired UG to initiate the vehicular access controls on their campus, how their system operates and the challenges associated with the system usage.

As opined by Russell (2015), qualitative research method involves explaining natural approach to subject matters. Meaning the method gives explanation to natural phenomena in terms of meanings people bring to them as they help us understand better things associated with nature and why they appear to be the way they are. This method gives answers to questions beginning with How? What? Why? and so on. It is in this regard that the researcher used this method to seek information on how local metal

technology can be employed in the designing of vehicular identifications that can respond to access control system and the need to analyse the UG vehicular access control system, while the quantitative method deals with numbers or figures; like how many respondents have challenges using the UG access control system? How many respondent have used the access system for a given period of time etc.

3.3 Research Design

The researcher adopted the following research designs to execute the research; action research, descriptive research, advocacy research, and experimental research in collecting data

3.3.1 Action Research

In selecting a more appropriate research design that helps to collect data and analyse them precisely pertaining to metal relief vehicle identification with access control chip for Kwame Nkrumah University of Science and Technology, action research under the qualitative method was the ideal research design for this study. This type of research involves the action of learning and performing. It involves identifying a problem, finding a solution to that problem and testing the solution (Rory, 2001).

This research design used, equipped the researcher after identifying metal can be used as an alternative material for vehicle identifications to study the material very well, find appropriate production technique, finishing and testing through practical demonstration of a system designed.

3.3.2 Advocacy Research

Another research design employed in achieving the success of this study was the advocacy research. According to Catherine, (2000), advocacy research is carried out with the intention of providing evidence and arguments that can be used to support a particular cause or position. The researcher employed this research design because there are already evidence of metal relief vehicle identifications usually customised as shown in chapter two, more visible from afar and do perform well under harsh condition. These produced metal relief identifications can contain access control chips as opined by many authors in chapter two above.

3.3.3 Experimental Research

Since Art is a science, another research design considered in achieving the purpose of the study was experimental research. An experiment is a procedure carried out to support, refute or validate a hypothesis. It provides an insight into cause-and-effect by demonstrating what outcome occurs when a particular factor is manipulated.

Although most experimental researches are conducted in the laboratories in the context of basic research, the principal advantage of choosing and using this research design was to provide the researcher the opportunity to demonstrate practically the produced metal relief identifications with the access system designed to prove that indeed access control chips can be mounted in metal casing to respond to an electronic barrier.

3.3.4 Descriptive Research

Descriptive research define analytically and precisely the facts and characteristics of a given population or area of interest (Dulock, 1993). The descriptive research design was not left out as far as the project topic is concerned. The researcher used this

design to describe and analysed some barrier design which responds to electronic tags and how they operate not leaving out the UG vehicular access control system.

3.4 Population and sampling

Population here is defined as a set of data of all possible measurements and observation of individual or items (Syed, 2012). It can also be defined a group of people or objects that possesses the characteristics that are questioned in the study.

The population for the study was users of the University of Ghana vehicular access Electronic cards.

- One hundred users consisting of lecturers, administrative staffs, students, campus security personnel and the commercial drivers on campus

3.5 Sampling Technique

Sampling on the other hand is a scientifically drawn group that actually possesses the same characteristics as the population (Carol, 2001). Apart from Carol's definition of sampling, Graham, (2009) also defines sampling as measuring small portion of a population and then making a general statement about the whole population. A sample is a subset of larger population where subset can be used to represent a group or population with this above assertion researcher came up with his population and sampling.

Convenience, snow ball, simple random and purposive sampling types were considered as and when it became necessary.

The simple random and purposive sampling were used to select or pick and interview the students, campus security personnel and the campus drivers (from 1month – more than 12 months of using the access control system) since they are noted for checking vehicle identification.

The convenience sampling technique was also employed to meet and interview the lecturers, and the administrative staffs who access the vehicular control system (from 1 month – more than 12 months of using the system).

3.6 Specific Treatment of Objectives

To design and produce sample metal relief vehicle identifications with access control chip for KNUST, the researcher made use of the following strategies by setting specific objectives to facilitate the process of getting answers to the research question. The objectives below were treated;

3.6.1 Objective One: To Analyse the Existing Access Control System for Vehicles in University of Ghana.

3.6.1.1 Data needed:

The inspiration behind the existing vehicular access control systems limiting myself to the University of Ghana access control system for vehicle, how it works and the associated challenges.

Here the researcher employed the descriptive research design to describe and analyse some barrier designs which responds to electronic chips, how they operate and their usage challenges focusing on the University of Ghana vehicular access control system.

3.6.1.2 Data collection and methods:

Interview and observation were the data collection methods the researcher used.

These methods played an important role in identifying and analysing the inspiration behind the UG access control system, how it works and the associated challenges.

3.6.1.3 Data Collection Instrument:

Interview questionnaires and observational checklist were the instruments employed to gather the data. Writing and recording of answers and taking pictures of how the University of Ghana access control system for vehicle were followed. Mobile phone and digital camera were the major tools used greatly to gather data for objective one.

3.6.2 The Existing Access Control System for Vehicles in University of Ghana.

Before the model of the vehicular access control system was executed to function with the metal relief identification with access control chip, it became necessary to study the existing vehicular access control system in University of Ghana. In view of this, the researcher limited himself to and studied the existing University of Ghana, Legon vehicular access control system. The study of the UG vehicular access system was through questionnaire and observation on the components of the system, it positioning, and how the system operates. A little information was gathered through observation of the KNUST vehicular access system; the component, component positioning and how it operates.

University of Ghana is the oldest and the largest Ghanaian public university. The university was founded in 1948, in the British colony of the Gold Coast, as the University College of the Gold Coast, it was originally affiliated to the University of London which supervised its academic programmes and awarded degrees. It gained full university status in 1961 and now has a population of over 40,000 students

With such huge population and easy accessibility due to numerous entrance to campus, it became necessary to strengthen security. This led to the construction of electronic access gates on the various main routes to campus and the issuing of a scannable electronic card (E-Card) to staff and students who use vehicles, and to

commercial drivers on campus at a renewal cost of four hundred Ghana cedis per annum in February 2014.

This created a lot of controversies initially by the public and some student groups on campus as they heavily criticised the initiative. These critics were of the view that, the university authorities had mounted a toll booth to extort money from the ordinary people who plied the staff village of the university campus and the poor "trotro" drivers who used the campus routes. The numerous challenges that arose as a result of the execution of the electronic access gates were handled amicably and the Okponglo entrance to campus was exempted.

The University of Ghana access control system for vehicles consist of an E- Card (in the form of a sticker) which is fixed at the right corner of the windscreen, a card reader or sensor which is positioned at the right side of the linear actuator (barrier) at the checkpoint, a led screen to display the vehicle's registration number and the expiry date of the E- Card, and a mini traffic light positioned on the left side of the barrier. The traffic indicator gives the final signal when it recognizes a valid E-card by showing red or green. When an approaching vehicle has a valid E-card, the light shows green and allows passage, but shows red when the vehicle has either an expired E- Card or does not have the card at all, denying entry into campus in both circumstances.

The access control system works when a vehicle with an electronic card approaches the gate, the E-Card which has the credentials of the user is brought close approximately 5 – 10 meters to the reader. The reader upon recognition, authenticates the validity of the card and sends signal to a control panel which regulates the movement to the linear actuator to either grant to deny access while the mini traffic indicator which is positioned at the left corner of the gate gives final signal by

showing red light meaning access denied and green light to show access granted. Every successful access shows some credentials of the user like the vehicle's registration number and the expiry date of the scannable electronic card on a displayed screen positioned about 15 meters away from the barrier.

For one to obtain the UG E-Card, the following requirements must be met; Letter of application for E-Card, Letter of consent (If the vehicle is not in your name), Proof of ownership (Form C or Form A), Photocopy of DVLA certificate (Not the sticker), Photocopy of insurance certificate (Not the sticker), Photocopy of driver's license (Front and Back), Photocopy of Student identity (Front and Back, If student), Proof of Academic Registration of Courses (if student).

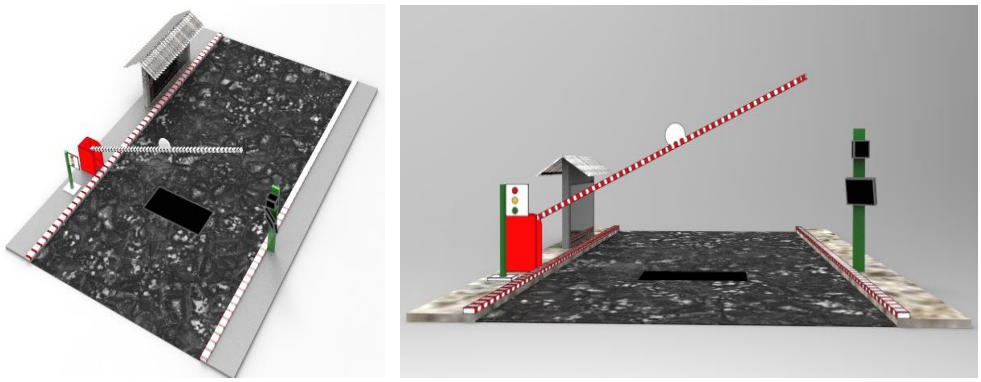

Figure 3.1: Shows the Rhino rendition of the top and side view of UG electronic vehicular access control system

After studying the University of Ghana vehicular access control system, a table was drawn to distinguish between both the UG and KNUST vehicular access control system.

Below is the table outlining the differences.

3.6.2.1 Table Outlining the KNUST and the UG Vehicular Access Control System.

UG Access system	**KNUST Access system**
Linear actuator (barrier) present	Linear actuator present
RFID reader/ sensor present	RFID reader/ sensor present
Chip embedded in a card (electronic card)	Chip embedded in sticker (electronic sticker)
Led screen present	Led screen absent
Traffic indicator present	Traffic indicator absent
Infrared/Photo sensor present	Infrared/Photo sensor present
E-Card is read from afar to grant access	Card is read from afar

Table 3.1: Outlines the UG and KNUST vehicular access control system.

3.6.3 Objective Two: To Design An Improved Access Control Model Based On the Findings in Objective One.

3.6.3.1 Data needed:

The appropriate components that makes up vehicular access control system, their functions, their installation positioning, programming, production technique, finishing and a practical demonstration of a designed system to respond to the local metal technology vehicle identification tag. The action, advocacy and the experimental research designs were employed here since the researcher aimed at identifying the appropriate components, investigating each component's function, finding appropriate production technique, finishing and testing through practical demonstration of the produced metal relief identifications with a system designed to respond to electronic chips.

3.6.3.2 Data Collection and method:

Interview, review of information from the internet, books and observation were the data collection methods the researcher used. These methods played important roles in identifying the appropriate components that constitutes to a well-constructed or improved vehicular access control system, the function of each component, installation positioning. These data collection methods helped in finding and analysing the appropriate production and finishing technique the researcher needed in executing the project.

3.6.3.3 Data Collection Instrument:

Internet connected laptop, interaction with some personnel at the university information technology services (UITS), lectures and some students and books were the instruments employed to gather the data. Writing of answers of the numerous appropriate metal and

production technique were followed. Mobile and laptop were the major tools used to gather data for objective two.

3.6.4 The Design of an Improved Vehicular Access Control Model Based On the Findings in Objective One.

A model of an electronic access control system to function with the metal relief identification was produced using the KNUST and UG vehicular access control system as a guide since they are the only public universities in Ghana with such control systems. A first successful casting and finishing of the metal relief identification piece was produced to function with designed system.

The following tools, materials and devices were used in the model making; card board, cutting knife, straight ruler, glue, pencil, saw dust, acrylic paint, water, glue gun, brush, pair of scissors, super glue, paper wall sticker, screw drivers, photo sensor indicators, traffic indicators, RFID reader, circuit board (control panel), electric motor, LED screen,

The following processes were involved in the model making;

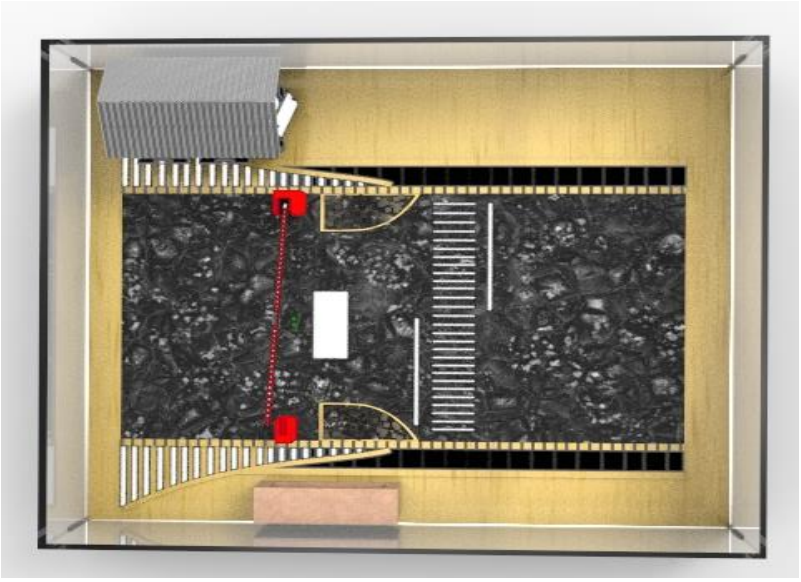

Figure 3.2: Shows the Rhino top view of the designed access control system.

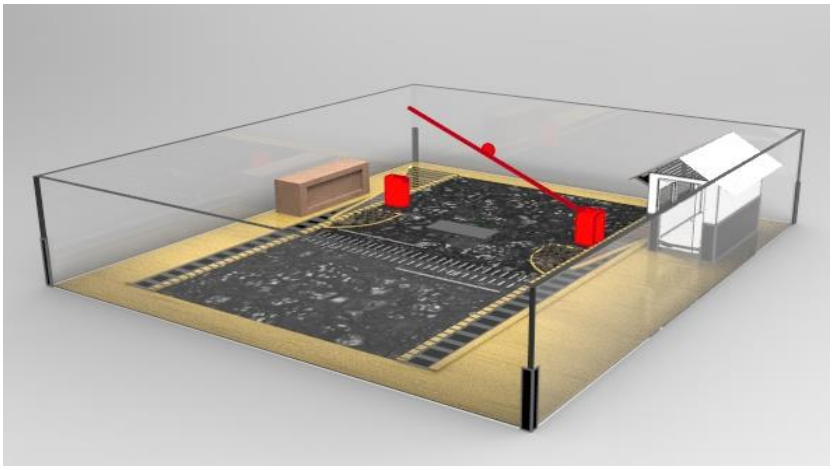

Figure 3.3: Shows the Rhino side view of the designed vehicular access control system.

3.6.4.1 Preparing Wooden Board as a Support

A wooden board was made in the form of road to help with the demonstration of the project.

Plate 3.1 Making of the board as a support.

Plate 3.2: Adding white glue to saw dust.

Plate 3.3: Applying white glue on the board.

Plate 3.4: Filling the saw dust on the glued board.

Plate 3.5: board allowed for the saw dust to dry.

3.6.4.2 Construction of the Various Units.

After preparing a board for demonstrating the project, the various unit that make the model of the access control for vehicles complete were considered and produced. Security check point, the barrier itself, display screen were all produced from paper and glued to their various positions on the board. The pictures below shows the processes involved in making the various units.

Plate 3.6: Marking on the hard paper

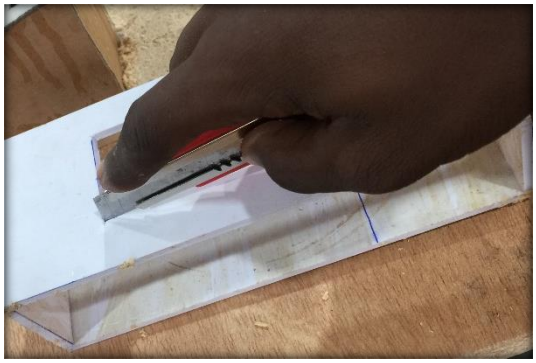

Plate 3.7: Cutting of the hard paper

The hard paper was marked with pencil the dimensions on the various units that will make up the model of the vehicular access control system and with the help of cutting knife, cut to the require sizes and shapes.

Plate 3.8: Gluing the card together with the help of glue gun.

Plate 3.9: Shows the glued security post

Plate 3.10: Gluing textured paper on the model security check point

Plate 3.11: finished model of the security check point.

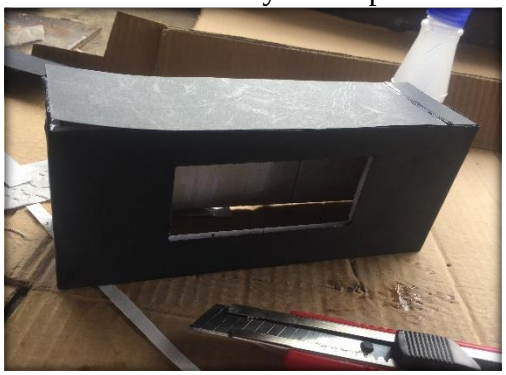

Plate 3.12: Cutting and gluing hard paper to make model display screen

Plate 3.13: Gluing textured paper at the edge of the model display screen.

Plate 3.14: Shows the model of the displayed screen

Plate 3.15: Shows the model of the linear actuator (barrier)

After making the paper models of the security check point, the displayed screen and the linear actuator (barrier), the board was painted in black and white to depict the scene of a road. Model pavement were made at the either sides of the road. The image below shows some processes involved in making the pavement and painting the entire unit.

Plate 3.16: Shows the arrangement of pavement on either sides of the modelled road.

Plate 3.17: Shows painting of the constructed road model

Plate 3.18: Shows the painted vehicular access control system model

Plate 3.19: Shows cutting a space to fix the RFID reader.

Plate 3.20: Shows fixing the RFID reader

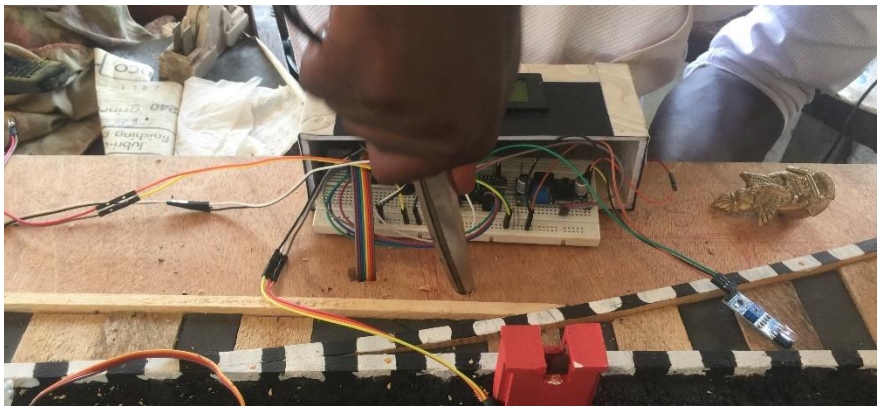

Plate 3.21: Shows the installation of the control board.

Plate 3.22: Shows the final model of the designed access control model to respond to the metal relief identification.

A system was programmed to make the access control model function to aid in easy demonstration of the project concept. Both the linear actuator and the displayed screen was programmed to respond to a command. The linear actuator which is being regulated by electronic motor was programmed in such a way that, after a successful system grant of access, within 3- 5 seconds, the bar opens up and after exit of vehicle, comes down automatic. In instances where the vehicle gets under the barrier and is unable to cross due to some unforeseen developed fault on the vehicle though the system granted access or the driver found intentionally wasting much time to cross, the model access control system has photo sensor which has been programmed in such a way that the raised bar will not fall and hit the top of the stopped vehicle. However, in about 2 minutes of still standing under the bar, the system will give an alarm signal to the driver of that vehicle so he or she can drive or with the help of someone push the car cross the barrier to grant entry of another vehicle.

An RFID reader which forms part of the model was programmed to upon recognising a valid tag embedded in the metal cast piece, authenticates and sends signal to the linear actuator through the control panel to grant access. Another programmed device in the model is the displayed led screen which is powered by a control panel. The displayed led screen has been programmed to shows the credentials of every successful granted access. On the display led screen, the name of the user of the tag, his or her status

example lecturer or student and the vehicle number will be displayed on the screen for the security at post to cross-check if it tallies with the approached vehicle especially with the vehicle's registration number. Lastly there is also a programmed traffic indicator in the created model to finally signal successful access grant or denial. The traffic indicators have red and green lights. The red indicator indicates denial of entry whiles the green indicates successful access grant.

3.6.5 Objective Three: **To employ local metal technology in the design of a vehicle identification tags to respond to a vehicular access control system.**

3.6.5.1 Data needed:

The appropriate metal, production technique, finishing for visibility and a practical demonstration of a designed system to respond to the local metal technology vehicle identification. The action, advocacy and the experimental research designs were employed here since the researcher aimed at identifying the appropriate metal, finding appropriate technique, finishing and testing through practical demonstration of the produced metal relief identifications with a system designed to respond to electronic chips.

3.6.5.2 Data Collection and method:

Interview, review of information from the internet, books and observation were the data collection methods the researcher used. These methods played important roles in identifying the appropriate metal that can last and has the ability to be seen at a distance when used to produce item(s) and again these data collection methods helped in finding and analysing the appropriate production and finishing technique the researcher needed in executing the project.

3.6.5.3 Data Collection Instrument:

Internet connected laptop, interaction with some personnel at the university information technology services (UITS), lectures and some students and books were the instruments employed to gather the data. Writing of answers of the numerous appropriate metal and production technique were followed. Mobile and laptop were the major tools used to gather data for objective three.

3.6.6 Employing local metal technology in the design of vehicle identification tags to respond to a vehicular access control system.

In creating design for the metal relief identification, the researcher thought critically considering the knowledge in product design principles and idea development and made sketches of the sticker products which can be seen from figures below.

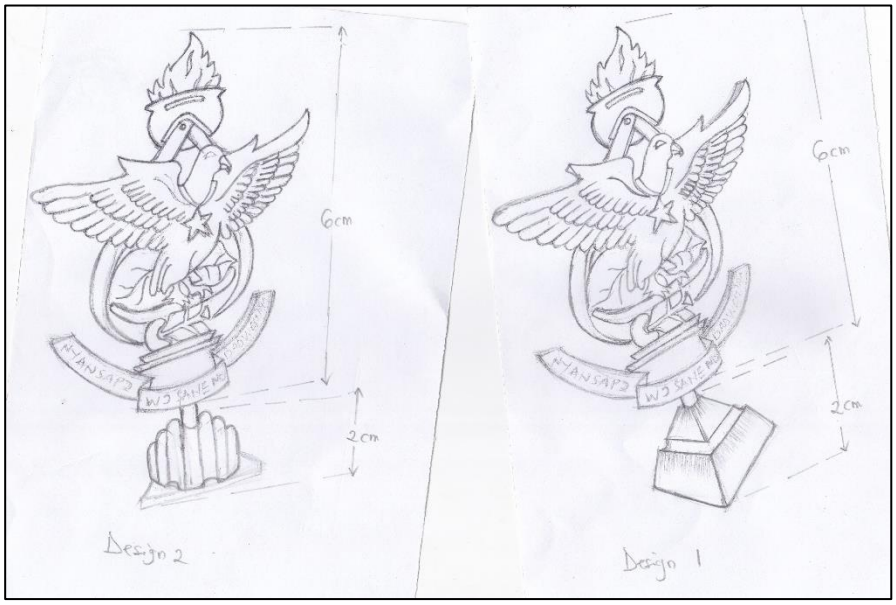

Figure 3.4: Shows a sketch of the concept for the metal relief identification tag.

Figure 3.5: Shows a sketch of the concept for the metal relief identification tag.

The sketches above were designed in rhino as shown in the figures below;

Figure 3.6

Figure 3.7

Figure 3.8

Figure 3.9

The emblem has the major details of KNUST, hence a design that can be easily recognised by all even from a distance.

3.6.6.1 Concept evaluation

The researcher considered evaluating the concepts above in fig 3.6-3.9. Six criteria were employed and these include

- Attractiveness: The ability of the metal relief identifications to easily attract the eye of whoever sees it either from a distance or near.
- User Friendly: The ability of the metal relief identifications to feel safe on the users' vehicle.
- Good finishing: The ability of the metal identification to possess a good finish and withstand unfavourable atmospheric temperature.
- Ability to Last: The ability of the metal identification to have long life span on the substrate it will be adhered onto.
- Distance Visibility: The ability of the metal identification to be recognised easily from a distance at day and night.
- Quality: The ability of the metal identification to last long without deteriorating.

3.6.6.2 Evaluation of the KNUST emblem for the metal relief identification tag designs

Table 3.2: Evaluation of concept

Criteria	Importance rating (100%)	Concept 1	Concept 2	Concept 3	Concept 4
Attractiveness	20	10	12	15	11
User Friendly	10	6	8	8	7
Good finishing	15	10	12	12	12
Ability to Last	10	6	8	8	8
Distance Visibility	25	20	22	22	22
Quality	20	15	15	15	15
Total	**100**	**67**	**77**	**80**	**75**

Table 3.2

The KNUST emblem (concept 3) met the criteria hence a good rating.

It is prestigious to be recognized in the society easily with this unique design having the details in design the major elements of KNUST emblem that can easily be identified by all and known by many people in the country.

3.6.6.3 Production Process for Making Elements

With the aid of the approved design and element above, the researcher began with the production of the sample metal vehicle identification stickers for the Kwame Nkrumah University of Science and Technology. There were specific processes an individual had to go through to make such samples, the diagram below shows the production process for the execution of the sample stickers.

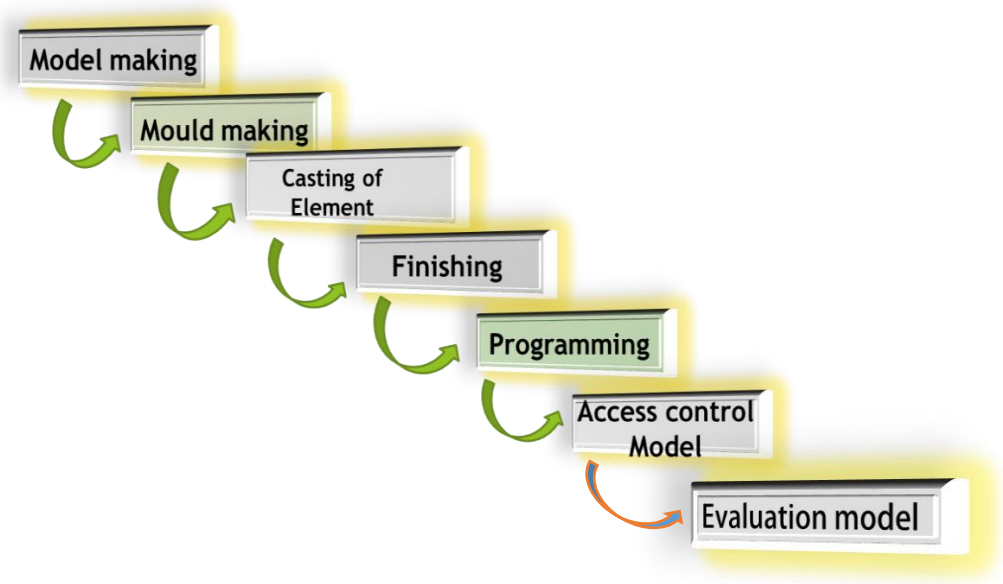

Fig 3.10: Framework of Production process

Before production, the most important and necessary factor was to acquire efficient tools and materials. Hence the tools and materials needed for the execution of the sample metal relief vehicle identifications for KNUST are stated as follows:

Modelling tools, grinding machine, washed clay, Plaster of Paris, Kiddy clay (artificial clay), building cement, bee wax/paraffin wax, micro torch, tweezer, water, cooking oil, ruler and pencil.

3.6.6.4 Things needed for the Model making

The following were the essential elements needed before modelling was done;

Design of elements, modelling tools, washed clay, Plaster of Paris powder, bee wax, vegetable oil, cement, water and Kiddy clay

3.6.6.5 Model making of the Chosen Concept

3.6.6.6 Tools making process

Due to the intricate and complex nature of the concept, it was expedient for the researcher to produce carving/ modelling tools that will fit the design pattern of the elements.

Plate 3.23: Grinding of tools

Plate 3.24: Smoothening the edge of tool

Edges of wall nails were shaped by grinding them on a rough stone as shown in plate 3.1. These nails were shaped according to the size that each design requires for a successful carving and modelling of elements. The nails were rubbed on a grade 600 emery paper which allowed the edges of the tools to become very smooth. This smooth-

edged tool enabled a smooth finish of the elements without blemishes after carving and modelling.

Plate 3.25 Set of carving /modelling tools after grinding and smoothening.

3.6.6.7 Processes of How the Element "KNUST Metal Relief Identification Tags" Were Modeled.

The sample KNUST metal identification stickers was successfully carved with the aid of the carving tools. The model was carved in a size that will be cute on wherever it will be fixed on the surface of a vehicle. The exact size of the model is 6×5cm.

Before carving, a template of the concept or the KNUST emblem was first printed, pasted and pierced from an aluminium sheet for metal, and then placed on a clay slab for tracing hence carving to commence. This is shown in Plate 3.4, 3.5 and 3.6 below

Plate 3.26: Transferring design onto the clay. Plate 3.27: Carving the edges

Plate 3.28: Shows the carved out edges for further detailing.

The model was then carved with the aid of the carving tools using a subtractive technique until a final model was obtained. The negative areas were scraped off to 0.5 cm as shown in plate 3.7, 3.8, 3.9 and 3.10 below using the flat edged carving tool whiles the positive areas were left to stand out.

Plate 3.29: Shows the gradual carving out of details of the model

Plate 3.30: Model being worked on to get an accurate design

Plate 3.31: Shows the gradual carving of model

Plate 3.32: Final model

3.6.6.8 Processes of Creating A 'POP' Mould for the Model

Plate 3.33: Shows building of wall around the model for the POP mould

Plate 3.34: Shows the built wall for the mould

Plate 3.35: Shows the POP being stirred to become slurry

Plate 3.36: Shows the slurry POP ready to be poured into the cavity.

Plate 3.37: Shows the pouring of slurry POP into cavity.

Plate 3.38: Shows the slurry POP being poured into the mould to settle.

Plate 3.39: Shows the removing of the clay wall around hardened POP

Plate 3.40: Shows the hardened POP being placed in water for the clay model to dissolve

Plate 3.41: Shows the cleaning off the dissolved clay in the cavity

Plate 3.42: Shows the POP mould created from the clay model.

Plate 3.43: Shows pressing of Kiddy clay into the mould

Plate 3.44: Shows Kiddy clay being used to pick the emblem

3.6.6.9 Wax Model Making

Bee wax was cut into pieces at this stage as shown in Plate 3.45 and softened in warm water as shown in plate 3.46. During this process, it was advisable to control the heat that penetrated into the wax because excessive heat can cause the wax to melt and this brings about porosity in wax models.

However, to get excellent wax models without defect, it was better to keep the heat under strict control. The bee wax was pressed consistently to allow uniform plasticity of the whole softened wax as shown in plate 3.47.

Plate 3.49 shows pressing the wax into the mould as Plate 3.50 shows the end result of pressing the wax into the mould.

Plate 3.45: Shows the cutting of bee wax into pieces for softening.

Plate 3.46: Shows bee wax being heated aluminium bowl with the aid of blow torch

Plate 3.47: Shows bee wax being pressed with in the finger tips to make it more plastic

Plate 3.48: Shows cooking oil (frytol) being spread in the POP mould for wax picking.

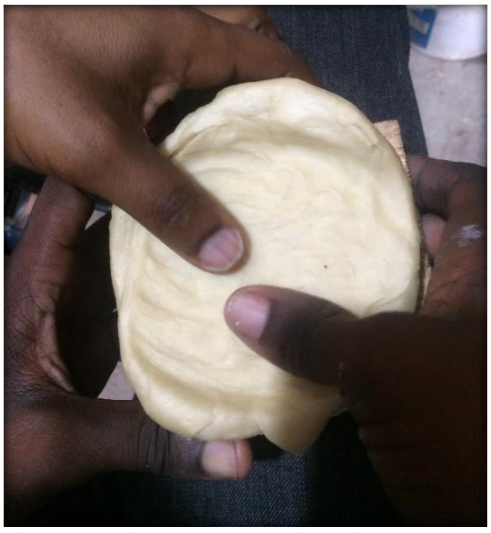

Plate 3.49: Shows plastic bee wax being pressed in the POP mould to pick the emblem.

Plate 3.50: Shows the wax model of the emblem.

Plate 3.51: Shows the trimmed wax models of the emblem.

3.6.6.10 Cement Mould Making

Another level in model making where the wax models made were cast in cement. The end result after drying and firing wax was a permanent mould for multiple picking of wax. This process was very necessary due to the fact that casting of emblems for stickers are usually mass produced. Therefore, it was very necessary to get a material that when settled and solidified can hold the design for long without damaging or distorting even when picked on countless times. The ideal material was cement, hence the cement mould making. This process was simple but needs patience, carefulness, and time.

First of all, the picked wax models were assembled and clay wall was built around it to form cavity for further process. Plate 3.30 shows the built wall around the emblem. The dried powdered cement as shown in plate 3.31 was made slurry by adding water as shown in 3.29 and 3.30. After that, clay walls were built for the wax models to contain the cement slurry as seen in Plate 3.31 below. The slurry was now poured into the cavity as seen in Plate 3. 32. The cement slurry in the cavity was made to dry under shade for three days and after that the clay walls were broken off and the wax stuck in the cement as shown in plate 3.33 was melted out for the cement block alone to be left.

The resultant cement mould were oiled to allow easy picking of wax as shown in plate 3.34. Plate 3.35 shows the first wax models picked.

Plate 3.52: Shows building of walls around the wax models to create a cement mould.

Plate 3.53: Shows the cement powder.

Plate 3.54: Shows the pouring water to the cement powder.

Plate 3.55: Shows the stirring of the powder cement.

Plate 3.56: Shows applying of slurry cement on the model to pick all the intricate design.

The reason for using painting brush to spread the slurry cement is to ensure that all the intricate and hollow spaces are well filled with the slurry cement to pick the shape perfectly.

Cement cast will be unsuccessful when the major details of a work doesn't appear after pouring of the slurry onto the model.

Plate 3.57: Shows pouring of the slurry cement onto the model.

Plate 3.58: Shows the cavity filled with the slurry cement.

Plate 3.59: Dried cement turned upside down, thus wax is seen stuck in the middle

Plate 3.60: Shows the fired cement moulds oiled for easy picking of wax

3.6.6.11 First Casting of Elements

For experiment sake, the researcher picked two of the finished wax models and was sent to Sokoban Krofrom in the Ashanti Region for casting. The reason was first to be certain of getting a good cast and secondly to demonstrate if the access control chip will work when mounted or planted in the cast metal piece. The casting process involved some processes. These are explained accordingly with pictures as shown below.

1. Soaking of wax models: The first thing done was to soak the wax models in water to clean off dirt, render them soft and also increase the ability of the POP coating that will be applied to the wax model to stick to every part of the design. This is seen in plate 3.61.
2. Fixing of runners: This was the second thing done to the wax models after soaking in water. This was done by applying molten wax to the back of the models by a heated rod. This rod was made to rest in fire for some time and then pierced into the back whiles holding a runner (wax rod) to make a permanent or firm stick. This is shown is plate 3.62.
3. Application of first coat: POP powder was mixed with water to form fine slurry. This was applied to the wax models such that it covered every area. It was applied systematically. After a coat, it was made to dry a little and the next coat was applied. This was done until the base of the work was fully clothed in POP. This is shown in Plate 3.63.
4. Grouping of wax models: After the first coating, it was advisable in order not to waste time by producing single works to join the coated wax models with wax connectors so that they form a bead at the top. Therefore, the ends of the runners were slightly heated and twisted to form a bead. This is shown in Plate 3.64.

5. Second coat application: this was done by mixing the POP slurry to become thick and then coated on the rest of the parts as shown in Plate 3.65. This application did not need fine slurry to apply.
6. Third coat application: the material used was clay and palm fiber. This was applied over the second coat. This coat when dried under a shade and served as a wall that keeps the POP from cracking when heated. The palm present in the mixture prevented the third coat from cracking. This is shown in Plate 3.66.
7. Dewaxing: after the coated models were dried, they were arranged by turning the mouth of the work upside down in the heating chamber. This was purposely done to allow easy flow out the wax during heating process. This process took approximately one and half hours. Plate 3.67 shows the heating chamber for dewaxing with charcoal loaded on top of the coated models.
8. Melting of metal: this was a simultaneous process with dewaxing period. Crucibles of high heat capacity were filled with brass scrapes. With the aid of little fire, charcoal and blower, the whole crucible was heated to allow the metal to become molten. This evidence of melting metal is shown in plate 3.68.
9. Removal of dewaxed moulds and pouring of molten metal: at this stage, the dewaxed heated moulds are removed from the heating chamber and placed on the ground. The sand in the ground was mixed with cutlass to allow the work to sit on the ground without falling. Then with the aid of a collector, the molten metal was scooped and poured into the dewaxed moulds. This is shown plate 3.69 and plate 3.70 respectively.
10. Breaking of moulds: when the moulds became cool after casting, they were broken with cutlass. The purpose of this was to remove the cast pieces from the mould. This is shown in plate 3.71.

11. Cutting of runners: when the cast pieces were removed, the runners that connected them were cut off using a sharp cutter.

The following are pictures that were taken for the process of casting of the elements.

Plate 3.61: Shows soaking of the model in water

Plate 3.62: Shows fixing of runners.

Plate 3.63: Shows making the first coating

Plate 3.64: Shows joining of coated models

Plate 3.65: Shows the second coating

Plate 3.66: Shows the third coating

Plate 3.67: Shows the mould being put In fire to dewax

Plate 3.68: Shows melting of metal

Plate 3.69: Shows removing of dewaxed mould.

Plate 3.70: Shows pouring of molten metal in the dewaxed mould.

Plate 3.71: Shows the breaking of the mould.

After breaking the mould to obtain the cast piece, the runners were cut off with hack saw.

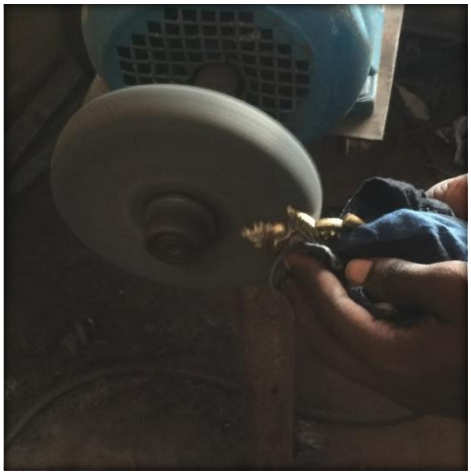

Plate 3.72: Shows the grinding of the work.

Plate 3.73: Shows filing of the work.

Plate 3.74: Shows grinding Of the chip slot

Plate 3.75: Shows the filing of the work

Plate 3.76: Shows sanding of the work with emery

Plate 3.77: Shows creating the dome. Plate 3.78: Shows buffing the cast piece.

3.6.6.12 Second Casting of Elements

After the first casting and testing of the sample metal stickers, the experiment was successful so the researcher became convinced and motivated to work on the rest of the wax models for casting. The remaining wax models were dressed neatly and sent to Sokoban Krofrom in the Ashanti Region again for casting. The casting process involved were the same as during the first casting.

Plate 3.79: Shows the remaining wax models dressed neatly for casting.

3.6.6.13 Finishing of the Sample KNUST Metal vehicle identification Stickers

The pieces that had the best appearance after casting were selected and taken through some form of cleansing process. The first step was to grind using grinding machine to reduce the weight and excess projections in order to make it have a thickness of 0.2cm. The minor projections were also filed with hand files and sanded with emery paper to ensure evenness of the cast piece. The next step after sanding the cast pieces were to rub with lemon and then brushed with brass bush. Thirdly, the cast pieces were bathed with Tripoli and rouge. The cast pieces were later rinsed in warm soapy water to remove the excess dirt on the surface after which they were displayed on the sun to dry, giving it a rich yellow colour like that of gold.

Plate 3.80: Shows the metal identification In a round.

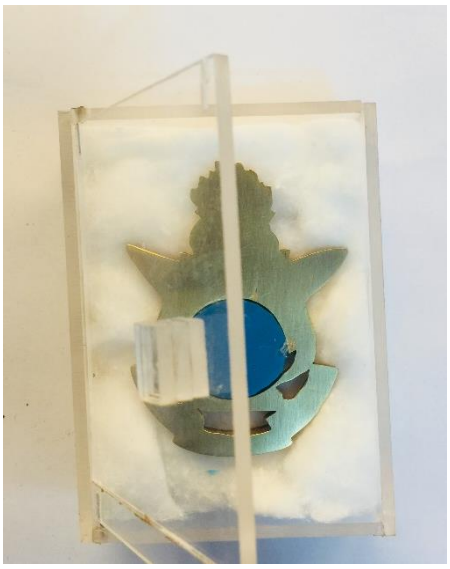

Plate 3.81: Shows the back view of the Identification tag

Plate 3.82: Shows the metal identification tag in relief.

The following questionnaire was given to the population to collect pertinent data;

1. Name of Respondent
2. Agency/ Department
3. Designation
4. How long have you used the UG access control sticker?
5. How does the UG access control system for vehicles work?
6. What do you think inspired the University to produce this sticker?
7. Do you think the University's vision for implementing the access control systems are met?
8. Please explain briefly.
9. What do you think informed the current position of the access stickers?
10. Do have an idea the type of access chip is mounted in the entry pass sticker?

    A. Yes/ No (If No, please skip to 13)

11. What type of access control chip is that?
12. Do you know of any other chips that is also appropriate for this purpose?

    Yes/ No

    A. If "yes", Give some examples

    B. How do you grade this example compared to the current one?

13. At what range/distance do you think the barrier sensor respond to the chip in the entry pass sticker?
14. Have you identified any problem with these stickers and the access control system?

    B. If "yes", what problem have you encounter?

15. Will there be any problem mounting the access chip in a metal casing?
16. Do you have any other comments to give?

3.7 Evaluation of Model

This is the last stage in the designing and production of the metal relief identification. It was expedient to demonstrate practically the produced metal relief identification to respond to a designed access control system. It became necessary to demonstrate the project practically to test the functionality. Provide solutions to any identified challenges associated with the finished product to make sure the purpose of producing the metal identifications are met.

The images below show the evaluation of the project;

Plate 3.80: Shows the front view of the metal relief identification

Plate 3.81: Shows the back view of the metal relief identification containing the electronic chip

Plate 3.83: Shows the metal relief identification being fixed on a miniature vehicle

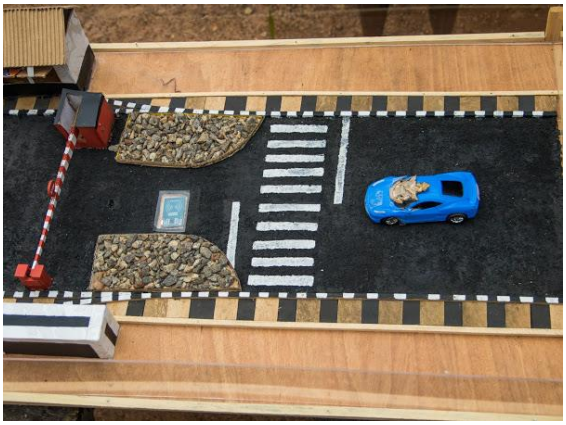

Plate 3.84: Shows the vehicle with the metal relief identification approaching the barrier

Plate 3.85: Shows the miniature vehicle Standing on the RFID reader to authenticate the identification and grant access

Plate 3.86: Shows the displayed screen displaying the name of the owner of the vehicle and the vehicle's registration number

Plate 3.87: Shows linear actuator (barrier) opened up to allow the vehicle pass.

Plate 3.88: Shows the miniature vehicle as it passes through the barrier after successful authentication.

In some instances where the vehicle is unable to drive through the barrier though authenticated, the linear actuator was designed not to fall until that vehicle has finally passed by. In the designing of the system, an infrared sensor was mounted few distance directly under the linear actuator. This infrared sensor functions when an opaque object covers it for some period of time usually three to five seconds. The moment the under of the vehicle gets close to cover the sensor, within three seconds, the system begins to peep signalling the driver of that vehicle to drive pass the barrier to allow another vehicle to be authenticated for access grant.

The images below illustrate how the infrared sensor functions.

Plate 3.89: The circled component fixed in the road shows the infrared (IR) sensor

Plate 3.90: Shows the linear actuator raised up as the vehicle stands on the sensor area.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Overview

This chapter contains information about the results obtained after data collection, data grouping, design making, production processes and testing. These data analyzed are discussed in this chapter. Thus, the results and discussion were fulfilled by considering the research questions below;

1. What is the nature of the vehicular access control systems in the University of Ghana?
2. What other components can be adopted to improve on the existing vehicular access control systems?
2. How can the existing tags be improved with the use of local metal technologies?

4.2 The Nature of the Vehicular Access Control Systems in the University of Ghana.

Limitation to the University of Ghana vehicular access control system, the researcher refers to components in this context as those tangible elements that constitute to the vehicular access control system on the UG campus. After comprehensive observation and interview at the University of Ghana concerning their vehicular access control systems, the researcher identified six (6) elements that make the component of their vehicular access control system. All these components play important role in ensuring a functional vehicular access system. As already discussed above in chapter 3, the components include; the identification tag (E-Card), a linear actuator (barrier), radio frequency identification (RFID) sensor or reader, led screen, traffic indicator, and vehicle loop sensor (infrared sensor) as popularly refered which are all controlled and

powered by a central unit. All these components make up the access control unit as it is explained vividly in chapter 3 above how the access system operates.

Through interview to obtain essential information, respondents were asked questions like: how long they have used the access sticker and the system, what they think inspired the university to produce the sticker, their opinion on the university's vision for implementing the vehicular access system; whether they are met or not, the problems they have encountered using the access system, and their opinion on mounting electronic chips in a metal casing to grant access.

4.2.1 Results obtained from respondents on how long they have used the electronic Card

In analysing the University of Ghana access control system for vehicles, it was important to find out from the respondents when they started using the access control system. One hundred respondents in all were successfully interviewed through questionnaires.

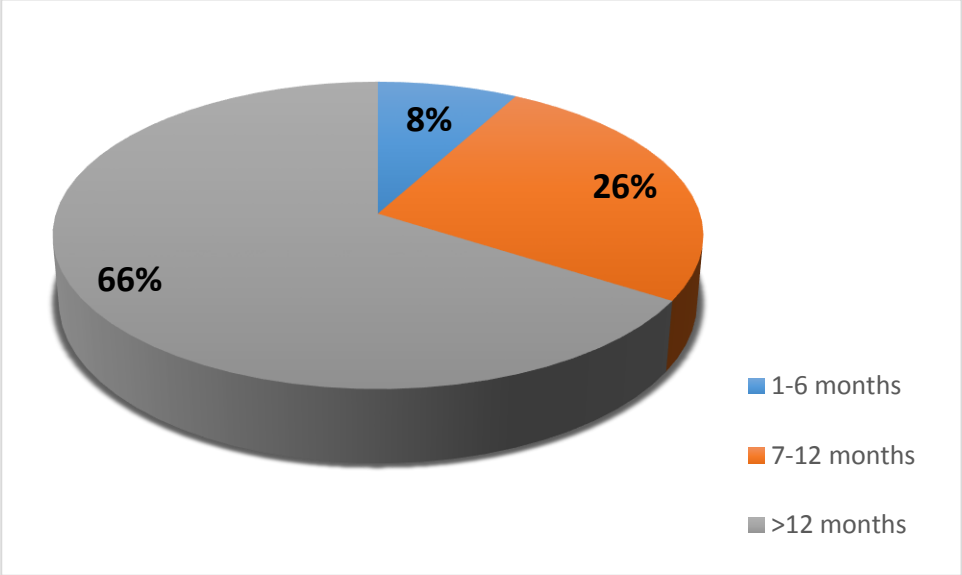

Figure 4.1: The percentage of patronage of the UG access control system for vehicles

Out of the one hundred respondents, eight (8) representing 8% answered that it's been a period of 1-6 months since they started using the UG E-Card and the access control system. Twenty six (26%) of the respondents also stated they have used the system for about 7-12 months. The rest of the respondents being sixty-six (66), represented by 66% also indicated that they have patronized the system for more than 12 months. The period of patronage was largely due to their status as a student or staff with a vehicle.

4.2.2 Results obtained from respondents on what inspired the University to produce the Card

It became necessary for the researcher to find out from the respondents their thought of the inspiration behind the construction of the electronic access gates and the electronic cards for vehicles.

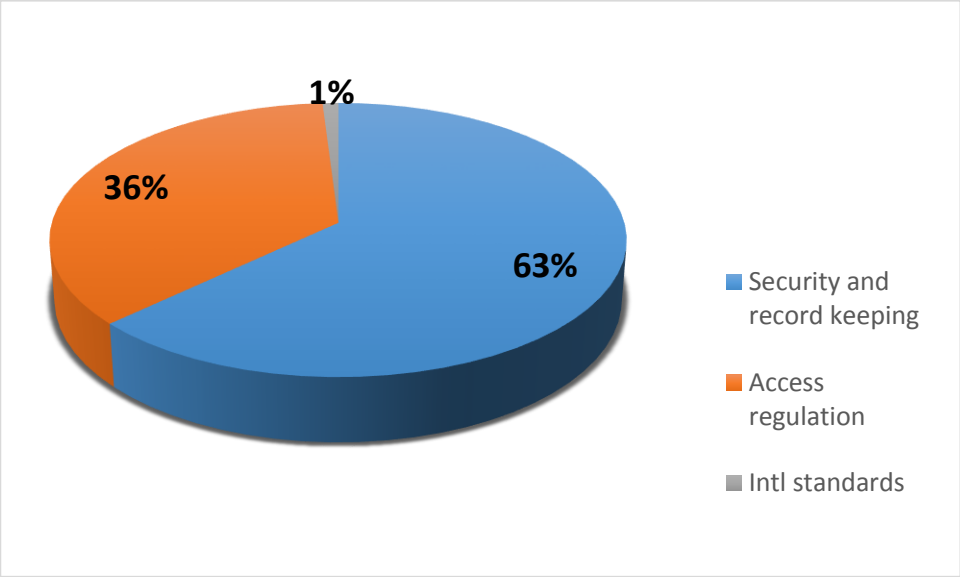

Figure 4.2: The percentage of what inspired UG to construct the electronic access gate for vehicles

Results obtained by the researcher from the respondents were categorized into three. Security and record keeping, access regulation and meeting international standards.

From Figure 4.4, sixty three (63), which represents 63% of the respondents said improved security and record keeping of vehicles on campus inspired the university to produce the electronic card and the construction of the vehicular electronic access gate system. They believe the coming into existence of this access control system for vehicles has protected members and properties of the university as security and record keeping of vehicles on campus have improved as compared to some years back when there was no such system to control movement. Thirty six (36) out of the respondents representing 36% also stated that, they felt access regulation led to the construction of the electronic access gate or system and the electronic card.

Respondents further stated that there were times drivers either private or commercial used the campus route as shortcut to their various destinations when there was huge traffic jam on the main road and this extended the traffic jam to campus when its routes were used as an alternative. A respondent answered that, it was due to meeting international standards that led the university to come up with the electronic access control system for vehicles. This response represented 1% of the total percentage of respondents.

4.2.3 Results obtained on the University's vision for implementing the access control systems

The respondents were further asked if they thought the university's vision for implementing the access control systems for vehicle have been met. This question became necessary to find out from the respondents in case there are challenges confronting the accessibility of the system.

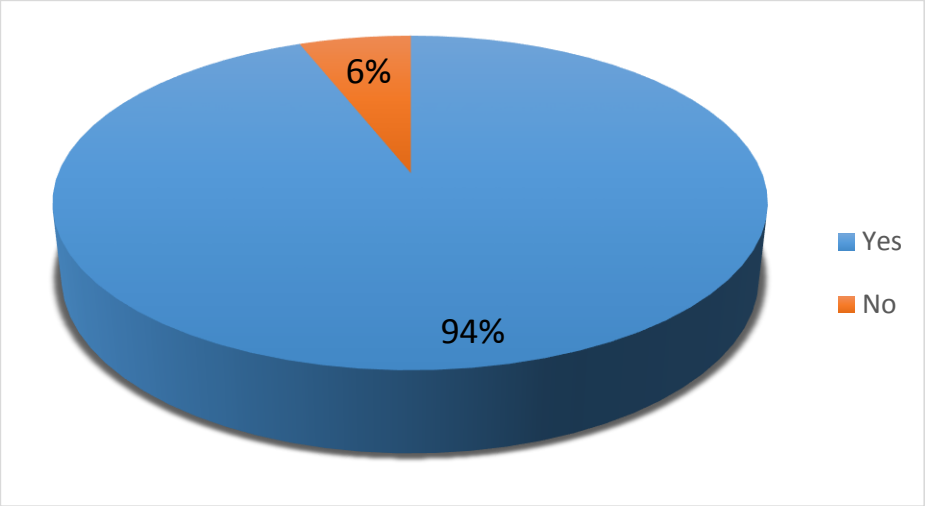

Figure 4.3: The percentage response of UG's vision for implementing the access control system for vehicles

Ninety four of the respondents representing 94% stated they feel the university's vision for implementing the access control system on campus has been met. While remaining 6% were of the view that the vision for implementing the access control systems hadn't been met due to some irregularities.

4.2.4 Results obtained from respondents on identified problems associated with the use of the UG access control system for vehicles

Despite the initial challenges and controversies which surrounded the initiation of the University of Ghana's vehicular access control system, it became important for the researcher to further ask respondents whether they faced challenges using the system.

Out of the one hundred respondents, seventy nine (79) representing 79% stated clearly they don't face any challenges using the system. The remaining twenty one (21), representing 21% said they faced problem. This is shown in Figure 4.6 below;

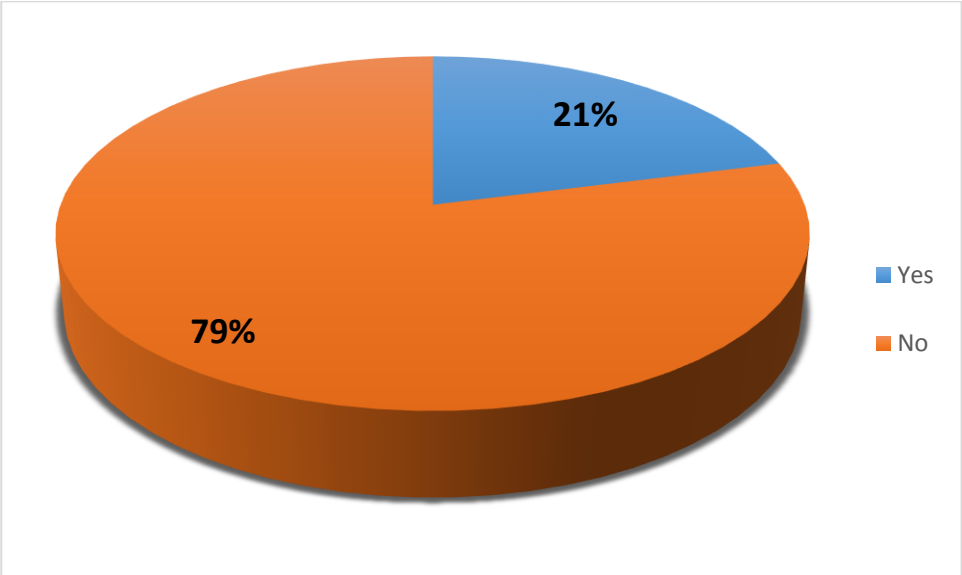

Figure 4.4: The percentage response of problems associated with using the UG access control systems for vehicles

The twenty one (21) respondents who said they faced challenges using the access control system were further probed to know the exact challenges they faced. Out of the twenty one, twelve (12), representing 57% indicated system failure as their challenge. This was manifested during times when cardholders got to the barrier and their cards could not be recognized by the system and had to fall on the security at post to use their cards to grant them access. Seven (7), representing 33% of the respondents stated that the linear actuator (barrier) were slow to open for entry or exit after being verified. Two (2) out of the 21 representing 10% also stated that in circumstances of power outage or erratic power supply, the system relied on standby generators which require high costs of operation and maintenance. They therefore recommended that authorities consider solar power as an alternative power source to the regular power supply.

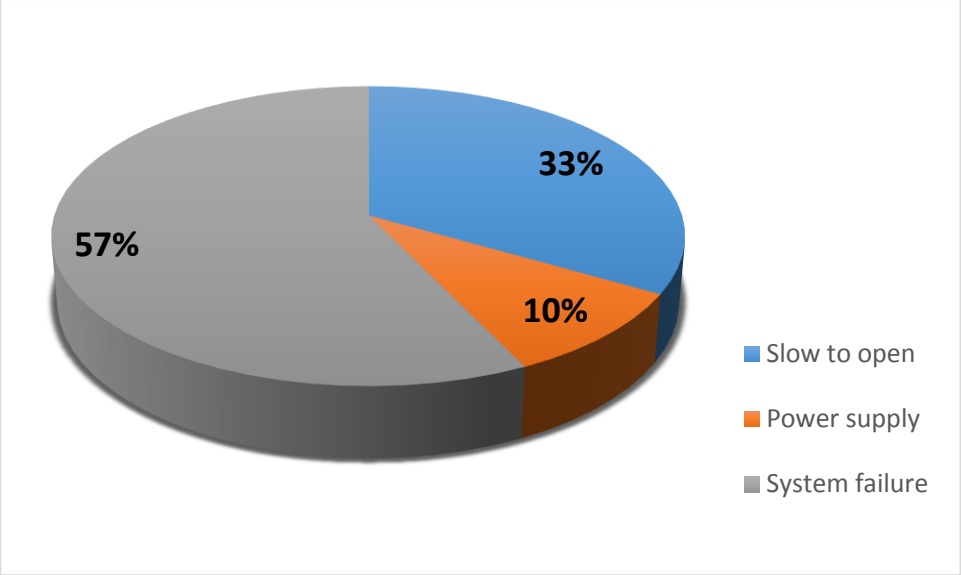

Figure 4.5: Problems associated with the use of the UG vehicular access control system

Aside the information obtained from respondents, the director of Physical Development and Municipal Services Directorates (PDMS), Mr. Charles Nti and one security man who gave his name as Nene, who was at post at the barrier close to the James Topp Nelson Yankah Hall were engaged. The gathered information from them indicated that, some of the staff and students abused the access control system. The E-Card which is meant to be fixed on the right corner of the vehicle's windscreen is found in the hands of the users and as they approach the barrier, show it to the sensor or reader to grant access. Instead of using one card per vehicle as embedded in the system during registration, this practice violates it to grant access to more than one vehicle. This according to the users is due to the 'huge' fee for acquisition of the E-card, as well as its renewal. On the part of the security, it sometimes create problems since the registered vehicle number may not match the approaching vehicle, although the card has granted access. In such situations, the security may deny access unless the driver has a valid proof of card registration documents.

Most of the users also get to the barrier without their cards claiming they had left them home and plead with security at post to grant them access. “It becomes very difficult to deny access especially when you are familiar with such persons”, according to the security.

Another key challenge associated with the use of the UG vehicle access control card is card theft. The card is the only means by which one can get access to campus by road through the main gates, so the need to have the E-Card is high. Some card holders complained of card theft according to one of the security men who was engaged in an informal interview.

4.2.5 Result obtained from respondents on mounting a chip in a metal casing.

This kind of question was asked to find out from the respondents what they think about a metal casing for electronic chip since majority of the electronic stickers or cards, and other electronic tags are plastic-cased.

From their response, mounting a security chip in a metal casing will not be a challenge since they believed metal casing has the tendency to improve its identification from a distance. They however advised that the thickness of the metal be closely monitored (since metals are opaque) to allow easy passage of electronic waves.

Below is a chart showing the percentage response;

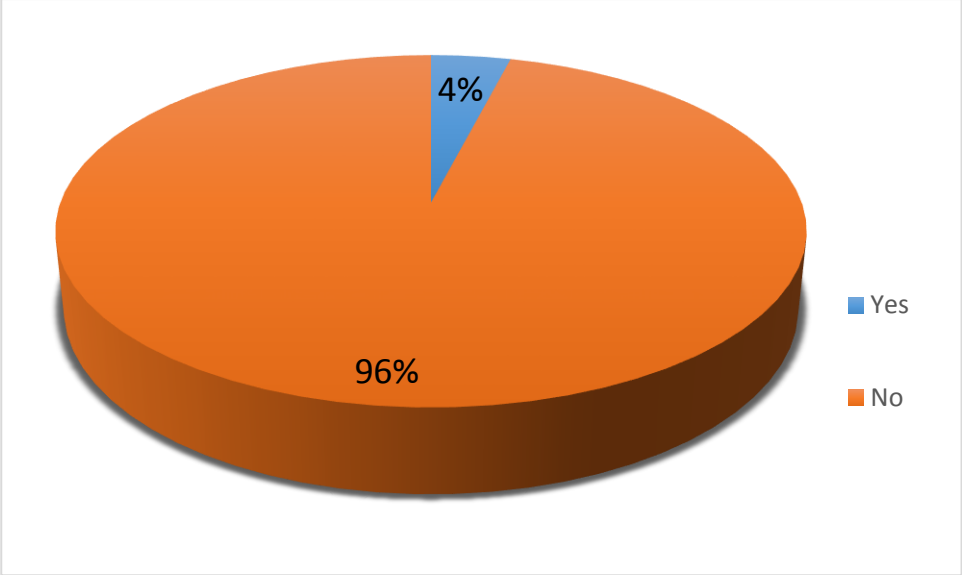

Figure 4.6: Response to mounting electronic chip in metal casing

However, 4 of the respondents representing 4% were of the view that it's not possible to mount electronic chip into metal casing with the reason that metal is not transparent and can't allow electronic waves to penetrate.

4.2.6 Analysis of the KNUST and UG vehicular access control system

From the table 3.2 in chapter 3 above outlining both KNUST and UG access system, some components that makes up the system were found to be present among the two universities' access system functioning the same purpose. However, the University of Ghana access system has a led displayed screen to show some basic details of every card holder's successful entry and a traffic indicator to give a final signal whether or not an access was granted or denied.

The led screen and the traffic indicator are the components which was not part of KNUST vehicular access control system.

These two components are however very important and should be taken into consideration by the authorities in charge of the KNUST entry stickers. This is because taking the led screen which displays some basic details like the vehicle's registration

number of the sticker holder for example, securities at post cannot monitor and find out whether every accessed vehicle is having the valid sticker belonging to the user of that accessed vehicle or may be the accessed vehicle was stolen from a staff on campus and is on the move out of the campus.

Another missing component in the KNUST vehicular access control system is a traffic indicator. This device gives final signal after authentication by the RFID reader. Meaning if a vehicle approaches the barrier and is not having a valid sticker with embedded electronic access chip, the traffic indicator will show a red light to signify accessed denied. A successful authentication will give a green light by the traffic indicator. This component when added to the KNUST vehicular access control system will help the securities at post to know and prevent any approached vehicle at the barrier from access to campus without any tolerance since drivers are capable of giving funny excuses.

4.3 Analysis of the Improved Access Control Model Based On the Findings in Objective One.

During the model making and the programming stage, the researcher got to know that passive tags are not suitable when embedding it in a metal casing since their waves find it difficult penetrating through metal.

The researcher also got to know that positioning of RFID reader at an angle to directly face and recognise any approaching credential was the best. An RFID reader can't be positioned at left corner of the barrier whiles a sticker or the metal relief identification with embedded chip is fixed at the right corner of a vehicle's windscreen. The angle frequency waves can't extend if the two are not positioned at one side to face each other for authentication by the reader. It was also know that, positioning the RFID reader at an angle of 90°C to face any approaching credential is the best since any

other angle direction like 120°C positioning can even pick signal from a packed vehicle which is some meters far away from the barrier.

Lastly in making a circuit to control a vehicular access system, it was expedient to add infrared sensor to the designed system to help regulate the movement to the linear actuator especially when a vehicle is unable to drive pass the barrier due to an unforeseen circumstances. Traffic indicators should not be left out too. The presence of the traffic indicator serves as signalling when an approached credential (sticker with embedded chip) on a vehicle has a valid or registered chip as registered on the system to permit access or is invalid or not registered in the system to deny access.

4.3.1 Pictures of the sample metal relief identification responding to the designed model vehicular access control system

Plate 4.1: Shows an image displaying the sample metal relief identification with electronic chip responding to a designed access control system.

4.4 Analysis of Employing Local Metal Technology in the Design of a Vehicle Identification Tags to Respond a Vehicular Access Control System.

4.4.1 Brass as a material suitable for casting sample metal relief Vehicle identification

The material that was deemed highly suitable for the sample metal relief vehicle identification with access control chip for Kwame Nkrumah University of Science and Technology was brass metal. Brass is an alloy made of copper and zinc. It is one of the most widely used alloys due to its unique properties.

It is used for decoration for its bright gold-like appearance by nature. Brass represents the true Ghanaian colour gold as loved by most Ghanaians. It is one of the most produced material by the local artisan. The properties of it influenced it to be chosen due to its ability to melt at high temperatures and flow easily to cast complex shapes without deformity, high malleability than bronze or zinc, it is not ferromagnetic, it is a poor breeding ground for bacteria, all brasses are known to be ductile and brass alloys are known for being easily formed (machinability)

4.4.2 Lost wax casting technique suitable for producing the sample Metal Relief Vehicle Identification with Access Control Chip for Kwame Nkrumah University of Science And Technology.

In adopting a sustainable and easy approach that can be learnt by other people for quick reproduction, the researcher considered the lost wax casting technique within the means of local artisans. Lost wax also called investment casting, precision casting or Cire-Perdue in French is an ancient technique of producing duplicate works with complex designs by the use of wax. This is a casting technique or method in which a molten metal is poured into a mould that has been created by means of a wax model.

Once the mould is made, the wax model is melted and drained away. A hollow core can be effected by the introduction of a heat-proof core that prevents the molten metal from totally filling the mould.

The steps involved in lost wax casting include the following;

- Model Making
- Mould making
- Casting
- Finishing

All these processes were used in the production of the sample metal relief vehicle identification with access control chip for Kwame Nkrumah University of Science and Technology as shown in Chapter three above.

4.4.3 Finishing of the sample Metal Relief Vehicle Identification with Access Control Chip for Kwame Nkrumah University of Science And Technology.

Since the sample metal stickers are to promote distance visibility, more attractive and pleasant to the eye, it was expedient to keep them free from rusting or corroding since it will be exposed to the environment and hand stains. Thus, this research was able to see to it that non-corroding material like brass was used for making the sample metal stickers. The sample metal relief vehicle identification with access control chip for Kwame Nkrumah University of Science and Technology at the end of the day were filed, sanded, polished and preserved with preservatives that made them resistant to the unfavourable atmospheric weather and hand stains.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION.

5.1 Overview

This final chapter gives a brief information of the findings derived from the intensive research. It further gives a vivid account of the conclusion of the whole research and the recommendations as well.

5.2 Summary of findings

In summary, the metal relief vehicle identification aside its ability to contain electronic access control chip to grant access into an electronic access gate institution, will be more visible and give good branding to the institution or the entities using it. Like Benz and BMW vehicles have crown and the metal impression on the bonnet respectively, it will be interesting and prestigious to the user of the vehicle if electronic chip is embedded in it to grant access into electronic gated institutions.

In the research, University of Ghana was found to be the first public university in Ghana to have adopted electronic gate system for vehicles and the use of electronic scannable card or sticker to grant access into their campus in the course of studying and analyzing the system.

The study was able to analyse the University of Ghana vehicular access control system taken into consideration what actually inspired them to initiate the system, the various component that constitute the system, how the system works, associated challenges and the respondents opinion on metal being a casing for electronic chip to respond to electronic barrier.

All these information gathered were relevant to the study serving as basis to compare with the Kwame Nkrumah University of Science and Technology's access control system for vehicles which was activated and open to operation early June 2018.

5.2.1 Principles For Producing the Metal Relief Identification With Access Control Chip For KNUST.

The study ascertained that for an aesthetic metal relief identification with access control chip to be produced, the metal identification should bear the qualities below;

- The details in the element of the metal identification should not be altered for easy identification.
- A durable and user friendly material should be used for the production of the metal relief identification.
- The metal relief vehicle identification should not be produced to have a thickness more than 0.2mm.
- The metal relief vehicle identification should be able to contain access control chip and should be functional.

5.2.2 Brass as a Suitable Material for Metal Relief Identification.

Using cheap materials to make sample metal relief vehicle identification with access control chip for Kwame Nkrumah University of Science and Technology was not the best. The researcher therefore used brass metal, one of the durable materials to depict the status level of the university and to produce a more lasting effect of the element. The produced element expected to produce a more lasting effect be designed in a low quality material, the element will lose it beauty and value within a short possible period, and the details on the element will not be seen clearly from afar as distance visibility of the element is keen.

Therefore it was significant to design the metal relief identification in a durable material like brass as seen in chapter three above.

The KNUST emblem was therefore casted in the brass metal since it was noted to have a unique yellowish color, tough and ability to cast complex shapes.

5.2.3 Lost Wax Casting as a Suitable Technique for Metal Relief Identification Making

The lost wax technique was the most appropriate procedure in metallurgy that can be used to portray the delicate features on the elements. One type of casting was done. Fortunately, the wax models applied with POP proved successful. It was able to bring out all the delicate features after casting.

5.2.4 Major Findings from the Analysis

It was identified after studying and comparing the KNUST and the UG vehicular access control system that, despite some challenges faced by some users of UG E-Card and the access system, their access system seems to be reliable since proper monitoring and records are kept on every accessed vehicle within a day. The inclusion of led screen in their system component to project every accessed vehicle's basic details like the vehicle's registration number has become difficult for non-card holders to use someone's card for entry since the vehicle's registration number of that non-card holder will match the registered vehicle number on their system. This in most cases lead to denial of entry by securities at post to ensure proper monitoring and record keeping. Again it was also identified that the UG vehicular access control system has traffic indicator to show when someone is granted access or is denied access as may be due to either using expired card or invalid card to grant access.

The led screen to display every accessed vehicle's basic details and traffic indicator being part of the UG's access system was found not to be part of the KNUST's vehicular access control system.

5.2.5 Major Findings during Other Techniques and Processes

It was find out that, in operating heat from the micro torch during warming of wax to pick model from mould for casting, it was identified the heat should be regulated to a lower temperature since operating the micro torch at a higher temperature melts the wax and cause porosity in the wax.

When pressing the wax into the cement mould, it was identified that, soft wax picks details of element better than when it cools down and becomes hard. When wax cools and becomes hard, it should be warmed again in water to obtain its initial flexibility property since it cannot be reformed when it becomes hard.

It was also found that, when working with POP to create mould, one should mix the slurry quickly to avoid setting before pouring into the cavity otherwise, a bad POP mould will be created and result in poor casting of element if that mould is further used to pick the shape of elements for casting. This bad POP mould created as a result becomes porous.

It was also found out during mounting of access control chip in the cast metal piece that, not all passive chips work when mounted in a metal casing due to its low frequency wave penetration through metals and the type of RFID reader should also be considered.

5.3 Conclusion

In conclusion, metal relief vehicle identification with access control chip like any other PVC entry sticker with embedded chip can also grant a vehicle access into any

electronic gated institution or community. What really matters is studying a particular electronic chip that can function when embedded in that material.

A critical look into the research confirms to the fact that, the processes generated was very significant for successful metal relief vehicle identification production.

It is advisable to regulate heat at a lower temperature to warm wax for picking of models from mould, it is also concluded that in making a POP mould, one should mix the slurry quickly to avoid early setting of material before pouring into a cavity, soft wax due to its flexibility and plasticity property is able to pick every intricate details of a given element. All these processes will serve as a guide to artists who want to learn the art of metal relief vehicle identification.

Brass metal as the material used for the production is durable and can stand or exist for a longer period, malleable and shiny to project the name of KNUST by way of branding.

During the production processes, POP coating around the wax model for casting was seen to be the best since every intricate design of the element was picked and came out clearly as expected after casting. Thus, any artist can try using this method of coating wax models.

Not all passive chips and their RFID readers work efficiently when mounted in a metal casing due to its poor frequency wave penetration through metals.

Lastly, it is concluded that, the inclusion of led screen in vehicular access control systems to display details of every accessed vehicle is the best since proper monitoring is achieved. Again, it is also necessary to include traffic indicator in vehicular access control systems to show when one is granted or denied access into a restricted environment through the light signal it shows.

5.4 Recommendation

The recommendations below were given by the researcher:

- The metal identification in a round is recommended for high profile officers while the flat design for ordinary Lecturers of the University.
- Preferably, active tags/ chips should be used when mounting in a metal casing because of its ability to read from a long distance from the RFID reader. They function well in metal because of their high frequency waves.
- For proper monitoring and good record keeping, the researcher recommends that led screen to display some basis details of every accessed vehicle into any restricted environment should be shown for further probing in case there are doubts.
- The researcher recommends to the access control system programmers that, the infrared (IR) sensor should be programmed to respond only to the accessed vehicle's credential to function in case that particular vehicle is unable to drive through the barrier. This is because since infrared sensors are sensitive to opaque objects when it comes in contact, it is likely and possible someone after successful access grant can intentionally block the sensor to allow other colleagues drive through as the linear actuator keeps raised.
- Other positioning approach of the RFID reader can be adopted to know which approach picks up signal from any approached sticker (credential) fast for quick authentication to permit access through a barrier as shown in chapter 2 above in plate 2.77 and plate 2.78. The image below shows another RFID reader positioning approach.

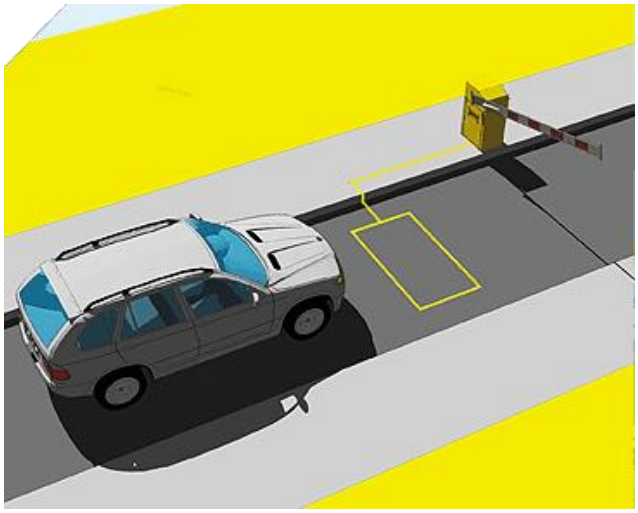

Plate 5.1: Shows an RFID sensor planted in the middle of the road
(Source: *www.ecotrafficsolutions.com.au*)

- Cooperate institutions and gated communities should embrace the use of metal for the production of an electronic identification to respond to electronic barriers.
- In order not to cause traffic when a particular approached vehicle at a barrier is not having valid sticker (credential) to permit entry, the researcher recommends that, there should be another linked road beside the barrier for that vehicle to return instead of going reverse.

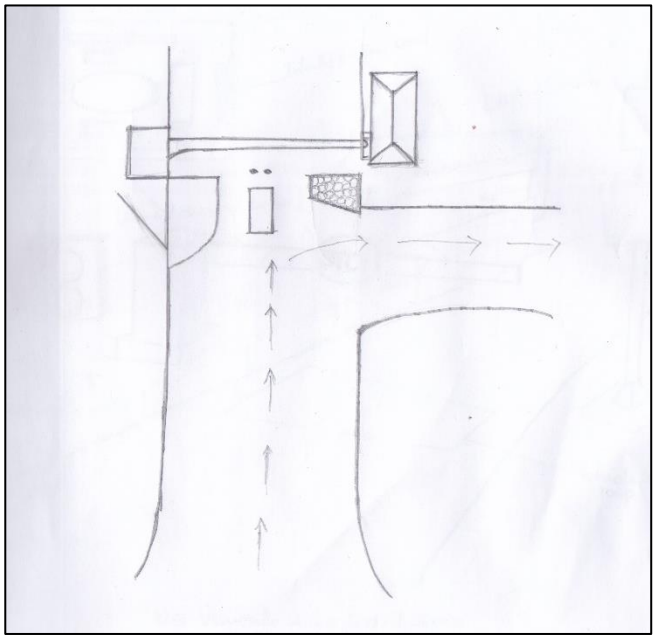

Figure 5.1: Shows a link road for vehicles that cannot access the barrier instead of going reverse to cause traffic.

- Metal artists should adopt the knowledge in this study to execute other interesting metal project to bring out the versatility of the material.
- Based on the result obtained when POP slurry was used as coating around the wax models during the casting process, the researcher recommends to artists and new beginners who want to cast intricate work with the hope of obtaining a fine detailed cast piece to resort to the POP coating approach.
- The researcher recommend to artists to press plastic or soft wax to pick the details of a work from it mould in order to achieve a model with fine and clearer details.
- The researcher recommends that slurry POP meant for making mould should be poured quickly into the created cavity since POP settles fast.
- Aside the lost wax casting technique, other local method for the production of a metal relief identification can be explored into by artisans to find out other appropriate technique.

  It is necessary to display the name of the owner of the vehicle, the vehicle's registration number and any other relevant information for easy identification of a person and his or her vehicle.

REFERENCES.

Alamin, M. Francis, S. Fred, N. (2012) ‘Corrosion detection using low-frequency RFID technology’, *Insight: Non-Destructive Testing and Condition Monitoring*, 54(2), pp. 72–75.

Archaeology wordsmith (2017) '*Chasing*' [Online] Available at: www.wikipedia.org/archaelogy.com [Accessed April, 2018]

Beverly L. Harrison, Roy Want, Kenneth P. Fishkin, Anuj Uday Gujar, Wesley R. Irish, 28-12-1999. Selectively Enabled Electronic Tags. New York, London: Sterling Publishing Co, Inc.

Blythe, P. T. (2004) ‘Improving public transport ticketing through smart cards’, pp. 47–54. Oxford, UK: Elsevier Inc.

Bouet, M. (2008) ‘RFID Tags : Positioning Principles and Localization Techniques’, pp. 1–5. England: Rockport Publishers, England.

Booker's INC (2017) '*Metal Chasing*' [Online] Available at: www.metalformingtechniques.com [Accessed February, 2018].

Britannica (2017). 'Embossing' [Online] Available at: www.britannica.com [Accessed November, 2017]

Cambridge dictionary (2016) *'Printing*' [Online] Available at: www.cambridgedictionary-wordmeaning.com [Accessed December,2017]

Campbell, J. (2003). *Metal Castings;Techniques and Processes.* UK: Elsevier Butterworth-Heinemann.

Carol, P. (2001) 'Qualitative inquiry and research design' UK: Elsevier Butterworth-Heinemann.

Catherine, C. (2000). The handbook of qualitative business management research. USA; John Wiley and Sons Inc.

Casden, M. S., 2004. *Wireless Data Input to RFID Reader.* Chatsworth: Soundcraft, Inc.

Chakrabarti, A. (2005). *Casting technology and cast alloys.* New Delhi, India: Asoke K. Ghosh, Prentice-Hall of India Private Limited.

Corwin, N. M. (2009). *Chasing and Repoussé.* Brunswick, Maine USA: Brynmorgen Press.

Davis, M. (2009). *Fundamentals of Branding.* England: Fairchild Books.

Dainelli, D. (2009) ‘Active and intelligent food packaging : legal aspects and safety concerns’, *Trends in Food Science & Technology*. UK. Elsevier Ltd,

Dressen, B. D. (2008) ‘Radio Frequency Identification Systems’, pp. 45–47. England: Rockport Publishers, England.

Dulock, H. L., (1993). Research Design: Descriptive Research. Journal of Pediatric Oncology Nursing.

Domdouzis, K., Kumar, B. and Anumba, C. (2007) ‘Radio-Frequency Identification (RFID) applications: A brief introduction’, *Advanced Engineering Informatics*, 21(4), pp. 350–355.

Elizabeth, M. (20th December 2016). What is Metal Etching? *WiseGEEK*, para 1-5.

Gayle Johnson, Look Waite and Steven Smith (1992) ‘Metal properties’ New York, London: Sterling Publishing Co. Inc.

Graham, A. (2009). 'Research Population and Sampling Techniques'. USA; John Wiley and Sons Inc

Huang, C. (2009) ‘An Overview of RFID Technology, Application, and Security/Privacy Threats and Solutions’.

IUPAC (2016) *'Adhesion*' [Online] Available at: www.iupac.org [Accessed May,2018].

Jones, I. R. Sampson, R. Bright, N. (2005) 'Radio Frequency Tags' *United States Patent*.

Keller, P. K. (April 14, 2007). Marketing Management; 1 edition. Pearson Learning Solutions.

Kelvin, S. (2009). Metal Casting processes, metallurgy, technique and design; UK: Elsevier Butterworth-Heinemann.

Kwesi, A & Graham, K. (2009). ‘Sampling of Population: Methods and application’. Surf Publications Ghana. Ltd, Accra: Sterling Publishing Co. Inc.

Louis A. Woolley, Charles F. Ferrara, Ian Greasley, James H. Weimar, (1998). Managing assets with active electronic tags. UK: Elsevier Butterworth-Heinemann.

Lim, N. Justice, K. Matthew, N. (2009) ‘Article Surveillance Tags’, 32(1), pp. 72–76. London: Sterling Publishing Co. Inc.

Lou, J. J. Alvin, L. Eugene T.P (2011) ‘A review of radio frequency identification technology for the anatomic pathology or biorepository laboratory: Much promise, some progress, and more work needed.’, *Journal of pathology informatics*, 2, p. 34.

Meek, J. B. (1973). *The Art of Engraving: A Book of Instructions.* F. Brownell & Son.

Muldoon, M. S. (2006). *Metal Embossing Workshop.* New York, London: Sterling Publishing Co, Inc.

Nicole, A. (2016). Foil tags; characteristics and properties. England: Rockport Publishers, England.

Penal Affairs Committee (1988). "Electronic tagging: a briefing paper". Quaker Social Responsibility and Education Journal. **X** (3): 13–19

Perry, D. (2013). Branding your Vehicle: The ultimate guide. *Handyman Startup,* Para 14-17.

Peris-lopez, P. Anthonio, S. Andre, A. (2002) 'LMAP : A Real Lightweight Mutual Authentication Protocol for Low-cost RFID tags'. *IEEE Transactions on Antennas and Propagation.*

Pocius, A.V (2002) 'Adhesion Science and Engineering' Brunswick, Maine USA: Brynmorgen Press.

Qing, X. and Chen, Z. N. (2007) 'Proximity effects of metallic environments on high frequency RFID reader antenna: Study and applications', *IEEE Transactions on Antennas and Propagation*, 55(11 I), pp. 3105–3111.

Rao, K. V. S., Nikitin, P. V. and Lam, S. F. (2005) 'Antenna design for UHF RFID tags: a review and a practical application', *IEEE Transactions on Antennas and Propagation*, 53(12), pp. 3870–3876.

Rouse, M., (2010). RFID Tagging. IOT Agenda.

Roberti, M., 2009. What is the lifespan of an active tag? RFID Journal, Issue 03-13-2009.

Rory, O. (2001) An overview of the methodological approach of action research. Brazil: Universidade Federal da Poraiba.

Russell, K. (2015) 'qualitative approache' Maine USA: Brynmorgen Press.

Schmidt, P. (March 2005). *What is Branding: Graphic Design Handbook.* England: Rockport Publishers, England.

Schmidt, P. (29th July 2013). *What is Branding; Graphic Design Handbook.* England: Jeff.

Shrikant, A. (2010). 'PS Adhesive and Coatings' USA; John Wiley and Sons Inc.

Syed, M (2012). Sample and Sampling Designs. Book Zone Publication, Chittagong, Bangladesh.

Tesoriero, R. Lucas, P. Gabrithe S. (2008) 'Using active and passive RFID technology to support indoor location-aware systems', *IEEE Transactions on Consumer Electronics*, 54(2), pp. 578–583.

Tomka, G. J., (2002). Materials World. Volume 10, pp. 12-15. UK: Elsevier Butterworth-Heinemann.

Ward, J. Max, L. Rhoza, M. (2006). 'RFID: Frequency, standards, adoption and innovation', JISC Technology and Standards Watch.

wikiHow Logo (2017) '*Removing metal emblems from a surface*' [Online] Available at: www.wikihowlogos.com
[Accessed March,2018]

Woolley, L. A. C. and Minoa, J. H. W. (1998) *United States Patent (19) Cl*.

Wong, L. (2005). *Brand Think.* Trafford: Trafford Publications.

Worgul, M. (2009). *Hot Embossing: Theory and Technology of Micro replication.* Oxford, UK: Elsevier Inc.

Yang, L. Xui, M. Syun, Q. (2007) 'RFID tag and RF structures on a paper substrate using inkjet-printing technology', *IEEE Transactions on Microwave Theory and Techniques*, 55(12), pp. 2894–2901.

APPENDICES

APPENDIX 1

Appendix 1 shows the questions used to collect relevant information from the population in the study.

RESEARCH QUESTIONAIRE FOR THE COLLECTION OF DATA TO SUPPORT A STUDY REGARDING METAL RELIEF VEHICLE IDENTIFICATION WITH ACCESS CONTROL CHIP.

Kwame Nkrumah University of Science and Technology

College of Art and Built Environment, Faculty of Art

Department of Integrated Rural Art and Industry

Date: …… Time: ……..……

1. Name of Respondent: ……..……

2. Agency/ Department ……..…….

3. Designation…….

4. How long have you used the UG access control sticker? (Please tick where applicable)

☐ 1 – 6 months ☐ 7 months – 12 months ☐ More than 12 months

5. How does the UG access control system for vehicles work?

6. What do you think inspired the University to produce this sticker?

……
……
……
……
……

7. Do you think the University's vision for implementing the access control systems are met?

   ☐ Yes ☐ No

   Please explain briefly

8. Are all the stickers placed in a particular position in the vehicle?

   ☐ Yes ☐ No

9. What do you think informed the current position of the access stickers?

10. Do have an idea the type of access chip is mounted in the entry pass sticker?

    Yes/ No (If No, please skip to 13)

11. What type of access control chip is that?

    ……

    ……

    ……

12. Do you know of any other chips that is also appropriate for this purpose?

    Yes/ No

12. A if “yes”, Give some examples

……

……

……

12.B How do you grade this example compared to the current one?

……

……

……

13. At what range/distance do you think the barrier sensor respond to the chip in the entry pass sticker?

……

……

……

14 a. Have you identified any problem with these stickers and the access control system?

☐ Yes ☐ No

14 . If “yes”, what problem have you encounter?

15. Will there be any problem mounting the access chip in a metal casing?

☐ Yes ☐ No

16. Do you have any other comments to give?

APPENDIX 2

IMAGES OF SOME PROCESSES EMPLOYED

Image 1: Preparing the board for the model

Image 2: Mixing sawdust and water.

Image 3: Adding white glue to the sawdust

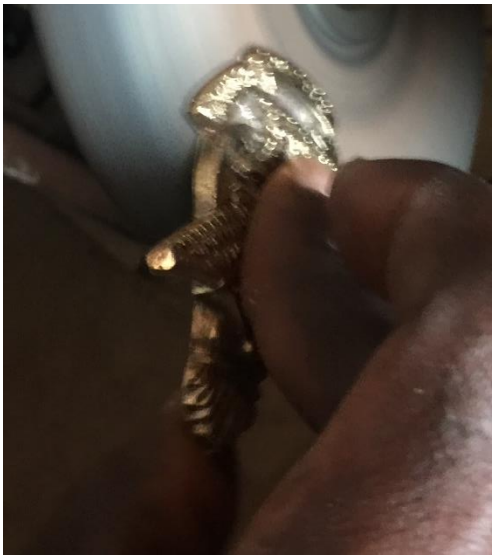

Image 4: Grinding the cast piece

Image 5: Filing the cast piece

Image 6: Grinding the space for the chip

Image 7: Sanding the cast piece

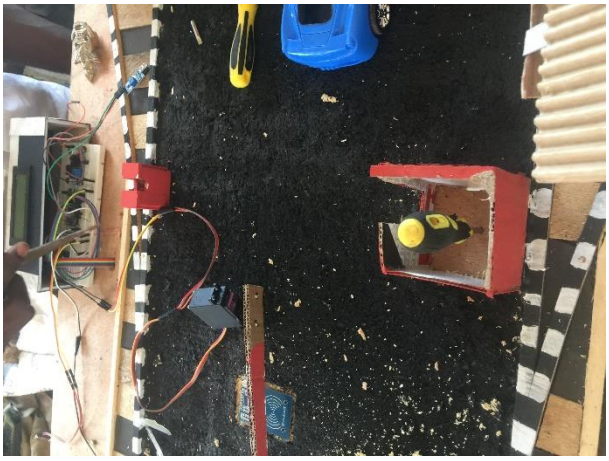

Image 8: Electrical installation of the designed model.

APPENDIX 3

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