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DESIGN AND CONSTRUCTION OF 5KVA, 220V, 50HZ SINGLE PHASE AIR COOLED ELECTRIC ARC WELDING MACHINE

BY

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TO

THE DEPARTMENT OF ELECTRICAL/ELECTRONIC ENGINEERING TECHNOLOGY, AUCHI POLYTECHNIC AUCHI,

EDO STATE

IN PARTIAL FULFILMENT OF THE REQUIREMENT

FOR THE AWARD OF HIGHER NATIONAL DIPLOMA (HND)

IN ELECTRICAL/ELECTRONIC ENGINEERING (POWER AND MACHINE OPTION)

FEBRUARY, 2022

ABSTRACT

This project work presents the design and construction of a single-phase 5KVA, 50HZ, 220V air-cool arc welding machine. The machine work with the transformer principle and it is capable of joining sheet of metals of the range of thickness between 0.5mm to 0.85m. The transformer is of the core-type, the design of the machine was done, constructed and tested and found to be working satisfactorily.

CERTIFICATION

We the under listed project ground certify that this is to certify that this project titled "Design and Construction of a 5KVA air cooled Arc Welding Machine" was carried out by us of the department of electrical/electronic engineering auchi polytechnic, auchi

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DEDICATION

This project work is dedicated to God Almighty who is the author of our lives for his grace, love and empowerment shown to us throughout our stay in the institution and to the completion of this project work.

This project is also dedicated to our loving and caring parents for their concern and also to friends and love ones for their contribution for the successful completion of our higher national diploma (HND) programmed.

ACKNOWLEDGEMENT

We are most grateful to the Almighty God who sustained us to this day and gave us good health and the grace to scale through this programme in spite of the ups and downs.

We also express our sincere gratitude and appreciation to our project supervisor **Engr. A. Omoregie** for his advice, cooperation and contributions.

We also want to use this medium to appreciate our Programme Coordinator **MR. Ezolome suleman** for his contribution toward our academic pursuit.

We will not forget to appreciate our follow students who together we scale through this programmed in peace, love and harmony

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LIST OF SYMBOLS AND ABBREVIATIONS

	SYMBOLS	MEANING
1.	a	Area of copper conductor in m2
2.	amp	Ampere
3.	volt	Voltage
4.	V_1	Primary voltage in volts
5.	V_2	Secondary voltage in volts
6.	I_1	Primary current in Amp
7.	I_2	Secondary current in Amp
8.	J^2	Current density in A/M2
9.	N_1	Primary number of turns
10.	N_2	Secondary number of turns
11.	B	Flux density in Tesla
12.	P	Power of the machine in wb
13.	R	Resistance
14.	Ø	Magnetizing flux in wb
15.	E.M.F	Electromotive force
16.	MMF	Magnetomotive force
17.	f	Frequency in Hz

18.	r	Reciprocal of reluctance
19.	Kw	Window space factor
20.	ŋ	Efficiency
21.	H	Magnetic strength in A/mm
22.	L	Length in mm
23.	d	Diameter in mm

CHAPTER ONE

INTRODUCTION

1.0 BACKGROUND OF THE STUDY

Welding is used to joining metal together to create or repair different metallic structures. They are several methods by which welding can be achieved.

The beginning of Welding could be found during the Bronze Age. The ancient Egyptian uses welding to create swords, shields, and other iron weaponry as early as 1,000 B.C.E.

Arc Welding

British innovator Humphrey Davy was the first person to use electrodes to produce an arc in 1801. Arc welding was first invented in the 19th century by British inventor Humphrey Davy.

Welding goes through more changes when C.L. Coffin comes up with a metal electrode to supersede the carbon electrode in 1890. The coated metal electrodes were introduced 10 years later. The electrodes were coated with a layer of lime to produce a more stable arc.

Modern Technology

Welding was boldly moved forward when alternating current began to be used in the 1930s. This led to the use of AC industrial welders that produced a smoother arc than the earlier direct current welders. In the 1950s, specialized welding began to emerge.

The welding processes using friction, a plasma arc, electron beams, and lasers were all developed in the latter half of the 20th century. The processes have applications in many industries. Laser welding was used in building automobiles, while electron beam welding was used to manufacture aircraft engines and other aircraft parts.

The modern forms of welding concentrate energy into a small space to produce massive amounts of heat. Electron beam welding focuses on a beam of electrons, while laser welding concentrates a laser beam.

1.2 STATEMENT OF THE PROBLEM

The major problem is lack of electricity, spatter, and deformation. Knife line attack was a kind of corrosion affecting welds when metals are not heated to the right temperature.

1.3 RESEARCH QUESTION

In this project work, what are the components/materials that make up the circuit of an electric welding machine (5KVA, 220V) single-phase, and what are the different stages in the circuit which is the source to discover facts about the project work?

1.4 PURPOSE OF THE STUDY

The purpose of the design and construction of arc welding machines is to bring an end to many problems, encountered by Engineers in the practical field. With the help of an arc welding machine, the problem of joining two or more metals together in constructional work is limited.

1.5 SCOPE OF THE STUDY

It is the type of machine that uses an electric power supply to create an electric arc between the base material to melt the metals at the welding point. This used alternating (AC) current, and consumable or non-consumable electrodes.

Nevertheless, there is room for improvement and further input into this work.

1.6 SIGNIFICANCE OF THE STUDY

There are several advantages of using arc welding machine compared with many other formats:

1. Cost –arc welding machine is well-priced and affordable, and the process often requires less equipment in the first place because of the lack of gas

2. Portability – this machine is very easy to transport

3. Shielding gas isn't necessary – processes can be completed during wind or rain, and spatter isn't a major concern.

4. Welding joints have a strength equal to the parent metal.

5. Welding is an economical process compared to riveting or bolting.

6. Welded joints are comparatively lighter in construction.

7. Repair & modifications of welded joints are easy.

1.7 LIMITATION OF THE STUDY

During construction of this work (electric Arc welding machine 5KVA, 220V single phase) there is the different factor that affects the design and construction of this work such as:

1. Lack of funds

2. Lack of materials

3. Time is taken to do the research

4. Lower efficiency – more waste is generally produced during arc welding than many other types, which can increase project costs in some cases

5. High skill level – operators of arc welding projects need a high level of skill and training, and not all professionals have these Thin materials – it can be tough to use arc welding on certain thin metals

Despite the limitation and problems encountered, I believe this project will serve as a stepping stone or guideline for any student or researcher who may wish to embark on this type of work.

Also, improvements can still be made on this work to solve a problem relating to welding.

1.8 TYPES OF ARC WELDING PROCESSES

This process can be categorized into two different types;

1. Consumable electrode method
2. Non-consumable electrode method

CONSUMABLE ELECTRODE METHODS

1. Shielded metal arc welding
2. Metal inert arc welding
3. Flux-cored metal arc welding
4. Submerged metal arc welding

The term 'arc welding' covers a large number of welding processes. What they have in common is the fact that they all use electric current to melt the filler metal and the parent metals.

The term 'arc welding' is commonly used only for manual arc welding with a coated electrode. That's why the process is called 'Manual Metal Arc welding.

When referring to other arc welding processes, welders use other terms, such as TIG, MIG, or CO2 welding, for example. In these processes, a gas is used to shield - to protect - the weld pool, and that's why these processes are often referred to as 'gas-shielded processes'. Gas-shielded arc welding can also be carried out manually, but it is more widely used for automatic or semi-automatic processes. (Weman 2003, p. 61).

Shielded Metal Arc

Shielded Metal Arc Welding is a common type of arc welding that is shielded metal arc welding, which is known as manual metal arc welding or stick welding.

An electric current is used to strike an arc between the base material and a consumable electrode rod or stick. The electrode rod is made of a material that is compatible with the base material being welded and is covered with a flux that gives off vapours that serve as a shielding gas and provide a layer of slag, both of which protect the weld area from atmospheric contamination. The electrode core itself acts as filler material, making a separate filler unnecessary. The process is very versatile, requiring little operator training and inexpensive equipment.

However, weld times are rather slow, since the consumable electrodes must be frequently replaced and because slag, the residue from the flux, must be chipped away after welding (Weman 2003, p. 63).

Furthermore, the process is generally limited to welding ferrous materials, though speciality electrodes have made possible the welding of cast iron, nickel, aluminum, copper, and other metals. The versatility of the method makes it popular in several applications including repair work and construction (Cary & Helzer 2005, p. 103).

Gas metal arc welding

Gas metal arc welding (GMAW), is called MIG (for metal/inert-gas) is a semi-automatic or automatic welding process. Gas metal arc welding was originally developed for welding aluminium and other non-ferrous materials in the 1940s. It is commonly used in industries such as the automobile industry for its versatility and speed.

Flux-Cored Arc Welding (FCAW)

Flux-cored arc welding (FCAW) is a variation of the GMAW technique. FCAW wire is a fine metal tube filled with powdered flux materials. An externally supplied shielding gas is sometimes used, but often the flux itself is relied upon to generate the necessary protection from the atmosphere. The process is widely used in construction because of its high welding speed and portability. (Weman 2003, p. 53)

Submerged Arc Welding (SAW)

The process is commonly used in industry, especially for large products. As the arc is not observable, it is typically automated. SAW is only possible in the 1F (flat fillet), 2F (horizontal fillet) and 1G (flat groove) positions.

2. NON-CONSUMABLE ELECTRODE METHOD

Tungsten/inert-gas welding (TIG) is a manual welding process. TIG uses a non-consumable electrode made of tungsten, an inert or semi-inert gas mixture, and separate filler material. It has a stable arc and high-quality welds, but it requires significant operator skill.

1.10 APPLICATION OF THE STUDY

There are many applications of welding both for industrial and domestic applications such as buildings of bridges, ships, pressure vessels, tanks, gasholders, and many other types of steelwork.

Welding has been outdated in construction works in heavy industries. Welding improves the appearance of the product. More also, welded ship cost less to build and is up to 10% lighter than reverted ship due to the elimination of rivet heads and overlaps.

Similarly, advantages are realized in other types of welding structures such as motor, air crafts, railways, pipelines as well as in food and chemical industries.

1.12 DEFINITION OF WELDING TERMS

Arc blow: This is the deflection of electricity from its normal path because of magnetic forces.

Arc Length: This is the distance from the end of electrodes to the point where the arc makes contact with the work surface.

Base Metal: This metal is to be welded, brazed, soldered, or cut.

Flux: Is the pressure of a force field in a specified physical medium.

Voltage (volt): It is the force that drives current around a circuit

Resistance (Ω): It is the opposition of current flow in a circuit.

Current (amp): It is the flow of charge in a circuit.

Current density (a/m2): The ratio of current to area

Flux density (wb/m2): The ratio of flux to the area

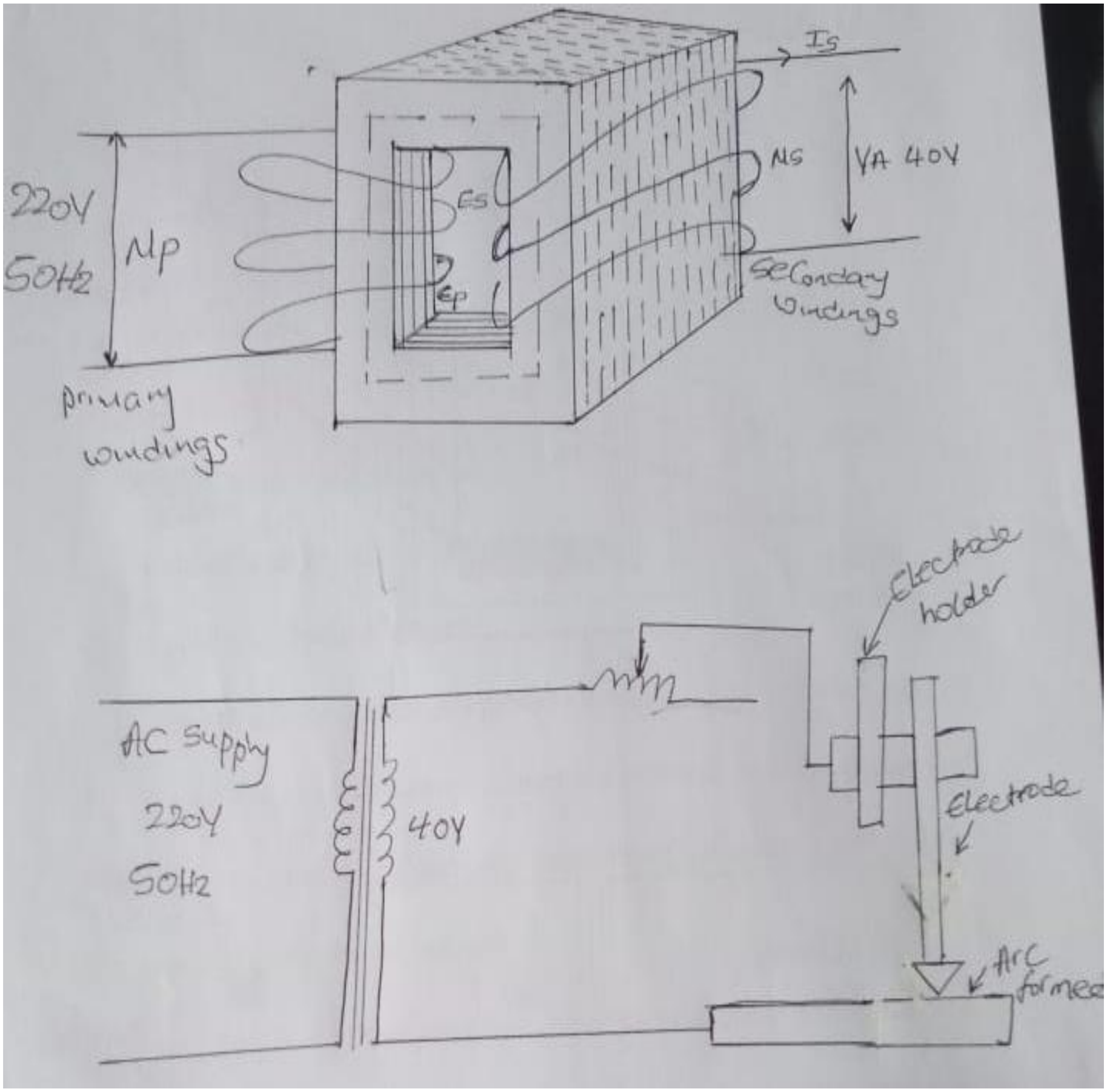
Impedance (z): Total resistance of an electric circuit to the flow of alternating current.

E.M.F (volt): It is the potential difference between the terminal of the cell when the circuit is open.

Inductance (h): This property of an electric conductor or circuit that causes an electromotive force to be generated by a change in the current flowing.

Capacitance (f): Is a device for storing electrical energy, consisting of two conductors in close proximity and insulating from each other

Power (watt): It is the rate at which energy is expended.



1.1 Circuit Diagram of an Arc Welding Machine

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION OF THE STUDY

Arc welding is a type of welding that uses an electric power supply to create an electric arc between the base materials to melt the metals at the welding point.

Assignment loop is a welding equipment specification that defines the number of minutes, within a 10 minute period, during which a given arc welder can safely be used. For example, an 80 A welder with a 60% assignment loop must be "rested" for at least 4 minutes after 6 minutes of continuous welding. (Weman 2003, p. 89). Failure to observe assignment loop limitations could damage the welder. Commercial- or professional-grade welders typically have a 100% assignment loop.

2.2 CURRENT LITERATURE REVIEW

1. Current density
2. Stacking factor (ks)
3. Windows area (aw)
4. Varnishing
5. Bobbing

2.3 RELEVANT THEORIES OF THE REVIEW

1. Current Density

This is the ratio of the conductor's current to the cross-sectional area of the conductor i.e J = Amm2. It is inversely corresponding to the area i.e it increases with the reduced area. The core area must not be very small because it will require a longer length of conductor and an increase.

2. Stacking Factor (Ks)

Is a measure used in electrical transformer design and some other electrical machines kx = 0.94?

3. Window Area (Aw)

This is the total square footage of all glass areas of a storefront.

4. Varnishing

The winding was dipped into a pool of vanish to remove dampness and also to hold the windings tightly together. Vanishing prevent overheating and vibration.

5. Bobbing

The bobbing is a thin plastic, which consists of two windings namely, the primary and the secondary windings. It is fitted into the Centre limb.

2.4 WELDING

Welding is a metal joining process in which coalescence is obtained by heat and pressure.

2.5 WELDING POWER SUPPLY

The welding power supply is a device that provides an electric current to perform welding. It can be as simple as a car battery and as sophisticated as a modern machine based on silicon controlled rectifier technology with additional logic to assist in the welding process.

2.6 POWER SUPPLY DESIGNS

The welding power supplies most commonly seen can be categorized within the following types: Transformer, Generator, and Alternator, Inverter, etc. (The transformer type shall be considered in this work because it is the least expensive among others)

2.7 BASIC PRINCIPLE OF ELECTRIC ARC WELDING

Electric arc welding is a fusion welding in which a current of low voltage and high amperage is transmitted from the welding machine to a metal electrode holder and flexible cable known as the leads.

The power supply is given to the electrode and the work.

2.8 ARC WELDING MACHINE

This is one of many fusion welding processes used to join metals. It uses an electric arc to create intense heat to melt and join metals.

2.9 SOME OF THE BASIC FEATURES OF AC ARC WELDING ARE:

1. Good forceful
2. There is an absence of arc blow
3. To create heat to melt and join metal
4. A good way to weld Aluminum
5. Is the application to produce welding on heavy gauge steel.

It consists of two coils namely, primary and secondary coils are electrically isolated from each other but are attractive through a common path of low reluctance provided by the soft iron core.

The principle of a transformer depends on the faradays law of electromagnetic induction and mutual, which provides the mutual links between the two electric circuits (primary and secondary windings) operating with no change of frequency. When a load is connected across the secondary terminals the secondary current by Lenz law produces the demagnetizing effect. Consequently, on a no-load, there is no secondary current and the secondary windings do not affect the primary current. The primary winding has a very high inductance and very low resistance.

Arc welding consists of a single-phase transformer. The welding transformer is a step-down transformer, which has an output voltage of 100 volts.

Unlike the step-up transformer, the step-down has a greater number of turns in the primary winding than the secondary winding, the secondary winding has low voltage than the voltage at the primary winding. The primary side of the transformer has low current than the secondary side of the transformer; hence the number of turns in the secondary winding is lower than the number of turns in the primary windings.

2.10 SUMMARY OF THE CHAPTER

The electric arc welding machine is based on the transformer using a.c power supply of 220v on the primary side and 40 volts on the secondary side hence it is a step-down transformer. The voltage is stepped down on the secondary side so that the current will be very high for it to weld effectively.

CHAPTER THREE

METHODOLOGY

3.1 RESEARCH DESIGN

The research design involves the independent variable and the dependent variable. The independent variable is manipulated or changed by the researcher to measure the effect of this change on the dependent variable.

The procedure used in getting for this work is searching the internet, knowledge from other work conductors in the past years, and personnel knowledge about the work. Also, a lecture was conducted by our project supervisor which help us in getting more information about the work.

3.2 POPULATION OF THE STUDY

In this project work, the source from which data was collected from the library, from the past person who carried out these same project work from textbook, internet and from my supervisor.

3.3 DESIGN SYNTHESIS

Electric Arc Welding

Involves low-voltage, high-current arcs between an electrode and the workpiece. The means of reducing power system voltage are: Transformer Method, Rectifier Method, or Motor Generator Method (Davies A. C, p.3).

Welding Transformer:- (Using Transformer Method)

The figure below shows the basic elements of a welding transformer and associated components. For a Transformer, the significant relationships between winding turn and input and output Voltages and Currents are as follows:-

N1N2=E1E2=I2I1 …………………………………….. (3.1)

Where

N1 is the number of the primary turns of the transformer

N2 is the number of the secondary turns of the transformer

E1 is the input voltage

E2 is the output voltage

I1 is the input current

I2 is the output current.

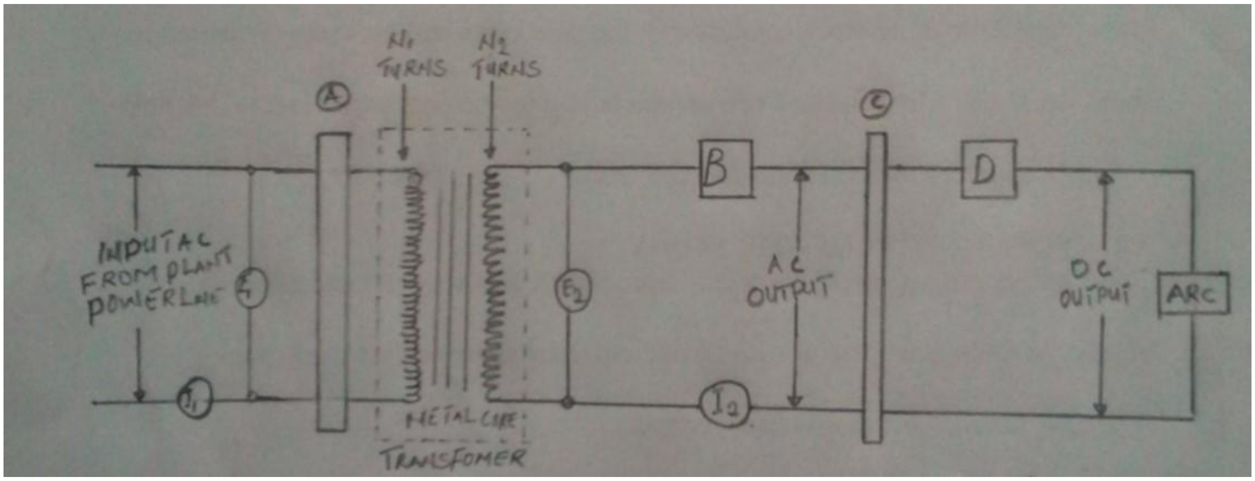


Fig. 3.1 Principal Electrical Element of a Welding Transformer Power Supply

Where:

A is the location of solid-state control parts if a primary solid-state inverter is used

B is the location of series control components if used

C is rectifier or SCR control of dc output, it is provided by the power supply

D is secondary switching solid-state device for chopper type control if used.

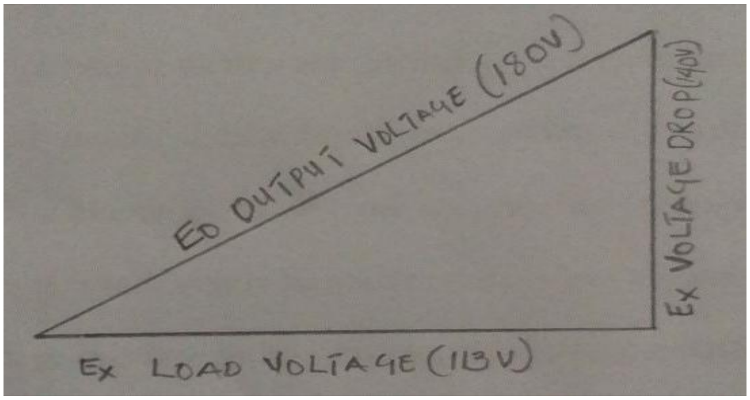


Figure 3.2 shows an ideal vector relationship of the alternating voltages for the circuit

Figure 3.4. In a resistive circuit, the voltage drop across the resistor could be added arithmetically to the load voltage to equal the output voltage of the transformer.

MATERIALS USED

When designing the machine, the basic knowledge of the principle of operation of an arc welding machine must be taken into consideration.

The part of the machine is the power transformer, which steps down the input voltage to the required output voltage. The transformer's efficiency can be improved by dipping the transformer into oil for cooling, by absorbing the heat generated in the coils as a result of the current flowing through the resistive conductors. Hence, cooling of the coil helps to prolong their life span.

The machine can be constructed using the three fundamental materials namely:

1. The magnetic substances

2. Electrical or conductor materials

3. The materials used to insulate

THE MATERIALS THAT ARE MAGNETIC

This includes ferromagnets of known and good characteristics. These materials have the important property of generating a spontaneous magnetic field, which gives room for easy varying of magnetization along the crystal axis. The materials must possess:

1 Very good Permeability

2 Losses with low hysteresis

3 Excessive resistance

4 Thermal conductivity

5 Sufficient flux density

6 Expansion coefficient

Excessive noise due to system vibration and considerable heat loss is minimized by arranging tightly with no traces of bends at the corners or centre of the lamination.

INSULATING MATERIALS

This is another welding material, and the conductor is usually sufficiently coated. An insulating material is used to separate the windings. The materials are usually made of leather. Insulation should not be overdone to avoid overheating of the transformer and low efficiency.

INSULATION

Insulation in the transformer coil is a means provided to confine the flow of electric current to a particular path. A breakdown of this insulation results in the short-circuiting of the coils. This may result in severely burnt parts of the transformer. Moreover, insulation is provided in the laminations of the purpose of this insulation is to minimize eddy current losses and further the winding coating and eliminate the presence of an air gap between the windings. The transformer core is covered in varnish, shellac, etc. by the use of the transformer core by the end-users.

WELDING ELECTRODES

These are welding rods that are melted into the base metal or work by an electric current passing through them. It can either be bare or flux-coated. The bare electrodes use direct current (dc) only. Electrodes used in welding are classified according to their operation characteristics, the types of coating qualities of the deposited metal are, welding position, coating composition, and welding arc machine.

To avoid the confusion of selecting electrodes for a specific job, the American Welding Society (AWS) has established a uniform numbering system for the classification of electrodes. American Welding Society classification numbers are stamped on the coating near the grip end of the electrodes. The classification numbers carry a prefix "E" with four or five digits rounded the following information:

Prefix "E" indicates that the electrode is for arc welding.

The first two (or three) digits of the metal's tensile strength

Third (or fourth) digit positions, e.g.

All positions

Horizontal and flat positions only

Flat positions only.

Fourth or (fifth) digit position, e.g., the type of coating and welding machine.

A typical example of a steel arc-welding electrode has the classification number E6013.

What time and where:

E is the arc welding electrode, which has a tensile strength of 60,000 pounds per square inch.

1 The first position of welding (Ac and DC-straight polarity).

2 is the welding current (Ac and DC-straight polarity).

NECESSITY FOR COOLING

Welding machines can be oil or air-cooling. Oil cooling is used for bigger machines while air-cooling is used for smaller machines.

In this project, the method of cooling adopted was air cooling. It is pertinent to note that oil-cooled is more efficient compared to air-cooled arc welding machines.

ELECTRODE HOLDER

In the entire arc welding process, some sort of device is required to transmit the welding current from the welding lead or cable. The welding current from the welding lead or cable is transmitted to the electrodes. They are of different forms and they have different names. In shielded metal arc welding, different types of electrode holders are used to grip the electrode. In carbon arc welding, two different types of electrode holders are used for gas tungsten arc welding. The device is called a welding torch. It holds the tungsten electrode and transits the current to it.

The electrode holder for shielded metal arc welding is by far the most common of these devices. It transmits an electrical current to the electrodes and is held by the welder. Electrode holders come in several designs, which include the pincher type and the collect type. For each type of electrode holder, there are three things: the current rating and duty cycle; the maximum electrode holder size accommodated; and the cable size that may be connected to the holder. All the electrode holders should be of the fully insulated type.

The maintenance of electrode holders is extremely important for efficient welding. It is desirable to select the light test weight holder with a holder with the required electrode size and the current-carrying capacity. (Kalpakjian and colleagues (2001).

There are two main types of electrode holders:

1. Type of Twist Grip

2. Type of spring

In the twist grip type, turning the handle operates a screw mechanism, developing a pressure grip on the electrode, while in the spring grip type, a coil spring is used to provide the necessary pressure required to hold the electrode.

GROUND CLAMP

The ground clamp provides the means for making both mechanically and electrically sound contacts with the work or welding table to provide a return path for the welding current. A spring pressure ground clamp is regarded as the most suitable type of general welding work.

WELDING CABLE

Welding cables are electrical conductors, they are called the electrode lead and the work lead. These leads carry the welding current from the power source to the arc at the point of welding and back to the power source. These cables, with the electrode holder and work connection, complete an electrical circuit.

The welding circuit can be the source of power waste and an economic loss. Power losses might result from the following:

1. Connection failure at the power source
2. Loss of connection at the working connector or electrode holder.
3. The use of excessively long cables causes an abnormal voltage drop.
4. Using a cable that is too small for the amperage of the duty cycle.

To determine what size of welding cable to use, three items must be considered:

1. The welding
2. The duty cycle, or operator factor
3. The total length of the welding circuit

There are three methods of determining the amount of power lost in the welding leads.

In the first method, use an accurate voltmeter to measure the voltage at the welding machine terminals and the voltage between the electrode and the work connection while welding. This measure the welding current. The difference between the voltage at the power source terminals and the electrode holder and work connection while welding. The difference between the voltages lost in the leads, then multiplied by the welding current, gives the amount of power lost in the leads. This is by the following formula:

V1 (at terminals) - V2 (at holder) x I = power loss

Alternatively, PL = (V1-V2) x................................ 3. 2

The other way to determine the power loss is to find the resistance of the welding cable and multiply this by the welding current squared.

PL=I2R.. 3. 3

The third way is by finding the voltage drop and multiplying it by the current.

PL = I x VD 3. 4

CABINET FOR POWER WELDING

The power cable is a conductor used to carry the electrical power from the disconnected or fused box of the building to the welding power source. Three-core cables are usually used for this application. The principle for determining the size of power conductor cables is the input power required by the welding machine.

The factor to be considered is whether the machine operates on single-phase or three-phase power.

The power cable is rated at a higher voltage than the welding cable since the input power to the machine can be 480 volts or higher. The sign of the machine will provide the amperage at the rated load and input voltage of the machine.

ELECTRODE DEFECTS

A common complaint about the quality of electrodes is finger nailing, is called the burning off of an electrode faster on one side than the other. Other factors that might cause finger nailing (1994) Lincoln Electric.

Finger nailing is the most common when using direct current and is more evident with the smaller electrodes (1/8 in (32mm) and 5/32 in (4mm) when used at low current.

The electrode can be damaged by ageing. Outdated electrodes of most types will have a furry surface on the coating. Usually, this is from the crystallization of sodium silicate.

3.5 INSTRUMENTATION/MATERIALS

To ensure the reliability of the instrument, we ensure that all instruments and materials used are legally or officially acceptable and are in workable condition, especially the voltmeter and amp meter that was used to test the output of the project work. By using a reliable instrument and material that is valid, our project work was done successfully.

CHAPTER FOUR

DATA ANALYSIS, INTERPRETATION AND DISCUSS

4.1 DATA ANALYSIS

The different parts of this work 5KVA arc welding machine comprise majorly of the transformer.

4.2 INTERPRETATION

TRANSFORMER

A transformer-style welding power supply converts the high voltage and low current from the utility mains into a low voltage and high current (I). The transformer may also have significant leakage inductance for short circuit protection in the event of a welding rod becoming stuck to the workpiece.

1.	Type of coil winding	-	shell type
2.	Machine rating	-	5kva
3.	Phase	-	single phase
4.	Cooling method	-	free (natural) air
5.	Primary (input) voltage (v1)	-	220v
6.	Secondary (output) voltage (v2)	-	40v

7.	Primary (input) current (i1)	-	24a
8.	Secondary (output) current (i2)	-	125a
9.	Frequency	-	50Hz
10.	Current density (j)	-	3.0a/mm2
11.	Window space factor (kw)	-	0.4
12.	Stacking factor (Ks)	-	0.9
13.	Assumed efficiency	-	95%
14.	Thickness of lamination sheet	-	0.5mm
15.	Net iron area	-	0.45d2m2
16.	Angular frequency (ω)	-	-4.4f or □√2 f2
17.	Flux density (bm)	-	1.8 tesla or 1.8 wb/m
18.	Magnetic strength (h)	-	1000a/m
19.	Power factor (p.f)	-	unity or 1

THE DESIGN CALCULATION

Input power = Output power /Efficiency ………………………. 4. 2.1

= 5KVA/0.95 = 5.263 x 10^3

Input current (I1) = 5.263 x10^3 / 220V = 24A

Cross Sectional Area of the Coil

To calculate for the cross sectional area of the coil (Ai), we know that

Turns/volt = 1/0.894 √5=0.5 turns/volt

In general

ET = 4.44Bm Ai f ……………………………………… 4.2.2

Where Ai = cross sectional area of the coil

BM = flux density in wb/m2 = 1.8wb/m2

F= Frequency = 50Hz E

Et = turns per volt = 0.5T/v

Thus Et = 4.44Bm Ai f

0.5 = 4.44 x1.8x50xAi

Ai = Ai 0.5 = 1.25 x 10-3 m2or 125mm2

4.44 x1.8x50

However, the cross-sectional of the coil is assumed to be circular i.e.

Ai = πr2/ 2= πd2/4 = πd2 .... 4.2.3

Ai = πd2=125 2

πd2=4x125

d2 = 4x125= 500 =159.134

π 3.142

d= √159.134

d= 12.61mm

CROSS-SECTIONAL AREA OF THE COIL IN THE PRIMARY

Ai = Ii …………………………………….. 4.2.5

J

Where Ii = primary current = 24A

j = Current density = 3.0A/mm2

Ai = 24A = 8mm2

3.0Amm2

FOR CIRCULAR CONDUCTORS

Diameter (di) for the coil in the primary winding is given as:

di = √a = √8 = 2.8mm

Now from I.EE regulations gauge 12 or 13 of copper conductors falls within this limit and can be used for the primary winding.

Also, cross sectional area of the coil in the secondary (a2) is assumed to be circular

i.e A2 = I2

J ………………………….. 4.2.6

Where I2 = secondary (output) current = 125A

J = Current density = 3.0A/mm2

A2 = 24A = 41.66mm2

3.0A/mm2

Then assuming circular conductor, the diameter, (d2) for the coil in the secondary winding is given as

D2 = √a2 = √41.66 = 6.5mm

Now from the I.EE regulation gauge 10 and above could be used for the secondary winding with an empirical formula of increasing the number of turns if the right gauge is not available.

THE NUMBER TURNS IN THE PRIMARY AND SECONDARY WINDING

The number of turns in the primary winding

n= V1Et ……………………………….4.2.7

Where Vi = primary (input) voltage 240v

Et = turns/v = 0.5T/v

Ti = 220 x 0.5 = 110 turns

Also: the secondary number of turns

n2 = V2Et ………………………..4.2.8

Where:

The secondary (output) voltage = 40V

Et = turns/ voltage 0.5

n2 =40x0.5 = 20turns.

THE CORE AREA DESIGN CALCULATION.

The core area is of square cross-sectional the gross area

Ag = 0.89d2 (from derived calculation)

But, cross-sectional area of the coil, Ai is given as:

Ai=0.9 x Ag …………………………………… 4.2.9

Where; stacking factor = 0.9

Ai = cross-sectional area of the coil

= 125mm2 = 12.5cm2

Ag = Gross area 0.894d2

12.5 = 0.9 x 0.894d2

12.5 = 0.80d2

d2=12.5 =15.63

0.80

d= √115.63 =3.95cem = 4cm

Thus, width of lamination = 0.71d (from derived calculation)

Width of lamination (W or L) = 0.71 x 4=2.84cm

Thus, to calculate the number of lamination, the thickness of the lamination sheet is 0.5mm. Then the number of lamination sheets required will be given as the number of the lamination sheet.

=Width of the lamination sheet

The thickness of lamination sheet ……………………………….. 4.2.10

Where: Width of lamination sheet = 57mm

Thickness of lamination sheet = 0.5mm

Thus,

Number of lamination sheet=57mm = 114 0.5m

Sheet or more;

However, to calculate for the window area (Aw), we have that

S = 2.22 fBmAijAῳk ῳx 10-3 KVA 4.2.11

Where;

S = input power =5.26KVA

F = Frequency = 50Hz

Bm = flux density = 1.8wb/m2

Ai = cross-sectional area of the coil = 125mm2

J =current density = 3.0A/mm

Aw = window area?

Kw = window space factor = 0.4

5.26KVA = 2.22x 50x1.8 x10-6 x 125x Aw x3x0.4 x 10-6KVA

Aw = 2.22 x 30 x 1.8x19" X125 x3x0.4x10-3/5.26

Aw = 4869.9 2 mm2= 48.70cm2

Since, the Window area (AW) is of square c TOSS

Sectional area:

L2 = Aῳ = 48.70cm2

L =√48.70 =6.97cm2ht gauge is not available.

Checking For Balancing Between Primary and Secondary Winding Copper in window area = a1Ti +a2 T2

Where

a1= cross sectional area of the coil in the primary

a2 = Cross sectional area of the coil in the secondary

T1= Primary number of turns

T2 = Secondary number of turns

And a1 = 8mm2

a2 = 41.66mm2

T1 =120T

T2 = 20T

Copper in window area = (7x110)+(41.66 x20)

Copper in window = 1713.2 mm2

Thus, window space factor (Kω̨)=

Copper in window area/Area of the window (Aω̨)

Where copper in window area = 1713.2mm2

Area of the window (Aῳ)= 4870mm2

Thus, window space factor (kῳ) = 1713.2mm2/4870mm2 = 0.35 = 0.4

Hence, the window space factor (KW) = 0.4 which corresponds with the assumed Kῳ given in the design parameters.

THE CONSTRUCTION OF A TRANSFORMER

The basic transformer feature is defined and differentiated by how the primary and secondary coils are wound on the laminated core.

There are two types of transformers:

1. The shell type

2. The core type

THE SHELL TYPE

The shell type is usually made from the "E" and "I" laminations, which are attached to form a core of three limbs, as shown in fig 3.5. This kind of windings is placed on the centre limb. The useful magnetic flux is contained within the closed region between the two coils. The shell-type construction can handle heavy currents and is mainly used in situations where we have low voltage windings, especially at the output. The shell type is therefore considered suitable for this project.

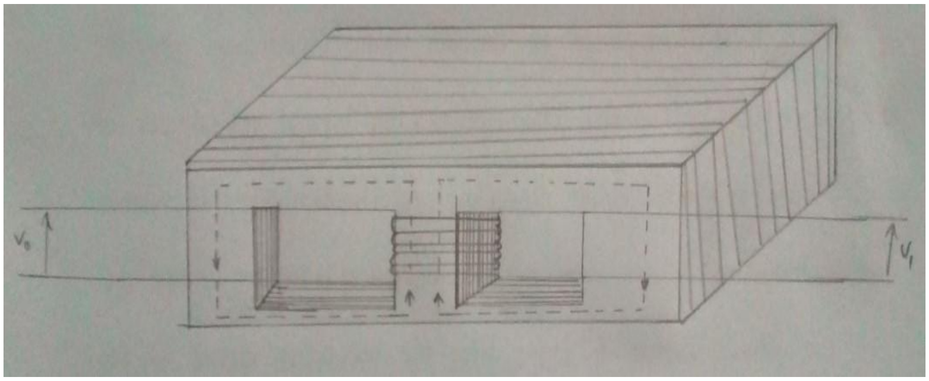


Fig. 4.1 Shell Type Transformer

THE CORE TYPE

The core type is made of a rectangular or square core with two limbs using the "U" and "I" laminations as shown in fig. 4.1. The primary and secondary coil is shared equally on each of the limbs. Accordingly, the useful magnetic flux links the two limbs. However, this type of winding is commonly used when a high voltage is required at the output terminals.

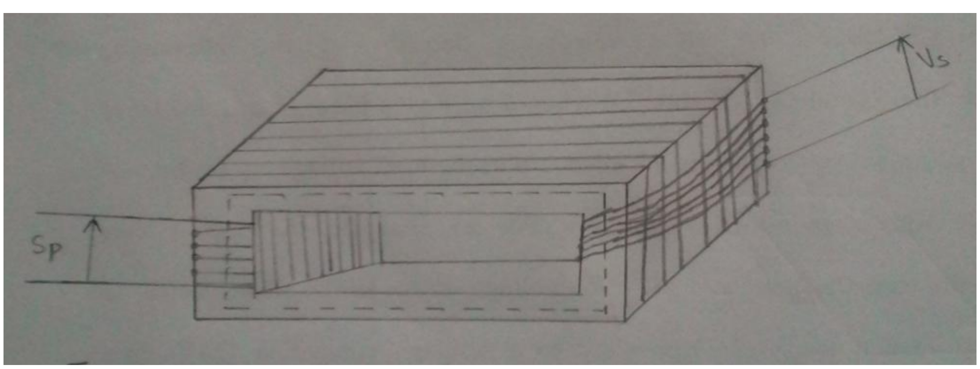


Fig. 4.2: Core Type Transformer

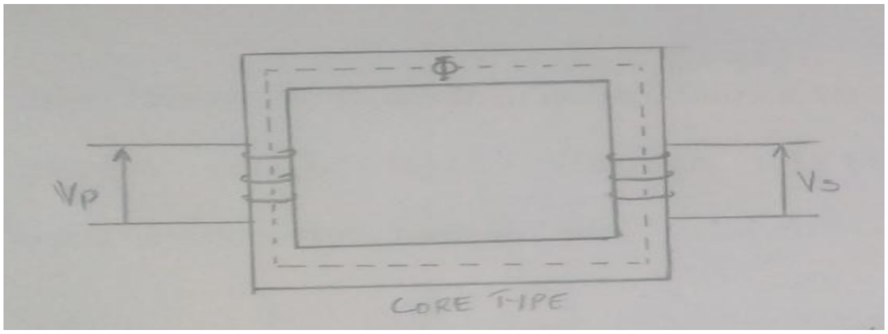


Fig. 4.2a: Circuit Diagram of the Core-Type Transformer

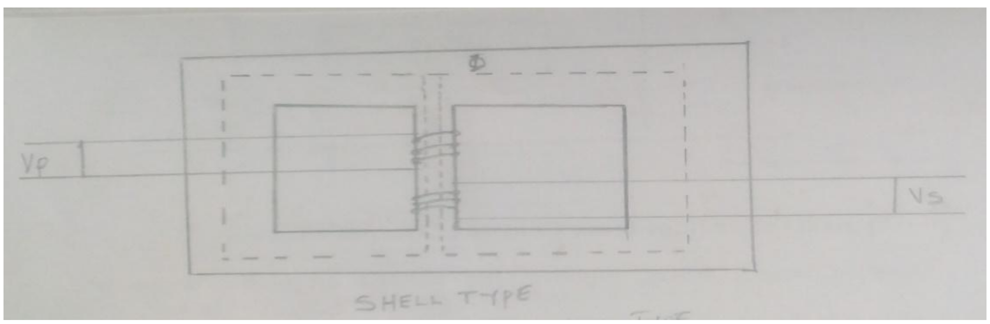


Fig. 4.2a: Circuit Diagram of the Shell-type Transformer

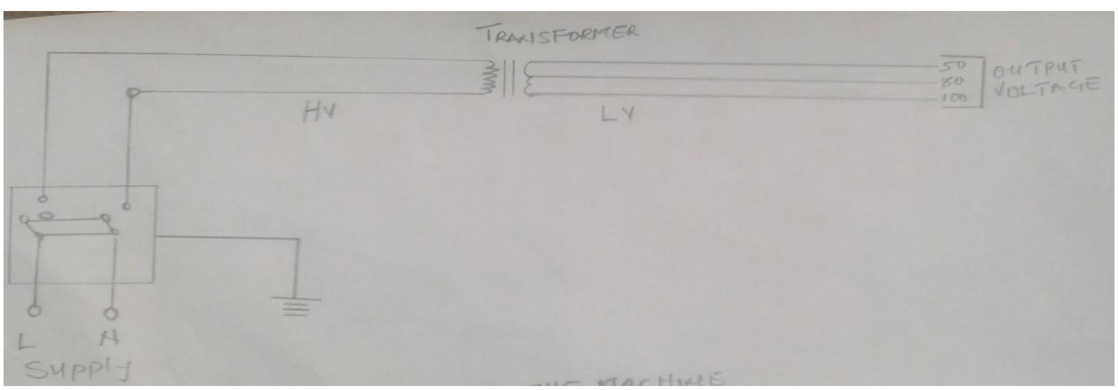


Fig. 4.3: Circuit Diagram of the Machine

Construction of parts

The construction is divided into two main parts.

(1) Magnetic component

(2) Electric component

Magnetic Part

This comprises mainly the laminated sheets. The calculated sheets were dipped into a silicon resin varnish and allowed to dry before the arrangement. However, they were properly cleaned to be dust and iron-filing free. The Vanish provides electrical insulation and also prevents the sheets from rusting. The laminated sheets are of the shape which was arranged accordingly to form a core of three limbs, as shown in fig. 4.4.

The laminations were held together by side plates bolted together at intervals along the yokes and limbs. These bolts, which necessarily pass through the cores, should be insulated from the side plates and the laminations, while the plates are insulated from the laminations. This insulation becomes necessary as, otherwise, the bolts would short circuit the lamination paths for eddy currents.

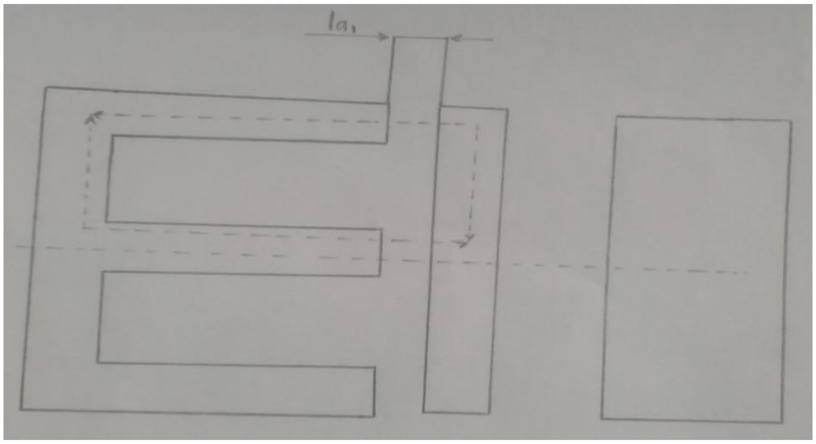


Fig. 4.4 Transformer Laminations

Part electrical

For this project, cylindrical or spiral winding was selected. In this type of winding, the limbs of the core were first insulated with leather rods. The secondary which is the low voltage winding was first placed on the core and wound spirally with the coils close to each other without spacing and the start lead at the top.

After winding the secondary coils, a layer of the leather rod was wrapped around them to provide insulation between both windings.

The primary high voltage windings were therefore placed on top and wound in the same manner as the secondary windings. This type of arrangement is advantageous since the potential difference between the low voltage winding and the core (which is at earth potential) is small, hence the likelihood of a fault occurring between the two were insignificant.

Insulation

Insulation in the transformer coil is a means provided to confine the flow of electric current to a particular path. The breakdown of insulation results in short-circuiting of the coils. This may result in severely burnt parts of the transformer. Moreover, insulation is provided in the laminations of the transformer core by the use of varnish, shellac, etc. As mentioned, the purpose of this insulation is to minimize eddy current losses. In addition, insulation is required to further the winding coating and to eliminate the presence of an air gap between the windings.

4.3 TRANSFORMER ENCAPSULATION/HOUSING

Once a transformer is constructed, it must be provided with a case, which renders the welding set more portable and prevents shock to the workman.

It is usually in the form of a metal box, and the size of the case depends on the size of the transformer and the desired cooling system.

Since this transformer is designed for an oil cooling system the casing needs not be perforated for ventilation as shown in the figure below;

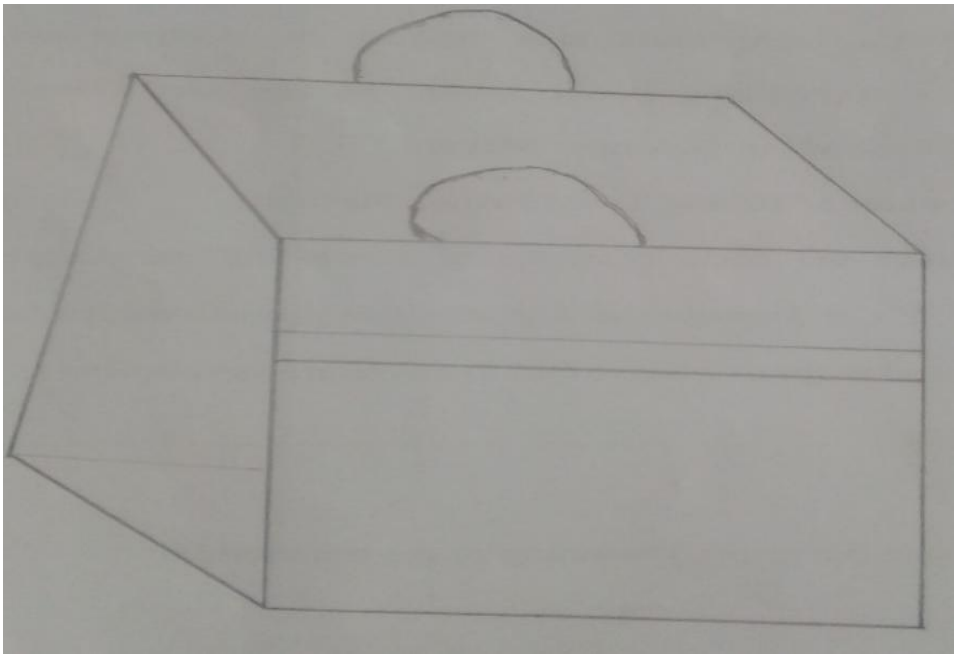


Figure 4.5 Casing / Encapsulation

4.4 WELDING DANGERS, PRECAUTIONS, SAFETY, AND UPKEEP

The most common hazards, which apply to all metalwork, are accidents resulting from being hit by moving machinery, exposure to hot metal, etc. The hazards, which are more or less peculiar to welding, are as follows:

1. Electrical jolt

2. Arc Beam Radiation

3. Explosion and fire

4. Air Contamination

Gases that are compressed

6. Cleaning and chipping welds, as well as other risks

Electrical Shock

The shock hazard is associated with all electrical equipment. This includes extension lights, electric hand tools, and all types of electrical-powered machines. The household (220V) is higher than the output voltage of a conventional arc-welding machine.

It is strongly advisable to use only welding machines that meet recognized national standards to avoid an unnecessary hazard. The highest industrial welding machines meet the National Electrical Manufacturers Association standards for electrical welding apparatus. This is mentioned in the manufacturer's manual and is shown on the nameplate of the welding machine. The NEMA specifications provide classes of welding machines, duty cycle requirements, and no-load voltage maximum requirements.

Manufacturers have recently made changes to improve machine safety in order to comply with the requirements of the Occupational Safety and Health Act (OSHA). This also involves the covering of the output terminals with insulating devices.

They also reduced the size of the ventilating holes so that the welder would not come into contact with the high voltage inside the case.

The National Electrical Code and all local codes require that all-electric arc welding machines be installed. Installation instructors are included in the manufacturer's manual that accompanies the welding machine. The manual also specifies the size of the power cable that should be used to connect the machine to the mainline.

In a transformer-type machine, the primary and secondary transformer windings are electrically isolated from each other by insulation.

The metal cases and frames of transformer machines must be grounded.

Discount switches should be employed with all power sources so that they can be disconnected from the mains for maintenance.

So too, electrodes, leads, and work leads should not be coiled around. The welding machine should be on standby should they ever coil the welder. Electrodes need to be removed from the holders whenever they are not in use.

The welding machine must be kept dry, and competent electrical maintenance personnel should properly dry it if it should become wet.

Arc Radiation

The brightness and exact spectrum of a welding arc depend on the welding process and the metals in the arc. The atmosphere of the arc, the length of the arc, and the welding current the higher the current and arc voltage, the more intense the light from the arc.

The electric arc is a very powerful source of light in the visible, ultraviolet, and infrared. Welders and others close to the welding arc must wear suitable protection from the arc radiation.

Fire and Explosions

Approximately 6% of the fires in industrial plants have been caused by cutting and welding, primarily with portable equipment, in an area not specifically designated or approved for such work.

All welding operations involve the three elements of the fire triangle: fuel, heat, and oxygen. The least is from the torch flame, the arc or hot base metal. Cutting and welding fires can be prevented by removing all combustibles from the welding area. Oxyfuel gas flames rarely cause fires when used in the normal workshop area. Fires and explosions have also been caused when this heat is transmitted through the walls of containers to the flammable atmosphere.

WELDING PROTECTION

1. **Eye Protection**

Welding must use protective welding helmets with special filter plates or filter glasses. Glasses should be in good repair since opening or crack can allow are light to get through and create discomfort.

2. Skin Protection

Welding should wear work or shop clothes without opening or gaps to prevent the arc rays from contacting the skin. If the rays contact the skin for some time painful "sunburns" or "arc burns" can result. People working close to the arc welding machines should also wear protective clothing.

COMMON FAULT AND POSSIBLE CAUSES IN ARC WELDING

S/N	DEFECTS	S/N	CAUSES
1.	poor Appearance	1.	Current too high Low
		2	Erratic manipulation of electrodes
		3	Faulty
2	porosity	1	Travelling too fast
		2	Arc too Long
		3	Current too Low
		4	Impurities in base metal
		5	Unpurified or damp electrodes.
3	Cracking	1	Wrong type of electrodes
		2	Rigid point
		3	Bead too Con cave
		4	Deposit cooling too fast
4	Excessive spatter	1	Current too high
		2	Arc too high
		3	Faulty or damp electrodes
5	Brittle Welds	1	Unsuitable electrodes
		2	Deposit is hardening
		3	Excessive base metal pick up
6	Slag difficult to remove	1	Current too high
		2	Electrode damp
7.	Difficult striking	1	End of electrode covered with slag
		2	Voltage / Amperage too Low
		3	Electrode Damp
8	Excessive Distortion	1	Welding Sequence incorrect

Precautions that should be taken in arc welding

1. Goggles and Head shield should give proper eye protection

2. It should have ample ventilation

3. Fit comfortably shades of coloured lenses are preferable.

4. Oxygen must not be used to supply air

5. Only air blowers or compressed air are safe.

6. Welding inside tank or drum is to be highly dangerous unless adequate precautions are taken

4.6 INSTRUMENTS USED IN THE TEST

The various test above were carried out with the aid of the following instrument below:

1. Multi-meter (Avo-meter)
2. Voltmeter
3. Current tester
4. Testing lamp

4.7 OBSERVATION

Iron loss: these are of two type

Losses due to eddy current, eddy current are alternating current which is induced into the metal core of the transformer by the alternating flux in the core.

(a) Hysteresis losses: these are due to the supply used in the core during the changing cycle of magnetism. A certain amount of magnetism remains after the current collapse. This holds on to the magnetism which must be neutralized and the energy used to neutralize it represents a loss.

(b) Losses: this loss is a heat loss, due to the excess current flowing through the copper of the winding. Its termed.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY OF RESULT

Summary, this project (electrical arc welding machine 5KVA, 220V single phase) is a unique machine for welding (jointing) metals together. This machine is a major transformer with a primary voltage of 220V and a secondary voltage of 40V. The voltage in the secondary was set to 40V so that the current will be high enough to be able to weld and join metals together. The primary current is 24V and the secondary current is 124V.

The earth cable and the electrode holder were connected to the output terminals of the transformer. The electrode was fixed to the electrode holder and the earth cable was fixed to the workpiece (metal) immediately there is a contact between the electrode and the workpiece (metal) there will be arcing as such there will be an increase in current.

The project work was tested and it worked fine and is reliable for industrial and domestic use.

5.2 PROBLEMS ENCOUNTERED

A Series of the problem were encountered in the course of this project such as lack/ insufficient base capital as the department provided.

5.3 POSSIBLE IMPROVEMENT

1. Functional machines should be used to ease the production process

2. The air gap should be reduced to the minimum by bolting the lamination firmly and applying varnish to the lamination.

3. To avoid insulation breakdown appropriate insulation separation of the primary and secondary coils should be done and possible, paper insulated conductors should be avoided.

4. To cut down the cost of production, materials that are cheaper and operational should be used e.g. the copper used in the transformer can be replaced with aluminium.

5. Government should be involved in research and development which can help to boost technological advancement in the academic sector.

5.4 CONCLUSION

This project write-up is based on the subject of arc welding machines, we believe that it will be useful for students of Higher Institutions or any interested person when embarking on such a project since it is prepared in simple terms which the reader can just go through and will build on.

5.5 RECOMMENDATIONS

We wish to recommend that though students do acquire technical knowledge from the project carried out, it would have been much better if such goals are fully realized. The availability of materials needed for a particular project should be given adequate consideration before assigning it to any student. Students can appreciate challenging projects, but cannot have enough capital to finance such projects.

Table 5.1 Bill of Engineering Measurements and Evaluations

Description/ Component	Material	Size	Quality	Unit cost	Total
Primary Coil (2.8mm)	Copper	Gauge 8	7kg	—	₦30,500
Secondary Coil (5.4mm)	Copper	7×2	9kg	—	₦35,000
Lamination Sheet	Silicon steel	—	4	₦3,500	₦14,000
Cutting of E-Shape	—	—	—	—	₦5,000
Vanish	Liquid	—	4 Cups	₦400	₦1,600
Electrode holder	—	—	1	—	₦2500
Bolts and Nuts	—	—	4	₦50	₦200
Metal casing	—	—	1	—	₦10,000
Welding Electrode/cable	—	—	4	₦400	₦1,600
masking tape	Textile	Large	1	₦300	₦300
Flat bar/angel bar	—	—	—	—	₦1,250
Other Accessories	—	—	—	—	₦2,500
miscellaneous/Trans	—	—	—	—	₦5,000
Cloth/Tailor	—	—	8	₦150	₦2,700
Total	—	—	—	—	₦112,150

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