DESIGN AND CONSTRUCTION OF ELECTRIC ARC WELDING MACHINE WITH OVER TEMPERATURE PROTECTION AND WELDING VOLTAGE DISPLAY

BY

AGBOUFA EBI ZUOKEMEPADE

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE (B. ENG) IN ELECTRICAL AND COMPUTER ENGINEERING IN THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE.

NOVEMBER, 2010

DEDICATION

This project is dedicated to God Almighty and my dearly beloved father.

DECLARATION

I, AGBOUFA EBI ZUOKEMEPADE, Matriculation number 2005/21995EE an undergraduate student of Department of Electrical and Computer Engineering, certify that the work embodied in this project is original and has not been submitted in any part or full to any other university.

AGBOUFA EBI ZUOKEMEPADE

08/02/2011
....
SIGNATURE AND DATE

CERTIFICATION

This project has been read and approved as meeting requirement for the award of B.Eng. in Electrical and Computer Engineering in the Department of Electrical and Computer Engineering, Federal University of Technology Minna, Niger State.

Dr. Jacob Tsado ……………………………

SUPERVISOR SIGNATURE AND DATE

Engr. A.G. Raji ……………………………

HEAD OF DEPARTMENT SIGNATURE AND DATE

……………………………

EXTERNAL SUPERVISOR SIGNATURE AND DATE

ACKNOWLEDGEMENT

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ABSTRACT

This project present the design and construction of electric arc welding machine with over temperature protection and welding voltage display unit. This was achieved through the design and construction of a step down transformer with high current capacity at the output, which supplies the welding current. An automatic over temperature shut down was incorporated to protect the welding transformer from being damaged due to overheating. The welding machine when tested worked reliably, the welding voltage was displayed when the welding process was carried out.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

1.0 INTRODUCTION

A welding machine is an electromechanical device that is useful for joining two or more metals together. It is obvious that quite a wide range of equipments today were made possible with the aid of the welding machine and these equipments beautify and make life very easy for us. This machine can be seen in places where metal work is carried out such as the fabrication and construction of metallic tanks, metallic doors, bicycles, kiosk, space crafts e.t.c, a wide variety of welding machines have been designed and constructed over the years and because of the usefulness of this machine in our everyday lives, its economic importance cannot be over-emphasized.

The welding machine is basically a step down transformer with a very high current at it secondary which is capable of generating heat sufficient enough to melt an electrode, used to join two or more metals together. This welding machine features a switch or a regulator in other to vary the input voltage to different values, to obtain varying output voltages suitable for different welding applications.

In other for the welder to be sure of the actual voltage that is been used, the welding machine also features a voltmeter to display the voltage used for any given welding application. The power outlet on the machine is to provide lighting to aid welding process at night and for charging of phones or other suitable applications.

The welding machines are usually classified as constant current [CC] or constant voltage [CV]. A constant current welding machine varies its output voltage to maintain a steady current, while a constant voltage welding machine will fluctuate its output current to maintain a set voltage. Examples of welding applications that uses this different types of welding machine are given below.

SHIELDED METAL ARC WELDING will use a constant current source while GAS METAL ARC WELDING and FLUX-CORED ARC WELDING typically use constant voltage sources. [1]

The nature of the constant voltage welding machine is required by Gas metal arc welding and flux-cored arc welding because the welder is not able to control the arc length manually. If a welder attempts to use a constant voltage welding machine to weld with shielded metal arc welding the small fluctuations in the arc distance would cause wide fluctuations in the machine's output.

The nature of the constant current welding machine is required by shielded metal arc welding because the welder can count on a fixed number of amperes reaching the materials to be welded regardless of the arc distance but too much distance will cause poor welding. [2]

1.1 ALL WELDING PROCESSES ARE CATEGORIZED AS VIZ:

1. **Fusion Welding:** This involves melting of the parent metal. Examples are:

a. Gas welding and thermit welding which utilize chemical energy for melting purpose

b. Carbon arc welding, metal arc welding, electro slag welding and electro gas welding which utilize electric energy.

2. **Non-fusion Welding:** This does not involve melting of the parent metal. Examples are

   a. Resistance welding which use electrical energy

   b. Forge welding and gas non fusion welding which use chemical energy

   c. Explosive welding, friction and ultrasonic welding etc which use mechanical energy[1]

The selection of a welding process depends on the

i. Cost involved

ii. Kind of metals to be joined

iii. Production technique adopted

iv. Nature of products to be fabricated [3]

1.2 AIMS AND OBJECTIVES

The aim of the project is to design and construct an electric arc welding machine with over-temperature protection and welding voltage display unit

1.3 METHODOLOGY

In the electric arc welding machine, there is a welding transformer, a thermostat, an electrode and oil which serves as the coolant. Most recent ones also features over temperature shutdown and lighting system to aid welding at night etc.

In this project the method of construction was that of constructing a welding transformer and controlling its operation automatically with a thermostat. The welding machine also incorporates a welding voltage display unit for displaying the welding voltages at various welding applications and an extension for lighting and other applications, like charging of phones etc.

The transformer due to its operation, generates a lot of heat and the need arises for cooling the transformer, so in order to cool the transformer, it is immersed in oil which serves as the coolant. The method of welding is that of positioning an electrode between one terminal of the welding transformer and the other terminal (earth) is placed on the work piece. Current passes through the electrode, causing it to heat, melt and deposit on the work piece. This is done with absolute concentration and precautions.

CHAPTER TWO

2.0 TRANSFORMER

A transformer is an electrical device which transfers electrical energy from one circuit to another through inductively coupled conductors which make-up the transformer's coils. A varying current in the primary winding creates a varying magnetic flux in the transformer's core, and thus a varying magnetic field through the secondary winding. This varying magnetic field induces a varying electromotive force (EMF) or "voltage" in the secondary winding. This effect is called mutual induction. [5]

If a load is connected to the secondary, an electric current will flow in the secondary winding and electrical energy will be transferred from the primary circuit through the transformer to the load. In an ideal transformer, the induced voltage in the secondary winding (Vs) is in proportion to the primary voltage (Vp), and is given by the ratio of the number of turns in the secondary (Ns) to the number of turns in the primary (N_p) of the transformer.

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \quad \text{.....................} \quad (2.1)$$

By appropriate selection of the ratio of turns, it allows a transformer with center-tapped alternating voltage to be "stepped up" by making N_S greater than N_p, or "stepped down" by making Ns less than N_p.

In the vast majority of transformers, the windings are coils wound around a ferromagnetic core, air-core transformers being a notable exception. Transformers range in sizes, from a thumbnail-sized coupling transformer hidden inside a stage microphone to huge units weighing hundreds of tons used to interconnect portions of power grids. All operate with the same basic principles, although the range of designs is wide. While new technologies have eliminated the need for transformers in some electronic circuits, transformers are still found in nearly all electronic devices designed for household ("mains") voltage. Transformers are essential for high voltage power transmission, which makes long distance transmission economically practical. [4]

2.1 DISCOVERY

The phenomenon of electromagnetic induction was discovered independently by Michael Faraday and Joseph Henry in 1831. However, Faraday was the first to publish the results of his experiments and thus receive credit for the discovery. The relationship between electromotive force (EMF) or "voltage" and magnetic flux was formalized in an equation now referred to as "Faraday's law of induction": [6]

$$|\varepsilon| = \left|\frac{d\Phi_B}{dt}\right| \quad \text{.......................... (2.2)}$$

Where is the magnitude of the EMF in volts and Φ_B is the magnetic flux through the circuit in (webers). Where $|\varepsilon|$ is the magnitude of the EMF in volts and Φ_B is the magnetic flux through the circuit in (webers) Faraday's experiments included winding a pair of coils around an iron ring, thus creating the first toroidal closed-core transformer.

Induction Coils

The first type of transformer to see wide use was the induction coil, invented by Rev. Nicholas Callan of Maynooth College, Ireland in 1836. He was one of the first researchers to realize that the more turn the secondary winding has in relation to the primary winding, the larger is the increase in EMF. Induction coils evolved from scientists' and inventors; Faraday's experiment with induction to get higher voltages from batteries. Since batteries produces direct current (DC) rather than alternating current (AC).Induction coils relied on electrical contact that regularly interrupt the current in the primary to create the flux changes in the secondary [7].

2.2 BASIC PRINCIPLE

The transformers is based on two principles; firstly, that an electric current can produce a magnetic field (electromagnetism), and, secondly that a changing magnetic field within a coil of wire induces a voltage across the ends the coil (electromagnetic induction). Changing the current in the primary coil changes the magnetic flux that is developed. The changing magnetic flux induces a voltage in the secondary coil.

An ideal transformer is shown in the adjacent figure. Current passing through the primary coil creates a magnetic field. The primary and secondary coils are wrapped around a core of very high magnetic permeability, such as iron, so that most of the magnetic flux passes through both the primary and secondary coils.

Induction Law

The voltage induced across the secondary coil may be calculated from Faraday's law of induction, which states that:

$$V_s = N_S \frac{d\Phi}{dt}, \quad \text{.................... (2.3)}$$

where V_s is the instantaneous voltage,

N_s is the number of turns in the secondary coil and

Φ is the magnetic flux through one turn of the coil. If the turns of the coil are oriented perpendicular to the magnetic field lines, the flux is the product of the magnetic flux density B and the area A through deal transformer which it cuts.[8] The area is constant, being equal to the cross-sectional area of the transformer core, whereas the magnetic field varies with time according to the excitation of the primary. Since the same magnetic flux passes through both the primary and secondary coils in an ideal transformer, the instantaneous voltage across the primary winding equals

$$V_P = N_P \frac{d\Phi}{dt} \quad \text{................... (2.4)}$$

Taking the ratio of the two equations for V_s and V_p gives the basic equation for stepping up or stepping down voltage.

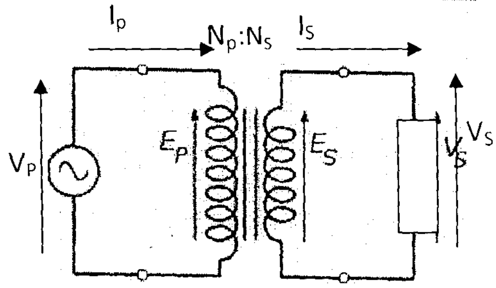
Ideal Power Equation

If the secondary coil is attached to a load that allows current to flow, electrical power is transmitted from the primary circuit to the secondary circuit. Ideally, the transformer is perfectly efficient; all the incoming energy is transformed from the primary circuit to the field and into the secondary circuit. If this condition is met, the incoming electric power must equal the outgoing power:

$$P_{incoming} = I_P V_P = P_{outgoing} = I_S V_S, \quad \text{........................ (2.5)}$$

Giving the ideal transformer equation

$$\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S} \quad \text{.............................. (2.6)}$$



$$\frac{V_P}{V_S} = \frac{I_S}{I_P} = \frac{N_P}{N_S}$$

Figure 2.1 The ideal transformer as a circuit element

Transformers normally have high efficiency, so this formula is a reasonable approximation. If the voltage is increased. Then the current is decreased by the same factor. The impedance in one circuit is transformed by the square of the turns For example, if impedance Z_s is attached across the terminals of the secondary it appears to the primary circuit to have an impedance of. This relationship is reciprocal, so that the impedance Z_p primary circuit appears to the secondary to be. [9]

2.3 Detailed Operation

The simplified description above neglects several practical factors, in particular the primary current required to establish a magnetic field in the core, and the contribution to the field due to current in the secondary circuit. Models of an ideal transformer typically assume a core of negligible reluctance with two windings of zero a voltage is applied to the primary winding, a small current flows, driving flux around the magnetic circuit of the core the current required to create the flux is termed the magnetizing current; since the ideal core has been assumed to have near-zero reluctance, the magnetizing current is negligible, although still required to create the magnetic field.

The changing magnetic field induces an electromotive force (EMF) across each Since the ideal windings have no impedance, they have no associated voltage drop, and so the voltages V_p and V_s measured at the terminals of the &former, are equal to the corresponding EMFs. The primary EMF, acting as it does in opposition to the primary voltage, is sometimes termed the "back EMF" This is due to Lenz's law which states that the induction of EMF would always be such that it will oppose development of any such change in magnetic field.

2.4 Practical Considerations

The ideal transformer model assumes that all flux generated by the primary winding links all the turns of every winding, including itself. In practice, some flux traverses paths that take it outside the windings. Such flux is termed leakage flux, and results in leakage inductance in series with the mutually coupled transformer windings. Leakage results in energy being alternately stored in and discharged from the magnetic fields with each cycle of the power supply. It is not directly a power loss (see "Stray losses" below), but results in inferior voltage regulation, causing the secondary voltage to fail to be directly proportional to the primary, particularly under heavy load.[10] Transformers are therefore normally designed to have very low leakage inductance.

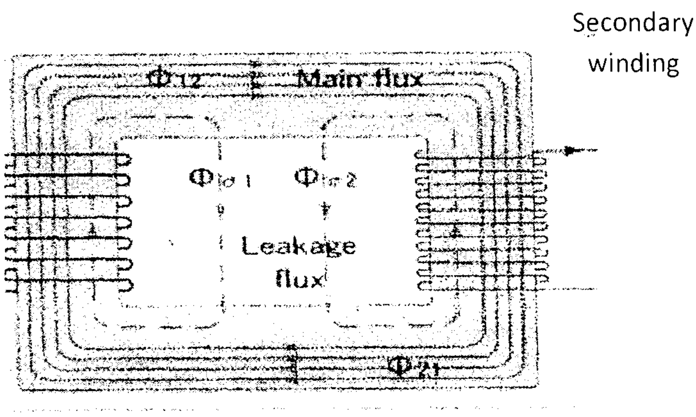


Figure 2.2 Leakage flux of a transformer

However, in some applications, leakage can be a desirable property, as shunts may be deliberately introduced to a transformer's design to limit the short-circuit current it will supply Leaky transformers may be used to supply loads that exhibit negative such as electric arcs, mercury vapor lamps, and neon signs; or for safely handling loads that become periodically short-circuited such as electric arc welders.

Air gaps are also used to keep a transformer from saturating, especially audio-frequency transformers in circuits that have a direct current flowing through the windings. Leakage inductance is also helpful when transformers are operated in parallel. It can be shown that if the "per-unit" inductance of two transformers is the same (a typical value is 5 %), they will automatically split power "correctly". [11]

2.5 THERMOSTAT

This is an automatic device that regulates temperature in an enclosed area by controlling heating or refrigerating systems.

The thermostat often uses a bimetallic strip, which is made of two thin metallic pieces of different composition that are bonded together.

Its operating principle is based on the fact that one of its components expands or contracts significantly during a temperature change. This expansion or contraction actuates a control on a furnace, cooling system, or piece of machine [13].

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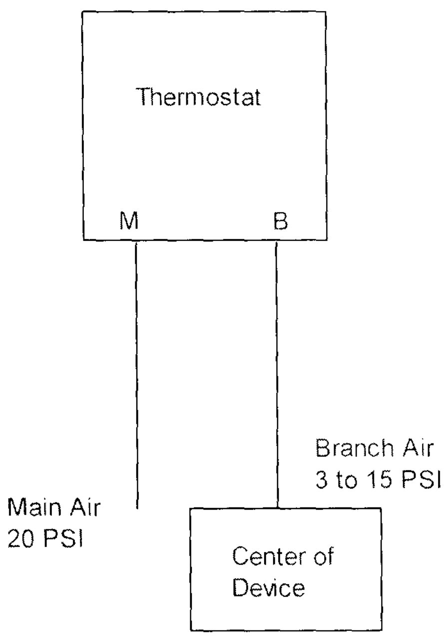

Figure 2.3: A Thermostat

Thermostat is important in ensuring that the heating system installed in your house works optimally. This gadget can set to turn your heat on or off, and to what temperature the heat will rise or fall. When used responsibly a thermostat can be your partner in managing your power bills. When shopping for a thermostat of any design it is advisable to select one with an energy star symbol [14].

2.6 TYPES THERMOSTAT

1. Line-voltage thermostats

These thermostats are used in single heating systems including radiant systems and baseboards. Line voltage thermostats are installed in series with heaters, mostly at 240V. In this type of connection the current flows through the thermostat and into the heater. Unfortunately, it is possible for the thermostat itself to reach the set room temperature, causing it to shut off even before the heater has brought the room to the set temperature.

2. Low-voltage thermostats

Low-voltage thermostats are more efficient when it comes to the controlling of current flow. These thermostats are used in central heating systems that use electricity, gas and oil. They are also used in water heating systems particularly in zone valves, and in electric unitary systems. With a low-voltage thermostat you will not only be able to accurately control current but you will also have an easier time using programmable controls. This ease is mostly due to the fact that they operate at 24V to 50V as opposed to the 240V used for line-voltage thermostat [15].

2.7 LINE AND LOW-VOLTAGE THERMOSTAT OPTIONS

A. Programmable thermostats.

With a programmable thermostat you can have the temperature in your house automatically adjusted according to preset times. This means that you will have an easier time conserving energy since you can let the gadget reduce the temperature in your hours of absence and increase the heat when you are around.

Programmable thermostats can be purchased in several models. The simpler ones allow you to program daytime and nighttime temperature settings while the more complicated

ones can be programmed to adjust temperature differently for different days and times of the week[17].

B. Mechanical thermostats.

These are perhaps the cheapest and easiest thermostats that you can install. They feature either vapor-filled bellows or bi-metallic strips, which respond to variations in temperature. Mechanical thermostats are often considered unreliable, particularly the cheapest models that make use of bi-metallic strips. The major letdown you will experience with these thermostats has to do with slow response of the bi-metallic strip, which may result in significant temperature variations either above or below the desired set points.

C. Electronic thermostats

Unlike mechanical thermostats, these thermostats make use of electronic gadgets to detect temperatures and subsequently initiate control for your heating system. They are quicker in responding to temperature variations.

You can have electronic thermostats either for line-voltage or for low-voltage purposes. These gadgets will offer you much convenience with features like programmability and automatic setback. For these reasons, electronic thermostats will cost you more than the mechanical alternatives [16].

2.8 THERMOSTATS FUNCTIONS

The thermostat is responsible for monitoring the temperature of your home. It decides when to turn the heat on and off. It is a vital part of your home and can help reduce your heating bills[18].

Suggested thermostat settings Sitting at home	21°C (70° F)
Working around the house	20°C (68° F)
Sleeping	18°C (64° F)
Empty house	16°C (61° F)

TABLE 2.1 Showing the Temperature of a House

CHAPTER THREE

3.0 DESIGN CALCULATION AND PARAMETER

A complete welding machine no matter how simple it may look like comprises of the following unit accessories, which are considered and constructed from one stage to another.

In designing this project work, with unique principle of operations, some standard values were taken.

For the purpose of this project, basic assumptions, which lead to calculations of the design parameters, were made.

The assumptions made are:

1. The two linkages are negligible so that there is no flow linkage between the primary and the secondary.
2. The working frequency is 50Hz
3. The lamination thickness (D) = 0.0375mm
4. Maximum flux density (Bm) = 1.2Tesla
5. VOLT/per Turn factor = 0.65
6. Current density (j) = $5A/mm^2$

3.1 Design of Welding Transformer

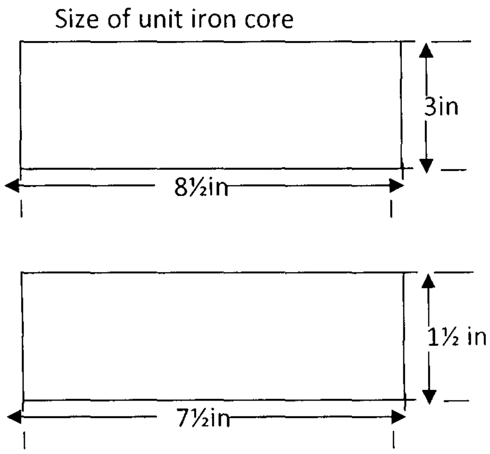

Figure 3.1 Transformer Core.

3.2 Determination of Volt per Turn of the Transformer

Due to the rating of the transformer which is 6KVA, there is need to calculate the output voltage per turn, so that the exact number of turns in the primary and secondary side of the transformer can be obtained this is made possible by using the formula or relationship given below.

$$V/_T = Voltage\ per\ turn$$

K = volt per turn factor (assumed)

KVA = rating of the transformer

Now

$$V/_T = k\sqrt{KVA}$$

$$= 0.65\sqrt{6}$$

$$V/_T = 1.59$$

That is the voltage per turn is 1.59

3.3 DETERMINATION OF NUMBER OF TURNS PER WINDING

By apply transformer E.M.F equation

$E = 4.44\varphi FN$.................................... (3.1)

But $\varphi = BmA$

For the primary winding we have

$E_p = 4.44BmApNp$............................. (3.2)

$\frac{E_p}{N_p} = 4.44BmAp$................................ .... (3.3)

That is

Number of primary turn $= \frac{EMF\ of\ primary}{EMF\ per\ turn}$

But $V/_T = 1.59$

Where Ep = 240v

Therefore $N_p = \frac{240}{1.59} = 150\ turms$

Hence the number of primary turns is 150 turns

From transformer equation

i.e. $\frac{N_p}{N_s} = \frac{V_p}{V_s}$

Where N_p = Primary turn (150)

N_s = Secondary turns

V_p = 230v

V_s = 100v

$$\Rightarrow \frac{150}{N_s} = \frac{240}{100}$$

$$N_s = \frac{150 \times 100}{240}$$

$N_s = 63$ turns

3.4 Determination of Cross Sectional Area of the Windings

From current density which is given as $J = \frac{I}{A}$

Where j = Current density

I = Current

A = Area

For the primary windings

$J = 5A/mm^2$

A_p = Primary area

But $I_p = \frac{6000}{240} = 25Amp$

Therefore

$$A_p = \frac{25}{5} = 5mm^2$$

Area of primary winding is $5mm^2$

For the secondary winding

$$I_s = \frac{2Transformer\ raating}{Secondary\ voltage}$$

$$I_s = \frac{6000}{100} = 60A$$

Using $J = \frac{I_s}{A_s}$

J = current density

I_S = Secondary current

A_S = Secondary Area

Now $A_s = \frac{I_s}{J}$

$$A_s = \frac{60}{5} = 12mm^2$$

Secondary winding area is $12mm^2$ hence, since the transformer is a step down transformer, which has high voltage and low current in the primary and low voltage and high current in the secondary. There will be a greater amount of heat generated in the secondary due to the high current than the primary. Hence the area of the secondary windings should be greater than the area of the primary windings. It thus shows that the calculated results is in line with the principle of the step-down transformer.

3.5 DESIGN OF THE TRANSFORMER CORE

Applying the transformer equation

$$\frac{E}{N} = 4.44FBmA$$

Now $E/_N = 1.59 \quad F = 50Hz$

$$Bm = 1.27\,Telsa$$

Substituting

1.59 = 4.44 x 50 x 1.27 x A

$$A = 56.4 \equiv 56cm^2$$

Area of core = $56cm^2$

STACK HEIGHT

The cross sectional area of the core is directly proportion to the square of the stack length (L).

$$A\alpha L^2$$

$$\rightarrow A = KL^2$$

K = constant of proportionality and is about 0.85 for one single transformer

$$A = KL^2$$

$$L = \sqrt{A/K}$$

$$L = \sqrt{56/0.85} = 8.1CM$$

3.6 DETERMINATION OF NUMBER OF LAMINATION

$$\text{Number of lamination} = \frac{\text{Lenght of stack}}{\text{Thickness of lamination}}$$

$$\frac{8.1}{0.0375} = 217$$

Number of laminations is 217

3.7 IMPLEMENTATION

The implementation of the electric arc welding machine is as follows.

The former of the transformer core was made first, the dimensions of the former are given below:

Height of former is 3½ inches

Length of former is 4½ inches

After the former was formed, it was place inside the formula with a wooden hollow block inside the former. The essence of the wooden block is to maintain the shape of the core. A long bolt is passed through the hole of the wooden block and a nut is used to tighten it at the other end. Before the copper wire was wound on the former, binding wires was placed first so that after the winding was done and the formula removed, the binding wires would be used to hold the windings together. The copper wire used in the primary windings was SWG 14 and that used for the secondary windings was SWG 9, because the secondary carries more heat than the primary windings.

After the two windings was made, vanish was then used to increase the insulation of the windings and also holding the windings together.

The lamination sheets was made, about 217 pieces, before the lamination was placed a fibre was made to separate the laminated sheets from the windings, this was so as to increase the insulation as much as possible.

The complete assembly was placed into a tank filled with oil that serves the purposes.

1. It adds to the electrical insulation between the windings.
2. It helps to conduct the heat away from core and windings to external heat exchangers.

The casing has the following dimension (34 x 34 x 34) cm

CIRCUIT DIAGRAM

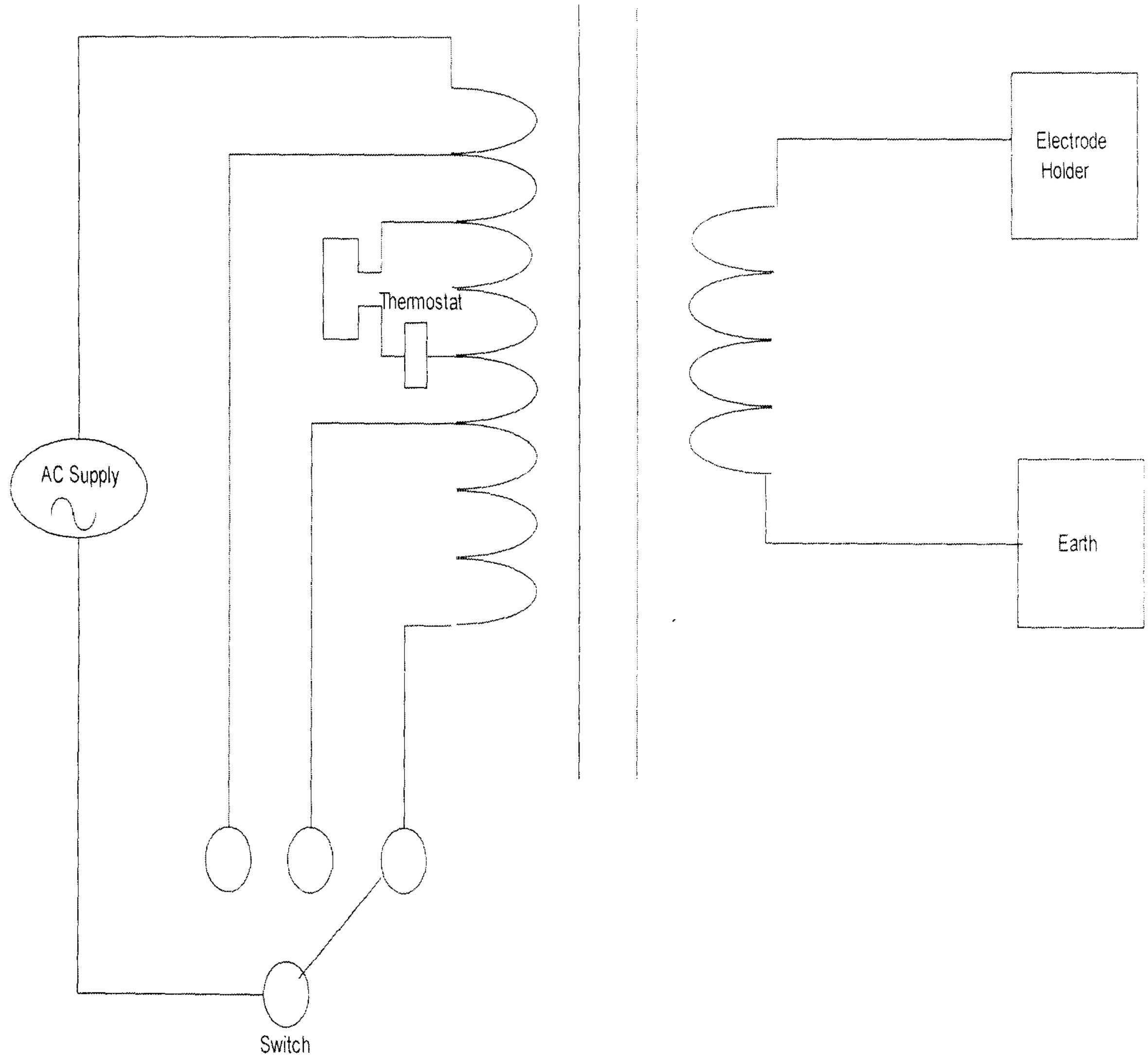

Figure: 3.2 Circuit diagram

Transformer parameters

1. Input voltage V_1 = 240V
2. Output voltage V_2 = 100V
3. Transformer rating = 6KVA
4. Frequency of the supply = 50Hz
5. Output current I_2 = 60A
6. Thickness of lamination = 0.0375cm
7. Length of lamination = 8½ inches
8. Width of lamination = 7½ inches
9. Number of lamination = 217
10. Secondary conductor area = 12mm^2
11. Number of turns in secondary = 63
12. Primary conductor area = 5mm^2
13. Number of turns in primary = 150
14. Maximum flux density = 1.27 tesla
15. Stack length = 8.1cm
16. Area of transformer core = 56cm^2

CHAPTER FOUR

TEST, RESULT AND DISCUSSION

4.0 TESTING

After the welding transformer was completed, test for continuity of the transformer winding were carried out with the help of a digital multimeter dialed to the ohm meter range. It was then connected to the a.c mains using thick copper wires. One of the terminals of the secondary windings was attached to the metallic workpiece, while the other was attached to an electrode through an electrode holder. An electric arc was formed and the electrode began to melt across the work piece, a molten pool was formed which then solidified into a hardened welded joint.

4.1 Result

Table 4.1 Result obtained

Input Voltage	Calculated result (Output Voltage)	Result obtained (Output Voltage)
1. High voltage (220V)	100V	90V
2. Low voltage (200V)	80V	70V
Automatic temperature shut down	To shut down at 80^0C	Shut down was achieved
Duty cycle		50%

4.2 DISCUSSION OF RESULTS

The maximum welding output voltage calculated was 100V when the supply voltage from the mains is 220V. In practice, what was measured was about 90volts. This could be as a result of losses from the transformer, which caused the voltage to drop. This however, did not limit the performance of the machine. Even with this voltage level, welding operations could be successfully carried out. 100V was simply chosen considering the fact that low voltage supply from the public supply mains is a common problem facing our country.

Hardly does the mains supply voltage approach 220volts. The output voltage was deliberately made high so that in the event of low voltage from the mains, welding could still be achieved.

Similarly, the low voltage output was calculated for 80volts but 70 volt was obtained which is still okay for welding of light metals.

The automatic over temperature shutdown responded as designed and also the duty cycle was found to be 50%. This means that the welding machine can only be operated continuously for 5 minutes period in every 10 minutes. If this machine is operated for periods longer than five minutes, its internal insulation will deteriorate, causing it early failure. The working specifications of this welding machine, causes the welding machine to work for five minutes in every ten minutes. Hence the duty cycle of this welding machine is 50%.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.0 CONCLUSION

In summary it can be concluded that the design and construction of an electric arc welding machine was successful. The automatic over-temperature shutdown operation was successfully implemented, although the output voltage measured from the welding machine was lesser than that calculated in the design, this must be as a result of transformer losses and low voltage input from the public supply. After the design and construction of the welding machine, during the testing of the welding machine, it was producing a humming sound that was not good for the performance of the welding machine.

5.1 Problems Encountered

1. Sourcing for the exact size of wire gauge chosen in the design was a problem; smaller size of wire gauge has to be combined to obtain the desired size.
2. The inadequate supply of electricity from the public power supply was a major challenge. This caused delay in completion of the project work.

5.3 Recommendations

1. The welding machine can be improved upon to feature a timing circuit to give the times for different welding processes
2. Very useful project carried out by students should be mass produced and sold to members of the public in other to solve societal problems and to generate revenue for the department
3. Good ideas and concepts conceived by the student in the course of their project work should be followed up by the department even if the student fails to actualize them in the course of the project. This can be done by funding researches which may eventually lead to the actualization of these ideas.
4. Most importantly in a Federal University of Technology such as FUT Minna. Practical and research work should be taught on a fifty-fifty bases with the theoretical work. So that competent engineers can be produced for the technological advancement of our country Nigeria.

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