DESIGN AND CONSTRUCTION OF AN ELECTRIC ARC WELDING MACHINE

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FACULTY OF ENGINEERING,
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SUBMITTED TO THE DEPARTMENT OF MATERIALS AND METALLURGICAL ENGINEERING, FACULTY OF ENGINEERING, UNIVERSITY OF BENIN IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR BACHELOR IN ENGINEERING DEGREE.

FEBRUARY, 2025.

CERTIFICATION

We hereby certify that this work was carried out by AIRHEN AMADIN MASCOT, AIYEMOWA DAVID SEUN, ALUFA EMMANUEL, BIOSEH COLLINS ODIAKOSE, COUPLE WISDOM, EDOSA EFOSA SIMON, ENWEREM MICHEAL KEMAKOLAM, OLUBAYO VICTOR of the department of materials and metallurgical engineering, University of Benin, Benin city, in partial fulfillment of the requirements for Bachelor in engineering Degree.

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(Project Coordinator)	

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(Project supervisor)	

DR. MRS. U.G UNUEROH	DATE
(Head of Department)	

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CHAPTER 1

Introduction

1.1: Study Background

In order to fuse two metal components, electric arc welding uses electrical heat to cause melting, which, when cooled, forms a solid connection. In order to protect the molten metal from exposure to the atmosphere and stop chemical reactions, slag is injected throughout this operation. A power source that creates an electric arc between the metal material and the electrode to be fused is necessary for this process. Both consumable and non-consumable electrodes, as well as alternating or direct current, are used by welders.

An electrode is a conductor that creates the heat required for melting and fusing by sending electric current to the metal to be welded. Whether an electrode is consumable or non-consumable depends on the specific arc welding process being used.

The electrical energy needed for the arc welding process may be obtained from a variety of power source methods. Constant voltage and constant current power sources are the most common varieties.

In arc welding, current is related to the amount of heat input, but voltage is directly correlated with arc length.

Shielded metal arc welding and gas tungsten arc welding are examples of manual welding processes that are coupled to a constant current power source. While the voltage varies throughout these activities, the current is usually kept constant.

On the other hand, automated welding processes like Gas Metal Arc Welding, Flux Cored Arc Welding, and Submerged Arc Welding are linked to constant voltage power supplies. During these processes, the current varies while the voltage remains constant.

In automated welding, the arc length stays constant with varying heat input, but in hand welding, the arc length fluctuates with constant heat.

The process is also affected by the current's direction.

An electric arc welding machine is a tool that reduces the time and practicality of the welding process.

The following techniques are used to permanently join metals:
The following techniques are used to permanently join metals: welding, brazing, soldering, riveting, and adhesive bonding.

1.1.1. The process of welding

a metal-joining technique that uses pressure and heat to achieve coalescence. The force of attraction between atoms may also be used to define it as a metallurgical connection.

In its most basic form, arc welding is one of the two methods of electrical metal arc welding machines (MAWMs); it is the apparatus in an electric circuit that generates the arc needed for arc welding.

1.1.2. Power source for welding

An apparatus that provides an electric current for welding is known as a welding power source. Welding typically requires high current (over 80 amperes), and spot welding may need more than 12,000 amperes. Low current may also be used, such as when gas tungsten arc welding two razor blades together at 5 amps. A welding power source may range from as basic as a car battery to as complex as modern equipment that uses silicon-controlled rectifier technology and other electronics to facilitate the welding process.

A step-down transformer supplies the welding power for an A.C. arc welding machine. This transformer reduces the input voltage, generally ranging from 220-240 volts, to a narrower range of 50-100 volts. Additionally, the A.C. arc welding machine contains a current control regulator, allowing the operator to vary the current (amperage) to match the electrode size being employed.

1.1.3. Power supply design

The most common kinds of welding power supplies may be divided into the following categories:

Transformer, generator, alternator, inverter, and so on.

(The transformer type was taken into consideration for this project since it is the least expensive option.)

Transformer Type: Typically ranging from 45 to 17 volts and 55 to 590 amps, a transformer type welding power supply converts high voltage and low current electricity from the utility mains into low voltage and high current. The more costly equipment uses a rectifier to convert the AC to DC.

This design typically allows the welder to select the output current by variously moving a primary winding closer or farther from a secondary winding, moving a magnetic shunt in and out of the core of the transformer, using a series saturating reactor with a variable saturating technique in series with the secondary current output, or by simply permitting the welder to select the output voltage from a set of taps on the transformer's secondary winding. Frequently, these transformer-type gadgets have the lowest prices.

The drawback of being the least expensive is that, since pure transformer designs operate at the utility mains frequency of 50 Hz or 60 Hz, they are usually large and massive. To avoid squandering shunt currents, such low frequency transformers need to have a substantial magnetizing inductance. In order to avoid short circuits in the event that a welding rod becomes adhered to the workpiece, the transformer may also have a high leakage inductance. The operator may be able to choose the output current by altering the leakage inductance.

1.2. The purpose and goal of the study

1.2.1. The research's objective

This project's goal is to design, fabricate, and build a 500W electric arc welding machine for the University of Benin's Department of Materials and Metallurgy Engineering.

1.2.2. The research objectives

The following are the objectives of this study:

i. Conduct a review of existing welding equipment literature.

ii. Create a blueprint for the machine's construction.

iii. Construct a mild steel enclosure to hold the finished components.

iv. Testing the device to ensure its effectiveness and safety.

1.3. Research scope and limitations

Due to its distinct design and construction, arc welding equipment comes in a variety of ranges. The machine's capacity and efficiency grow as the range increases, which might be 1.0KVA, 1.5KVA, 2.0KVA, 3.0KVA, etc.

This project is limited to this range for specific reasons, however it is neither the arc welding machine's minimum nor maximum range. These include stress, lack of resources, restricted tools and equipment, and financial difficulties.

1.4. Research's significance

These days, electric arc welding transformers are used for routine fabrication and maintenance operations as well as machine assembly. Power sources include light, medium, and heavy structural construction. Adopting arc welding equipment has many safety advantages, such as lowering the risk of arc burn and reducing exposure to hazardous fumes. This welding device helps individuals avoid doing dangerous tasks.

CHAPTER TWO

LITERATURE REVIEW

2.1. INTRODUCTION

The joining of two or more disparate components into a temporary or permanent union is a frequent and, for the most part, unavoidable procedure in manufacturing. This is because two or more metals must be joined in order to create a working entire unit out of metals or junk.

Temporary joining, often referred to as mechanical joining, is done so that the joints may be taken apart for upkeep. Fasteners, folded joints, and force fitting are the three primary categories. Ibhadode (1997)

As the name suggests, permanent joints are ones that are impossible to dismantle. Welding, brazing, soldering, and adhesive joining are the primary varieties.

According to Ibhadode (1997), welding is a technique used to create junctions that are at least as strong as the parent metals or materials—the materials from which the component components are created. He went on to say that welding procedures often include elevating the materials' junction temperature to a high level.

Additionally, he divided welding into solid-phase, gas, electric resistance, and electric arc welding. Fusion welding is the term used to describe the first three.

Regarding electric arc welding, Ibhadode (1997) claimed that when an electric current passes between two electrodes that are just a small distance apart, an electric arc is produced.

The welding rod is one electrode, and the welded work piece is the other. Striking an arc is the first step in the process. One way to create an arc is to softly touch the electrodes on the metal or to quickly scrape the electrodes against the metal (Ibhadode, 1997).

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The arc column's temperature may range from 5000°C at the outside to

Depending on the kind of arc plasma and the current passing through it, the interior temperature might reach 30,000°C or greater. (1988, American Welding Society).

Shielded manual metal arc welding (SMMAW), tungsten inert gas (TIG), metal inert gas (MIG), electro-slag, plasma arc, and other types are examples of electric arc welding.

According to Ibhadode (1997), the electrical resistance heating of the metals to be welded provides the thermal energy needed for fusion welding in the case of electric resistance welding. He said that this was founded on the idea that all metals have some electrical resistance, which prevents electric current from flowing through them and causes heat to be produced.

The connection provides the amount of heat Q produced.

Q = (I^2)Rt.

where I stands for current, R for the metal's resistance, and t for the current application time.

Furthermore, he claimed that when two metals are tightly forced together, their electrical resistance at the interface is far higher than the metal's own, causing additional heat to be produced there. The metals will finally weld together after exerting compressive pressure if the heat is high enough to cause the metals to melt at the surface. Additionally, it was mentioned that the high power needed for heat generation—up to 100 KVA—can only be maintained for a short period of time. As a result, the process's use in producing lengthy continuous welds is restricted. Spot, seam, projection, and flash butt welding are a few types of electrical resistance welding.

The phrase "gas welding," also known as "oxy-acetylene welding" (Ibhadode, 1997), refers to a welding procedure that uses a suitable filler metal and flame heating to create coalescence between two comparable metals. Acetylene is supposed to be burned in pure oxygen to produce the required flame. Acetylene combustion produces the maximum temperature, even though other gases like propane, hydrogen, and butane may also produce flames that are comparable. This makes it the most often utilized fuel gas for welding and cutting, along with its readily available nature, affordability, and simplicity of flame control.

According to Ibhadode (2007), solid phase welding creates a metallic connection by intimately bringing the clean faces of the components to be brought together. Usually, pressure is used. Solid phase welding includes a variety of techniques, including friction welding, ultrasonic welding, and forging.

2.2. Historical Context

The first known instances of welding date back many millennia, to the Bronze and Iron Ages in Europe and the Middle East, respectively. In The Histories of the Fifth Century BC, the ancient Greek historian Herodotus claims that Glaucus of Chios "was the man who single-handedly invented iron-welding." (Herodotus. The Histories) The iron pillar in Delhi, India, which was built around 310 AD and weighed 5.4 metric tons, was made possible by welding (Cary and Helzer, 2005).

Forge welding, in which blacksmiths continuously hammered hot metal until bonding happened, advanced throughout the Middle Ages. Vannoccio Biringuccio produced De la pirotechnia in 1540, which provides details of the forging process (Lincoln Electric, 1994).

The procedure was mastered by Renaissance artisans, and the industry grew over the next decades.

Vasily Petrov, a Russian scientist, discovered the electric arc in 1802, and he later suggested that it could be used for a variety of practical purposes, including welding. Nikolai Benardos, a Russian inventor, developed the first electric arc welding technique, known as carbon arc welding, using carbon electrodes in 1881–1882. In the late 1800s, Russian inventor Nikolai Slavyanov (1888) and American inventor Charles Coffin (1890) developed metal electrodes, and around 1900, A. P. Strohmenger introduced a coated metal electrode in Britain, which produced a more stable arc. In 1905, Russian scientist Vladimir Mitkevich suggested using a three-phase electric arc for welding, and in 1919, C. J. Holslag invented alternating current welding, but it wasn't popular for another ten years (Cary and Helzer, 2005).

Resistance welding was also developed in the last decades of the 19th century, with Elihu Thomson receiving the first patents in 1885 and producing further advancements over the next 15 years. Thermite welding was invented in 1893, and around that time, another process, oxyfuel welding, became well established. Edmund Davy discovered acetylene in 1836, but its use in welding was not practical until about 1900, when a suitable blowtorch was developed. (Cary and Helzer, 2005) At first, oxyfuel welding was one of the more popular welding methods due to its portability and relatively low cost, but as the 20th century went on, it lost favor for industrial applications and was largely replaced by arc welding as metal coverings (known as flux) for the electrode that stabilize the arc and protect the base material from impurities (Weman, 2003).

Arc welding was first used on aircraft during the war, as some German airplane fuselages were built using the process. (Lincoln Electric, 1994) Another notable example is the world's first welded road bridge, which was designed by Stefan Bryta of the Warsaw University of Technology in 1927 and constructed across the river Studwia Maurzyce near Lowicz, Poland in 1929. The British used arc welding extensively during World War I as the various military powers tried to decide which of the several new welding processes would be most effective. (WeldingHistory.org)

Significant advancements in welding technology occurred in the 1920s, including the introduction of automatic welding in 1920, which involved continuously feeding electrode wire. Shielding gas gained a lot of attention as researchers tried to protect welds from the effects of oxygen and nitrogen in the atmosphere. The main issues were porosity and brittleness, and the solutions that emerged included the use of hydrogen, argon, and helium as welding atmospheres (Cary and Helzer, 2005). The next decade saw additional advancements that made it possible to weld reactive metals like magnesium and aluminum, which, when combined with innovations in automatic welding, alternating current, and fluxes, contributed to a significant expansion of arc welding in the 1930s and then during World War II. (http://en.wikipedia.org/wiki/Welding#History)

Many novel welding techniques were developed in the middle of the century, and stud welding was introduced in 1930. It quickly gained popularity in shipbuilding and construction.

The same year saw the invention of submerged arc welding, which is still widely used today. The first underwater electric arc welding was successfully performed in 1932 by a Russian named Konstantin Khrenov. Gas tungsten arc welding was ultimately mastered in

In the 1950s, shielded metal arc welding was developed using a flux-coated consumable electrode, and it quickly became the most popular metal arc welding process. In 1957, the flux-cored arc welding process was introduced, which allowed the self-shielded wire electrode to be used with automatic equipment, leading to greatly increased welding speeds. Electroslag welding was introduced in 1958, and its cousin, electro gas welding, was introduced in 1961. The diffusion bonding method was proposed in 1953 by the Soviet scientist N. F. Kazakov.

(N.F. Kazakov, 1985).

Other recent advancements in welding include the 1958 invention of electron beam welding, which made deep and narrow welding possible by using a concentrated heat source; the 1960 invention of the laser, which has proven particularly useful in high-speed, automated welding; the 1967 industrial use of electromagnetic pulse welding; and the 1991 invention of friction stir welding in the UK, which has found high-quality applications worldwide. However, all four of these new processes remain relatively costly due to the high cost of the required equipment, which has limited their applications.

2.3. A simple circuit for welding

The figure below shows the basic arc-welding circuit: an AC or DC power source, equipped with any necessary controls, is connected to the work piece via a work cable, and to an electrode holder of some kind that electrically contacts the welding electrode via a "hot" cable.

When the electrode tip and the energized circuit come into contact with the workpiece and are removed while remaining in close proximity, an arc is formed across the gap.

The electrode and base metal are melted by the arc's about 6500°F temperature at the tip, creating a pool of molten metal known as a "Crater" that solidifies behind the electrode as it moves along the joint, creating a fusion connection.

2.4. The fundamentals of arc welding

A low-voltage, high-amperage current is sent from the welding machine to a metal electrode holder and flexible wire, called the leads, in the fusion welding technique known as electric arc welding.

Sparks are created when the electrode is scratched on the work surface because of partial contacts between the electrode and the workpiece, which essentially creates an electric circuit. When the conductors—the electrode and the workpiece—are separated, an electric arc is created, where the electrical energy is transformed into heat and reaches a temperature of about 70°C.

An alternative explanation of the principle is that the welding is "closed" when the electrode is struck on the work and slightly withdrawn, creating an arc. This contact allows current to flow in the form of electrons once the initial high voltage overcomes the resistance to current flow, a process known as ionization of the arc gap.

The parent metal melts or fuses in the arc, forming molten droplets of metal and flux when the core of the electrode transfers electrical energy to the arc and melts with the flux coating. The arc is made up of a region of very high-temperature gases (about 600°C) from the flux coating, and the forces of the arc, assisted by gravity and surface tension, project the molten droplets into the weld pool, where they solidify under the protective layer of the solidified flux, now known as slag. The flux also provides a shield of gas, protecting the molten metal at the electrode tip and the molten weld pool.

2.4.1. Machine for arc welding

To achieve drooping V/I characteristics, it is composed of a step-down transformer with a tapped secondary that has an adjustable reactor connected in series. The secondary voltage is tapped to offer a range of voltage-current settings.

However, because of the alternating current flow, it is more difficult to start the arc than with DC. AC arc welding is generally faster because larger electrodes and more current can be used because of the minimum magnetic blow conditions. The inability to change polarity and its unsuitability for welding cast iron and non-ferrous metals are its drawbacks. The main advantage of AC arc welding is that there is almost no magnetic blow; the reversal of current flow every 120° of a second minimises the magnetic fields; it also produces good penetration and has low operation and maintenance costs.

2.4.2. A few fundamental aspects of arc welding

Arc blow is not present.

Once achieved, the weld arc is straightforward to hold.

It is appropriate for welding aluminum.

often used while welding large gauge steel in production.

The soft iron core of arc welding equipment provides a common low-reluctance channel that connects the main and secondary coils, which are electrically separate but magnetically connected.

When a load is connected across the secondary terminals, the secondary current, in accordance with Lenz's law, produces a demagnetizing effect; consequently, under no load, there is no secondary current, and the secondary windings do not affect the primary current. The transformer's principle relies on the presence of magnetic flux, which provides the mutual links between the primary and secondary windings with no change in frequency. Additionally, an arc welding machine is made up of a single-phase transformer.

The welding transformer is a step-down transformer with a 100 volt output voltage, while three-phase transformers are also available.

The step-down transformer differs from a step-up transformer in that it has more turns in the primary winding than in the secondary winding. This means that the secondary voltage is lower than the applied voltage at the primary winding, and the primary current is lower than the secondary current. As a result, the secondary winding has fewer turns than the primary winding.

2.5. ARC WELDING PROCESS TYPES

Arc welding procedures come in a variety of forms, some of which are described below:

2.5.1. SMAW, or shielded metal arc welding

This kind of arc welding, also called Manual Metal Arc (MMA) welding or just stick welding, is a process where metals are melted and fused when an arc is heated between a covered metal electrode and a workpiece. The electrode's core provides filler metal, while the flux, or outer coating, provides slag and protective shielding gas (Source: http://www.millerwelds.com).

2.5.2. GMAW, or gas metal arc welding

Also referred to as Metal Inert Gas (MIG) welding, this process joins metals by heating them to their melting points using an electric arc that is protected from airborne impurities by a shielding gas and sits between the metal and a continuous, consumable bare electrode wire (Source: http://www.millerwelds.com).

The most effective and economical way to weld aluminum and its alloys is to use a hand-manipulated gun to continually feed the electrode to the arc (Source: Ibhadode, 1997).

2.5.3. FCAW, or flux-cored arc welding

By heating metals with an arc between a continuously-fed, consumable, tubular electrode wire and the workpieces, FCAW, also referred to as flux-cored welding, is a type of arc welding that eliminates the need for shielding gases by acting as a shielding agent using flux in the electrode's core.

http://www.millerwelds.com is the source.

Because flux-cored arc welding requires a power source (often constant voltage) and an electrode that is continually supplied with flux, it is typically regarded as an automated or semiautomatic process (Source: http://www.millerwelds.com).

2.5.4 Welding using Tungsten Inert Gas (TIG)

It is also referred to as gas tungsten arc welding (GTAW). Heliarc is a form of arc welding in which metals are joined using a non-consumable tungsten electrode. To create a clean, robust weld joint, an inert gas, usually argon, is used to shield the weld pool from impurities, preventing oxidation of the tungsten electrode, the molten weld puddle, and the heat-affected zone next to the weld bead.

http://www.gawdawiki.org is the source.

2.5.5. SAW, or submerged arc welding

This arc welding method uses an electric arc or arcs to heat a bare metal electrode or electrodes and the work, producing fusion without the application of pressure. Filler metal is taken from the electrode and sometimes from an additional welding rod.

A granular, fusible substance that is often transported to the job site from a flux hopper provides shielding (Source: http://www.weldguru.com). (Source: http://www.hobartwelders.com)

2.6. ARC WELDING MACHINE OPERATIONS

The following are some words that Weman (2003) emphasized and clarified to help people understand how an arc welding equipment works:

Electrical Circuit

DC, or direct current

AC, or alternating current

The Ampere

The Volt

Opposition

Ohm's Law

Continuous Possibility

Continuous Current

Drop in Voltage

Voltage in an Open Circuit

Voltage of Arc

The Polarity

2.6.1. Circuit Electric

In the context of welding, creating an arc completes an electric circuit, which is a complete channel for electricity.

The image below illustrates this:

(A picture of a welding machine setup showing the electrode holder and workpiece connected by cables.)

2.6.2. Current Alternation

This kind of current occurs when the electron flow periodically flips direction, or polarity.

The graph displays:

- "Three (3) Complete Cycles of 60 Cycle Current"

- Labels provide electrical degrees ranging from 90° to 1080° and "1/60 sec." intervals.

2.6.3. Current flowing directly

DC current is necessary for GMAW and is commonly used for SMAW. This type of current has a one-way electron flow (polarity), which allows the welder to control the location of the heat. The electrode will be slightly hotter than the base metal when it is positive, and the base metal will be slightly hotter than the electrode when it is positive (+).

The following is a visual representation of the direct current:

2.6.4 Amperes

One ampere is equivalent to 6.24150948×10186.24150948 \times 10^ {18} electrons passing by a point per second. Heat is produced when electricity flows through a resistance; in the case of welding, an air gap between the electrode and the base metal is a high resistance; the more amperage that flows through the resistance (air gap), the more heat is produced.

Additionally, the electrode has resistance; if the current density (a measure of amperage) is too high for the electrode's diameter, it will overheat; if the current density is too low for the electrode's diameter, it will be difficult to start.

2.6.5. The voltage

In SMAW, the voltage at the electrode controls the arc's harshness and ease of initiating. Voltage is a measure of electromotive force (emf), which is expressed in volts.

Open Circuit Voltage (OCV) is the starting voltage, and a greater voltage makes starting easier.

2.6.6. Opposition

The property of a material that prevents an electrical current from flowing through it is called resistance, and it is measured in Ohm's (Ω). Heat (BTU) is generated when an electrical current flows through resistance, and the quantity of heat generated depends on the resistance (Ohm's) and the current (amps).

2.6.7. The Law of Ohms

According to Ohm's law, the potential difference (R) in an electrical circuit is exactly proportional to the current (I) flowing through a material.

$E = IR$ is a common mathematical expression.

Rearranging Ohm's Law for amperage demonstrates that amperage (current flow) is determined by the voltage divided by the resistance: $I = E/R$. This is useful for teaching electrical safety principles since amperage is the dangerous component of electrical current.

This only suggests that at a given voltage, less current will flow with higher resistances.

Constant Voltage and Constant Current 2.6.8

Electrical arc welding power supplies are modified so that either the voltage or the amperage is relatively constant as the other factor changes because, in the normal operation of a transformer, the voltage decreases as the amperage increases and the voltage decreases as the amperage increases (Weman, 2003).

As a result, two distinct power supply types are made possible: constant current and constant potential (voltage) power supplies.

Gas Metal Arc Welding (GMAW) is characterized by a constant current power source, where the current (amperage) remains generally constant while the voltage is adjusted.

Shielded Metal Arc Welding (SMAW) has the property that when the voltage is altered, it remains generally constant in a constant potential power source.

2.6.9. Drop in Voltage

An electrical circuit will not function as intended when there is an excessive voltage drop, which is the decrease in voltage between the source and the load. The main cause of voltage drop is resistance, which can take the form of localized resistance (connection) that generates excessive heat.

2.7. POWER SUPPLIES FOR ARC WELDING

To supply the electrical energy necessary for arc welding processes, a number of different power supplies can be used. The most common classification is constant current power supplies and constant voltage power supplies. In arc welding, the voltage is directly related to the length of the arc, and the current is related to the amount of heat input. Constant current power supplies are most often used for manual welding processes such as gas tungsten arc welding (GTAW) and shielded metal arc welding (SMAW), because they maintain a relatively constant current even as the voltage varies. This is important because in manual welding, it can be difficult to hold the electrode perfectly steady, and as a result, the arc length and thus voltage tend to fluctuate. Constant voltage power supplies hold the voltage constant and vary the current, and as a result, are most often used for automated welding processes such as gas metal arc welding, flux-cored arc welding, and submerged arc welding. In these processes, arc length is kept constant, since any fluctuation in the distance between the wire and the base material is quickly rectified by a large change in current. For example, if the wire and the base material get too close, the current will rapidly increase, which in turn causes the heat to increase and the tip of the wire to melt, returning it to its original separation distance. (Cary and Hazer, 2005)

Arc welding also depends on the direction of the current used. Direct current is typically used in consumable electrode processes like shielded metal arc welding and gas metal arc welding, but the electrode can be positively or negatively charged. In welding, the positively charged anode will have a higher heat concentration, so altering the electrode's polarity affects the weld properties; a positively charged electrode will melt more quickly, increasing weld penetration and welding speed; conversely, a negatively charged electrode produces shallower welds (Kalpakjian, Serope, and Schmid 2001).

Both direct current (DC) and alternating current (AC) can be used in non-consumable electrode processes, like gas tungsten arc welding. With direct current, however, a positively charged electrode produces shallow welds, while a negatively charged electrode produces deeper welds

(Lincoln Electric, 1994). Alternating current quickly switches between the two, producing medium-penetration welds.

Types of Welding Equipment 2.8

According to Ibhadode (2007), there are a variety of arc welding machines available, and the choice of machine is primarily based on the application. For short production runs, manual equipment may be necessary to provide flexibility, while for long production runs, automatic equipment may be needed to assemble high production rates.

Typically, an arc welding machine is a transformer that, for instance, transforms a 230 volt power source and a low power current of 10 to 100 ampere into an arc welding-suitable current (Ibhadode, 2007).

Transformer type welding machines output A.C. voltage, while electric motor or engine-driven generators output D.C. voltage. A.C welding transformers are either air-cooled or oil-cooled. Welding machines can use either alternating current (A.C.) or direct current (DC). Some machines can use both A.C. and DC by using a selection switch. (Ibhadode, 2007)

Specifically designed for the shielded manual metal arc welding machine (SMMAW) process, the A.C. welding transformer is a multipurpose machine that is used everywhere arc welding is performed. If the electrode size is compatible with the power source rating, it is also widely used for arc-arc cutting and gouging.

Because it can be used with almost any kind of manual electrode, the constant-current D.C. welding generator is appropriate for use with SMMAW. Because of its portability, versatility, and ease of maintenance, D.C. welding generators are especially well-suited for maintenance welding, while the constant voltage D.C. welding generators are typically utilized for automated welding procedures (Ibhadode, 2007).

2.9. A.C. AND D.C. WELDING MACHINE COMPARISON

Some significant distinctions between the A.C. and D.C. machines were noted by Ibhadode (2007).

The following are some benefits of A.C. welding over D.C. welding:

For the same capacity, the welding transformer is less expensive than the D.C. welding generator set.

Since the welding transformers don't have any spinning components, maintenance costs are essentially nothing.

Compared to the D.C. welding set, the A.C. welding transformer has a little higher efficiency.

(Arc blow is a magnetic phenomenon that results in the distortion of the arc shape or a deflection of the arc away from the point of welding; it is more common in D.C. welding and generally absent in A.C. welding.) Arc blow and other arc deflection caused by undesired magnetic fields are virtually eliminated.

However, Ibhadode (2007) also mentioned the following benefits of D.C. SMMAW:

A variety of electrode types may be utilized with D.C. manual arc welding, which is often used for most electrodes other than mild steel. For instance, D.C. welding is more effective when used to weld cast iron, bronze, and aluminum.

The D.C. arc may be utilized with bare wires and lightly covered electrodes, but the A.C. arc requires the use of covered electrodes.

Because D.C. welding uses lower voltages than A.C., there is less chance of electric shock when the operator is sweating or in wet environments.

2.10. HOW A SHIELDED METAL ARC WELDING PROCEDURE WORKS

The design of an electric arc welder for the SMAW process is the focus of this project, hence it is crucial to go into great detail on how a SMAW process works.

Figure: Arc Welding Setup for Shielded Metal (www.Wikipedia.org)

First of all, the arc is struck by bringing the electrode into contact with the workpiece, and a very light touch is applied to the base metal. Then the electrode is pulled back slightly. This initiates the arc and thus the melting of the workpiece and the consumable electrode and causes droplets of the electrode to be passed from the electrode to the weld pool. As the electrode melts, the flux covering disintegrates, giving off shielding gases that protect the weld area from oxygen and other atmospheric gases. In addition, the flux provides molten slag which covers the filler metal as it travels from the electrode to the weld pool. Once part of the weld pool, the slag floats to the surface and protects the weld from contamination as it solidifies. Once hardened, it must be chipped away to reveal the finished weld. As welding progresses and the electrode melts, the welder must periodically stop welding to remove the remaining electrode stub and insert a new electrode into the electrode holder. This activity, combined with chipping away the slag, reduces the amount of time that the welder can spend laying the weld, making SMAW one of the least efficient welding processes. In general, the operator factor, or the percentage of operator's time spent laying weld, is approximately 25%. (Cary and Helzer, 2005).

The electrode, the workpiece composition, and the location of the joint to be welded all influence the actual welding method used, and the welding speed is also influenced by the electrode and welding position.

Sloped, vertical, or upside-down welding requires more operator skill and frequently requires the use of an electrode that solidifies quickly to prevent molten metal from flowing out of the weld pool, but this usually means that the electrode melts less quickly, increasing the time required to lay the weld. In contrast, flat welds require the least operator skill and can be performed with electrodes that melt quickly but solidify slowly, allowing for higher welding speeds (Lincoln Electric, 1994).

2.11. POWER SUPPLY FOR SHIELDED METAL ARC WELDING

While most SMAW applications are manual, requiring an operator to hold the torch, maintaining a suitably steady arc distance is difficult if a constant voltage power source is used instead, as it can cause dramatic heat variations and make welding more difficult. Jeffus and Larry (1999) state that the power supply used in SMAW has constant current output, which ensures that the current (and thus the heat) remains relatively constant even if the arc distance and voltage change. However, because the current is not maintained absolutely constant, skilled welders performing complex welds can vary the arc length to cause slight fluctuations in the current.

Stick, GTAW, MIG, Flux-Cored, and Gouging high-output welding power supply The preferred polarity of the SMAW system is largely dependent on the electrode being used and the desired weld properties. Heat accumulation on the electrode from direct current with a negatively charged electrode (DCEN) increases the electrode melting rate and decreases the depth of the weld, while reversing the polarity so that the electrode is positively charged (DCEP?) and the workpiece is negatively charged increases the penetration of the weld. Alternate current changes the polarity more than 100 times per second, resulting in an even heat distribution and balancing electrode melting rate and penetration (Jeffus and Larry, 1999).

They added that the typical equipment used for SMAW is a step-down transformer and a rectifier, which converts alternating current into direct current. Since the welding machine is typically powered by high-voltage alternating current, the welding transformer is used to lower the voltage and increase the current; for example, the power supplied by the transformer is approximately 17–45 V at currents up to 600 A, rather than 220 V at 50 A. Various types of transformers can be used to achieve this effect, such as multiple coil and inverter machines, each of which manipulates the welding current in a different way.

Inverters, which are smaller and therefore more portable, use electronic components to change the current characteristics. The multiple coil type modifies the current by either changing the distance between the primary and secondary coils (in movable coil or movable core transformers) or by changing the number of turns in the coil (in tap-type transformers).

Additionally, it was noted that although electrical generators and alternators are commonly used as portable welding power supplies, their use is less common in industry due to their lower efficiency and higher costs, and the complexity of using a combustion engine as a power source makes maintenance more difficult. In one sense, however, they are simpler: the need for a separate rectifier is eliminated because they can provide either AC or DC. The engine-driven units are most useful in fieldwork, where welding frequently needs to be done outdoors, and in locations where transformer-type welders are unusable due to the lack of a power source to convert.

2.12 ELECTRODE CLASSIFICATION

The electrode is coated in a metal mixture called flux, which releases gases as it breaks down to prevent weld contamination, introduces deoxidizers to purify the weld, causes weld-protecting slag to form, improves arc stability, and provides alloying elements to improve the weld quality. (Cary and Hazer, 2005) The electrode selection for SMAW is dependent on several factors, such as the weld material, welding position, and the desired weld properties.

Three categories of electrodes may be distinguished:

The electrode type known as "fast-fill" is designed to melt rapidly in order to optimize welding speed.

Fast-freeze electrodes are designed to solidify rapidly, which allows for a wide range of welding locations by preventing the weld pool from changing a lot before hardening (Lincoln Electric).

In the sense of the first two, fill-freeze and fast-follow are intermediate electrodes.

Although there are many practical options, the composition of the electrode core is usually similar or even identical to that of the base material. This is particularly true for alloy steels like HSLA steels, and electrodes with compositions similar to those of the base materials are frequently used for welding nonferrous materials like copper and aluminum (Lincoln Electric, 1994). However, it was also stated that there are instances in which it is desirable to use electrodes with core materials that are significantly different from the base material, such as stainless steel electrodes, which are frequently used to weld carbon steel workpieces with carbon steel workpieces and stainless steel electrodes.

Electrode coatings can be made of a variety of substances, such as rutile, calcium fluoride, cellulose, and iron powder. Rutile electrodes, coated with 25% to 45% TiO_2, are easy to use and have a good appearance of the resulting weld, but they produce welds with a high hydrogen content, which encourages embrittlement and cracking. Electrodes containing calcium fluoride (CaF_2), also referred to as basic or low-hydrogen electrodes, are hygroscopic and need to be stored in dry conditions; they produce strong welds, but have a coarse and convex joint surface; cellulose electrodes, especially when combined with rutile, provide deep weld penetration; however, due to their high moisture content, special precautions must be taken to prevent excessive risk of cracking. Lastly, iron powder is a common coating additive because it increases the productivity of the electrode, sometimes by as much as doubling the yield (Weman and Klas, 2003).

The American Welding Society developed a system for identifying different electrodes by assigning them a four- or five-digit number. The first two or three digits of the number specify the tensile strength of the weld metal, in thousand pounds per square inch (ksi); the penultimate digit typically identifies the welding positions that are permitted with the electrode, usually using the values 1 (usually fast-freeze electrodes, implying all position welding) and 2 (usually fast-fill electrodes, implying horizontal welding only); the last two digits together specify the welding current and type of electrode covering; when applicable, a suffix is used to indicate the alloying element being contributed by the electrode (Cary and Helzer, 2005).

(Lincoln Electric, 1994) Common electrodes include the E6010, a fast-freeze, all-position electrode that operates with DCEP and has a minimum tensile strength of 60 ksi (410 MPa).

Its cousin E6011 is similar, but it uses alternating current. The E7024 is a fast-fill electrode that is mainly used to make flat or horizontal welds using AC, DCEN, or DCEP. Examples of

CHAPTER 3

FABRICATION AND METHODOLOGY

The selection of materials, calculations, and manufacturing processes involved in the creation of an electric arc welding machine are covered in this chapter.

Definition: The method of uniting two pieces of metal such that the connection forms at their original boundary surfaces is called welding. To make a metallic connection, the two components that will be joined—with or without extra metal—are melted using heat, pressure, or both. Welding is a key technique in contemporary industry, with significant benefits and effects in mechanical engineering, building, and many other areas.

3.1. Arc Welding Machine Components:

The transformer, the housing or casing, the cooling fan, the insulated wires, the handle, the switch, the welding tong, and the ground clamp

3.1.1. The Accommodation

The remaining internal components are concealed by this exterior metal. It is constructed from gauge mild steel, which is strong enough to support the machine's whole weight. A key component of the unit's design is its housing, or casing. The device is made to be very convenient.

The material that is used must thus be both strong and lightweight. The casing of this design was made of galvanized steel. The device is portable and very simple to handle since the steel was formed into the shape of a cube and has a handle attached.

The following are the dimensions:

- Dimensions: 34.3 cm x 24.1 cm x 25.4 cm x 1.4 mm in thickness

3.1.2. Taking Cooling into Account

The winding insulation will be harmed by high temperatures. Small transformers are cooled by air circulation and heat radiation since they don't produce a lot of heat. Natural convective air cooling, sometimes aided by fans, may effectively cool power transformers rated up to several hundred kVA. Heat removal is one of the design challenges with bigger transformers.

Transformer oil, which cools and insulates the windings, is submerged in some power transformers. The mineral oil is very refined and stable at the working temperature of the transformer. According to Wikipedia.com,

The cooling fan

By drawing air through the transformer, this device aids in controlling the temperature of the transformer engine. Because the transformer produces a lot of heat when the welding machine is operating and must be cooled, the fan acts as a heat regulator.

Fig: pictorial view of a Cooling fan.

3.1.3. The Insulated Cables

These are of two types. One is smaller, which is connected to the primary coil terminal. The insulated cable is used for the purpose of connection to the (220-240V) main electric supply, which serves as the source of energy for the welding machine.

The other insulated cable is capable enough to withstand very high current generated from the secondary coil terminal. Attached to these are an electrode holder (welding tong), which holds the electrode used as a medium of welding, and also a ground clip, which holds one of the metals to be welded together in order to complete the welding circuit.

Fig: insulated cable.

3.1.4. Handle

This is a bent plastic attached to the top main cover of the housing unit for the purpose of handling and carrying the welding machine from one place to another.

3.1.5. Switch

The switch is used to turn the arc welding machine's power ON and OFF. On the arc welding machine, the circuit breaker protects against overcurrent and acts as an isolator. An electrical circuit can be broken by an isolator by halting the current or rerouting it to another conductor.

3.1.6. Welding Tong

This is an electrode holder and clamping tool used to hold the electrode firmly in any position. Through the hollow insulated handle, the welding cable is connected to the holder. The electrode holder's construction enables rapid and simple electrode exchange.

Fig: Welding Tong.

3.1.7. Ground Clamp

The grounding clamp in an electrical welding circuit serves the purposes of making the welding possible by completing the circuit through the workpiece.

Figure: pictorial view of a Ground Clamp.

3.2. A TRANSFORMER

It is crucial to comprehend the fundamental theories and workings of a transformer in order to understand this design. Theraja (1997) asserts that a magnetic field surrounds a conductor when an alternating current flows through it. A voltage is induced into the second conductor if it is positioned in the field that the first conductor has formed such that the flux lines connect the two conductors. The foundation of transformer theory and application is the utilization of a magnetic field from one coil to induce a voltage into a second coil.

The primary winding and the secondary winding are the two sets of windings or coils that make up a transformer's electric circuit. The transformer's secondary winding is its output, and the primary winding is the component that is connected to the supply. Electrical energy will be transported from the main circuit to the load via the transformer if a load is connected to the secondary winding, which will cause an electric current to flow in the secondary winding. The induced voltage in the secondary winding (Vs) of an ideal transformer is proportional to the primary voltage (Vp) and may be calculated as follows: $Vs/Vp=Ns/Np$, which is the ratio of the secondary's (Ns) to primary's (Np) turns.

A transformer enables an alternating current (AC) voltage to be "stepped up" by making Ns higher than Np or "stepped down" by making Ns less than Np by carefully choosing the ratio of turns.

With the remarkable exception of air-core transformers, the windings of the great majority of transformers are coils twisted around a ferromagnetic core. (Wikipedia.org)

Transformers come in a variety of sizes, from tiny coupling transformers concealed behind stage microphones to massive devices weighing hundreds of tons that are used to link different parts of power networks. Despite the broad variety of designs, they all function according to the same fundamental ideas. However, some electronic circuits no longer require transformers thanks to new technologies. Transformers are still found in nearly all electronic devices designed for household "mains" voltage. Transformers are needed for high-voltage electric power transmission, which makes long-distance transmission economically possible. (Wikipedia.org)

The Transformer

This is the key component of the machine which can undoubtedly be referred to as the welding machine. The transformation of the energy occurs here. It comprises of layered lamination, the former, the coils and the insulator.

i. Stack Lamination: This is the mechanical portion of the transformer which provides for stiffness and stability in terms of construction. A medium for the formation of magnetic flux is necessary for the appropriate working of the machine and is a combination of I-shaped laminations which, as far as the project is concerned, are carved out of steel (mild steel). This is where the bulk transformation of energy occurs.

ii. The Former:

Any non-conductive substance that can tolerate the transformer's maximum heat dissipation while in use, such as asbestos or thermosetting plastic, may be used. The coils in the system are coiled on these formers. Depending on how the lamination is cut, this may have a hollow cubic shape, a cylindrical shape, or any other shape. It is often positioned in the former for the best energy conversion in the electric field of the field coil (primary coil) into the output coil (secondary coil).

iii. Depending on the welding machine's power, there are often two sorts of coils. To resist the high potential energy source, the main winding, which has hundreds of turns and a very tiny "standard wire gauge," is used. Known as the secondary coil, the other coil is composed of tens of turns of thick "standard wire gauge." In order to efficiently do the welding task, this runs at low potential but produces a very high current.

iv. The Insulator: This substance has a very high non-conductivity, stability, and thermal ability. For the purpose of safe operation, it is utilized to isolate the main coil from the secondary coil and the lamina

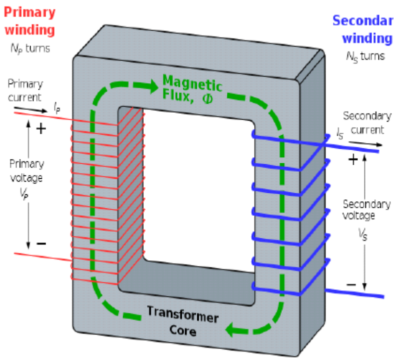
Figure pictorial view of a welding Transformer

3.3. BASIC PRINCIPLE OF A TRANSFORMER

In order to understand the operation of a transformer, there are laws, equations, and considerations that must first be understood.

3.3.1. Ideal Transformer

The transformer is based on two principles: first, that an electric current can produce a magnetic field (electromagnetism), and second, that a changing magnetic field within a coil of wire induces a voltage across the ends of 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 below.



(Diagram of a basic transformer unit with labeled parts: Primary winding, Secondary winding, Magnetic Flux, Transformer Core, Primary Current (Ip), Secondary Current (Is), Primary Voltage (Vp), Secondary Voltage (Vs), etc.).

Based on the diagram, A magnetic field is produced when current flows through the main coil. The majority of the magnetic flux flows through both the main and secondary coils because they are wound around a core with very high magnetic permeability, such iron. Given the main current and voltage in the stated directions (which in reality will be alternating current), the load current and voltage will be in the indicated directions if a load is attached to the secondary winding. (2011, Wikipedia)

3.3.2. The Law of Induction

Faraday's rule of induction, which says that "An electromotive force (emf) is always induced whenever the magnetic flux linked with a circuit changes," may be used to compute the voltage induced across the secondary coil. Furthermore, the rule asserts that "The rate of change of flux-linkages equals the magnitude of the induced emf." Theraja (1997).

With regard to the transformer, the rule may be written mathematically as: $Vs=Ns\ d\Phi/dt$……………………………. (1) where Φ is the magnetic flux through one coil turn, Ns is the secondary coil's number of turns, and Vs is the instantaneous voltage.

The flux is the product of the magnetic flux density B and the area A across which the coil cuts if its turns are aligned perpendicular to the magnetic field lines. While the magnetic field changes over time in response to the primary's excitation, the area remains constant and is equivalent to the transformer core's cross-sectional area.

Since the same magnetic flux goes through both the primary and secondary coils in an ideal transformer, the instantaneous voltage across the primary winding equals: $Vp = Np\ d\Phi/dt$……………………………. (2) The fundamental formula for increasing or decreasing the voltage may be obtained by dividing the two equations for Vs and Vp:

Ns/Np = Vs/Vp The answer is yes. (3) The essential functional feature of every transformer is its turns ratio, or Np/Ns. This may sometimes be expressed as the reciprocal, Ns/Np, in the context of step-up transformers. An irreducible fraction or ratio is a typical way to represent the turns ratio. Instead of 0.667 or 100:150 fraction or ratio, for instance, a transformer with primary and secondary windings of 100 and 150 turns, respectively, is stated to have a turns ratio of 2:3.

3.3.3. Equation of Ideal Power

Electrical power is transferred from the main circuit to the secondary circuit if the secondary coil is connected to a load that permits current to flow. All incoming energy is converted from the main circuit to the magnetic and then into the secondary circuit when the transformer is operating at maximum efficiency. The incoming and exiting electric power must be equal if this requirement is satisfied:

$$P_{incoming} = I_P V_P = P_{outgoing} = I_s V_s$$

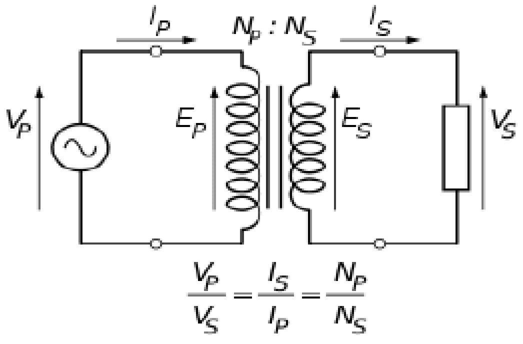


Fig: showing the ideal transformer as a circuit element (*Wikipedia)*

The ideal transformer equation is then stated as:

$$Ns/Np = Ip/Is = Vs/(Vp)$$

The current decreases by the same amount as the voltage is raised. The square of the turn's ratio changes the impedance in a single circuit. For instance, the main circuit perceives the secondary coil to have an impedance of (Np/Ns)2Zs if an impedance Zs is connected across its terminals. Because of this reciprocal connection, the secondary circuit perceives the main circuit's impedance Zp to be (Ns/Np)2Zp. William and Flanagan (1993).

3.3.4. Detailed Procedure

A number of practical considerations are overlooked in the above simplified explanation, including the main current needed to create a magnetic field in the core and the contribution of current in the secondary circuit to the field.

According to Say (1983), ideal transformer models usually assume two windings with zero resistance and a core with very little reluctance. A little current runs when a voltage is given to the main winding, which moves flux along the core's magnetic circuit. The magnetizing current, which is the current needed to generate the flux, is very small yet necessary to generate the magnetic field since the ideal core is thought to have almost zero resistance.

Every winding experiences an electromotive force (EMF) due to the fluctuating magnetic field. The voltages Vp and Vs, measured at the transformer's terminals, are identical to the respective EMFs because the ideal windings have no resistance and no corresponding voltage drop. Because it acts against the main voltage, the primary EMF is frequently *referred to as the "back EMF." The reason for this is Lenz's law, which stipulates that an electromagnetic field will always be induced in a manner that opposes the growth of any such change in the magnetic field. (James and Calvert, 2001)*

3.5. APPLICABLE THOUGHTS

An examination of how a practical transformer functions reveals several notable distinctions between an ideal and a practical transformer. A few of them are described here.

3.5.1. Flux of Leakage

According to the ideal transformer model, all of the flux produced by the main winding connects all of the windings' turns, including its own. In actuality, some flux follows routes that lead it outside of the windings. This kind of flux is known as leakage flux, and it causes leaking inductance in series with the transformer windings that are mutually connected. The graphic below illustrates this.

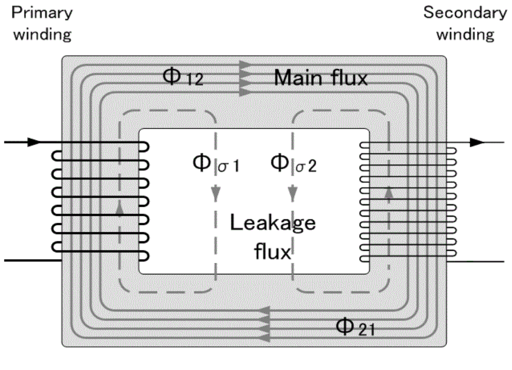


Fig Showing Leakage flux of a transformer (Wikipedia, 2011)

With each power supply cycle, leakage causes energy to be alternately stored in and released from the magnetic fields. Although there isn't a direct loss of power, it leads to worse voltage control, which makes the secondary voltage—especially when there is a high load—not quite proportionate to the primary. As a result, transformers are often made with very low leakage inductance. However, because leakage flux is crucial to the transformer's functioning, it is hard to completely eradicate it. Energy is transferred from the primary to the secondary by the combined action of the electric field around the windings and the leakage flux. (2011, Wikipedia)

Long magnetic pathways, air gaps, or magnetic bypass shunts may be purposefully added to a transformer's design to restrict the short-circuit current it will deliver in some situations where more leakage is needed. Leaky transformers may be used to safely handle loads that are regularly short-circuited, like electric arc welders, or to provide loads that show negative resistance, such neon signs, electric arcs, and mercury vapor lamps. (2011, Wikipedia)

3.5.2. Frequency's Impact

The flux in the core is the integral of the applied voltage with respect to time, as shown by the time-derivative part in Faraday's Law. With a core flux that increases linearly with time, a perfect transformer would theoretically operate with direct-current excitation. In reality, the flux would grow until the core reaches magnetic saturation, which would result in a significant rise in the magnetizing current and transformer overheating. Therefore, alternating (or pulsed) current is required for all practical transformers to function. Keith and Billings (1999)

At a certain flux density, a transformer's EMF rises with frequency. Because a particular core may transmit more power without reaching saturation and fewer turns are required to attain the same impedance, transformers that operate at higher frequencies can be physically more compact.

A transformer's magnetizing current will decrease if it operates at its specified voltage but at a higher frequency than planned; conversely, it will rise if it operates at a lower frequency. It may be necessary to evaluate voltages, losses, and cooling when operating a transformer at a frequency different than its design in order to determine whether safe operation is feasible. For instance, in order to prevent overvoltage at frequencies greater than their specified limits, transformers would need to be fitted with "volts per hertz" over-excitation relays.

Determining the transformer windings' transient reaction to impulse and switching surge voltages requires an understanding of their inherent frequencies. (2011, Wikipedia)

3.5.3. Transformer Losses

An perfect transformer would be 100% efficient and have no energy losses. Energy is lost in the windings, core, and surrounding components of real transformers. Generally speaking, larger transformers are more efficient, and those qualified for power distribution often exceed 98%. (Schach and Kubol, 2001)

Transformer losses, omitting related circuitry, may be described as "no-load" or "full-load" losses and fluctuate with load current. While hysteresis and eddy current losses account for more than 99 percent of the no-load loss, winding resistance accounts for the majority of load losses. Even an idle transformer can drain the electrical supply and incur operating costs due to the high no-load loss; designing transformers for lower loss necessitates a larger core, thicker wire, and high-quality silicon steel or even amorphous steel for the core, which raises the initial cost and creates a trade-off between the two. (Martin and Heatcoat, 1998)

Transformer losses are separated into two categories: iron loss, which occurs in the magnetic circuit, and copper loss, which occurs in the windings. (2011, Wikipedia)

3.5.3.1. Losses of Copper

Heat generated by electrical currents in the conductors of transformer windings or other electrical devices is sometimes referred to as "copper loss." Core losses, which come from induced currents in nearby components, and copper losses are both undesired energy transfers. Regardless of whether the windings are composed of copper or another conductor, such aluminum, the word is used. As a result, winding loss is often used. Because an empty transformer will have some winding loss, the related phrase load loss is closely similar but distinct.

In honor of Joule's First Law, copper losses are sometimes known as "I squared R losses," as they are caused by Joule heating. According to this, the square of the current flowing through the windings and the electrical resistance of the conductors determine how much energy, or power, is lost per second. (2011, Wikipedia)

I2R = Copper Loss

where R is the conductor's resistance and I is the current flowing through it. The computed power loss is expressed in watts, where I is in amperes and R is in ohms.

3.5.3.2. Losses of Iron/Core

Heat and occasionally noise are produced when a transformer or inductor loses some of the power that should ideally flow through the device. Hysteresis loss and eddy current loss are the two main causes of these losses, while there are other causes as well. The magnetic field produced in the primary, secondary, and harmonic windings of the transformer is what causes hysteresis loss. On the other hand, the high-frequency current flowing along the conductor's outside edge is what causes eddy current loss or the skin effect. (Source: Wikipedia)

3.6. Transformer Equivalent Circuit

An analogous circuit model (shown in Fig. below) based on an ideal lossless transformer may be constructed to combine the physical constraints of the real transformer.

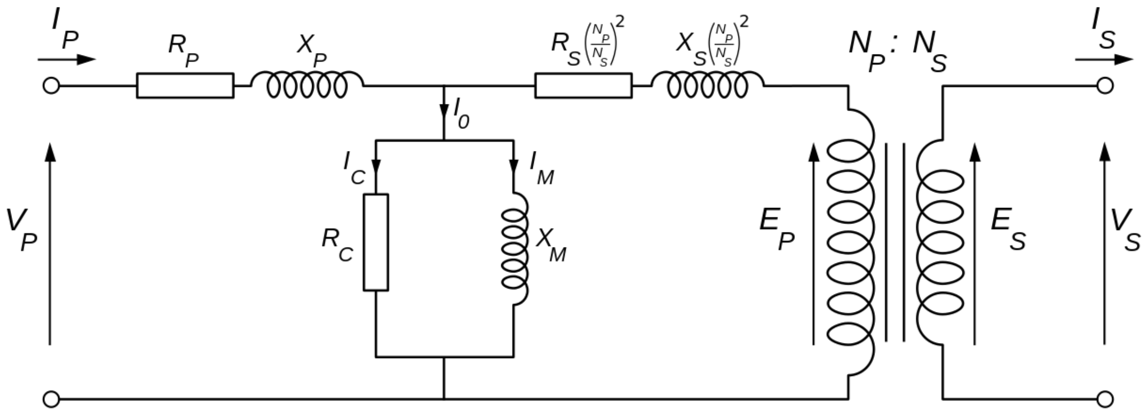


Fig showing the equivalent circuit of a transformer (Wikipedia, 2011)

The in-series resistances Rp and Rs indicate the current-dependent power loss in the windings. Flux leakage may be represented as reactances of each leakage inductance Xp and Xs in series with the perfectly coupled area as it causes a portion of the applied voltage to drop without assisting in the mutual coupling.

Iron losses are proportional to the square of the core flux during operating at a certain frequency and are mostly caused by hysteresis and eddy current effects in the core. A resistance RC placed in parallel with the ideal transformer may be used to simulate the iron loss since the core flux is proportional to the applied voltage. (2011, Wikipedia)

To sustain the mutual flux inside a core with limited permeability, a magnetizing current (IM) is necessary. Saturation effects make the connection between the magnetizing current and flux non-linear, yet they are often disregarded in most circuit equivalents for simplicity's sake. A magnetizing reactance (reactance of an effective inductance) XM in parallel with the core loss component may be used to represent the impact of the core flux 90◦ lagging behind the induced EMF with a sinusoidal supply. Sometimes, RC and XM are referred to as the model's magnetizing branch. The transformer's no-load current is represented by the current I0 drawn by the magnetizing branch if the secondary winding is left open-circuit.

After multiplying the components by the impedance scaling factor (NP/NS)2, the secondary impedances RS and XS are sometimes transferred (or "referred") to the main side, which is the magnetizing branch of the model. The transformer's no-load current is represented by the current I0 drawn by the magnetizing branch if the secondary winding is left open-circuit.

The resultant model is commonly referred to as the "exact equivalent circuit," despite the fact that it still makes many assumptions, including the assumption of linearity. Moving the magnetizing branch to the left of the primary impedance, assuming that the magnetizing current is low, and then adding up the primary and referred secondary impedances to get the so-called equivalent impedance may simplify the analysis.

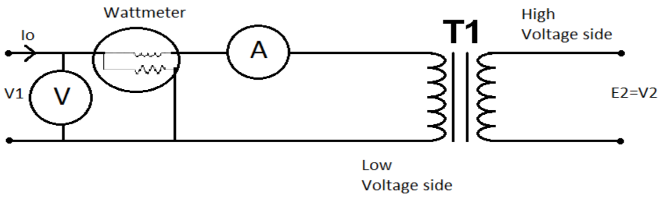
The outcomes of two transformer tests—the open-circuit test and the short-circuit test—can be used to determine the characteristics of the equivalent circuit of a transformer.

3.7. Test of the Transformer

The circuit structure of the practical transformer's equivalent was established earlier. Solving that circuit for any load state will provide the performance metrics of interest. The several expressions that the transformer designer utilizes to create the transformers provide him access to the equivalent circuit characteristics. However, they are often unavailable to users. Additionally, the equivalent circuit varies when a transformer is rewound with differing primary and secondary windings. Test procedures are mostly reliant on the comparable circuit characteristics. The electrical parameters may be found by analyzing the analogous circuit. However, the test procedure is the most reliable if the transformer's temperature needs to increase. The transformer may be tested in a number of ways: Short circuit and open circuit tests.

3.7.1. Test of the Open Circuit

In electrical engineering, the open-circuit test, often known as the "no-load test," is one technique used to ascertain the no-load impedance in the excitation branch of an actual transformer (Wikipedia, 2011).



Open Circuit Test (Wikipedia, 2011)

The secondary of the transformer is left open-circuited. A wattmeter is connected to the main. An ammeter is connected in series with the main winding. A voltmeter is not required since the applied voltage and the voltmeter reading are identical. The rated voltage is applied at the primary.

If a normal voltage is supplied, a normal flux will be created. Given that it is dependent on the applied voltage, normal iron loss will occur. Iron loss is thus greatest at the rated voltage. This maximum iron loss is measured using a wattmeter. Because the series winding of the transformer has a far lower resistance than the excitation branch, all of the input voltage is lost across the excitation branch. Thus, the wattmeter measures simply the iron loss.

Because the secondary is open, the transformer's primary only uses no-load current. This current is very low when there is no load. Since copper losses rely on current, they may be ignored.

The current, voltage, and power at the main winding are measured in order to calculate the admittance and power factor angle. Wikipedia, 2011

Right now, the Io is really low.

If W is the wattmeter measurement, then W = V1 Io COSΦ0. There are a lot of things that need to be done. (i) 〖cosΦ〗_0= W/(V_1 I_0) is a rewrite of the equation above. Yes, is the response. (ii) Consequently, I_m=I_0 sinΦ_0 The answer is yes. I_w = I_0 〖cosΦ〗_0 (iii) Yes, is the response. (IV) Resistance

X0 and R0 may be found using the previously described equation: X_0= V_1/I_m (v) ……………………………….à V_1/I_w = R_0 The reason is that... (vi) As a result, Z_0= √(R_0^2+ X_0^2) There are several tasks that must be completed. (vii)

Or, in (viii), Z_0=R_0+jX_0 Management Y_0 = 1/Z_O In addition, (ix) G_0= W/(V_1^2) is the formula for the conductance G0. The susceptibility is thus B_0= √(Y_0^(2)- G_0^2. (xi) In contrast, Y_0=G_0+jB_0 There are several tasks that must be completed. (xii) In this instance, the wattmeter value is W.

The applied rated voltage is denoted by V1.

I0 is the current without any load.

Im is the magnetizing component of the no-load current.

Iw is the main reason for no-load current loss.

Z0 is the exciting impedance.

Y0 is the exciting admittance.

3.7. 2. Check for Short Circuits

The purpose of the short circuit test is to determine the series branch characteristics of the equivalent circuit. As the name suggests, the primary applied voltage, current, and power input are monitored while the secondary terminals are maintained short-circuited. Assume the appropriate values are Vsc, Isc, and Wsc. Usually, the supply voltage required to flow the rated current through the transformer is just a few percent of the nominal voltage. The excitation current, which is negligible even at rated voltage (less than 1%), is disregarded throughout this test. Consequently, it is believed that the shunt branch is absent. The sum of the primary and secondary copper losses is known as Wsc. The reactive power absorbed by the leakage reactance of the two windings is equal to the reactive power utilized. Wikipedia, 2011

3.8. The voltage Managing a Transformer

Modern power systems operate at a number of standard voltages. As a consequence, the equipment running on these systems receives input voltages at these precise values within predefined tolerance limits. In many cases, this voltage may not be enough on its own to provide the loads the best working conditions. A transformer is placed between the load and the supply terminals in these circumstances. The transformer experiences additional dips as a result of the load currents. Even if the supply provider controls the input voltage, the user still has to be worried about the voltage at the load. Allowing an excessive voltage drop to occur within the transformer lowers the load voltage and affects its performance. Consequently, it is necessary to quantify the drop that happens within a transformer when a certain load current is pulled from its output leads at any power factor. Voltage regulation is the phrase used to describe this decrease, which is expressed as a ratio of the terminal voltage. Wikipedia, 2011

(V_(s,nl)-V_(s,fl))/v_(s,fl) = VR, where Vs, nl and Vs, fl stand for the no-load and full-load voltages, respectively.

3.9. Efficiency of Transformers

The efficiency of a transformer is important when it comes to energy loss. Power losses in a transformer are addressed via efficiency. If a transformer is less efficient, it will release more heat. In mathematics, efficiency is defined as the ratio of a transformer's power output to power input, where the power input is equal to the power output plus losses. The symbol η is used to signify efficiency. For example, η = (power output/power input) times 100 and power input =

power output + losses

Transferring electrical energy from the main coil to the secondary coil while it is working is a transformer's principal purpose. The transformer's copper coils and iron core will convert some of the electrical energy into heat energy. This conversion causes the transformer to emit heat while it is operating. Excitation losses in copper and steel are represented by the heat generated by the transformer, which reduces its efficiency. Wikipedia, 2011

3.10. CLASSIFICATION OF TRANSFORMERS

Because they are an electric machine without any moving parts, transformers are known as static electric machines. They may be divided into many categories, as will be discussed below: by power capacity, which ranges from less than one volt-ampere (VA) to over a thousand MVA; by frequency range, which includes radio, audio, and power; By cooling type: air-cooled, oil-filled, fan-cooled, or water-cooled; by voltage class: a few volts to hundreds of kilovolts; By use: impedance matching, power supply, output voltage and current stabilizer, or circuit isolation; By purpose: rectifier, distribution, arc furnace, amplifier output, etc. Winding turns ratios include step-up, step-down, variable, many windings, and isolating with an equal or nearly equal ratio. Wikipedia, 2011

3.11. TRANSFORMER CONSTRUCTIONAL FEATURES

The features of transformer construction may be broadly divided into Core Construction. Configurations of windings Cooling Elements

3.11.1. Establishing the Foundation

Among the factors that affect a transformer core's composition are frequency, voltage, and current. Size constraints and construction costs should also be considered. Common core materials include air, steel, and soft iron. All of these things are suitable for certain purposes but unsuitable for others. When the frequency of the voltage source is high (more than 20 kHz), air-core transformers are often used. Iron-core transformers are often used when the source frequency is low (below 20 kHz). If the transformer has to be both physically small and effective, a soft-iron-core transformer is very advantageous. An iron-core transformer provides better power transmission than an air-core transformer. A transformer with an efficient power transmission is made possible by a core composed of bonded steel sheets. These steel laminates are formed into a core after being insulated with a non-conductive material, such varnish. Approximately fifty of these laminations are needed for a core that is one inch thick. As discussed later in this section, laminations are utilized to reduce specific losses. The most efficient transformer core is the one with the best path for the most lines of flux and the least amount of electrical and magnetic energy loss.

There are two main types of laminated steel core transformers. The first is called Core-type, after the hollow square that passes through the center of the core.

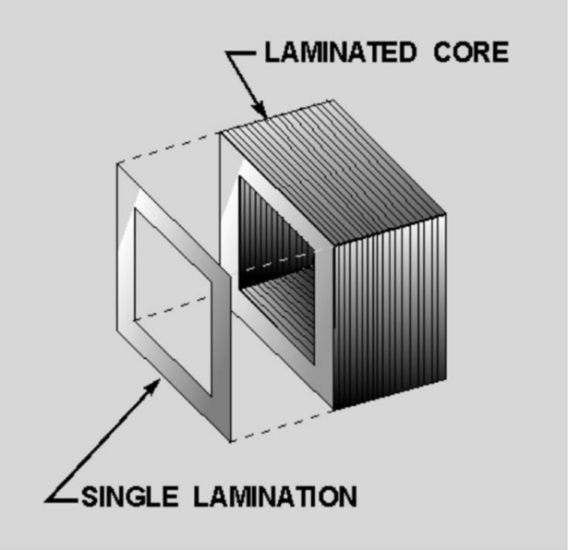


Fig Showing a Core – Type Construction (www.sayedsaad.com)

The image in the Figure above illustrates the Core-Type Construction of a transformer. It depicts:

- A laminated core, which consists of multiple layers of steel sheets stacked together.
- A single lamination, showing how each individual sheet contributes to the overall laminated core structure.

The diagram visually explains how transformer cores are designed using laminated sheets to minimize energy losses.

The other, which is the most popular and efficient transformer core, is the shell type, as illustrated in Figure 3.7. As shown, each layer of the core consists of E- and I-shaped sections of metal. These sections are butted together to form the laminations. The laminations are insulated from each other and then pressed together to form the core. (www.sayedsaad.com)

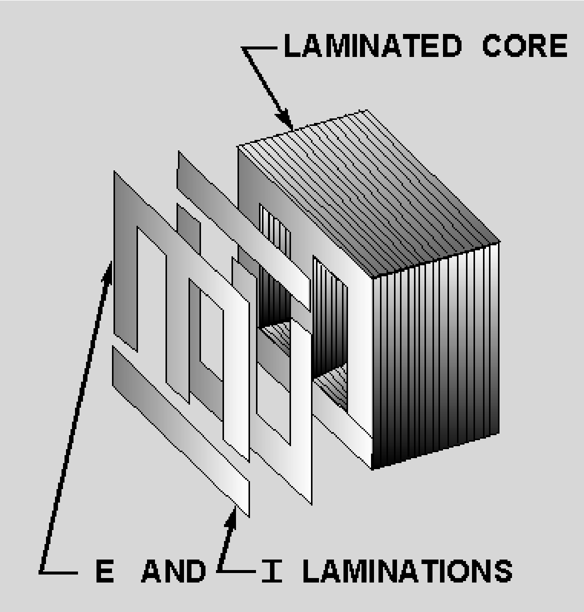


Fig Shell – Type Core Construction (www.sayedsaad.com)

3.11.2. Winding Arrangements

The conducting material used for the windings depends upon the application, but in all cases, the individual turns must be electrically insulated from each other to ensure that the current travels throughout every turn. For small power and signal transformers, in which currents are low and the potential difference between adjacent turns is small, the coils are often wound from enameled magnet wire, such as Formvar wire. Larger power transformers operating at high voltages may be wound with copper rectangular strip conductors insulated by oil-impregnated paper and blocks of pressboard.

Both the primary and secondary windings on power transformers may have external connections, called taps, to intermediate points on the winding to allow selection of the voltage ratio.

3.12. DESIGN ANALYSIS AND CALCULATION

The calculations involved in rewinding the transformer are explained below, using the ideal transformer equation.

$$\frac{E_P}{N_P} = \frac{E_S}{N_S} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$\frac{E_S}{E_P} = \frac{N_P}{N_S} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Equation (1) is the transformer law, where:

- Ep = applied voltage

- Es = induced secondary voltage
- Np = number of primary turns
- Ns = number of secondary turns

Since the induced voltage in the primary coil equals the applied voltage, and since the induced volts per turn is the same for both primary and secondary, the ratio is called the transformer turns ratio. When a load resistance is connected to the secondary coil, secondary voltage causes current in the secondary to flow in a direction that always tends to cancel flux in the core. This tendency to cancel the flux reduces the induced voltages in both the primary and secondary coils. When the induced voltage in the primary decreases, the primary current increases due to the applied voltage across the primary winding, bringing the flux back to its initial amount. Equilibrium is established when the total magnetic motive force (MMF) is just sufficient to induce a voltage equal to the voltage applied across the primary coil. This is equal to the magnetizing MMF.

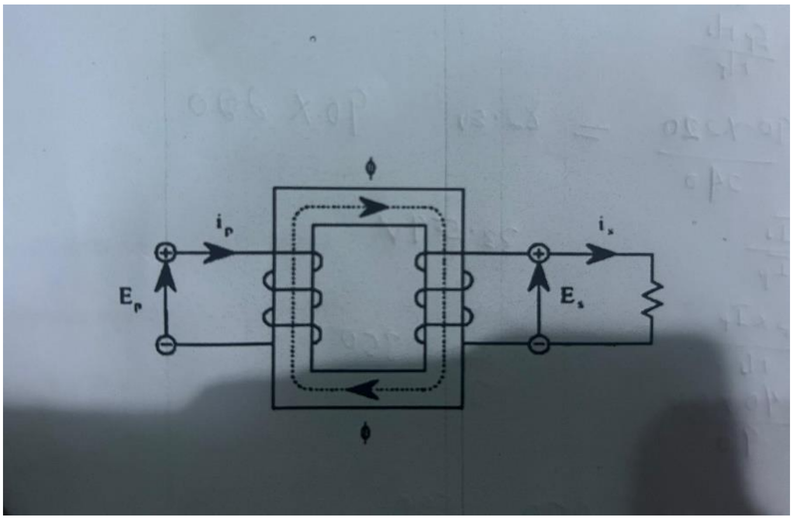


Figure shows the transformer winding with the load connected to the secondary

$MMF_{pri} + MMF_{sec} = MMF_{magnetizing}$ ………………………………………… (3)

The magnetizing MMF is insignificant in comparison to the primary MMF and secondary MMF, both of which have significant currents flowing while the primary and secondary windings are under load.

$MMF_p + MMF_s = 0$ ……………………………………………………… (4)

$(N_p \times i_p) + (N_s \times i_s) = 0$ …………………………………………………… (5)

$N_P I_P + N_S I_S = 0$

$N_P I_P = -N_S I_S$

$\frac{i_p}{i_s} = -\frac{N_s}{N_p}$ ……………………………………………………… (6)

The minus sign in equation (6) indicates that the currents in the primary and secondary windings are in opposite directions with respect to producing a magnetic flux in the core. While this is true, the minus sign can be dropped in order to express the ratio of primary current to secondary current.

$Ip/is = Ns/Np$ ……………………………………………… (7)

The second transformer law is found in equation (7).

Equation (1) is multiplied by equation (7) to get (Ep/Es)×(ip/is)=(Np/Ns)×(Ns/Np)=1. (8).

(E×i)p = (E×i)s

The formula (Ip/is)=(Es/Ep)……………………………………………………………………………… …………………� (9)

The instantaneous power delivered to the secondary coil to the load (Pin = Pout) is equal to the instantaneous power given to the main coil from the applied voltage, according to equation (9). The transformer rules apply regardless of the currents' phase angles.

The standard wire gauge chart may be used to choose the appropriate conductor for the main or secondary winding.

In order to ascertain the secondary voltage: Np (number of primary turns) = 240 The number of secondary turns is Ns = 90. Ep (primary voltage) = 220V (secondary voltage) =?

Applying the transformer equation:

(Ep/Np) =(Es/Ns) (10)

(Np/Ns) = (Is/Ip) = 82.5V (Es = (90×220)/240

$(590\times6)/90 = 39.33A$ is Is.

The electromotive force (emf) equation may be used to calculate the transformer's flux:

$E=4.44FN\Phi m$ Aside from that, (11),

Where: Vp = emf per revolution = E F = frequency = 50 Hz Φ = maximum flux N is the number of main turns.

$220/(4.44\times50\times590) = \Phi m$

3. $\Phi m = 1.68Wb$ $\Phi m = 1.68\times10-3$

To determine a single-phase transformer's transformer power rating:

$(V\times I)1000$ = power rating (KVA). There are a lot of things that need to be done. (12)

where V is the voltage and I is the current.

Applying equation (12):

$KVA = (3244.725 \approx 3.25KVA)/1000 = (82.5\times39.33)$

Chapter Four

OUTCOME AND CONVERSATION

This chapter discusses the manufacturing process and the final product. The techniques used consist of: Measuring and Cutting: An electric arc welding drawing was created prior to the start of any further steps. The meter tape, meter square, chipping hammer, hacksaw, wire brush, and other welding and measurement instruments were collected together with all other required welding equipment. The 1.4mm galvanized plate was accurately measured and shaped according to the measurements and design standards. Welding: A box was created by joining the galvanized plates. The welded seams and surfaces were cleaned and polished after the welding process was finished. During this procedure, appropriate safety measures were used. Finishing: The last stage of getting metal goods ready for use is finishing. Finishing enhances a product's longevity and resistance to corrosion while also making surfaces look their best. The arc welding was painted, the welded seams were cleaned and polished, and rough surfaces were smoothed using emery paper, also known as sand paper. Painting was done to guarantee the final product would look excellent and to stop rusting. Drilling: Bolts and nuts were used to create the desired effect of a detachable CASING / HOUSING (housing cover and its base). Therefore, in order to enter the bolts, tiny holes were bored on certain spots.

4.1. SETUP AND EXAMINATION

4.1.1. THE BUILDING

The following is a list of materials required for the construction: Laminated cores composed of gauge 22 mild steel that has been cold rolled. Aluminum conductors Bobbin material for insulation (hard and varnish). Nuts and bolts Cable for welding An electrical cord An electric holder The casing

The machine was built using the following equipment and tools: A wire cutter A spanner Stripping knife made of copper Pliers Hammer A welding machine

This project was completed using a methodical, productive approach. Winding the main and secondary turns on their respective spindles was the first step in the building sequence. The lamination was set up according to the guidelines.

4.2. ACTIONS TAKEN TO PRODUCE THE TRANSFORMER A rectangular hollow former was purchased, a wooden cuboid that matched the dimensions and shape of the former's hollow was placed inside it, a hole about 8 mm in diameter was drilled through the middle of the wood, a headless 8 mm bolt was inserted through the hole, and two nuts were used on both ends of the bolt to secure the wood. To enable the former to revolve in tandem with the drilling machine's chuck when triggered, one end of the headless bolt was placed into the machine's chuck. The main coil, which had 240 turns overall, was wound using aluminum wire of size 12swg (standard wire gauge), with five loops, each with 50 turns, spaced apart by an insulator. The main coil and secondary coil were similarly separated by an insulator, and the secondary coil, which had a total of around 90 turns, was wound with aluminum wire of size 8swg (standard wire gauge). The main coil's two ends were positioned on one side of the former, while the secondary coil's two ends were positioned on the other side. After removing the wooden cuboid until it was full, E-shaped laminated plates were inserted into the former's hollow from both ends. Bolts were then inserted through the four corners to secure the stack lamination, creating the laminated core. The transformer was then prepared for testing.

4.3. Information on Construction

As you will remember, the majority of the design calculations in chapter four were predicated on a few specified parameters. The objective of reproducing this facts is construction.

Rating of the transformer = 3.5 KVA

The primary voltage is equal to (220V/230V).

82.5V is the secondary working voltage.

The core material's maximum flux density is 1.4 wb/m^2.

50 Hz is the operating frequency.

4.4. ACTIONS TAKEN TO COMPLETE THE HOUSING AND CASING

The top and bottom components of the casing are two distinct pieces that were constructed independently and joined together with the use of screws to create the casing.

4.4.1. The lower portion Two 24.1 cm by 25.4 cm rectangular metal sheets were cut. Stick welding was used to join three sides of the rectangle sheet to a square hollow sheet that was roughly 1 inch in size. An additional 1 inch was folded from the two opposing edges of a bottom plate that was cut to measure 34.3 cm by 24.1 cm. The bottom plate's folded edges were joined to the two metal sheets in (2) above by welding. The square metal has holes bored on its sides for screws to be fastened to. On one side of the buttressed steel plate, where the fan would be mounted, horizontal incisions of around 5 to 6 inches in length were created.

4.4.2 The upper portion The upper portion of the shell was built without the use of welding. An "n" was formed by folding a rectangular sheet in three sections, with the central portion serving as the top and the other two as the sides. The dimensions of the top are 34.3 cm by 24.1 cm, and the sides are 34.3 cm by 25.4 cm. It has apertures on the sides to improve ventilation and holes drilled for screw attachment. The top portion was bored with holes, and a handle was fastened with screws.

4.5. Bobbin

A bobbin or former is used to maintain the coil's shape and shield the interior of the winding. These interlayer papers, which are leather-void paper types with different classifications ranging from A to F, are used for insulation. They serve as interlayer paper, protecting the coil from electrical stressors and preventing it from sinking into the layer below in addition to providing insulation. On the other hand, excessive insulation should be avoided as it may result in a significant quantity of heat that might melt the insulation when the specified temperature is exceeded. The thickness of the insulating layer in between layers ranges from 0.127 to 0.256 mm. It should be mentioned that more insulation is needed between windings, if not for electrical purposes, but maybe to provide the heat winding a suitable basis. When it comes to voltage distribution, the insulation between the coil and the core and between the windings is selected to allow for 0.0508 mm of paper for every 100 volts and twice the operating voltage + 1000 volts. One of three things might cause the exposed insulation to break: by flashing Punching through the paper By moving through the surface

The hardboard that was utilized to insulate the machine and surround the main bobbin was the source of the bobbin materials.

figure showing process of bobbin

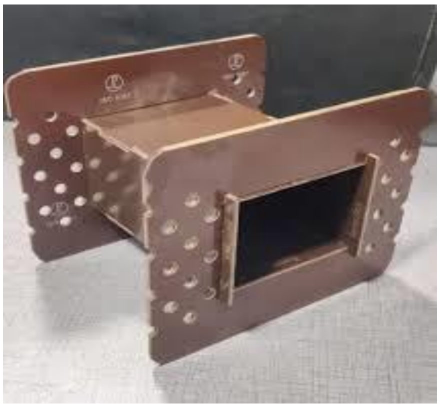


Figure 5.4 Final shape of the FORMER

Four bobbins were used, two for the primary winding and two for the secondary windings. The bobbins were formed after bending the marked end. A masking tape was used to hold marked cardboard paper together in a rectangular form before proceeding on winding.

4.6. Windings

This is the most important part of the transformer since without it the machine cannot perform the various functions outlined at the initial stage. The windings of the transformer were designed in the appropriate winding direction. The primary winding was wound around the bobbin in a clockwise direction, while the secondary winding was wound in an anticlockwise direction.

Figure: winding operation being carried out.

4.7. Fixing and Slotting the Windings into the Core

The coils were laid in such a way that cognizance was taken to prevent excessive noise or humming of the transformer. One of the steps taken was to wrap the secondary winding with a winding cloth sheet and paint it with varnish. Then, the hardboard was cut to the shape of a rectangle and made two rectangular holes at equal intervals from the center, having considered the window space area.

The first hardboard was placed in order to insulate the windings from the abrasive nature of the core and subsequently a burnt winding. The two primary windings were then placed, followed by the hardboard and the two secondary windings. It should be noted that the core assembly is just a completed rectangle, and the bobbin carrying the coil was made in such a way that they fit into these core area, though additional packing was made so that it will stay firmly to avoid excessive vibration.

Figure Showing the primary and secondary windings of the transformer.

4.8. ASSEMBLING OF THE ELECTRIC ARC WELDING MACHINE

- The complete unit of the transformer was permanently screwed to a metallic casing at the base of the transformer.

- The cooling fan was attached to the rear side of the casing with the aid of screws.
- A switch was placed on the space carved out for it on the front part of the casing.
- The transformer was placed in the middle of the casing and was attached to the bottom plate with the aid of bolts and nuts.
- Insulated cable was passed through a hole on the rear plate into the casing, with the live wire connected to one terminal of the switch and the neutral wire to the fan, the other wire from the fan was connected to the second terminal of the switch, the two joints of wire of the cooling fan was connected to the terminals of the primary coil of the transformer.
- An electrode holder which carries the current from the welding power source to the electrode was then fixed. It serves two main functions; To hold the electrode and to provide a comfortable and safe insulated handle for the welder.
- Two welding cables were connected to two bolts and held firmly by the use of nuts, the bolts on which the secondary coil terminals were also connected.
- Welding Tong was connected to one free end of the welding cable while the ground clamp was connected to the free end of the welding cable.

Pictorial View of the welding machine

4.9. WELDING MACHINE PERFORMANCE CHECK

The transformer was tested to make sure it operated as intended since it is the main component of the arc welding equipment. The welding machine's performance was assessed using a variety of test types, including the open circuit test (no-load test) and the short circuit test (load test). There are essentially three kinds of losses in the transformer, and they are:

1. Losses of aluminum
2. Losses from stray loads
3. Losses of iron

4.9.1. Losses of aluminum

The energy loss that results from the electrical resistance in the transformer's aluminum windings is referred to as the "Aluminum loss."

4.9.2. Losses from stray loads

When bolts and nuts are not correctly fastened or tightened, stray load losses arise. Additionally, the system will vibrate if the machine is unsteady when clamped or fastened to its chassis. Stray load losses may result from the joints' unequal flux distribution.

4.9.3. Loss of iron

When a ferromagnetic material is exposed to a growing magnetic field, hysteresis and eddy current losses cause the iron losses to develop. In order to limit heat on the winding, high-quality cold-rolled steel is coated with silicon and laminated sheets are employed to reduce eddy current dissipation.

4.10. THE IMPORTANCE OF SAFETY

The following succinctly describes the safety issues that were taken into account when completing this project:

Use of safety equipment

Goggles and a welding hand shield are among the safety equipment used during the welding process to screen the eyes from radiation, flying debris, bright light, irritation, and other hazards. To avoid burns from the welding, first contact with flying particles, and heat resistance, overalls and aprons were worn.

To avoid burns and electric shock, use gloves and boots.

Safety Measures

During the electric arc welding machine's manufacture, the following safety measures were taken:

1. All tools and equipment were examined for flaws before to use.
2. Tools were only utilized for their intended uses.
3. To hold the workpiece firmly during drilling and cutting operations, clamps and vices are used.
4. Measurement errors caused by parallax were avoided.
5. Always use the appropriate personal protective equipment (PPE) and safety gear while doing activities.
6. Emery paper was used to smooth down sharp edges and uneven surfaces.
7. The electric arc welding equipment was assembled with bolts, nuts, and screws securely fastened.

Conclusion, Restrictions, and Suggestions of Chapter 5

We had a number of difficulties throughout this assignment that put my ability to solve problems and comprehend technical concepts to the test. But we were able to get beyond these challenges with the help of in-depth study and insightful advice from subject-matter specialists. We would like to provide the following suggestions in order to enhance the efficiency and design of electric arc welding equipment, based on the information and experience gained throughout this project:

5.1. FINALLY

This project's main goal, to use locally accessible resources to create an electric arc welding equipment for the resources and Metallurgical Engineering department, was accomplished. This experience emphasized the value of practical skills in engineering school while also deepening our awareness of the intricacies involved in welding machine design. Future initiatives in the fields of welding technology and engineering in general will surely benefit from the knowledge gathered from this study.

5.2. RESTRICTIONS

Designing and constructing a dependable and effective welding machine requires sourcing premium parts for the transformer, lamination, and cooling systems. This endeavor, however, may be quite difficult, especially if there are limited financial resources available.

A careful selection of high-quality components is necessary for the transformer, which is essential for stepping down or up the voltage to the necessary level, in order to guarantee excellent performance and dependability. The efficiency, dependability, and lifetime of the machine may be greatly impacted by the selection of insulating materials, winding arrangement, and transformer core material.

In a similar vein, exact control over the material quality, thickness, and dimensional tolerances is necessary throughout the lamination process, which entails joining many layers of metal sheets to create the transformer core. Any changes to these values may result in higher core losses, decreased magnetic permeability, and hampered machine performance.

High-quality parts including fans, heat sinks, and ducting materials are also required for the cooling system, which dissipates heat produced during the welding process. Overheating, shortened machine life, and poor weld quality may all be caused by inadequate cooling.

Purchasing reasonably priced yet dependable components is essential since low-quality or low-cost substitutes might have serious repercussions. Using inferior components may result in:

Increased downtime and decreased machine dependability
decreased product longevity and compromised weld quality
Costlier upkeep and repairs
Reduced safety for operators and possible liability hazards

As a result, choosing high-quality components must be given first priority, even if doing so results in higher initial expenses. Manufacturers and engineers may guarantee the creation of dependable, effective, and secure welding equipment that satisfies performance requirements and offers consumers long-term value by doing this.

5.3. ADVICE

i. Early and thorough exposure to real-world design and manufacturing applications is essential for engineering students. Students will get a deeper comprehension of engineering principles by combining academic knowledge with practical practice. In addition to improving their technical proficiency, this strategy will encourage originality and creativity in their problem-solving. In order to prepare students for future employment in the industry, educational institutions should think about introducing seminars, internships, and group projects that let students work on real-world engineering difficulties.

ii. We advise using a larger number of turns in the transformer winding to improve the performance of electric arc welding equipment. The transformer's output power may be greatly increased by increasing the number of turns, which will enhance welding efficiency. In the end, this modification may produce stronger and more dependable welds by improving penetration of the welding material and creating a more steady arc. To guarantee the best possible performance of the welding equipment, engineers and designers should give this factor top priority throughout the design stage.

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