DESIGN AND CONSTRUCTION OF AN ELECTRIC OVEN FOR BAKING OF 230V, 1000W

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A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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DEDICATION

I dedicate this project to Almighty God, My Mummy, My Brothers, Mr. Nwachi Ogbonna and Sheikh Idris Nwachi.

Declaration

I Nwachi Agha, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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Acknowledgement

All praise is due to Allah, Lord of the whole Universe who granted me favour to start this program and by His grace has brought it to an end. Without God we cannot make it, but with Him all things are possible.

I would like to express my deepest gratitude to my brother, Mr. Nwachi Ogbonna who all my life has being striving hard to give us the best. For his patience, encouragement and excellent advice he is always giving me. My gratitude also goes to my beloved Mummy, Mrs. Ugwama Nwachi and my brother, Sheikh Idris Nwachi.

I would also like to extend my gratitude to my entire family, the Nwachi family for all their relentless sacrificial effort praying and labouring in one way or the other with their moral advice to see my successful completion of this program.

My sincere gratitude also goes to my project supervisor Prof. Oria Usifo for his fatherly advice and guidance throughout this project work.

My appreciation is also directed to my friends, Dalhatu Njidda, Kasim Nasiru, Kasim Oloje and Abdul Qadri Ndatsu. I love you all.

ABSTRACT

This project is to design and construct an electric oven for baking of 230volts with power consumption of 1000watts.

This unit is capable of baking fast foods and other kinds of foods without the food necessarily coming into direct contact with the source of heat. Such foods like bread, variety of cakes, meat, and their likes can be baked or cooked as a result of the heat content of the oven which is generated at high temperature by the thermostatically controlled heating element.

Thus, this electric oven is constructed from local materials obtained from our market. This unit has also been tested and found to be effective and functioning according to the designed specifications and is capable of withstanding the test of its foreign equivalent favourably.

Consequently, the low cost of producing this oven gives it a striking advantage over the foreign ones.

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CHAPTER ONE

INTRODUCTION

In the dark ages before now, man has always cooked his foods either by bringing the food into direct contact with the source of heat or by cooking it in hot water or oil in a container directly in contact with the source of heat. Hence, these methods have always proved effective.

However, man has sought for a neater, more convenient, faster, economical and more hygienic way of cooking his foods. To this margin, he has decided to find a means of generating and conserving heat in a controlled manner. It is for this concept that in our modern world, efficient electric ovens for baking are being produced to meet the recent demand.

Nevertheless, the modern electric ovens are indeed simple to operate and maintained but are however expensive and may have limit of operation or applications since it cannot be operated in an environment where there is no electricity. Consequently, this project is meant to design and construct an electric oven for baking of 1000Watts and 230Volts which is cheaper than the one obtainable in the market but to meet the designed specification of the ones in the market in which foods such as bread, cakes, pies and their likes can be baked at predetermined selected temperature ranges.

It is kept in mind that different foods may require different temperature to be baked; So in this design, the heat source is the application of current through a high resistance element which produces heat energy in accordance to Watts law; $P = IV\cos\theta$. But since it is a resistive load, therefore the current and the voltage are in phase i.e $\theta = 0$ and $\cos\theta = 1$, therefore $P = IV$. Where V is the applied voltage and I is the current. Also

from ohm's law, R = V/I, where R is the resistance of the element. The total heat energy produced is not fully used in baking due to heat loss by conduction, convection, and radiation. Hence to minimise this, lagging materials are used to keep the temperature at pre-set value. Since the temperature required to bake one type of food differs from the other, this implies that a temperature regulating device known as thermostat is incorporated in the electric oven. Thus this will cut off the power supply when the temperature of the oven has reached the pre-set value; and will also automatically switch ON when this temperature falls a little bellow the pre-set value.

An electric oven being a chamber of an enclosed compartment for heating and baking of foods is constructed from different local materials obtained from the local market and these materials are relatively cheaper than the ones in the ones in the modern market. These local materials are used in the construction of the cabinet, which is housing the heating element.

1.1 OBJECTIVES

- The major objective of the electric ovens is to bake foods which must not come into direct contact with the source of heat and this must be done at a preset temperature.
- Another objective of the electric oven is to achieve uniform flow of heated air for baking of our foods.
- For energy efficiency, selection and continues signal indicating desired baking temperature.
- To achieve or make a difference in the taste of foods which might vary a little.

1.2 METHODOLOGY

An electric oven being a chamber of enclosed compartment for baking of foods is being made from different local materials obtained from our local market. These local materials are used in the construction of the cabinet, which is housing the heating element.

This heating element generates heat which is being used by the oven for the baking of foods. Current flows through the wire in the centre of the resistance element where the electrical energy is converted into heat energy. There is a thermostat used for regulating and controlling the temperature of the oven.

1.3 SCOPE

This project is meant to design and construct an electric oven for baking of 1000Watts, 230Volts and 50Hz to meet the designed specification of the ones in the market in which foods such as breads, cakes and their likes can be baked at preset temperature range.

CHAPTER TWO

LITERATURE REVIEW

2.1 THE SCOPE OF THERMAL INSULATION

The early man during the Dark Age realised that the conservation of heat energy was effected by using insulators. However, he did not assign any name or give any designed technical functions for it. This he achieved by wrapping himself with clothes whenever it rained thereby finding the relationship between the quantity of heat flow and the number of clothes he wrapped.

The insulator was used for two purposes by the early man;

a) For temperature control.

b) For heat energy conservation.

In the progress of this achievement with time, man started using insulating materials to build for himself comfortable environment during the cold season; because he discovered that if fire was made and heat energy so produced is controlled and preserved, will stay for a long period to comfort him. He also used the heat energy produced by the fire to warm and cook his food by bringing the food in a container in direct contact with the fire.

In this present dispensation, the activities have remained, but with modifications due to the progress in the side of technological growth and advancement. Insulation was one of the early man's achievements; however he discovered that he has to consider some factors before choosing any material for use as an insulator.

This is because when a material is combustible, it cannot come in direct contact with fire. There are some materials he used for shelter which have to be kept far away

from the fire. Such materials included woods and leaves. This shows that he learned and was conscious of the temperature limits and combustion tendencies of his insulators.

Consequently, he was selective and careful as to which material he will depend upon for a particular range of heat to be preserved since a single particular material was not suitable as an insulator for all applications. But modern food ovens have no smoke and the risk of possible fire outbreak is much reduced.

2.2 PROCESS OF HEAT GENERATION

Apart from other ways of heat production such as burning of fuels like coal, woods, kerosene, liquefied petroleum gas, the heating effect of electric current is another way and for obvious reasons, it is ideal to have chosen the heating effect of electric current on a resistance element as the method of heat production which emphasis will be laid on.

2.3 PRINCIPLE OF HEAT PRODUCTION USING A RESISTANCE ELEMENT

Electric energy is converted into heat energy whenever an electric current flows through a resistance element. This is because the flow of electric current gives rise to production of heat, so many electrical appliances when connected to power supply produces heat, example electric stove, electric soldering iron and electric iron just to mention but a few. Hence, this heating effect can be used in our food ovens to bake our foods.

For instance, if a current of I(amps) flows through a resistance element of R (ohms) for a time t (seconds), then the heat energy produced is $I^2 R / t$ (Joules). But in

most heating equipment, all the heat produced is not usefully employed; some are lost due to surrounding or is used to heat the container's body and as a result, the efficiency of the heating equipment is less than 100%. Using Ohm's law, $R = {}^{V}/_{I}$, and James watt law says $P = IV$. From this James watt law, one can now determine the power injected into the oven with all the parameters as defined earlier.

2.4 TYPES OF RESISTANCE HEATING ELEMENT

Already we know that many domestic electric appliances have heating elements such as kettle, laundry Iron, room heaters / warmers etc. It is important that such elements must not come into contact with their encasements to avoid the danger of short circuit or earthing which might result to electric shock to the user.

The materials used in producing these heating elements includes nickel base alloys, copper mangaro alloys, copper - nickel, zinc alloy, (nickel silver) etc. But alloys used for electrical heating elements must be adapted for continues use of atmospheric environment.

Some times at about 1000^{0}c or above, these alloys must also show good processibility i.e. capable of being drawn into flexible allies. The various manner of shaping the elements for various applications are as follows:

a.) Coil element

A coil heating element consists of a long section of Nichrome wire and is used mainly in places where there is little chance that any one will accidentally touch. It is commonly, placed in the grill work of a space heater or inside an electric dryer.

b.) Tabular or carlod element

The principle of operation is the same as that of the coil element. The tabular heaters are electrically safe and are commonly used in electrical cooking appliances. They are manufactured in several steps; first spiral wound nichrome resistance wire is impacted in magnesium oxide. The wire is then encased in a nickel steel alloy sheaths.

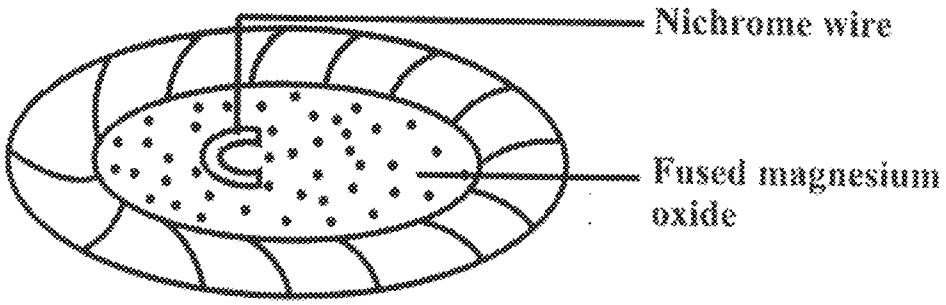

Fig.2.1 cut away view of a tabular heating element

c.) Flat surface heating element

Like tabular element this use Nichrome wire as their primary source of heat. flat surface units made of Nichrome wire coils cemented into cast iron cooking surfaces are more common likewise units using a ceramic base instead of metal are introduced.

d.) Double spiral element

This is of two spiral elements with a double spiral shape as shown in the fig 2 below.

They are used in modern switch-heat surface unit, the two elements can have the same power rating but the inner one normally has a smaller power rating.

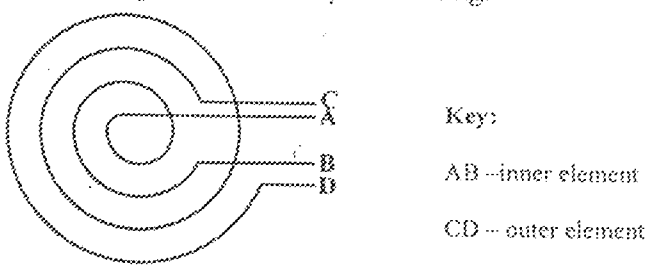

Fig.2.2 Double spiral element

2.4.1 Types of housing for various heating element

Heating elements normally consist of one or more resistance wire enclosed in an overall heat conducting material but insulated by mica- asbestos, poxalin magnese oxide, (a white chalky substance).

The method of insulation depends on the type of heat production being used on daily basis. The electric oven in particular happened to be an example as well as a laundry iron, electric toaster, food warmers etc.

Some of the common encasements used are:

a.) Porcelain: Spirally heating elements can be placed inside the grave of porcelain moulded plate design for the oven.

b.) Fire clay slab: Here the spirally wound element made of Nichrome wire of hot plate is embedded in between two fire clay but has the disadvantage of being easily broken.

c.) Chrome iron: In this case the heating element is placed or inserted in a chromed or brass pipe and are commonly used in immersion watts heater, kettles etc.

There is always insulation around the elements so that it might not come in contact with the pipe to prevent fatal electric shock to users.

2.4.2 Types of arrangement of heating element

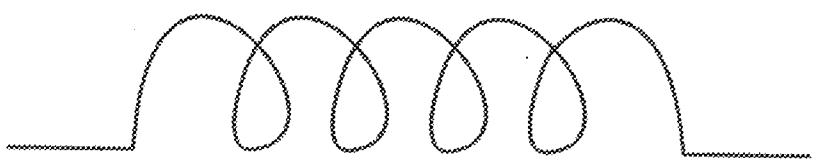

Fig. 2.3 Single coil type

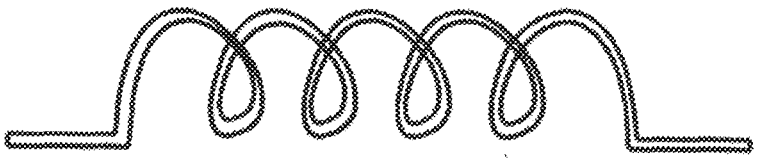

Fig. 2.4 Coiled-coil type (double)

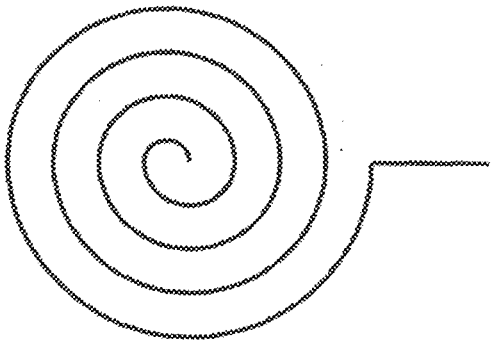

Fig. 2.5 Spiral type

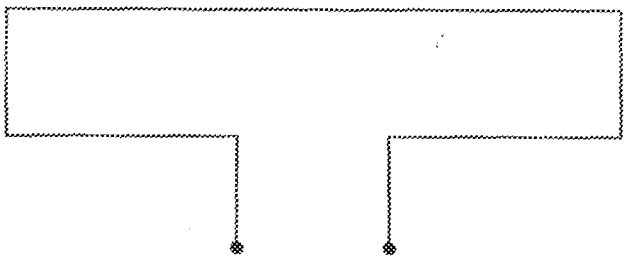

Fig. 2.6 Span type

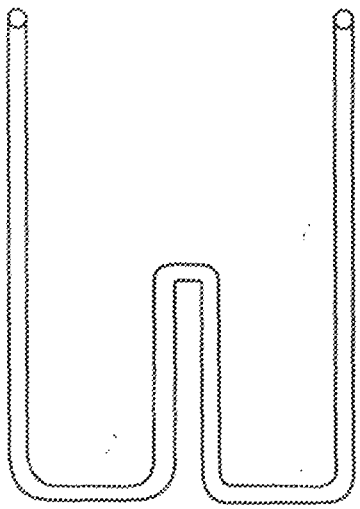

Fig.2.7 Fork type

2.5 CHOICE OF HEATING ELEMENT

We have known the various types f heating elements i.e. types of material used for making the heating element and how the elements are enclosed. The heat requirement then determines the type of element we shall use.

In the construction of the oven, the Fork type element is better used since the construction of the oven is such a way that the heat produced should be sufficient enough to bake whatever is put in the oven. And the Fork type element occupies a large space; consequently, the heat produced is evenly distributed within the oven.

2.6 HEAT TRANSFER PRINCIPLES

Heat is a form of energy and is due to the motion of molecules which all substances are composed. The effect of adding the heat is simply to increase the speed at which its molecules move and hence their energy.

2.7 HOW ELECTRIC OVEN HEATS

Any wire carrying current becomes warm because of the energy of motion of electrons. As electrons move through the conductor, some collide with atoms to give up a proton of their energy which makes it self apparent as heat.

Some conductors are so designed to keep heat losses minimum such as underground and distribution cables, while others are design to generate heat. These ones that generate heat are often coiled to some length to form heating elements when mounted on suitable refractory supports.

The heat so generated by these heating elements is transferred in three ways viz:

a.) Conduction: This is the transfer of heat from one place to the other through a material as a medium by the vibrational motion of the molecules of the material.

b.) Convection: Convection is a way of heat transfer through gases or air as a medium. In this method of heat transfer, the hotter air raises upwards while the cold air goes down to be heated by the heat from the heating source.

c.) Thermal radiation: This is heat transfer without a material medium. In this method heat travels as electromagnetic waves which can occur in a total vacuum as well as in a medium. Radiated heat transfer is proportional to the fourth power of the absolute temperature, where as conduction and convection is proportional to the linear temperature difference.

But in nature, all the three are combined in any basic process of heat transfer as electric ovens are no exception ass due consideration will be given at the design stages.

2.8 THERMAL EXPANSION

Matter is made up of molecules and when these molecules gain kinetic energy due to heating effect, they vibrate and the distance between the molecules will increase this causes expansion. Any increase in temperature, increases the average separation of the molecules consequently the volume, area, and length of the material will also increase with any increase in its body's temperature.

The expansivity of solid is less than that of a liquid. In solid the molecules are close parked and there is attraction between them, but in liquid there are little spaces between the molecules with only a little attraction, more so the molecules of a liquid can vibrate easier than that of a solid. So the expansion of the liquid is more than that of the solid.

The fractional increase are presented by

$$\frac{\Delta V}{V} = Y\Delta T \qquad \text{..... (i)}$$

$$\frac{\Delta A}{A} = B\Delta T$$

$$\frac{\Delta L}{L} = \Delta T$$

The quantities Y, B and A are known as the Volume, Area and Linear thermal expansion coefficients respectively. Where Δ is equal to the change, V is the volume, L is the length and 'A' is the area to be measured at 20^{0} when Y and A are used. The table below gives more details.

Table 2.1 Thermal expansion of different metals

SN	SUBSTANCE	X10 $^{-5}$	YX10 $^{-5}$
1	DIAMOND	1.2	3.5
2	HEAT RESISTING GLASS	3	9
3	GLASS SOFT	9	27
4	CONCRETE	10	30
5	IRON	12	36
6	BRASS	19	57
7	ALLUMINIUM	25	75
8	MERCURY	80	182
9	RUBBER	-	240
10	CLYCOIN	-	500
11	GASOLINE	-	950
12	BENZENE	-	1240
13	ACETONE	-	1490

CHAPTER THREE

DESIGN, CONSTRUCTION AND OPERATION OF OVEN

The electric Oven is designed to operate at 230V, 50Hz and 1000W but due to losses, this supply sometimes may fall between 220V and 230V which is still adequate for the successful operation of the Oven.

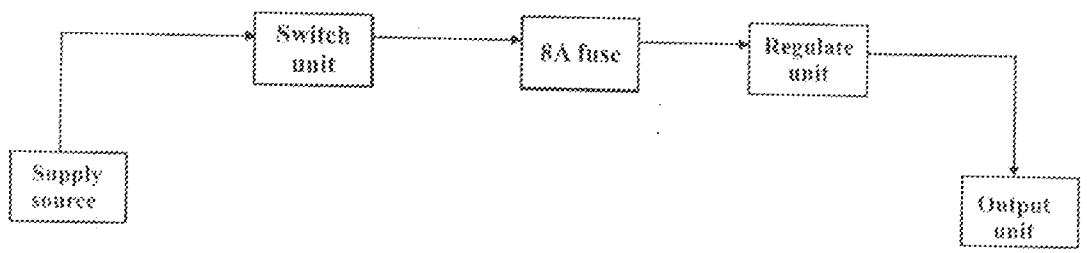

Fig. 3.1 block diagram of an electric oven

3.1 CALCULATIONS

3.1.1 Design of heating element

The design is based on a voltage of 230 volts with power consumption of 1000 watts. From equation of power consumption (i.e James Watt's Law), we have that

$$P = IV \qquad \text{(3.1)}$$

Where,

P = Power consumption in watts (w)

V = Voltage in volt (v)

I = Current in ampere (A)

From equation (3.1), we would have:

$$I = \frac{P}{V} \qquad \text{(3.2)}$$

Substituting the values into equation (3.2) above, we have;

$$I = \frac{1000}{230} = \quad 4.35A$$

This implies that the current (I) of the heating element is 4.35Amperes.

Thus, the resistance of the heating element can be obtained from the relationship below.

From ohm's law, we have that;

$$V = IR \qquad \text{..... (3.3)}$$

Where

I and V are as defined above.

R is the resistance of the heating element.

V = 230Volts

I = 4.35Amps

Hence, from equation (3.3) we would have that;

$$R = \frac{V}{I} \qquad \text{..... (3.4)}$$

If we substitute the values into equation (3.4), we would have;

$$R = \frac{230}{4.35} = 52.9\Omega$$

Therefore, resistance of the heating element is 52.9 Ohms.

Design data

Voltage = 230V

Wattage = 1000W

Current = 4.35A

Resistance = 52.9Ω

Considering the 40Watts lamp for visualizing what is being baked, we would have;

$$I = \frac{40}{230} \quad = 0.174A$$

Thus, the total current of the electric oven is;

$I_{Total} = 4.35 + 0.174$

$I_{Total} = 4.524A$

3.1.2 Law of electric heating

The law of electric heating is known as Joules law given by the equation:

$$H = I^2RT \text{ joules} \quad \text{----------} \quad (3.5)$$

Where,

H = Heat

R = Resistance

I = Current

T = Time

The heat, H could be expressed as VIt, ωt and $\frac{V^2t}{R}$ joules. Where V is the voltage, I and R are as defined above and t is time in seconds.

The mechanical equivalent of the heat produced can be expressed in calories.

Therefore, 1 calories = 4.2 joules

Hence, $$H = \frac{I^2RT}{4.2} \quad \text{----------} \quad (3.6)$$

3.1.3 The efficiency of the oven

The efficiency of the oven can be given as:

$$\eta = \frac{W}{W + A + B + C + D} \quad \text{----------} \quad (3.7)$$

Where,

A = heat used in raising temperature of the oven.

B = heat used in raising temperature of container in calories

C = Conduction of heat through walls.

D = escape of heat due to opening of door.

The heat required to raise the temperature of the oven element W, can be obtained by the formula,

$$W = M \times S \times (T_2 - T_1) \quad \text{..... (3.8)}$$

Where,

M = mass

S = specific heat capacity

T_2-T_1 = change in temperature.

It should be noted however that this loss occurs only when the oven has cooled down and it would remain constant so long as the temperature of the oven does not change.

Heat used in raising the temperature of containers is usually calculated in exactly the same way as the oven.

$$\text{Heat loss (through walls)} = \frac{KA}{t}(T_1\text{-}T_2)\ W/M^{\circ}C \quad \text{..... (3.9)}$$

Where,

t = thickness of walls in (M)

A = area of walls in (M^2)

T_1 & T_2 = inside and outside temperature respectively.

K = thermal conductivity

Heat loss due to opening of the door is difficult to calculate in that it depends on the operator. However, the door is usually not left opened for too long.

Hence, the relationship of the heat produced electrically, the heat absorbed mechanically and useful heat can be expressed as shown below:

$$\frac{VIt}{J \times \eta} = M \times S \times (T_2 - T_1) \quad \text{..... (3.10)}$$

i.e. Electrical heat energy converted = Absorbed useful mechanical to mechanical energy from energy converted into heat energy heating element.

Where,

V = voltage in volts

I = Current in amperes

J = joules

η = efficiency

M = mass of substance

S = specific heat in ($J/g^{o}c$)

T = temperature in ^{o}c.

3.1.4 Resistivity and thermal properties of some materials

The table below shows the resistivity and thermal properties of some materials.

Table 3.1 Resistivity and thermal properties of some materials

MATERIALS	RESISTIVITY ρ at $20^{o}C n\Omega^{m}$ -m	THERMAL SPECIFIC HEAT J/kg ^{o}C	PROPERTIES THERMAL CONDUCTIVITY $W/m^{o}C$	MELTING POINTS ^{o}C
Aluminium	28.3	960	.218	660
Constantan	500	410	22.6	11190
Copper	17.24	380	394	1080
Gold	24.4	130	296	1083
Iron	101	420	79.4	1535
Nichrome	1108	430	11.2	1400
Tungsten	55.1	140	20	3410
Nickel	85.4	460	90	1455
Silver	16.2	230	408	960
Air	-	994	0.024	-
Pure H_2O	$2.6x10^{+3}$	4180	0.58	0.0

3.2 DESIGN REQUIREMENT

A good design of an electric oven should have the following:

a.) It should be able to provide adequate temperature uniformly throughout the oven.

b.) There should be a suitable temperature range.

c.) The temperature control should be reliable and there should be effective insulation against heat loss.

d.) There should be an accurate time which guards the oven.

e.) It should be easy to operate and maintain

3.2.1 Dimensions of the oven

The dimensions of the oven were chosen, taken into consideration the size of the dough, number of dough to be baked at a time. Hence, this oven can bake a very large number of cake or pie at a given time.

Outside dimension of oven

L_o = length = 91cm

W_o = width = 61cm

H_o = height = 91cm

A lagging space of 2.5 inches was made on all sides of the oven to prevent heat loss. The dimensions of the baking compartment are:

Length = 88.5cm

Width = 58.5cm

Height = 88.5cm

The volume of the oven (baking compartment) was calculated to be:

Volume = length × width × height

$= (88.5 \times 58.5 \times 88.5)\ cm^3$

$= 458186.625\ cm^3$

Table 3.2 Cost of materials / accessories

S/N	ITEM	QUANTITY	SPECIFICATION	COST (₦)
1	Heating Element	1	1000W	1000
2	Thermostat	1		400
3	Control Switch	1		100
4	Fuse	1	5A	60
5	Indicator lamp	2	250V	300
6	40 watt lamp	1	40W	50
7	Cable (twin)	2.0m	$2.5mm^2$	100
8	3 Pin Plug	1	13A	150
9	21" × 11" Heat resistance Glass	1		500
10	Glass fibre	Lot		4,000
11	17 feet Mild steel square 1x1 pipes	4	Black	3,400
12	Steel 4x8	4		16,000
13	Accessories e.g. (plugs, screws, etc)	Lot		200
14	Painting			1000
15	Grill (trail)	Half Sheet		1,500
16	1 inch angle Iron	1		950
17	17 feet ¼ square pipe	3		1,800

3.2.2 Design of the cabinet

The cabinet which provides both the outer and inner walls has a structural frame made of mild steel of 2x2 pipes and a rectangular shape box measuring 3 × 2 × 3 feet in dimension.

The cabinet consist of two iron trays known as the grill; one heating element, one thermostat, two indicator lamps, a 40w lamp to brighten the inner chambers and connecting wires. The galvanized mild steel is used because of its strength proportion. It has a strength limit of 280 N/MM^2, field strength of 480 N/MM^2 and has a resistance to corrosion. It conserves the internally generated heat thereby making the heat more available within the oven.

The construction has available features which include automatic oven lighting. There is one door with heat resistance glass for vision.

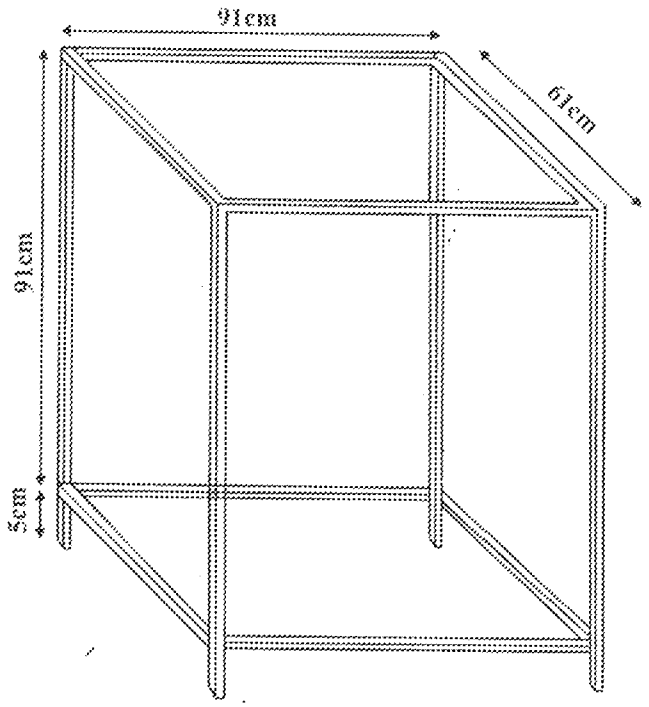

Fig. 3.2 Frame structure

The frame fractures are used in order to provide support and also provide space in between the walls where the insulating material could be placed effectively. The steel is used to cover the frame structure internally and externally, thereby creating a hollow space between them, where the insulating material is placed.

Also, a provision of about 13cm is created by the side of the oven. With this design, the control switch, all the wiring, the switch for the 40W bulb, pilot lamps are placed.

Also, this protruding provision made for the electrical installations gives the oven a befitting shape. See diagram below.

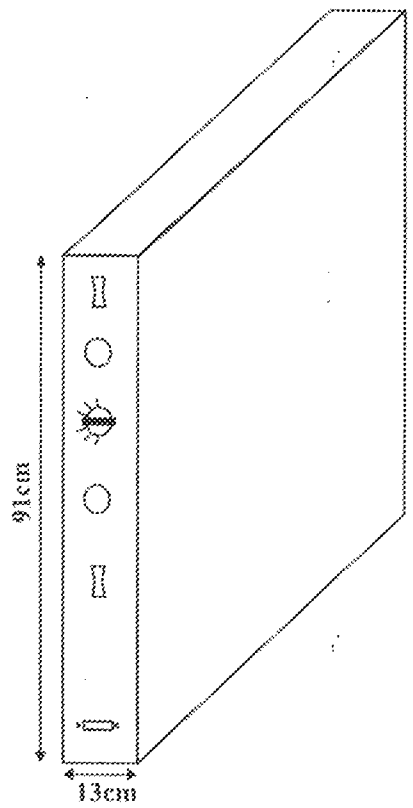

Fig. 3.3 The protruding structure for electrical installations

3.2.3 The door

The door is also made of steel with an opening in the middle where the transparent heat resistance glass is fixed for visualising what is being baked. The door has a

dimension of 68 × 75cm. The space surrounding the glass is properly insulated against heat loss. The door also has a handle for opening and closing of the door.

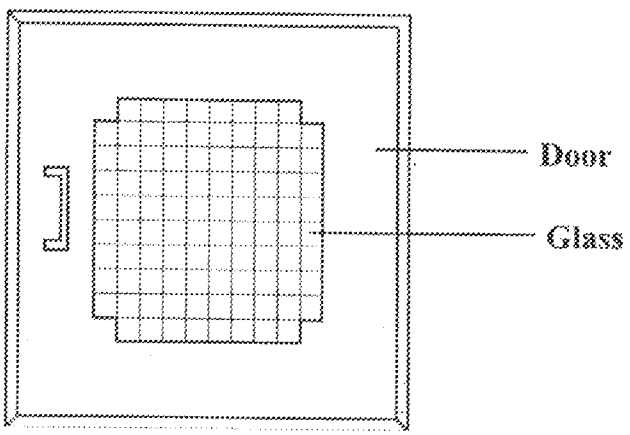

Fig. 3 4 the door

3.2.4 Selection of materials

A number of important factors were considered when selecting the materials for the construction of the oven. They are considered in terms of environment to which the oven is subjected to during its service life time and these can be classified as follows.

a.) External influence (e.g. temperature magnitude and type of loading).

b.) Corrosive atmosphere.

c.) Wear out.

Other factors influencing the behaviour of materials are stream ducting, toughness, stiffness etc.

3.2.5 Shape and size

The oven was designed and constructed in such a way to be portable for easy transportation and handling. Hence, the major objective of the oven is to bake foods which must or may not come in direct contact with the source of heat and should be done at a predetermined temperature.

3.3 INSULATION

Poor conducting materials such as wood, cotton fibre, glass fibre, paper, cork etc can be used as insulating materials to prevent heat loss by transferring heat between bodies. The heat produced in the oven is meant to be retained in the inner casing therefore some insulating materials are needed to resist heat radiation.

3.3.1 Choice of insulating material for the oven

With due consideration of the thermal characteristics of the insulating material which were mentioned earlier and the level of heat range with the oven, wood particle board and aluminium foils was used as the insulating materials.

It is a material of low thermal conductivity used for prevention of heat loss which is referred to as lagging materials.

3.3.2 Insulating the oven

The conduction of heat through the walls of the oven was reduced by constructing the oven with double walls. The space between the walls is packed with heat insulating materials (wood particle board and aluminium foils). These substances are not only poor conductors of heat but have the characteristics of being non inflammable. Thus any material of low thermal conductivity used for the purpose of preventing heat loss is called lagging material.

Note: The oven has two types of heat insulation:

a.) The wood particle board: To prevent heat loss by Conduction and Convention.

b.) The Aluminium foils: To prevent heat loss by Radiation.

3.3.3 Installation of the element

The heating element is placed on the bottom side of the oven. The bottom side was chosen to house the heating element due to the fact that heated air will move upward

because it is less dense while the cold air will move downwards due to convection current set up. This process of placing the element on the bottom of the oven is also used in room heaters. See the diagram below

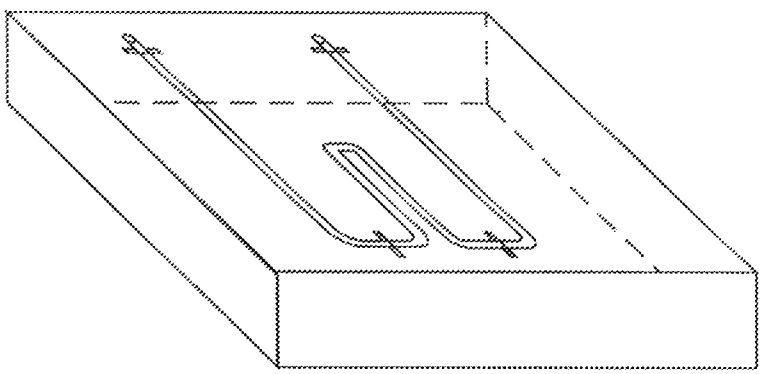

Fig. 3.5 heating element inside the oven

3.3.4 The grills

The oven has grills that divide the inside into three chambers. The grills are used as the floors to place the food that is to be baked and the plate that conceals the element also can be used as a floor to place the food that is to be baked.

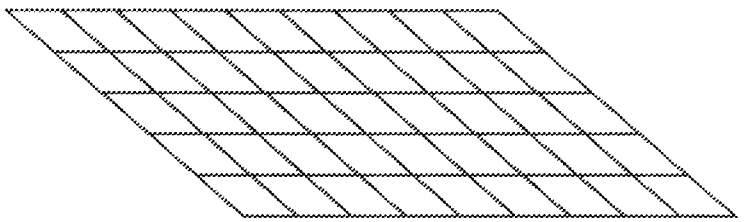

Fig. 3.6 The grill

3.3.5 Painting

The oven is painted with two colours i.e. white vitreous enamel is used for the interiors while black is used for the exteriors. Also, the white vitreous enamel is also used for the door and the entire front view and the top of the oven.

White was used for the interiors due to the fact that white surfaces or shining surfaces are good reflectors and poor emitters. While dull or black surfaces are good protectors.

Below are two sketches of the complete oven.

a.) With the door opened and one of the side views to show the manner of installation with all dimensions indicated.

b.) With the door closed to show the transparent heat resistance glass and the complete outlook of the electric oven.

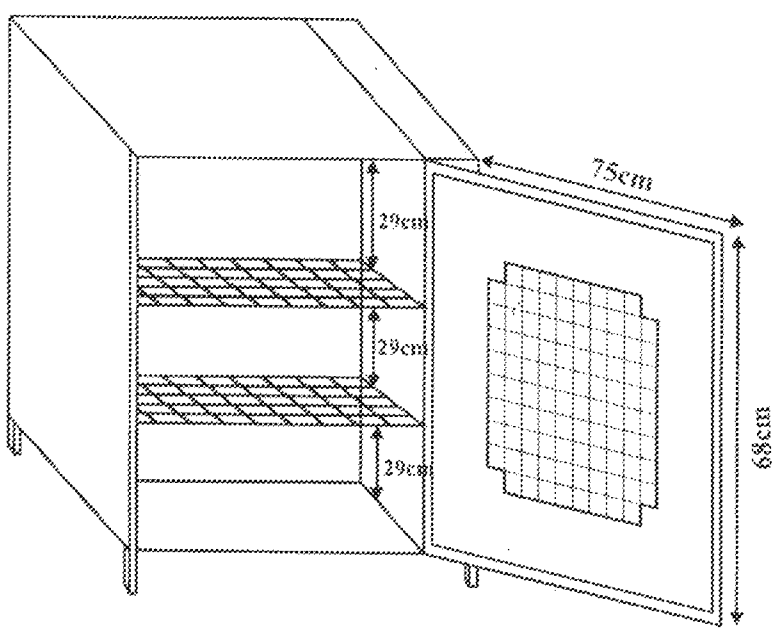

Fig. 3.7(a) complete outlook of the electric controlled oven with the door opened

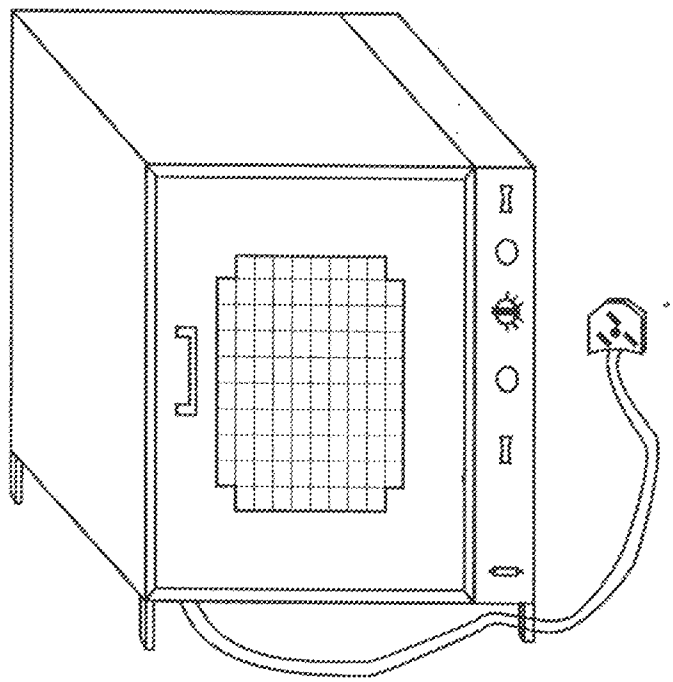

Fig. 3.7(b) complete outlook of the electric controlled oven with the door closed

3.4 THE CONTROL SYSTEM

When heat is produced by the element, it has to be regulated to suit the heat requirement of the oven. This can be achieved by the voltage control to the element. Therefore, the control devices are used to ensure the safety of the oven and to protect the food to be baked from burning.

3.4.1 The switch

This controls the incoming supply to the oven by putting the power supply ON or OFF when ever desired.

3.4.2 The fuse

This cut off the supply on the occasion of short circuit or over current which might flow through the circuit. Hence, it protects the circuit from damage.

3.4.3 The thermostat

This is a temperature operated device used to control heating equipment so that the required temperature is maintained. This forms the most important part of the control of the oven.

The temperature sensing device is like a bulb which contains volatile liquid connected to the bellows by means of a capillary tube. The boiling point of the liquid depends on the pressure acting on it. So if the temperature rises, the liquid evaporates; thus rising the pressure of the system until a state of equilibrium is reached (i.e until the pressure is such as to make the boiling point of the liquid equal the temperature.

The variation in pressure causes the movement of the bellows which is being used to operate switch. The advantage of this type of thermostat is that the temperature sensing part is situated inside the oven for accurate sensing and rating of temperature.

3.5 OPERATION OF THE OVEN

The oven uses an electric heating element to generate heat. Current flows through the wire in the centre of the resistance element, where the electrical energy is converted into heat energy. The heat is conducted through the insulator that surrounds the resistance element, into the metal jacket, then to the surrounding air.

The electric oven is controlled by a thermostat; when it is switched ON, the temperature sensing device then operates the thermostat, this cut off supply to the heating element and the temperature begins to fall. When the temperature has fallen sufficiently, the temperature sensing device commands the thermostat to close again and supplies the heating element with power. These cycles of events continues provided that the oven OFF and ON switch remain permanently ON.

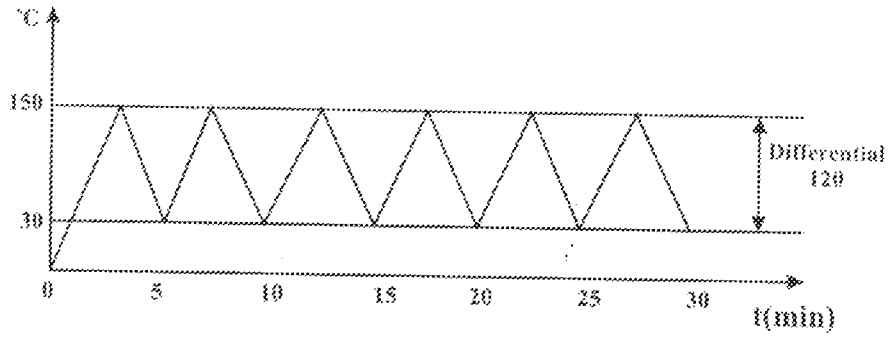

Fig 3.8 temperature – time relationship of a thermostatically controlled oven

From the graph, it can be seen that the temperature is not held constant. It fluctuates between two levels.

The difference between the levels is called the differential of the thermostat. If the difference becomes too large, then the temperature is not controlled with sufficient accuracy. On the other hand, small difference causes the frequent operation of the switch which causes wear out of the contacts of the thermostat. So it is advisable to make the differential moderate.

Below is the circuit diagram of the oven.

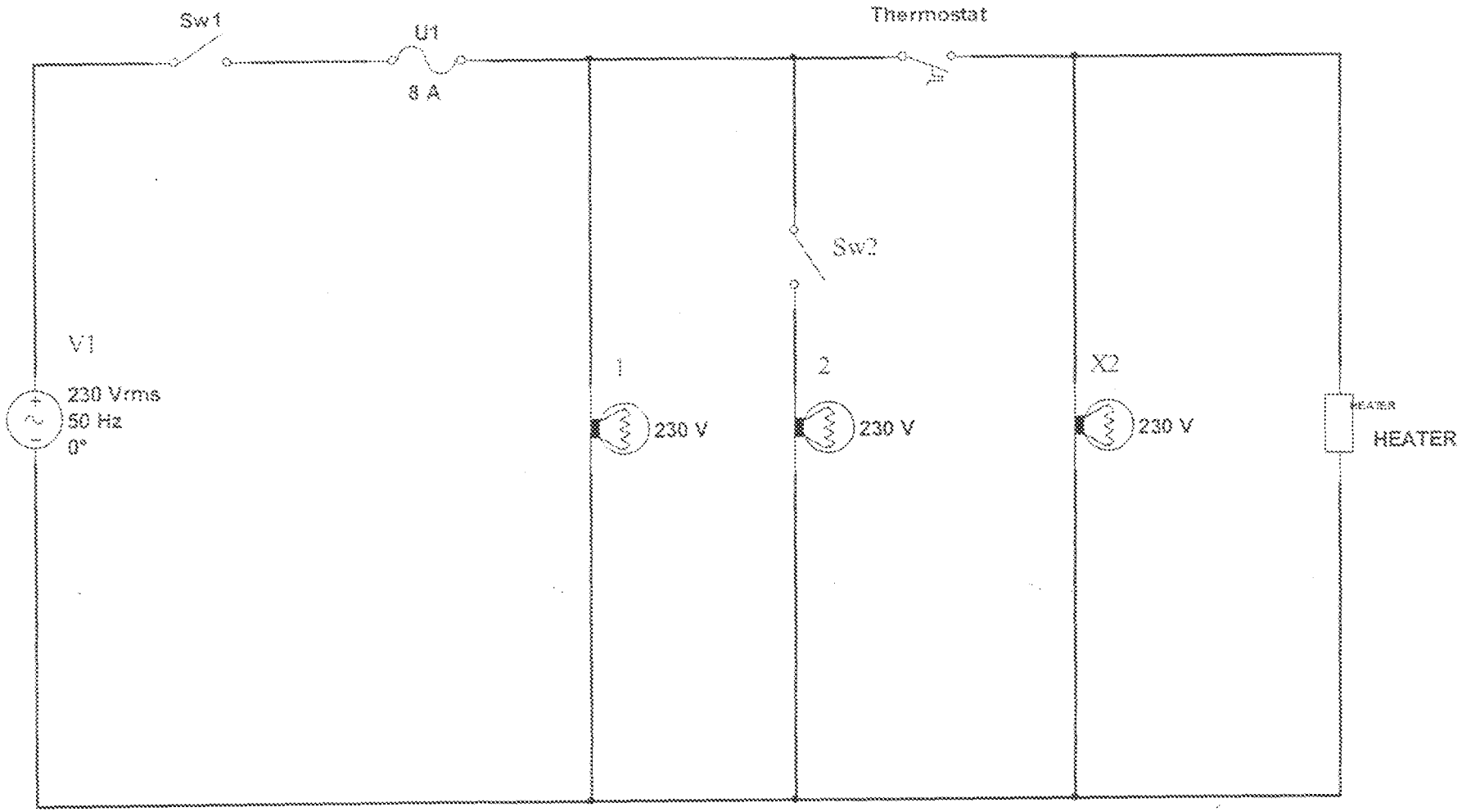

Fig. 3.9 Electric Oven Circuit Diagram

The figure above shows how the oven is connected starting from the power supply to the element. The power is taken to the element through an 8A fuse to protect the circuit. This is connected in series with the ON and OFF switch; from the switch the connection goes to the indicator lamp and to the 40watts lamp all connected in parallel, then to the thermostat connected in series. From the thermostat to the oven indicator lamp or pilot lamp connected in parallel, then finally to the heating element which connects to the neutral.

The installation is properly earthed at the necessary points.

CHAPTER FOUR

TESTING, RESULT, DISCUSSION AND MAINTENANCE

4.1 TESTING

The oven was tested and found to be suitable and effective for baking of foods, a 230V, 50Hz and 1000w was supplied to it and the control devices adjusted to vary the supply voltage and it was found to be working as designed to perform.

The following tests were carried out:

a.) Earth leakage test.

b.) Insulation resistance test.

c.) Continuity test.

4.2 RESULTS

During the testing, it was found that there is no leakage of current from the heating element to the general body of the oven which could result to electric shock to the user. While the continuity test shows that there is continuity between the corresponding circuits.

The oven was then powered but because the thermostat was tuned to the minimum, there was no response. However the power supply indicator lamp came ON showing that there is power supplied to the oven. When the thermostat was adjusted, it was found that at various temperature ranges, the oven operated satisfactorily. With the maximum temperature, the expansivity of the inner casing was calculated using the principle of expansion in chapter two.

The extra growth in dimension of material are quite small, therefore it is advisable that whenever the oven is not in use, it should be switched off.

Table 4.1 Test of voltage, temperature and time

VOLTAGE(volts)	TEMPERATURE °C	TIME (mins)
230	150	5
200	150	10
180	150	16
150	150	20
120	150	30
Less than 120	0	Infinity

When temperature is held constant at 150°C which is the highest temperature of the oven, and the voltage regulated to 230V, the time taken for the oven to get to 150°C will be 5mins. Also, when the voltage is adjusted to 200V, the time taken is increase to 10mins. And when regulated to 180V, it takes 16mins. To 150V, the time taken is 20mins. Thus, 120V being the lowest voltage, the electric controlled oven takes 30mins which is the highest time it can take the oven to attain a temperature of 150°C. Moreover, when voltage is regulated below 120V, the oven will automatically not operate under this condition.

Nevertheless, the above test shows that at a high voltage, the oven takes lesser time to generate a temperature sufficient enough for baking. While on the other hand, at lower voltage, it takes more time to generate sufficient temperature for baking.

4.3 DISCUSSION

The metal frame structure was welded to the inner part and the outer case was grooved to form a box as required in the design specification. The inner casing was

welded peripherally to the metal frame structure and the lagging material (wood particle board and aluminium foil) was glued to the back side by means of some adhesive.

The outer casing which is made of the same material as the inner casing (steel sheet) was fastened to cover the lagging materials and welded to the metal frame structure. The heating element was installed below the basement of the inner casing on the mild steel which is clipped to the basement.

At the right side part of the oven, the connections are made, where you have the thermostat firmly placed. The thermostat control knob is fixed in a position through an opening on the right part side of the oven. A red coloured light indicator to show the presence of power supply and a yellow coloured indicator light to indicate a working condition of the oven is also included on the control panel.

There is also an 8Amps fuse to protect the circuit and ON and OFF switch all included on the panel. Hence, there is a 40W lamp installed inside of the oven for vision. There is adequate precaution to prevent any live wire from coming in contact with the general metal structure and the supply cable was connected as seen in fig 3.7(b).

4.4 MAINTENANCE

Maintenance is the upkeep in good condition of an appliance to perform its designed function or it can be seen as putting equipment back to its operational standard.

4.4.1 Need for maintenance

It is important to maintain this electrical equipment so that it will keep fulfilling its designed functions and to be sure of its reliability.

Reliability is the characteristics of equipment expressed as the probability that it will perform a required function under stated conditions for a given period of time. To achieve this, the oven must be well maintained for the following objectives:

a.) To minimize breakdown.

b.) To prolong the life span of the oven.

c.) To increase or maintain its reliability.

d.) To reduce replacement of parts.

4.5 FAULTS

The common faults that can be found associating with the oven are;

a.) Open circuit.

b.) Short circuit: this can be caused by the thermostat failing to operate or welded switch contacts as a result of overheating.

Other faults that may occur in the electric controlled oven are as shown below with their causes and remedies.

Table 4.2 Symptoms, Causes and remedies associated with an oven

S/N	SYMPTOMS	CAUSES	REMEDY
1.	Appliance shocks the user continuously.	Earth leakage or short circuit.	Visually inspect and make test between conductors and earth, and between live and neutral.
2..	Appliance blows fuse or trips circuit breaker.	Same as above.	Same as above.
3.	Appliance as does not heat.	No input voltage or open circuit.	Test for supply voltage and test fuse.
4.	Appliance does not go off.	Faulty, thermostat or thermostat contact or switch contact shorted.	Test the switch and the thermostat.
5.	Indicator lamp goes off when ever control switch is turned ON.	The live conductor is destranded or partial contract on the terminal.	Visually inspect and check the mechanical contracts and electrical connections.
6.	Indicator lamp does not cycle ON and OFF.	Defective thermostat.	Test to see whether contacts are permanently opened or closed.

CHAPTER FIVE

CONCLUSION

The main aim of this project is to design and construct an electric oven for barking of 230V, 50Hz and 1000 Watts. In the previous chapters,

I have discussed on how an oven could be made using scrap materials while the heating element is used as means of heat production.

This element is placed below the basement of the casing; the thermostat and indicator lamps are all used. These are all moulted by the right hand side of the oven to provide easy control.

The lagging materials (wood particle board and aluminium foil) was chosen because it posses the quality of heat resistance and it lagged between the walls to prevent heat loss. The thickness of the lagging materials used also depends on the quantity of heat desired to be produced and conserved.

The purpose of the oven is to bake; therefore the heat produced must be at high temperature sufficient to bake the food inside it. The position where the heating element is installed provides even distribution of heat within the oven. Also maintenance of oven is simple since only few parts require servicing which can be dismantled and assembled easily.

The oven was tested and found to be highly suitable for baking.

It is also designed to operate on A.C single phase of 230V, 50Hz and 1000Watts but due to distribution losses, the voltage varies between 220V and 230V which is still adequate and suitable for the successful performance of the oven.

5.1 RECOMMENDATION

It is time for us to think of how we can make use of the scrap products of this country by converting them into items of good service to populace.

Let every profession think of the waste product around them and how they can convert them into items that can be useful to community. A variable project of this nature (i.e design and contraction of an electric oven) is a good example. It is recommended that the Electrical Engineering Department and the school authority should have a production section/Department which should be commercially oriented to carry out the production of this unit which is cheaper than the ones obtainable in the market. Since the materials used by students are locally available, it can therefore be produced easily.

By commercializing the project, the department and school authority in general can generate funds internally and become self sustained and will be able to offer better incentives to lecturers and other staff of the institution.

Hence, this will improve their financial stand. Thus, by this the school can generate revenue from the sales of these ovens.

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