1. ELECTROLYTIC PROCESS:

1.1 Definition and Basic principle of Electro Deposition:-

A: Electro deposition is the process of coating a thin layer of one metal on top of different metal to modify its surface properties. It is done to achieve the desire electrical and corrosion resistance reduce wear & friction, improve heat tolerance and for decoration.

Electroplating Basics:

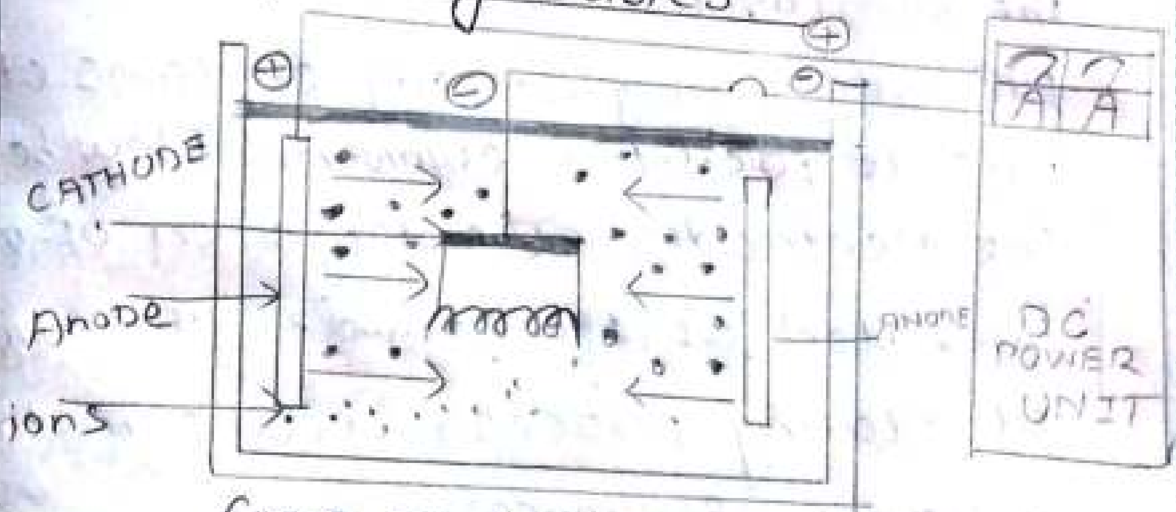


fig 1. Electrochemical plating

Figure-1, schematically illustrates a simple electrochemical plating system. The "electro" part of the system includes the voltage/current source and the electrodes, anode and cathode, immersed in the "chemical" part of the system, the electrolyte or plating bath, with the circuit being completed by the flow of ions from the plating bath to the electrodes. The metal to be deposited may be anode and be ionized and go into solution in the electrolyte, or come from anodes, while gold salts are usually added to the plating bath in a controlled process to maintain the composition of the bath. The plating bath generally contains other ions to facilitate current flow betn the electrodes. The deposition of metal takes place at the cathode. The over all plating process occurs in the following sequence:

1. power supply pumps electrons into the cathode.

2. An electron from the cathode transfers to a positively charged metal ion in the solution and the reduced metal plates on to the cathode.

3. Ionic conduction through the plating bath completes the circuit to the anode.
4. At the anode two different processes take place depending on whether the anode material is soluble, the source of the metal to be plated, or insoluble, inert. If the anode material is soluble, a metal atom gives up an electron and goes in to the solution as a positively charged metal ion replenishing the metal content of the plating bath. If the anode is inert a negatively charged ion from the plating bath gives up an electron to the anode.
5. The electron flows from the anode to the power supply completing the circuit. The deposition of metal at the cathode requires an electron so the rate of deposition depends on the flow of electrons that is, the current flowing from the rectifier. The thickness of the deposit, therefore, depends on the current and the length of time the current is applied. The relationship is a result of Faraday's law which relates the weight of a

Substance produced by an anode or cathode electrode reaction during electrolysis as being directly proportional to the quantity of electricity passed through the cell.

1.2 Faraday's Laws of Electrolysis:-

From his experiments, Faraday deduced two fundamental laws which govern the phenomenon of electrolysis. These are:

(i) First Law:-

The mass of ions liberated at an electrode is directly proportional to the quantity of electricity i.e. charge which passes through the electrolyte.

or

The weight of a substance liberated ~~at an~~ from an electrolyte in a given time is proportional to the quantity of electricity passing through the electrolyte.

That is $W \propto Q \propto It$, where I is the current and t is the time.

W = Zit

Where Z is a constant called electro-chemical equivalent.

If I = 1 ampere & T = one second then, Z = W, which gives a definition of Z.

The electro-chemical equivalent of a substance is the amount of that substance by weight liberated in unit time by unit current.

(ii) Second law :-

The masses of ions of different substances liberated by the same quantity of electricity are proportional to their chemical equivalent weights.

or

If the same current flows through several electrolytes, the weights of ions liberated are proportional to their chemical equivalents.

The chemical equivalent of a substance is the weight of the substance which can displace or combine with unit weight of hydrogen. Obviously, the chemical equivalent of hydrogen is 1 by definition.

1.4 Definition

1. Current Efficiency:-

On account of the impurities which cause secondary reactions, the quantity of a substance liberated is less than that calculated from Faraday's Law.

Current efficiency is the ratio of the actual mass of a substance liberated from an electrolyte by the passage of current to the theoretical mass liberated according to Faraday's law. current efficiency can be used in measuring electro deposition thickness on materials in electrolysis. Current efficiency is also known as faradic efficiency, faradic yield and columbic efficiency.

Energy Efficiency:-

On account of secondary reactions, the voltage actually required for the deposition or liberation of metal is higher than the theoretical value which increases the actual energy required.

Energy efficiency is defined as = $\frac{\text{theoretical energy}}{\text{actual energy required}}$

It is a process by which a metal is deposited over another metal or non-metal. Electro-plating is a very common example of such process.

1.5 Principle of Electro Deposition:-

(i) Current Density:-

At low values of current density the ions are released at a slow rate and the rate of growth of nuclei is more than the rate at which crystals grow and the rate ~~of~~ at which fresh nuclei are formed. Therefore, at low current densities the deposit will be coarse and crystalline in nature. At higher values of current density the quality of deposit becomes more uniform and fine-grained on account of the greater rate of formation of nuclei. If the current density is so higher that it exceeds the limiting value ~~of~~ for the electrolyte hydrogen is released and spongy and porous deposit is obtained.

ii) Electrolytic Concentration:-

This is more or less complementary to the first factor, i.e. current density since by increasing the concentration of the electrolyte higher current density can be achieved. Increase of concentration tends to give better deposits and some people therefore favour it.

Temperature :-

The temperature of the electrolyte has two contradictory effects. One, at comparatively high temperature there is more diffusion and even at relatively high current density smooth deposits may be produced. Two, the rate of crystal growth increase the possibility of coarse deposits. At moderate temperatures the deposits are good. In chromium plating the temperature is maintained at 35°C, and in nickel between 50°C to 60°C.

Addition Agents

The quality of a deposit is improved

by the presence of an addition agent which may be colloidal matter or an organic compound, otherwise the metal deposits in the form of large crystals and the surface becomes rough. Materials used as addition agents are gelatin, agar, glue, gums, rubber, alkaloids, sugar etc. The addition agents are supposed to be absorbed by crystal nuclei and prevent their growth into large crystals. The discharged ions start to build up new nuclei and the deposit of metal is fine-grained.

Nature of electrolyte:-

Smooth deposits are obtained from Solutions having complex ions, e.g. Cyanide silver from nitrate solution forms a coarse deposit while from cyanide solution it forms a smooth deposit. Therefore, the formation of smooth deposit largely depends upon the nature of electrolyte used.

Nature of the metal on which deposit is to be made:

This factor influences the growth of crystals since it is believed that the operation of crystals is in continuation of these in the base metal.

(vii) Throwing power:-

The throwing power of an electrolyte may be regarded as the quality which produces a uniform deposit on a cathod having an irregular shape. since the shape is irregular. The distance of the various parts of the cathode from the anode is not the same and therefore the conductance of the electrolyte is not the same for all parts of the cathode. The phenomenon of throwing power has not been clearly understood so far. In an electrolyte of low conductance, the current will concentrate on the parts of the cathode which are nearer the cathode resulting in poor throwing power. If the electrolyte has good conductance, the throwing power will also be good. One way to improve the throwing power is to keep a good distance between the cathod and the anode there by providing more or less the same conductance for all parts of cathode. presence of colloidal matter improves the throwing power but increase of temperature may produce the opposite effect.

1.8) State simple example of Extraction Of Metals :-

A: This is done in two ways:

1. The ore is treated with a strong acid to obtain a salt and the solution of such a salt is electrolyzed to liberated the metal.
2. When the ore in molten state is available it is electrolysed in a furnace.

Extraction of Zinc:-

The ore consisting of zinc is treated with concencered trated sulphuric acid, roasted and passed through other processes to get rid of impurities by precipitation. The zinc sulphate solution is the electrolysed. The cells consist of large lead-lined wooden boxes having aluminum cathods and lead anodes. The current density is about 1000 amperes per square meter. zinc is deposited on cathodes.

Refining of Metals:-

Electrolytic extraction gives about 98 to 99 percent pure metal. further refining is done by electrolysis.

The anodes are made of the impure metal extracted from its ores and the electrolyte is a solution of the salt of the metal. pure metal is deposited on the cathode.

Example-1

A 20 cm long portion of a circular shaft 10cm diameter is to be coated with a layer of 1.5mm nickel. Determine the quantity of electricity in Ah and the time taken for the process. Assume a current density of 195 A/sq.m and a current efficiency of 92%. Specific gravity of nickel is 8.9.

A: Wt. of nickel = 8.9 gm/cm3

wt of nickel to be deposited

$= \pi \times 10 \times \frac{15}{10} \times 8.9 \times 10^{-3}$ kg

Electron chemical equivalent of nickel is 1.0954 kg per 1,000 Ah

Quantity of electricity required

$$= \frac{838.1 \times 10^{-3} \times 1000}{1.0954 \times 0.92}$$

$= 833$ Ahr

Current density $= 195 A/m^2$

Time taken $= \frac{833}{\pi \times 10 \times 20 \times 10^{-4} \times 195}$

$= 68$ hours.

19 # Applications of Electrolysis :-

Electrolysis has wide applications in industries.

Some of the important applications are, as follows,

(i) production of hydrogen by electrolysis of water.

(ii) Manufacture of heavy water (D_2O).

(iii) The Metals like Na, K, Mg, Al, etc; are obtained by electrolysis of fused electrolytes.

(iv) Non-metals like hydrogen, fluorine, chlorine are obtained by electrolysis. ~~of fused electrolytes.~~

(v) In this method pure metal is deposited at cathode from a solution containing the metal ions Ag, Cu etc.

(vi) Compounds like NaOH, KOH, Na_2CO_3, white lead, $KMnO_4$ etc. are synthesised by electro synthesis method.

(vii) Electroplating :- The process of coating an inferior metal with a superior metal by electrolysis is known as electroplating.

2 ELECTRICAL HEATING

Electric heating is extensively used both for domestic and industrial applications. Domestic applications include (i) room heaters (ii) immersion heaters for water heating (iii) hot plates for cooking (iv) electric kettles (v) Electric irons (vi) pop-corn plants (vii) Electric ovens for bakeries and (viii) Electric toasters etc. Industrial applications of electric heating include (i) melting of metals (ii) heat ~~tre~~ treatment of metals like annealing tempering, soldering and brazing etc (iii) moulding of glass (iv) Baking of insulators (v) Enamelling of copper wires etc.

2.1 Advantage of Electrical heating:

As compared to other methods of heating using gas, coal and fire etc, electric heating is far superior for the following reasons:

(i) Cleanliness. - Since neither dust nor ash is produced in electric heating. It is a clean system of heating requiring minimum cost of cleaning.

(ii) No pollution:- Since no ~~fuel~~ flue gases are produced in electric heating, no provision has to be made for their exit.

(iii) Economical:- Electric heating is economical because electric furnaces are cheaper in their initial cost as well as maintenance cost since they donot requive big space for installation or for storage of coal and wood. More over, there is no need to construct any chimney or to provide extra heat installation.

(iv) Ease of control :- It is easy to control and regulate the temperature of an electric furnace with the help of manual or automatic devices. Temperature can be controlled within ± 5°C which is not possible in any other form of heating.

(v) Special Heating Requirement :-

Special heating requirements such as uniform heating of a material or heating one particular portion of the job without affecting its other parts or heating with no oxidation can be met only by electric heating.

(vi) Higher Efficiency :- Heat produced electrically does not go away waste through the chimney and other by products. Consequently, most of the heat produced is utilised for heating the material itself. Hence, electric heating has higher efficiency as compared to other types of heating.

vii) Betten Wonking Conditions:

Since electnic heating produces no irritating noises and also be radiation losses are low, it results in low ~~material~~ ambient temperature. Hence, working with electric furnaces is convenient and cool.

viii) Heating of Bad Conductors:-

Bad conductors of heat and electricity like wood, plastic ~~and~~ bakery items can be uniformly and suitably heated with dielectric heating process.

(ix) Safety:- Electric heating is quite safe because it responds quickly to the controlled signals.

(x) Lower Attention and Maintenance cost:-

Electric heating equipment generally will not require much attention and supervision and their maintenance cost is almost negligible. Hence, labour charges are negligibly small as compared to other forms of heating.

2.2 Mode of heat transfer and stephen's law.

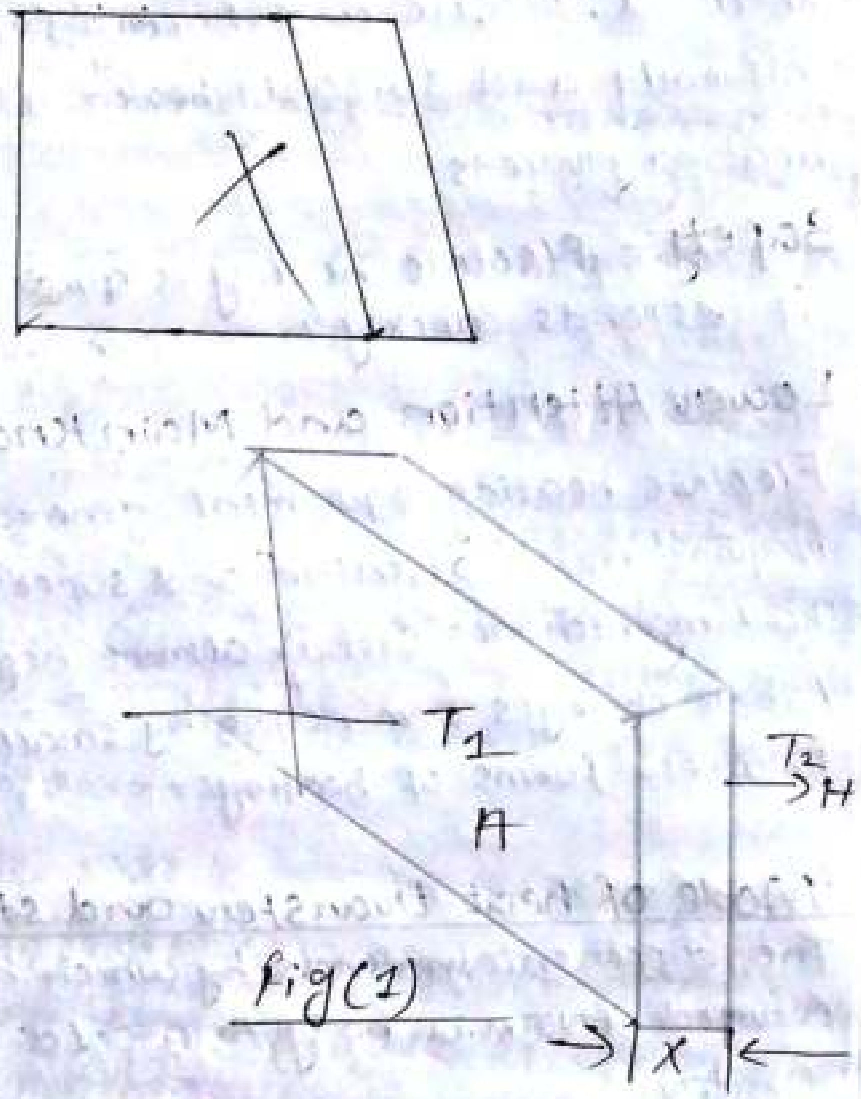
The different methods by which heat is transferred from a body to a cold body are as under.

1. Conduction
2. Convection
3. Radiation

1 Conduction :

In this mode of heat transfer, one molecule of the body gets heated and transfers some of the heat to the adjacent molecule and so on. There is a temperature gradient between the two ends of the body being heated.

Consider a solid material of cross - section A sq. m. and thickness x metre as shown in fig.1.



Fig(1)

If T_1 & T_2 are the temperatures of the two sides of the slab in °K, then heat conducted between the two opposite faces in time t seconds is given by :

$$H = \frac{KA(T_1 - T_2)t}{x} \quad —(1)$$

where k is thermal conductivity of the material.

(ii) Convection :-

In this process, heat is transferred by the flow of hot and cold air currents. this process is applied in the heating of water by immersion heater or heating of Buildings. The quantity of heat absorbed by the body by convection process depends mainly on the temperature of the heating element above the surroundings and upon the size of the surface of the heater. It also depends, to some extent on the position of the heater. The amount of heat dissipated is given by $H = a(T_1 - T_2)$. where is a constant and T_1 & T_2 are the temperatures of the heating surface and the fluid in $\mathring{K}$ respectively. In electric furnaces, heat transferred by convection is negligible.

(iii) Radiation :-

It is the transfer of heat from a hot body to a cold body in a straight line without affecting the intervening medium. The rate of heat emission is given by stefan's law; according to which heat dissipated is given by equn 2.

$$H = 5.72\, ek \left[\left(\frac{T_1}{100}\right)^4 - \left(\frac{T_2}{100}\right)^4\right] \ W/m^2 \quad — (2)$$

where, K is radiating efficiency and e is known as emissivity of the heating element. If 'd' is the diameter of the heating wire and 'l' its total length, then its surface area from which heat is radiated.

$$S = \pi d l \quad -(3)$$

If H is the power radiated per m^2 of the heating surface, then,

$$\text{Total power radiated as heat} = H \pi d l \quad -(4)$$

If p is the electrical power input to the heating element, then

$$p = \pi d l \times H \quad -(5)$$

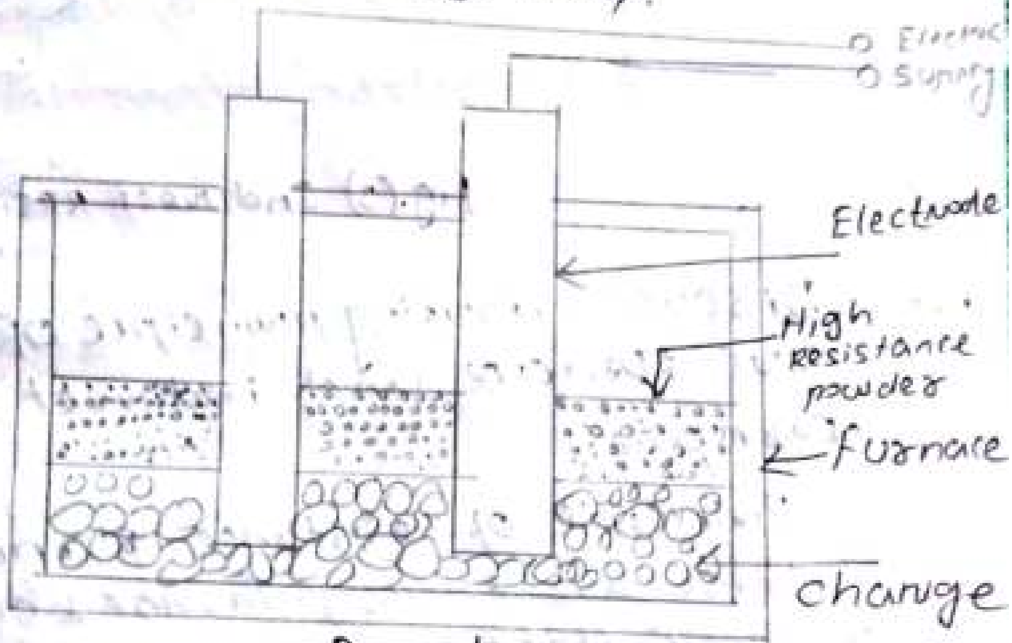
2.3 ~~Principle~~ Principle of Resistance heating (Direct ~~heating~~ resistance & indirect resistance heating).

Resistance heating:-

It is based on the 'I^2R' effect. When current is passed through a resistance element, I^2R loss takes place which produces heat. There are two methods of resistance heating.

(a) Direct resistance heating:-

In this method the material (or charge) to be heated is treated as a resistance and current is passed through it. The charge may be in the form of powder. Small solid pieces are liquid. The two electrodes are inserted in the charge and connected to either a.c. or d.c. supply (fig.2). Obviously, two electrodes will be required in the case of d.c. or single phase a.c. supply but there would be three electrodes in the case of 3-phase supply. When the charge is in the form of small pieces, a powder of high resistivity material is sprinkled over the surface of the charge to avoid direct short circuit. Heat is produced when current passes through it. This method of heating has high efficiency because the heat is produced in the charge itself.



Direct Resistance heating

(b) In-Direct Resistance heating:-

In this method of heating, electric current is passed through a resistance element which is placed in an electric oven. Heat produced is proportional to I^2R losses in the heating element. The heat so produced is delivered to the charge either by radiation or convection or by a combination of the two. Sometimes, resistance is placed in a cylinder which is surrounded by the charge placed in the jacket as shown in the fig. 3. The arrangement provides uniform temperature. Moreover, automatic temperature control can also be provided.

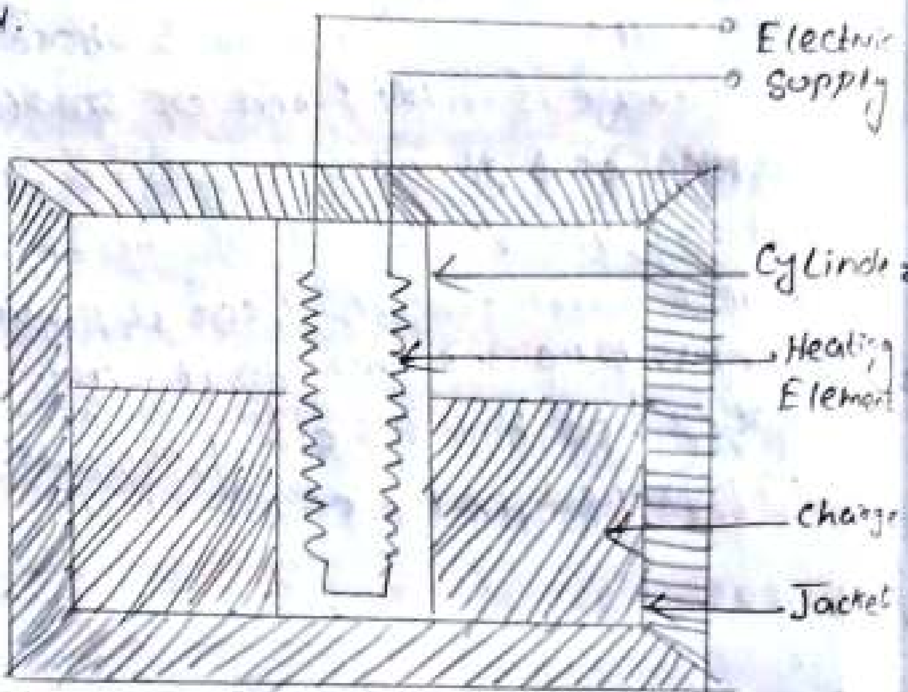


fig.(3) Indirect Resistance heating

2.4 Discuss working principle of direct arc furnace and indirect arc furnace.

A: Principle of Resistance furnace:-
These are suitably-insulated closed chambers with a provision for ventilation and are used for a wide variety of purposes including heat treatment of metals like annealing and hardening etc. staving of enamelled wares, drying and baking of potteries, vulcanizing and hardening of synthetic materials and for commercial and domestic heating.

Temperatures up to 1000°c can be obtained using heating elements made of nickel, chromium and iron. Ovens using heating elements made of graphite can produce temperature up to 3000°c.

Heating elements may consist of circular wires or rectangular ribbons. The ovens are usually made of a metal frame work having an internal lining of fire bricks. The heating element may be located on the top, bottom or sides of the oven. The nature of the insulating material is determined by the maximum temperature required in the oven. An enclosure for charge which is heated by radiation or convection or both is called a heating chamber.

Temperature control of Resistance furnaces :-

The temperature of a resistance furnaces can be changed by controlling the I^2R or V^2/R losses.

Following different methods are used for the above purpose:

1. Intermittent switching:

In this case, the furnace voltage is switched ON & off intermittently. when the voltage supply is switched off, heat production with in the surface is stalled and

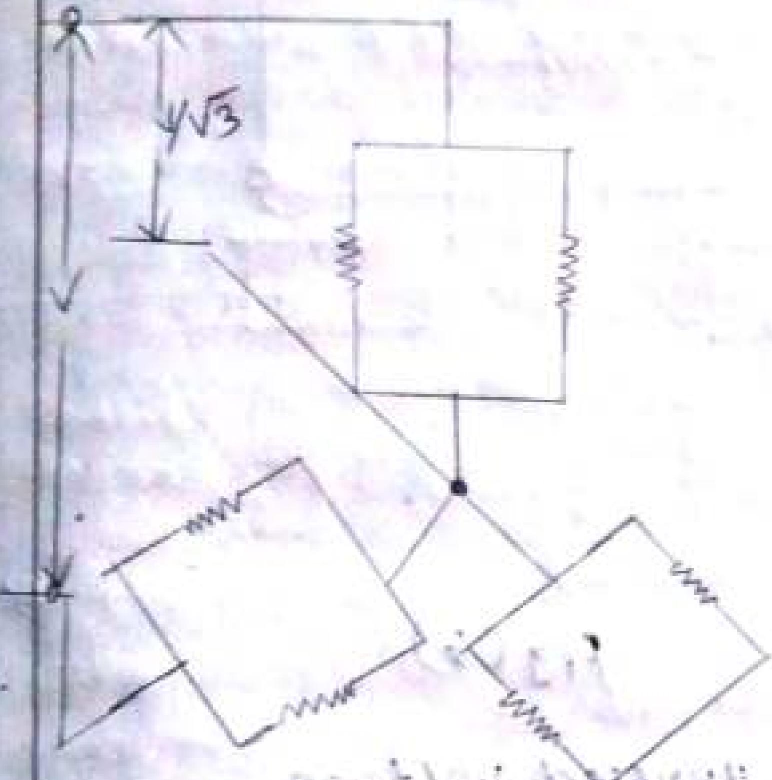
hence it temperature is reduced.
When the supply is restored, heat production starts and the furnace temperature begin to increase. Hence, by this simple method, the furnace temperature can be limited bet^n two limits.

(2) By changing the Number of Heating Elements.

In this case, the number of heating elements is changed without cutting off the supply to the entire furnace. smaller the number of heating elements, lessen the heat produced. In the case of a 3-phase circuit, equal number of heating elements is switched off from each phase in order to maintain a balanced load condition.

3. Variation in circuit configuration.
In the case of 3-phase secondary load, the heating elements give less heat when connected in a star than when connected in delta because in the two cases, voltage across the elements is different. In single-phase circuits, series and parallel grouping of the heating elements causes change in power dissipation resulting in change of furnace temperature.

As shown in fig-6 heat produced is more when all these elements are connected in parallel than when they are connected in series or series-parallel.



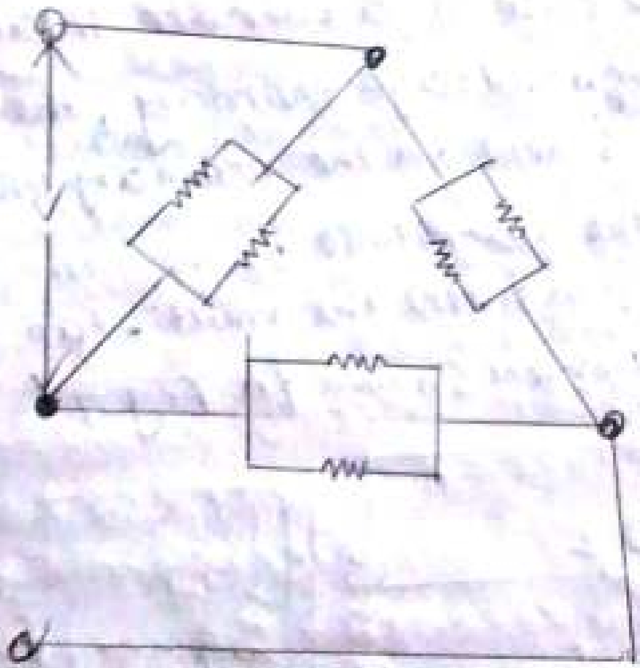


Fig (5)

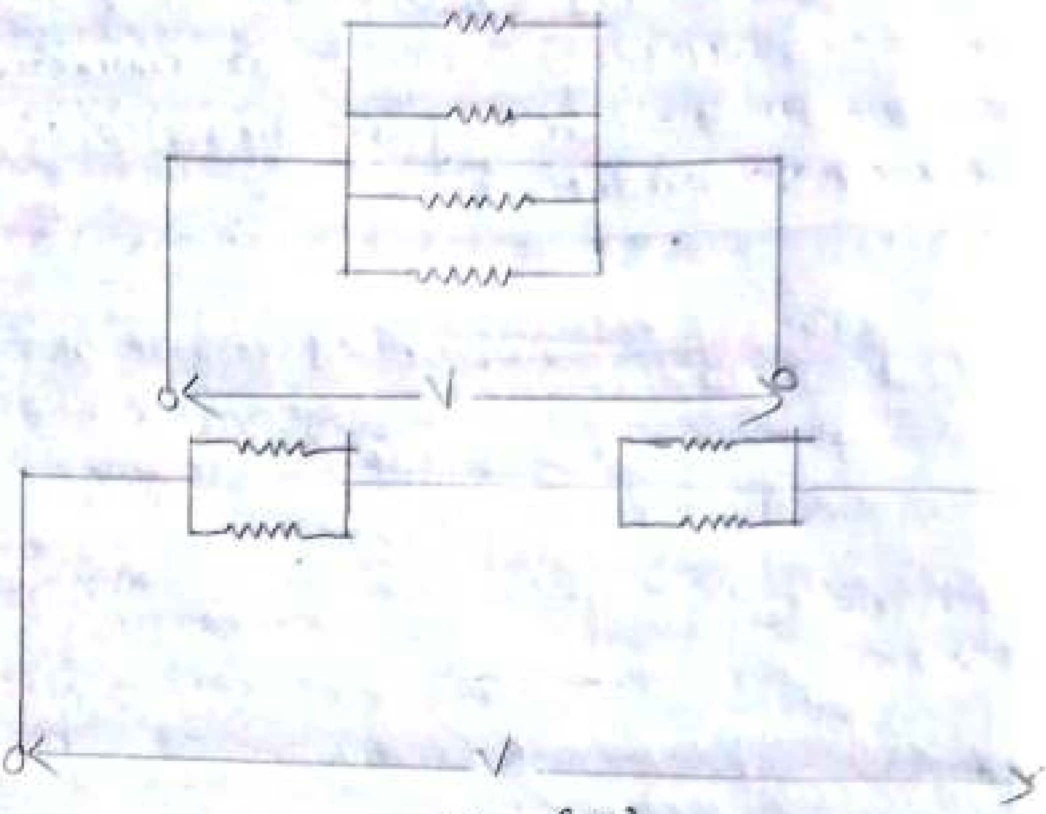


fig (6)

(4) Change of Applied voltage

(a) In the case of a furnace transformer having high voltage primary, the tapping control is kept in the primary winding because the magnitude of the primary current is less. consider the multi-tap step-down transformer shown in fig. 7.

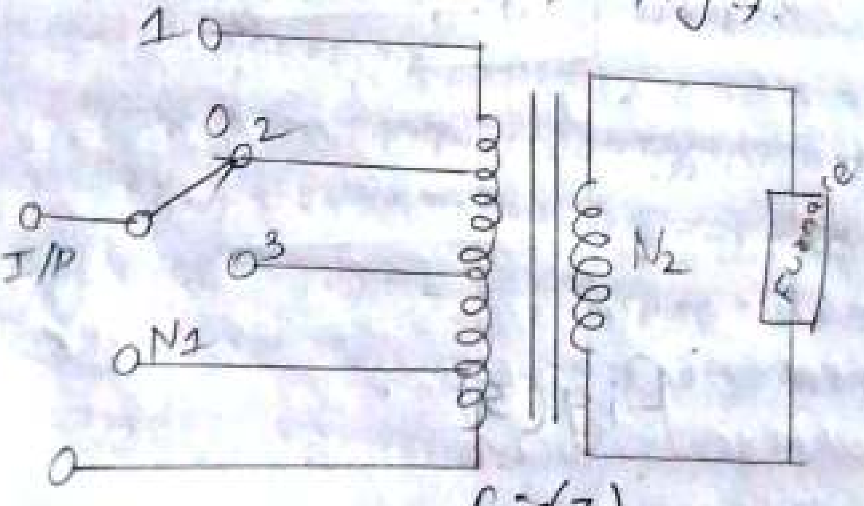
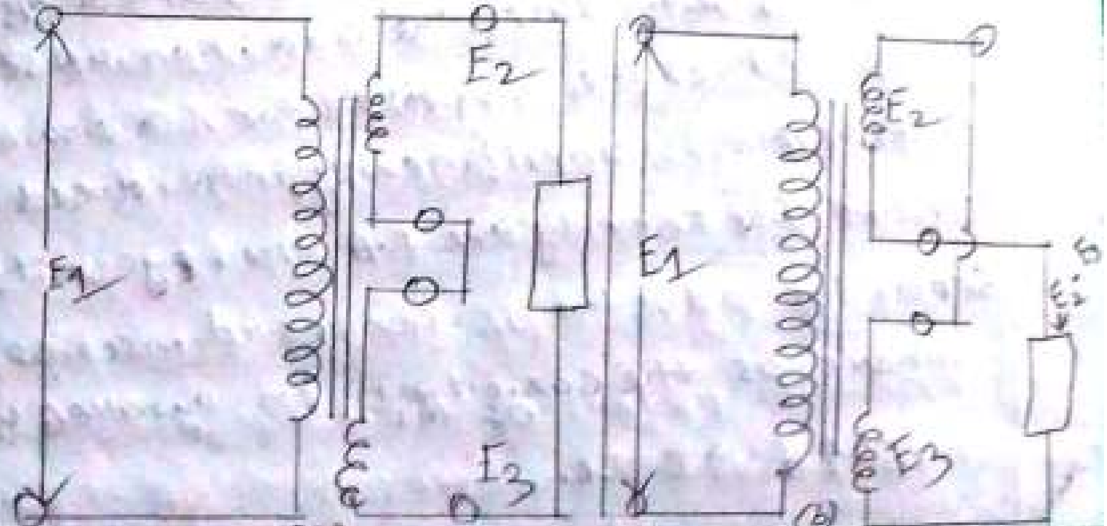


fig (7)

Let the four tapings on the primary winding have 100%, 80%, 60% and 50%. When 100% primary turns are used, secondary voltage is given by $V_2 = (N_2/N_1) V_i$, where V_i is the input voltage. When 50% tapping is used, the number of primary turns involved is $N_1/2$. Hence, available secondary voltage $V_2 = (2N_2/N_1) V_i$. By selecting a suitable primary tapping, secondary voltage can be increased or decreased causing a change of temperature in the furnace.

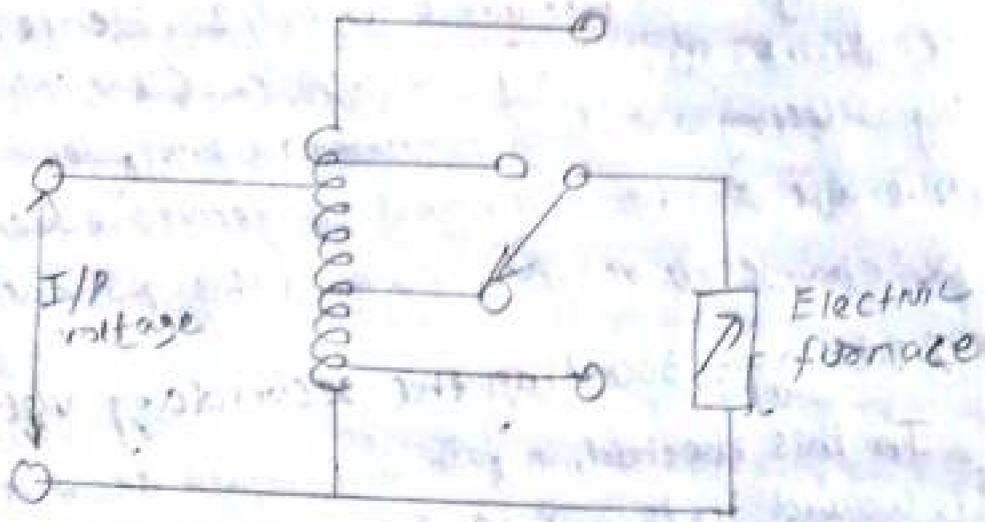
(b) Bucking- Boosting the secondary voltage.

In this method, the transformer secondary is wound in two sections having unequal number of turns. If the two sections are connected in series aiding, the secondary voltage is boosted i.e., increased to (E_2+E_3). When the two sections are connected in series-opposing the secondary voltage is reduced i.e, there is bucking effect. Consequently, furnace voltage becomes (E_2-E_3) and, hence, furnace temperature is reduced.



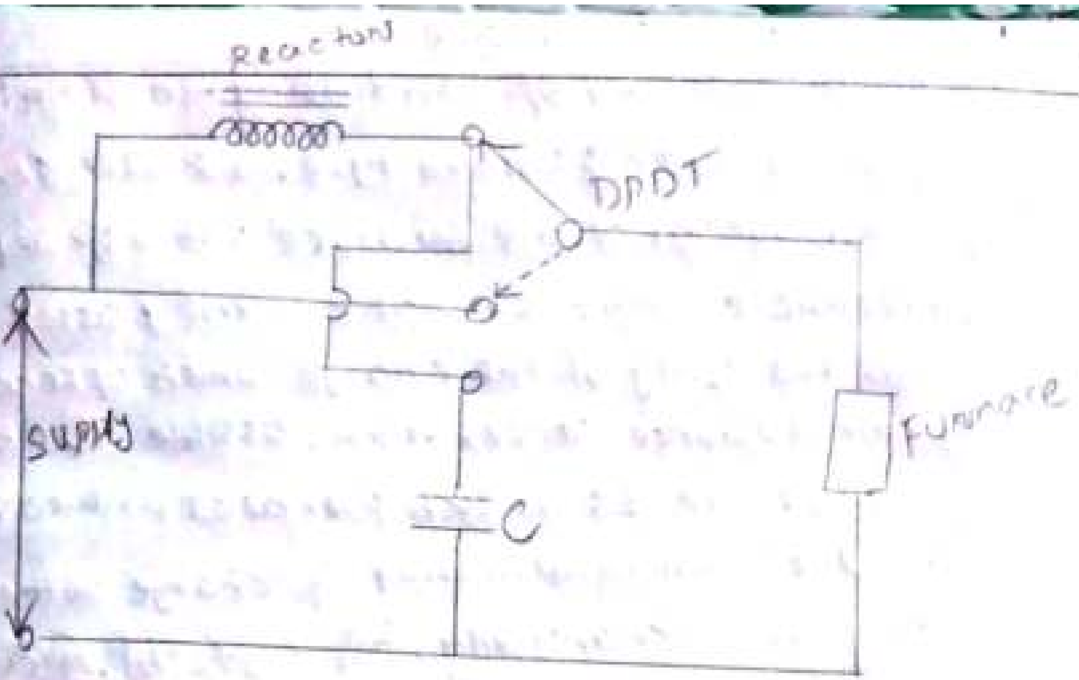
(c) Autotransformer Control.

The use of tapped transformer used for decreasing the furnace voltage and, hence, temperature of small electric furnaces. The required voltage can be selected with the help of a voltage selector.



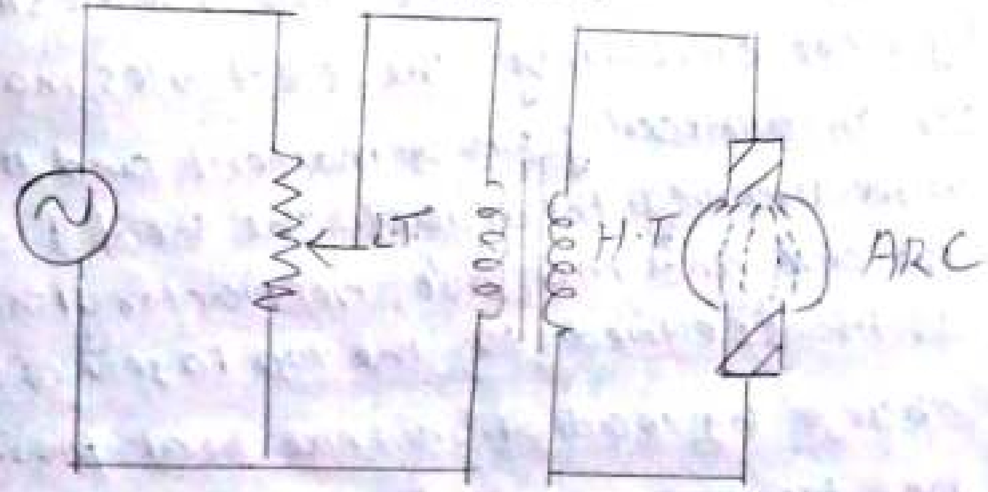
(d) Series Reactor voltage:-

In this case, a heavy-duty core-wounded coil is placed in series with the furnace as and when desired. Due to the drop in voltage across the impedance of the coil, the voltage available across the furnace is reduced. With the help of D.P.D.T. switch, high / low, two mode temperature control can be obtained as shown in the fig. 1a. Since the addition of series coil reduces the power factor, a power capacitor is simultaneously introduced in the circuit for keeping the p.f. nearly unity. As seen, the inductor is connected in series, where as the capacitor is in parallel with the furnace.



Arc Furnaces :-

If a sufficiently high voltage is applied across an air-gap, the air becomes ionized and starts conducting in the form of a continuous spark or arc thereby producing intense heat. When electrodes are made of carbon/graphite, the temperature obtained is in the range of 3000°C - 3500°C. The high voltage required for striking the arc can be obtained by using a step-up transformer fed from a variable a.c. supply as shown in fig. 11(a)



(a)

fig(11)

Direct Arc Furnace :-

It could be either of conducting - bottom type or non- conducting bottom type. As seen from fig 12(a), bottom of the furnace forms part of the electric circuit so that current passes through the body of the charge which offers very low resistance. Hence, it is possible to obtain high temperatures in such furnaces. Moreover, it produces uniform heating of charge without stirring it mechanically. In fig 12(b), no current passes through the body of the furnace. Most common application of these furnaces is in the production of steel because of the ease with which the composition of the final product can be controlled during refining. Most of the furnaces in general use are of non-conducting bottom type due to insulation problem faced in case of conducting bottom.

Indirect Arc furnace :-

A single phase indirect arc furnace which is cylindrical in shape. The arc is struck by short circuiting the electrodes manually or automatically for a moment and then, withdrawing them apart. The heat from the arc and the hot refractory lining is transferred to the top layer of the charge by radiation. The heat from the hot top layer of the charge is further transferred to other parts of the charge by Conduction. Since no current passes through the body of the charge, there is no inherent stirring action due to electro-magnetic forces set up by the current. Hence, such furnaces have to be rocked continuously in order to distribute heat uniformly by exposing different layers of the charge to the heat of the arc. An electric motor is used to operate suitable grinders and rollers to impart rocking motion to the furnace. Rocking action provides not only through mixing of the charge, it also increases the furnace efficiency in addition to increasing the life of the refractory lining material. Such furnaces are mainly used for melting nonferrous metals although they can be used in iron foundries where small quantities of iron are required frequently.

2.5 Principle of induction heating

The heating process makes use of the currents induced by the electro-magnetic action in the charge to be heated. In fact, induction heating is based on the principle of transformer working. The primary winding which is supplied from an a.c. source is magnetically coupled to the charge which acts as a short circuited secondary i.e. charge. The secondary current heats up the charge in the same way, as any electric current does while passing through a resistor. If V is the voltage induced in the charge and R is the charge resistance, then heat produced = V^2/R. The value of current induced in the charge depends on :

(i) Magnitude of the primary current
(ii) Turn ratio of the transformer
(iii) Co-efficient of ~~magnitude~~ magnetic coupling.

Low frequency induction furnaces are used for melting and refining of different metals.

25.1 Working principle of direct core type, vertical core type and indirect core type induction furnace.

(a) Core-type furnace:-

A:- It operates just like a two winding transformer. These can be further sub-divided into (i) Direct core-type furnaces,
(ii) Vertical core-type furnaces and
(iii) Indirect core-type furnaces.

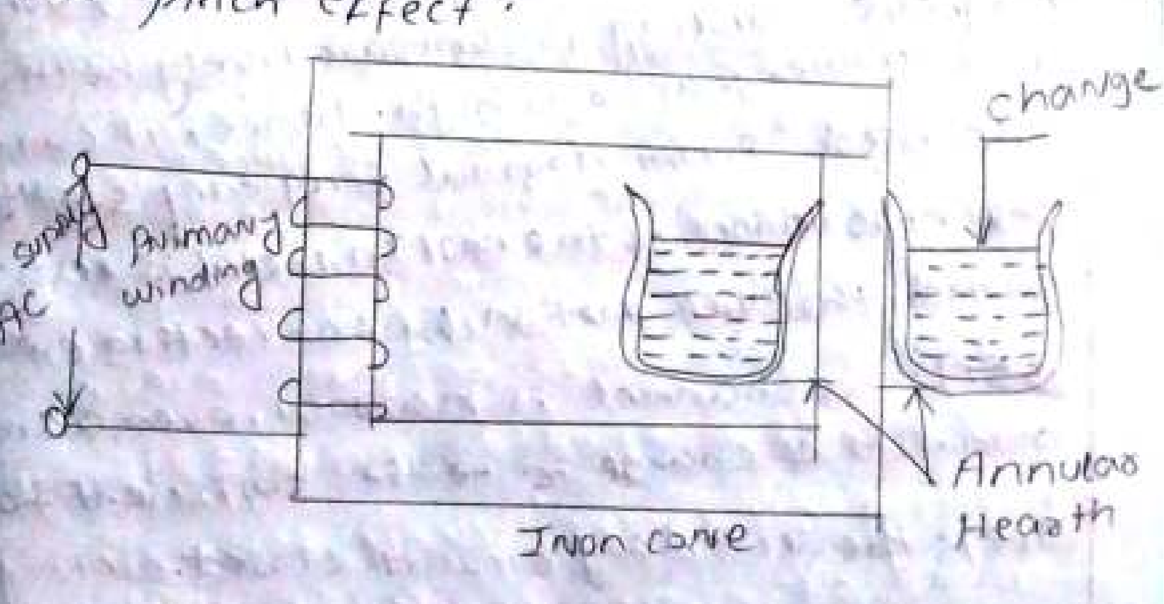
(b) Coreless-type furnaces:-

In which an inductively-heated element is made to transfer heat to the charge by radiation.

* Core Type Induction furnace:-

It is shown in fig. 14 and is essentially a transformer in which the charge to be heated forms a single-turn short-circuited

Secondary and is magnetically coupled to the primary by an iron core. The furnace consists of a circular hearth which contains the charge to be melted in the form of an annular ring. When there is no molten metal in the ring, the secondary becomes open-circuited there-by cutting off the secondary current. Hence, to start the furnace, molten metal has to be pored in the annular hearth. Since, magnetic coupling between the primary and secondary is very poor. it results in high leakage and low power factor. If the transformer secondary current density exceeds 500 A/cm2 then, due to the interaction of secondary current with the alternating magnetic field, the molten metal is squeezed to the extent that secondary circuit is interrupted. This effect is known as "pinch effect".



This furnace suffers from the following draw backs:

1. It has to be run on low-frequency supply which entails extra expenditure on motor generator set or frequency converter.
2. It suffers from pinching effect.
3. The crucible for charge is of odd shape and is very inconvenient for tapping the molten charge.
4. It does not function if there is no molten metal in the hearth i.e. when the secondary is open. Every time molten metal has to be poured to start the furnace.

* Vertical core type induction furnace:-

It is also known as Ajax-Wyatt furnace and represents an improvement over the core-type furnace discussed above. It has vertical channel (instead of a horizontal one) for the charge, so that the crucible used is also vertical which is convenient from metallurgical point of view. In this furnace magnetic coupling is comparatively better and power factor is high. Hence, it can be operated from normal frequency supply. The circulation of the molten metal is kept up round the vee portion by convection currents. As Vee channel is narrow, even a small quantity of charge is ~~order~~ sufficient to keep the secondary circuit closed.

Indirect Core-Type Induction Furnace:

In this furnace, a suitable element is heated by induction which, in turn, transfers the heat to the charge by radiation. So far as the charge is concerned, the conditions are similar to those in a resistance oven. The secondary consists of a metal container which forms the walls of the furnace proper. When primary winding is connected to a.c. supply, secondary current is induced in the metal container by transformer action which heats up the container. The metal container transfers this heat to the charge. A special advantage of this furnace is that its temperature can be automatically controlled without the use of an external equipment.

~~2.6 Principle of dielectric heating and its application.~~

2.5.2 Principle of coreless induction furnace and skin effect.

A:- The three main parts of the furnace are (i) primary coil (ii) a ceramic crucible containing charge which forms the secondary and (iii) the frame which includes supports and tilting mechanism. The distinctive feature of this furnace is that it contains no heavy iron core with the result that there is no continuous path for the magnetic flux. The crucible and the coil are relatively light in construction and can be conveniently tilted for pouring.

The charge is put into the crucible and primary winding is connected to a high frequency a.c. supply. The flux produced by the primary sets up eddy-currents in the charge and heats it up to melting point. The charge need to be in the molten state at the start as was required by core-type furnaces. The eddy-currents also set up electromotive forces which produce stirring action which is essential for obtaining uniforms quality of metal. Since flux density is low (due to the absence of the magnetic core), high frequency supply has to be used because eddy current loss

$$W_e \propto B^2_{max} f^2$$

However, this high frequency increases the resistance of the primary winding ~~is not made of cu wire but consists of hollow cu~~

due to skin effect, thereby increasing primary cu losses. Hence, the primary winding is not made of cu wire but consists of hollow cu tubes which are cooled by water circulating through them. Since magnetic coupling betn the primary & secondary windings is low, the furnace p.f. lies between 0.1 & 0.3. Hence, static capacitors are invariably used in parallel with the furnace to improve its p.f. Such furnaces are commonly used for steel production and for melting of non-ferrous metals like brass, bronze, copper and aluminimum. etc. along with various alloys of these elements.

Some of the advantages of coreless induction furnaces are as follows:

1. They are fast in operation
(2) They produce most uniform quality of products.
(3) They can be operated intermittently.
(4) Their operation is free from smoke, dirt, dust & noises.
(5) Their charging and pouring is simple.
(6) They have low ~~electrical~~ erection & operating costs.

2.6 Dielectric Heating:-

It is also called high-frequency capacitive heating and is used for heating insulators like wood, plastic and ceramics etc. which cannot be heated easily and uniformly by methods. The supply frequency required for dielectric heating is between 10-50 MHz and the applied voltage is up to 20kv. The overall efficiency of dielectric heating is about 50%..

Advantages of Dielectric Heating:-

1. Since heat is generated within the dielectric medium itself, it results in uniform heating.
2. Heating becomes faster with increasing frequency.
3. It is the only method for heating bad conductors of heat.
4. Heating is fastest in this method of heating.
5. Heating can be stopped immediately as and when desired.

2.7 Principle of Microwave heating & its application.

A: When an electric field is applied to metal, for example, the flow of electrons (that is, current) does not occur when a so-called insulator is placed within that electrical field for an electric conductor having freely moving electrons. However, the the phenomenon of polarization, where positive and minus electric charges are displaced from the equilibrium point, resulting in a separation of the changes, does occur. Substances with this kind of nature are called a "dielectric". As frequency increases, the component electrons of a dielectric spin, collide, vibrate, rub against each other, and otherwise move violently. changes in polarity at this time are intense, occuring several ten to several hundred millon times per second. this energy becomes "heat", which causes heat to be generated inside the dielectric.

y. Applications of Microwave Heating

Heating food

One obvious example of microwave heating is in a microwave heating is in a microwave oven and press the "start" button, electro magnetic waves oscillate within the oven at a frequency of 2.45 GHz. These fields interact with the food, leading to heat generation and a rise in temperature. The efficiency of micro wave heating depends upon the material properties. for example, if your place foods with varying water content in a microwave oven, they will heat up at different rates.

Treating Cancer:-

Another application that leverages the effects of microwave heating is cancer treatment, in particular hyperthermic oncology. This type of cancer therapy involves subjecting tumor tissue to localized heating, without damaging the healthy tissue around it

3

PRINCIPLES OF ARC WELDING

It is the process of joining two pieces of metal or non-metal at faces rendered plastic or liquid by the application of heat or pressure or both filler material may be used to effect the union.

3.1 Explain principle of Arc welding

An electric arc is formed whenever electric current is passed between two metallic electrodes which are separated by a short distance from each other. The arc is started by momentarily touching the positive electrode (anode) to the negative metal (or plate) and then withdrawing it to about 3 to 6 mm from the plate. When electrode first touches the plate, a large short-circuit current flows and as it is later withdrawn from the plate, current continues to flow in the form of a spark across the air gap so formed. Due to this spark (or discharge) the air in the gap becomes ionized i.e. is split into -ve electrons and +ve ions. Consequently, air becomes conducting and current is able to flow across the gap in the form of an arc. The arc consists of lighter electrons which flow from cathode to anode and heavier positive ions which flow from anode to cathode. Intense heat is generated when high velocity electrons strike the anode. Heat generated at the cathode is much less because of the low velocity of the impinging ions. It is found that nearly two-third of the heat is developed at the anode which burns into the form of the heat is developed near the cathode. The above statement is true in all d.c. systems of welding where positive side of the circuit is the hottest side. As a result, an electrode connected to the positive end of the d.c. supply circuit will burn 50% faster than if connected to the negative end. This fact can be used for obtaining desired penetration of the base metal during welding.

3.2 Types of arc welding.

A: There are four basic positions in which manual arc welding is done.

1. Flat position:- It is of all the positions, flat position is the easiest, most economical and the most used for all shielded arc welding. It provides the strongest weld joints. Weld beads are exceedingly smooth and free of slag spots. This position is most adaptable for welding of both ferrous and non-ferrous metals particularly for cast iron.

2. Horizontal position:- It is the second most popular position. ~~and~~ It also requires a short arc length because it helps in preventing the molten puddle of the metal from sagging. However, major errors that occur while welding in horizontal position are under-cutting and over

lapping of the weld zone.

(3) Vertical position :- In this case, the welder can deposit the bead either in the uphill or down hill direction. Downhill welding is preferred for thin metals because it is faster than the uphill welding. Uphill welding is suited for thick metals because it produces stronger welds.

(4) Over head position:- The welder has to be very cautious otherwise he may get burnt by drops of falling metal. This position is thought to be the most hazardous but not the most difficult one.

3.3 Explain principles of resistance welding

A:- It is fundametally a heat and squeeze process. The term 'resistance welding' denotes a group of processes in which welding heat is produced by the resistance offered to the passage of electric current through the two metal pieces being welded. These processes differ from the fusion processes in the sense that no extra metal ~~pieces being welded. These processes differ from the fusion processes in the sense~~

is added to the joint by means of a filler wire or electrode. According to Joule's law, heat produced electrically is given by $H = I^2Rt/J$. Obviously, amount of heat produced depends on (i) square of the current (ii) the time of current and (iii) the resistance offered. As seen, in simple resistance welding, high amperage current is necessary for adequate weld. Usually, R is the contact resistance between the two metals being welded together. The current is passed for a suitable lengh of time controlled by a timer. The various types of resistance welding processes may be divided in to the following four main groups:

(i) spot welding (ii) seam welding (iii) projection welding and (iv) butt welding which could be further subdivided into flash welding, upset welding and stud welding etc.

Advantages:-

Some of the advantages of resistance welding are as under:

1. Heat is localized where required.
2. Welding action is rapid
3. No filler material is needed.
4. Requires comparatively lesser skill
5. Is suitable for large quantity production
6. parent metal is not harmed.

Spot welding:-

Q. Descriptive study of Different resistance welding methods.

A. The process depends on two factors:

1. Resistance heating of small portions of the two work pieces to plastic state and
2. Application of forging pressure for welding the two work pieces. Heat produced is H = I²Rt/J. The resistance R is made up of (i) resistance of the electrodes and metals themselves (ii) contact resistance between electrodes and work pieces and (iii) contact resistance between the two work pieces. Generally, contact resistance between the two work pieces is the greatest. Mechanical pressure is applied by the tips of the two electrodes. In fact, these electrodes not only provide the forging pressure but also carry the welding current and concentrate the welding heat on the weld spot directly below them. It consists of a step-down transformer which can supply huge currents (up to 5,000 A) for short duration of time. The lower arm is fixed whereas the upper one is movable. The electrodes are made of low-resistance, hard copper alloy and are either air cooled or butt-cooled by water circulating through the rified drillings in the

electrode. flat domes are used when spot-welding deformation is not desired. The weld size is determined by the diameter of the electrode.

~~St~~ Seam Welding:-

The seam welder differs from ordinary spot welder only in respect of its electrodes which ~~the~~ are of disc or roller shape. These copper wheels are power driven and rotate whilst gripping the work. The current is so applied through the wheels that the weld spots either overlap or are made at regular intervals. The continuous or overlapped seam weld is also called stitch weld whereas, the other is called roll weld. Seam welding is confined to welding of thin materials ranging in thickness from 2 mm to 5 mm. It is also restricted to metals having low harden ability rating such as hot-rolled ~~gar~~ grades of low alloy ~~steels.~~ steels.

Projection welding:-

It can be regarded as a mass-production form of spot welding. Technically, it is a cross between spot welding and butt welding. It uses the same equipment as spot welding. However, in this process, large-diameter flat electrodes (also called platens) are used. This welding process derives its name from the fact that, prior to welding, projections are raised on the surface to be welded. As seen, the upper and lower platens are connected across the secondary of a step-down transformer and are large enough to cover all the projections to be welded at one stroke of the machine. When platen A touches the work piece, welding current flows through each projection. The welding process is started by first lowering the upper platen. A on to the work-piece and then applying mechanical pressure to ensure correctly-forged welds. A variation of projection welding is the metal fibre welding which uses a metal fibre rather than a projection point.

Butt welding:-

In this case, the two work pieces are brought into contact end-to-end the butted ends are heated by passing a heavy current through the joint. As in other forms of resistance welding, the weld heat is produced mainly by the electrical resistance of the joint faces. In this case, however, the electrodes are in the form of powerful vice clamps which hold the work-pieces and also convey the forging pressure to the joint. This process is useful where parts have to be joined end-to-end or edge-to-edge. i.e. for welding pipes, wires and rods. It is also employed for making continuous lengths of chain.