CLASS NOTE

OF

UTILISATION OF ELECTRICAL ENERGY AND TRACTION

5TH Semester Electrical Engineering

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CHAPTER-1
ELECTROLYTIC PROCESS

ELECTROLYTE:-

- The substances which decomposed where on electric current is passed through there are called electrolyte.

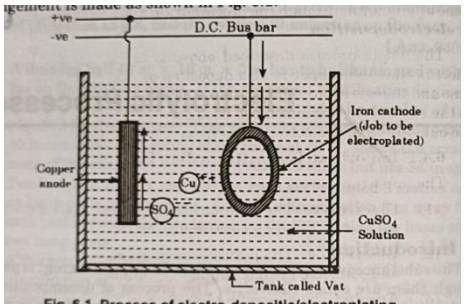


Fig. 6.1. Process of electro-depositic/electroplating.

ELECTROLYTIC PROCESS:-

- The process of decomposition of electrolyte by the passage of electric current through them is called electrolytic process or electrolysis.

ELECTROPLATING:-

- The process of decomposing a metal on the surface of some other metal by electrolysis is called electroplating.

NEED OF ELECTROPLATING:-

- To protect the metal against corrosion.
- To give shining appearance.
- To repair damage cast steel.
- To replace workout material from a casting.

ANODE:-

The electrode connected to the positive terminal of the supply is called anode.

CATHODE:-

The electrode connected to the negative terminal of the supply is called cathode.

CHEMICAL EQUIVALENT OF THE WEIGHT:-

The chemical equivalent weight of a substance defined as the ratio of atomic weight and valiancy.

ELCTRO CHEMICAL EQUIVALENT:-

Electro chemical equivalent is the amount of deposited on passing a DC current of one ampere for one second. Through its solution.

PRINCIPAL OF ELECTRO DEPOSITION:-

If two electrode are dipped in an electrolyte and potential is applied to them , then the molecular of substance dissolved on the electrolyte is broken into two types of ions , i.e. +ve ions and –ve ions.

Let us consider a ring of ring of iron to be given copper cutting so we have make following arrangement.

- Here, the electrolyte used in the given example is the solution of CuSo4. When electric supply is given to the solution through two electrodes it is dissolve into Cu++ ions and so4- ions.
- Hence the positive terminal of DC supply is connected to the copper rod and negative terminal is connected to the iron ring which is plated by copper.
- After getting the electric supply Cu++ ions attracted towards the negative terminal i.e. to the cathode and received two electrons from the supply to become copper atom.
- The negative So4- ions attracted towards the anode which made up copper is So4- ions after transfer of two electrons to the anode it becomes So4 radical & it attract the 'cu' anode to from CuSo4 molecule. Which will once again dissolve water to maintenance the electrolyte density to it's original level**.**

ALL THE SEQUENCE EXPRESS CHEMICALLY AS FOLLOWS:-

$\mathbf{Cuso_4}$ ---------> $\mathbf{Cu^{++}}$ **+** SO_4^{--}

AT ANODE:-

So_4^{--} less + two electron, So_4 molecule is radical form cu^{+} $\xrightarrow{+So_4}$ $CuSo_4$

AT CATHODE:-

Cu^{++} + Two electrons = mercuric copper

- So the phenomenon of some metallic cutting or the surface of some other metal through the process of electrolysis is called electroplating deposition.

APPLICATION OF ELECTROLYSIS:-

1. Extraction of metal from either ore.
2. Extraction of zinc, aluminum.
3. Electrotyping.
4. Electro forming.
5. Electro deposition.
6. Production of chemical.
7. Hectors clearing.

FARADAY'S LAW'S OF ELECTROLYSIS:-

Faraday was developed two law's on the phenomenon of electrolysis, which are called as faraday's law's of electrolysis.

FARADAY'S 1ST LAW:-

The mass of the substance liberated from an electrolyte in a given time is directly proportional to quantity of electricity pass in that time.

So, if W = is the weight of substance deposited in gram (gm) then

$$W=ZIT$$

Where,

Z is a constant which is called electrochemical equivalent. It is depends upon the nature of the substance.

I = strength of current in ampere

T = time in second

FARADAY'S 2nd law:-

If the same current flows for a given time through several electrolyte then the weight of substance liberated is proportional to their chemical equivalent.

According to this law if we take two electrolyte of $CUSO_4$ and $NISO_4$ in which same current flow to same time then.

= weight of copper deposited by given quantity of electricity

Weight of nickel deposited by some quantity of electricity

CURRENT EFFICIENCY:-

- Due to impurities which cause secondary reaction so the quantity of substance liberated is less than the calculated from faraday laws i.e.

  Current efficiency = Actual quantity of substance liberated /theoretical quantity

- It should le lies between 90 to 98 %

ENERGY EFFICIENCY:-

- Due to secondary reaction the actual voltage required for the deposited of metal is higher than the theoretical value which increases actual energy required so energy efficiency is defined as the ratio of theoretical energy required to the actual energy required .

FACTORS AFFECTING THE AMOUNT OF ELECTRO DEPOSITION:-

Following factor are effect the amount of electro deposition.

- **TIME :-**
  Time is directly proportional to the quantity of electro deposition so more mass will be deposited in more time and less mass will be deposited in less time provided other condition same .

- **EFFICIENCY:-**
  Greater is the efficiency greater is the quantity of metal deposited for given time.

- **Current**

  The value of current also directly proportional to the mass of metal deposited.

  Greater is the current greater in quantity of metal deposited.

  If we increase current beyond a certain limit the metal deposited will different colour and it's called burnt metal.

- **Strength of solution**

  If the strength of solution is more than the mass of metal deposited will be more.

Factor governing the better electro deposition

In order to get fine and smooth appearance suitable condition have to be provided.

The factor which effect the appearance of the deposited metal are discussed bellow:

- **Current density:**

  Law value current density the iron are released at slow rate there fore the deposited will be & crystalline in nature.

- At higher value of current density the quantity of deposit become more uniform and fine.
- If the current density is so high that exceed limiting value for the electrolyte then a spongy porous deposited is obtained.
- **Electrolytic concentration**
- These factor depend upon the current density because by increasing the concentration of electrolyte higher current density can be achieved.
- Increase of concentration of the electrolyte tends to better deposit and it is generally becomerded to use concentrated electrolyte.
- **Temperature**
- The temperature of the electrolyte is different for different metal to have better deposit.
- Ex: In chromium melting the temperature is maintained 35° Celsius.
- For Cu ----------→ 50° c
- For Nickel----------→ 50° – 60° c

- **Addition of agent**
- The quantity of a deposited is improved by the presence of an additional agent which may be an organic compound such as gums, rubber alkalic, sugar… etc.
- **Nature of Electrolyte**
- The smoothness of the deposited depends on the nature of electrolyte.
- Ex: Silver nitrate forms a rough deposit while that from Cyanide solution forms a smooth deposit.
- Nature of Metal upon which deposit is to be metal:
- This factor influence the growth of in cry station In the base metal.
- throwing power
- The throwing power of an electrolyte may be regardless as the quantity which produces a uiform deposit on a cathode having an irregular shape.
- The throwing power can be improve be :i) increasing the distance between the object and anode so that the relative variation in resistance between the anode and the different part on the object is required.
- By using some colloidal matter which results in increasing the current density.

CHAPTER-2
ELECTRIC HEATING

INTRODUCTION:-

Electrical heating is preferred over other types of heating methods i.e by wood , coal , coal and gas.

- All heating requirements can be fulfilled by some methods of electric heating .
- We know that when ever current 'I' is flow through any circuit resistance 'R'. power disipited in that circuit is I^2R worked.
- If the current rows for T second energy consume is I^2RT joule or watt sec. .
- The energy is converted to heat so the principle is when electric current passes through a medium heat is produced there are three modes of transmission heat.

1. Conduction ⟶ solid (←←←)
2. Conversion ⟶ liquid (↑↓)
3. Radiation ⟶ gaseous (sun light)

APPLICATION OF ELECTRIC HEATING:-

Electric heating is a estensively used in both domestic and industrial application.

1. **Domestic application:-**
   I. Room heater for heating the building.
   II. Immersion heaters for water heating.
   III. Hot plates for cooking.
   IV. Gyser .
   V. Electric kettles.
   VI. Hot air driers.
   VII. Electric iron.
   VIII. Coffee percolators.
   IX. Pope corn plant.
   X. Electric overs for baking products.
   XI. Electric toasters.
2. **Industrial purpose:-**
   I. Melting of metals.
   II. Heat treatment of metals like tampering,soldering,brazing etc.
   III. Electric welding.
   IV. Moulding of glass for making glass appearances.
   V. Baking of insulators.
   VI. Moulding of plastic components.

VII. Enamelling of copper conductor.
VIII. Heat treatment of pointed surfaces.
IX. Making of plywood.
X. Enamelling of copper conductor.

ADVANTAGES OF ELECTRICAL HEATING:-

i. Clean and neat atmosphere:-
   - There is no dust and smoke while operating controlled temperature.
   - The temperature can be controlled which is not possible in the other method of heating.

ii. No pollution:-
   - Absence of flue gas result no pollution of atmosphere means it doesnot produce any smoke .

iii. Controlled temperature:-
   - The temperature can be controlled with 5 degree C which is not possible in non electrical heating process.

iv. Ease of control:-
   - The heating can be started instaneously or stopped at a required time keeping a time gape between switching off and coiling of heating circuit.

v. Localised application :-
   - A work place can be heated up to particular depth for heat treatment where as the piece as a whole recives heat in non electrical heating process.

vi. Low ambient temperature:-
   - The temperature around an electrical furnace is much lower as compared to that around non electrical furnace is trouble for the workers.

vii. Uniform heating:-
   - The heating can be generated from with in the work piece resulting in uniform heating through induction heating.

viii. Cheap furnaics:-
   - The electrical furnace does not require big space for installation no storage of fuel is necessary.

ix. Heating of bad conductor:- (Heat electricity):-
   - Wood, plastic and a backery items can be uniformely and suitable heated with dielectric heating process.

x. Mobility of job:-
   - Pieces undergoing heat treatment can be mounted on a conveyer passing through the heating cabinets making use of electric heaters.

❖ **STEPHEN'S LAW:-**

It states that the total radient heat energy emitted from a surface is proportional to the fourth power of its absolute temp.

$E = e8T^4$

e = I – R =Emissitivity.

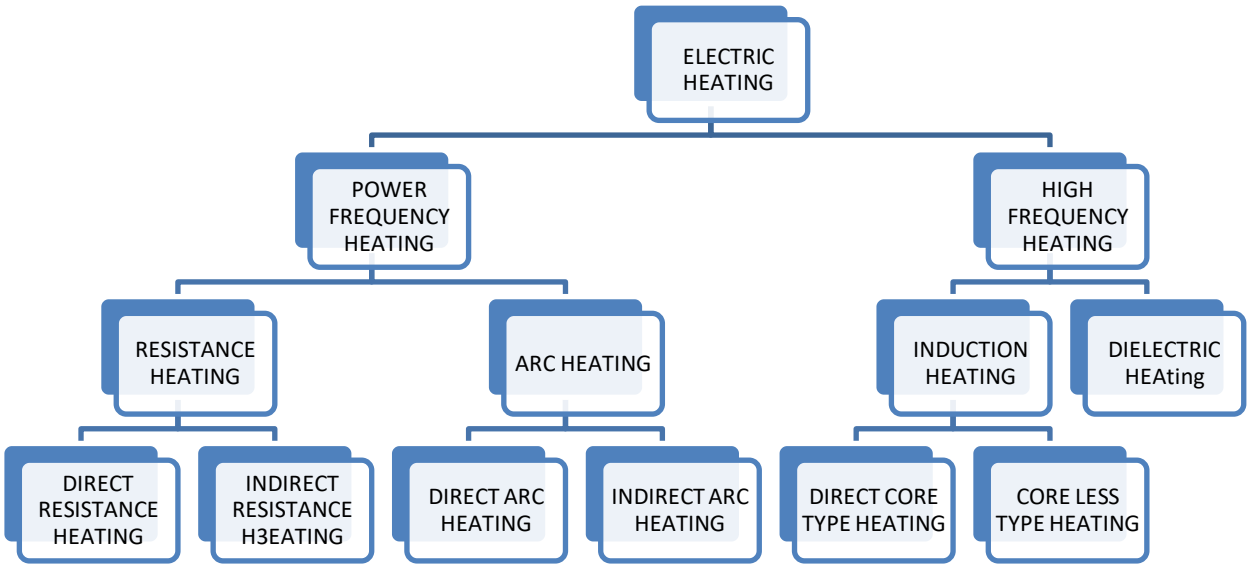
R =0 (If object is perfectly block)

8 = 5.66 e^{-8}w/m

T = temperature

xi. HIGHEST EFFICIENCY:-

Heat produce electrically does not go waste most of the heat is utilize by the material being heating.



MODE OF HEAT TRANSFER:-

- There are three modes of transmission of heat
- Conduction
- Convention
- Radiation
- Liquid are heated by convention method.
- Solid are heated by conduction method.
- Distant object are heated from the source of heat by a radiation.

DIRECT RESISTANCE HEATING:-

- In this method of heating the material or charge to be heated is taken as a resistance and current is passed through it.
- The two electrodes are ——— in the charge and connected to the supply.
- In case of D.C or single phase A.C two electrodes required there will be three electrodes in case of three phase supply.

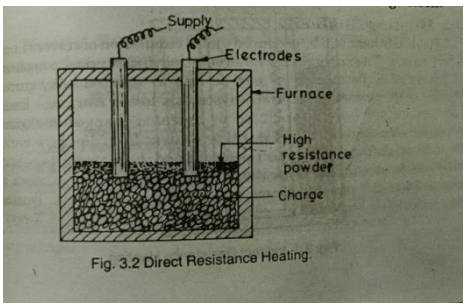


Fig. 3.2 Direct Resistance Heating.

- When metal pieces are to be heated a power of high resistivity material is sprinkled over the surface of the charge to be avoid directly short circuit.
- The current flows through the charge and heat is produced.
- The operating temperature is between 500^0c to 1400^0c.

INDIRECT RESISTANCE HEATING:-

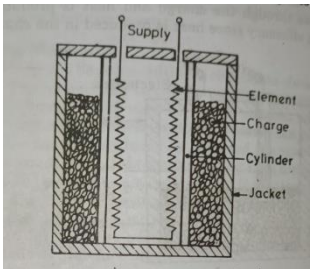


Fig. 3.3. Indirect Resistance Heating.

- In this method the current is passed though a highly resistance element which is either Placed above or below the over depending upon the nature the nature of the job to be performed .
- The heat proportional to I^2R losses produced in heating element delivered to the charge either by radiation or y convention.

RESISTANCE HEATING:-

- The method is based upon the I^2R loss. When ever a current is passed through a resistance material heat is produced due to I^2R loss.

ARC FURNACES:-

- The furnace used for melting / extraction of ferrous and nonferrous metal need a high temperature operation.
- One of the methods is through production of electric arc which gives an arc temperature between 300^0c to 3500^0c on LT operation.
- Arc is the flow of current through an air gap between two conducting diod bodies.
- There are two methods of striking one arc between two electrodes
    - **1)** H.T strike
    - **2)** L.T strike

1. **H.T STRICKE:-**

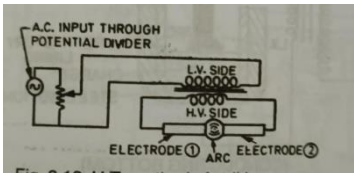


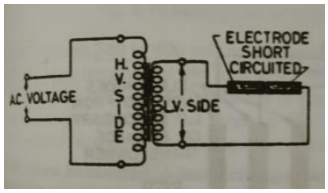
Fig. 3.13. H.T. method of striking an arc.

- A constant gap is maintained across a pair of electrodes say made of carbon.
- The electrodes are connected across the H.T secondary of a step up transformer.
- The primary is fed with variable AC voltage.
- A stage comes when the medium between the two electrodes is ionized and becomes conducting.
- At this stage when an arc is struck between the electrodes.
- The H.T required is dependent upon the size and nature of the gap.

2. **L.T STRIKE:-**
    - A low voltage of the order of mains voltage enough to strike the arc.
    - In this case the electrodes arc connected to the lower voltage side of the transformer.
    - These are momentarily short circuit and immediately separated resulting in product on arc.

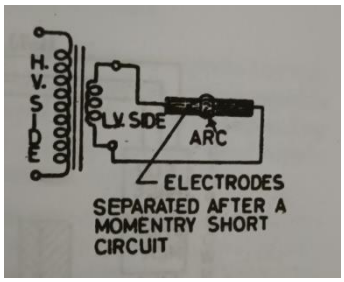
- The L.V strike method furnace divided in to two types
    a) Direct arc furnaces
    b) Indirect arc furnaces

A. **Direct arc furnaces**:-



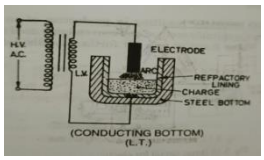
- ✓ When the arc is struck between electrodes and the change to be heated so that the arc current flows through the change and there is a divided contact between the arc and the change.

B. Indirect arc furnaces;-



- ✓ The arc setup between two electrodes does the heating indirectly.
- ✓ The arc does not come in contact with the charge but heat is transferred through radiation.
- ✓ From arc to top layer of change and through conductor from top layer to the bottom layers in the charge.
- ✓ Electrically direct arc furnaces further subdivided into two categories

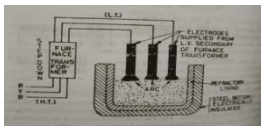
    a. Conducting bottom
    b. Non conducting bottom



a) **Conducting bottom**:-

The current is flows through the body of the furnace

b) Non conducting bottom:-



- ✓ The current is not flows through the body of the furnaces.
- ✓ Most of the furnaces used are non conducing bottom type.

B **. indirect arc furnace:-**

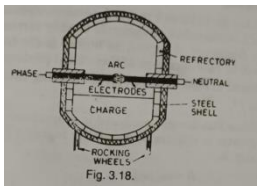


Fig. 3.18.

In this indirect arc furnaces low voltage or single phase supply is applied across the electrodes the arc is structure by short circuit the electrode manually of automatically for a moment and the separated the heat from the arc is transferred to the charge top layer and refractory lining through radiation and from top layer of the charge to other radiation and from top layer of the charge to other portion conduction.

Induction heating

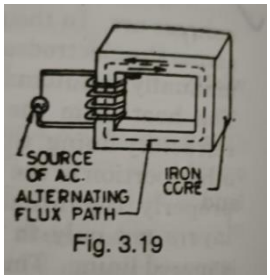
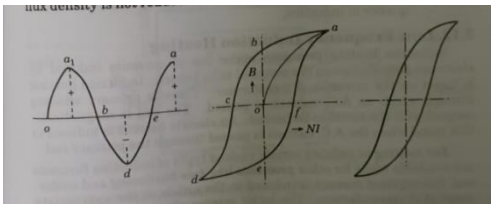


Fig. 3.19

- Eddy current loss:-

  When ever flux linking with any conduction body charges the result in an induced electro motive force which is a function of rate of change of flux or rate of charge of current is known as eddy currents.

- Hysteresis:-
  - We also know that if a pieces of magnetic material is magnetized and de magnetized time and again some energy is lost in the process.
  - The losses so occurring in any electromagnetic devices are named of hysteresis losses.



- Low frequency induction heating
  - Induction heating by the process of electromagnetic action in the material to be heated.
  - It Is based on the principle of the transformer.
  - There is primary winding through which then A.C current is passed.
  - The coil is magnetically coupled with the metal be heated . an electric current is induced in this metal when the AC current is passed through the primary coil.
  - There are different type of induction heating:-

    1 . core type

    a. Direct core type
    b. Vertical core type
    c. Indirect core type

A. Direct core type:-

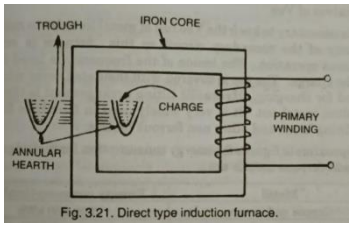
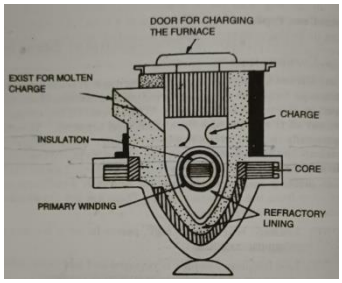


Fig. 3.21. Direct type induction furnace.

- The change is magnetically coupled to the primary winding. Electromagnetic forces are setup by the high current in the molten metal. When there is no molten metal no current will flow in the secondary.
- It is like a transformer the change forms the secondary winding and consists of one turn only formed by the metal to be melted.
- The current in the change is very high setup the order of several thousand ampere.
- The change in magnetically coupled to the primary winding.

❖ Disadvantage:-
- Leakage reactance is high , power factor is low due to poor magnetic coupled.
- Low frequency supply is required and addition as motor generator set or a frequency converter is required.
- Odd shape of are not convenient from magnetically point of view.
- Furnace can't function if the secondary circuit is open. It must be closed.

B. Vertical core type induction furnace:-



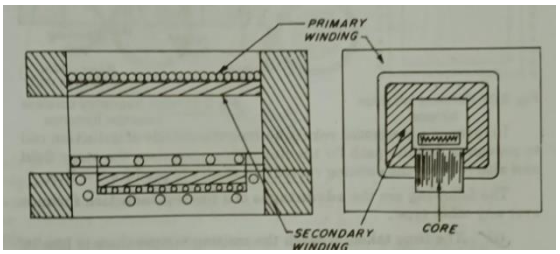
- This furnace is an improved over core type furnace.
- It has vertical channel for the change thus the curable used is also vertical which is suitable from metallurgical point of circuit.
- The modified form of this furnace is known as Ajax watt vertical core type furnace.

- The magnetic coupling in this furnace is better than core type
- Hence leakage reactance is comparatively low power factor is high, so it can operate from normal frequency supply.
- The circulation of molten metal is kept up round the vee portion by convention currents, As indicated and by the electromagnetic forces between the current in the lower halves of vee.

❖ Advantages:-

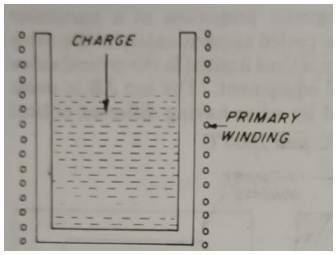
- High efficiency heat , low operating costs and improved production .
- Accurate temperature control, uniform castings reduced metal losses and reduction of rejects.
- Absence of crucibles.
- Consisting performance and simple control.
- Ideal working conditions in a cool atmosphere with number dirt, noise or fuel.
- Absence of combustion gasses resulting in elimination of the most common source of metal contamination.
- Comparatively high power factor with normal supply frequency since primary and secondary are both on the same central core.

C. Indirect core type induction furnace:-



- The induction principle can also be used for general heat treatment of metallic and other charges.
- The heat is transmitting to the change by the process of radiation.
- The secondary windings forms the walls of a metal container and the iron core links the primary as well as secondary winding.
- Due to relatively poor power factor (0.8). it most process some special advantage for its commercial success.
- The main advantages of this method are temperature control method.
- The temperature ranging between 400^0 c to 100^0 c.

D. Coreless induction furnaces:-



- The flux produced by the primary winding set up eddy currents in the charge. The eddy currents developed in any magnetic current.

Eddy current $\dot{\alpha}B^2 * F^2$

Where B = flux density

F = frequency

- The eddy current are sufficient to heat the metal to melting point and set up electromagnetic forces which produce striking action.

❖ Construction:-

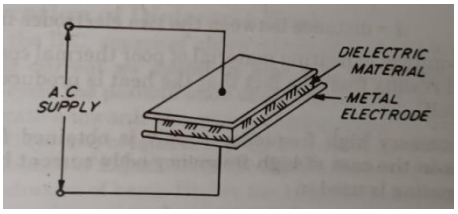
- The furnace has a refractory lining the primary coils are wound around it.
- The alternating flux produced by the primary winding induces eddy currents in the charge.
- The artificial cooling of primary coil is necessary because of high amount of copper losses.

- The coil is constructed in the form of hollow tube through which cold water is circulated.

❖ Advantages:-
- Time taken to reach the melting temperature less.
- Peruse control of power into the charge can be employed.
- Cru of any shape can be used.
- Charging and pouring is simple.
- No dust, smoke and noise.
- Erection cost furnace is low.
- Automatic slirring in the charge due to eddy current.

- **Skin effect:-**
  - The alternating current distribution is not uniform.
  - The alternating current tends to concentration near the surface of conductor and no current flows through the core of conductor.
  - This phenomenon is called the skin effect and it causes the resistance of the conductor to increase.

- **Dielectric heating:-**



  - This is also sometimes called high frequency capacitive heating and is employed for heating of insulating material like wood plastic and ceramic etc….. .
  - The supply frequency applied for this type of heating between 10-20 mega cycles per second and the applied voltage up to 20kv.
  - The principle of operation of dielectric heating is that when a capacitor is subjected to sinusoidal leading the voltage exactly by90^0.
  - The angle between voltage and current is slightly less than 90^0

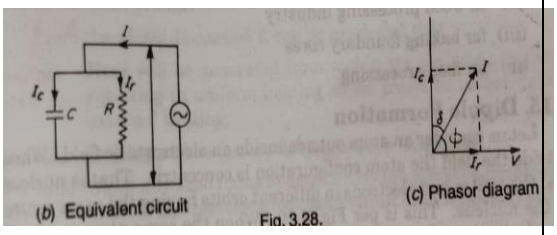


Fig. 3.28.

  - There is a small component of current which is in phase with the applied voltage and in turn produces a power less in the dielectric.
  - The material to be heated is placed two sheet type electrodes which forms a capacitor and its equivalent circuits.

- **Application of dielectric heating:-**

1. Plywood industry

2. Sand core baking
3. Plastic industry
4. Tobacco industry
5. Bakeries
6. Electronic sewing
7. Dehydration of wood
8. Removal of moistures from oil emulsion
9. Electro medical application
10. Book binding

Micro wave heating:-

- In system electricity is converted in to electromagnetic waves, which generates energy and this energy is used to cook the food.
- These waves are nothing but high frequency radio wave similar to those used by radio or tv.
- The wave length of these waves is very short of every high frequency also known as micro waves.
- In the over micro waves are confined inside the over cavity and reflected of to its wave and doors once the door is opened all micro waves are automatically switched off.
- These micro waves vibrate millions of times per second 2000-2500 MHz.
- When micro wave energy comes into contact with some substance it is reflected transmitted or observed. These waves are reflected by water/moisture present in the food.
- When this energy is observed , heat is produced and cooking takes place.

❖ Application of micro wave heating:-

I. Baking manufacture or bread /toast etc… .
II. Drying of paper and textiles.
III. Food processing/kitchen work.
IV. Treatment of discusses UKC ,cancer etc… .
V. Manufacture of plastics.
VI. Processing of cement and timber etc… .

❖ Advantages:-

I. It has neat and clean system.
II. It provide uniform heating to the substance.
III. The system provides quick heating.
IV. The depth of perturbation of heat in to the material is much more.
V. Within the material , the heat is generated directly which give and much faster temperature rise.

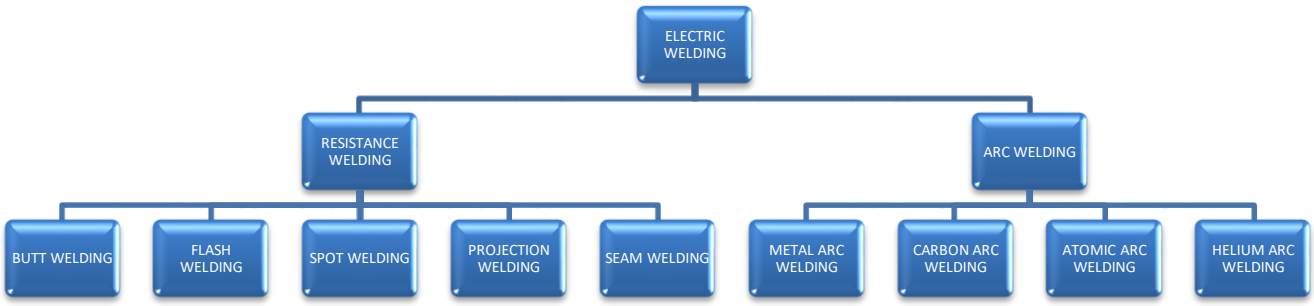
CHAPTER-3
PRINCEPLE OF ARC WELDING

WELDING:-

It is defined as a process in which metals are joined by heating them to a suitable temperature without the application of pressure and addition of filler material.

ELECTRICAL WELDING:-

In the branch of welding in which electric current is used to produce the large heat required for joining together into firm union: two pieces of metal.



ARC WELDING:-

- When two conductor are connected to a suitable source of electric current momentarily in contact and then separating by small distance an electric arc produced.
- This arc gives rise to temperature and heat is produced. The heat utilized to meet the part of work piece and the filler metal and this form the joint.
- Temperature required 3000*c and 100v for safety of the operating.
- Current ranges from 30 to 500A for manually operator welding and 75 to 600A for automatic operated.

USES:-

- For joining the metal parts to repair fractional casting.
- The filling by the deposition of new metal on the worm parts.
- It is used for cutting metal.

ARC Welding are classified into various types:-

(I)Carbon arc welding

(2)Metal arc welding

(3)Atomic hydrogen arc welding

(4)Helium or Argon welding

Principle of ARC welding:-

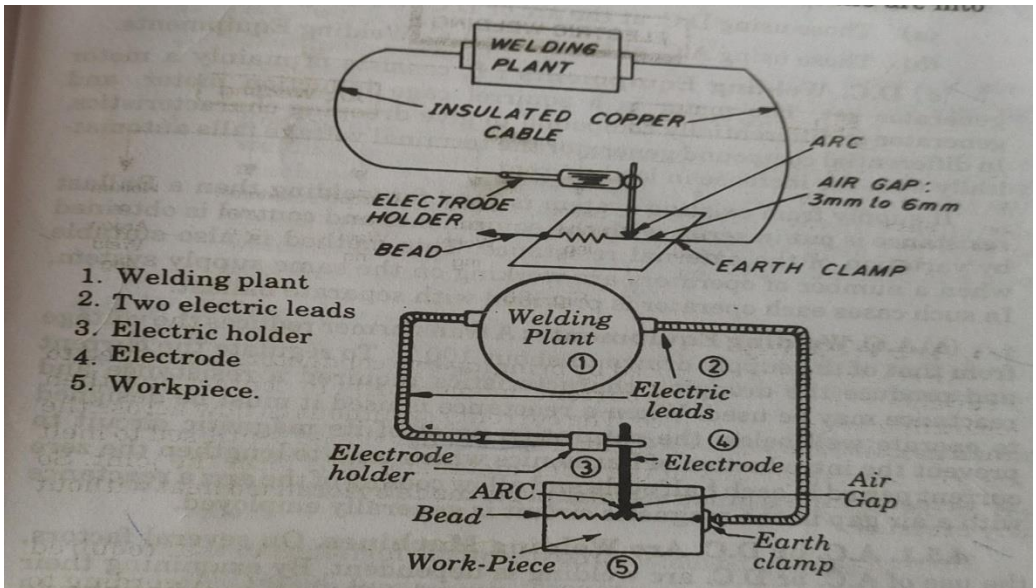


Fig. 4.1. Principle of arc welding.

- One terminal is connected to the electrode and the other to work piece and the circuit is competed through air gap.
- The air provided between the tip of the electrode and the surface of work piece about 3mm to 6mm.
- Due to the interruption by the air gap or gas. Heat is produced and the temperature attained varies from 3700*C to 4000*C.
- Electrical energy is converted at the arc into heat energy.
- The sparking voltage is usually in the region of 80 to 100Vin case of A.C and 60 to 80V in case of D.C.

TYPES OF ARC WELDING

(1) Metallic Arc welding
(2) Carbon Arc welding
(3) Atomic Arc welding
(4) Helium or Argon Arc welding

(1)**Metallic Arc welding:-**

- In this arc system a metal rod is used an electrodes and the arc is struck between this electrodes & work which respectively from the two terminals.
- The arc down between the metal electrode and the work create a temperature of over 3500*C.
- In this system of welding both AC & DC are used.

(2)**Carbon Arc welding:-**

- This method used for welding copper and its alloys.
- The carbon electrode which is kept negative with respect to the work if N.C is used
- If the carbon electrode is made +ve, the carbon particles have a tendency to go into the welded joint and cause brittleness.
- The electrode should kept –ve and the work +ve.
- For this type of welding only DC can be used.

(3)Atomic hydrogen Arc welding:-

The essential of the atomic hydrogen arc welding process are

- Electrodes energy is supplied to an arc between two tungsten electrodes where it is transformed into heat.
- Molecular hydrogen is blown through this arc and transformed catalytically into the atomic form which acts as a vehicle for transform of energy from the arc to the work.
- In the direction away from the area sudden decreases of temperature cause the rapid decreases in the concentration of atomic hydrogen and a release of the heat of recombination.
- For this welding open circuit voltage of 300v is necessary and for hard welding a current range up to 50amp.
- This method is successfully used for welding stainless steel & non-ferrous metal etc.

(4)**Helium or Argon Arc welding:-**

- This method is used for welding Al & Mg alloys.
- An arc is struck between electrode of tungsten and the work & helium argon is used to give an inert atmosphere so that oxidation of welded joint doesn't take place.
- Standard DC & AC welding equipment may be used provided the open circuit voltage is around 100V for AC and 70V for DC.

FEATURES OF ARC WELDING

(1)Good forceful arc

(2)Weld arc is easy to hold once it is obtained

(3)A good way to held aluminum.

(4)There is an absence of arc blow.

(5)The most popular application is production welding on heavy gauge steel.

RESISTANCE WELDING

- The principle of resistance welding is the generation of heat in the joint by passing a heavy current through the parts, this being followed by the application of mechanical pressure which welds the plastic metal and retires the grain structure.

Generation of heat

- The heat generated, H by passage of an electric current I through resistance R is given by.
  $H=I^2Rt$

R=the actual electrical resistance of the joint where the weld is to take Place.

I=the current in ampere.
t= the time in second.

- The temperature attained depends on this quantity and is affected by heat losses .The amount of current necessary is 4400 to 5000A per sq.cm of area to be welded. The pressure varies from 280 to 505 kg per sq. cm.
- The resistance welding may be defined as the method in which a sufficiently strong electric current is sent through the two metals in contact to be welded bringing the two pieces to the molten state and this applying mechanical pressure at this time to complete the joint.

Advantages:-

(i)It is a quick method of joining two pieces.

(ii)There is very little wastage of metal.

(iii)The welds arc consistently uniform.

RESISTANCE WELDING:-

(A)BUTT WELDING:-

In this process, heat is generated by the contact of resistance between two components. The faces of the component should be mechanical or edge prepared.

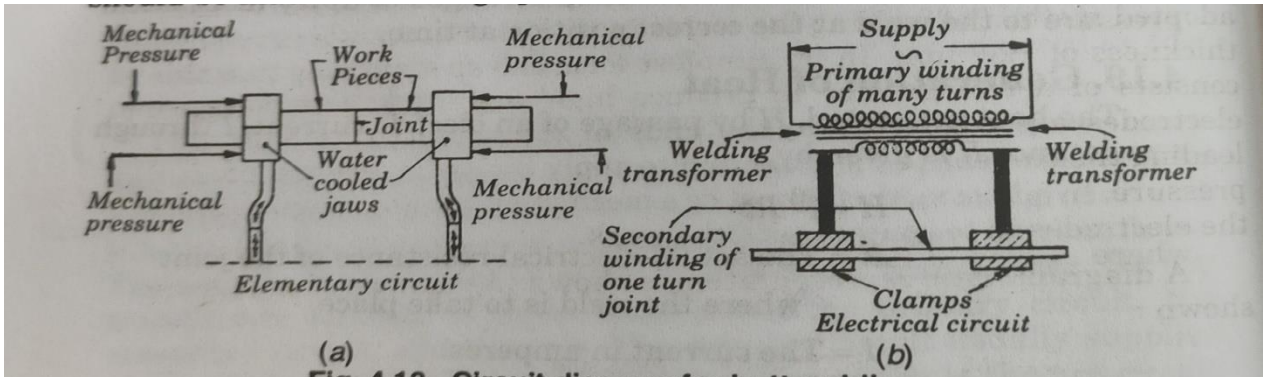


Fig. 4.13. Circuit diagram for butt welding.

Application:-

1.Where the parts are joined end to end or edge to edge.

2.for welding pipes, wires and rods.

(B)FLASH WELDING:-

- This is similar to butt welding except for the difference that in this case current is applied to the parts before they are brought together so that when they meet arcing or flashing take place.
- The two places to be welded are damped strongly in a flash welding machine, the parts are brought together & the resistance to the current flow heat the contacting surfaces.
- As soon as the metal has been brought to its melting temperature, the current is shut off, the pieces arc rapidly brought together under considerable pressure.
- When this action takes place the squeezed molten metal gives off sparks or flash.
- As the metal is heated to its plastic state, the pieces are forced together under high pressure which forces fused metal and slag out of the joint making a good solid weld.

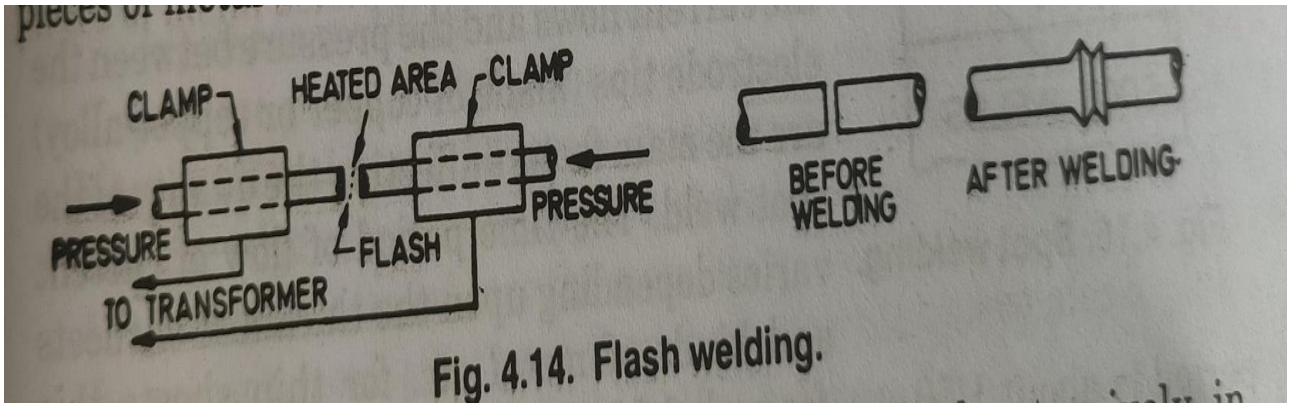


Fig. 4.14. Flash welding.

APPLICATION:-

- Production work particularly in welding rods and pipes together.

(C) SPOT WELDING:--

- This is the simplest and most universally adopted method of making lap welds in thin sheets upto a maximum thickness of 12.7mm
- The spot welding machine consists of a transformer to produce high current as low voltage.
- Electrodes are connected to the ends of the secondary winding for leading the current to the work and to apply the necessary mechanical pressure.
- In the process of materials to be welded are over lapped and pressed between two water cooled electrodes and a impulse of current is passed through the assembly.
- For spot welding 5000amp of current is required &the voltage between the electrodes is usually less than 3volts.
- The open circuit voltage is less than 12volts
- The time period of flow of current varies depending upon the thickness of sheets and kinds of metal.

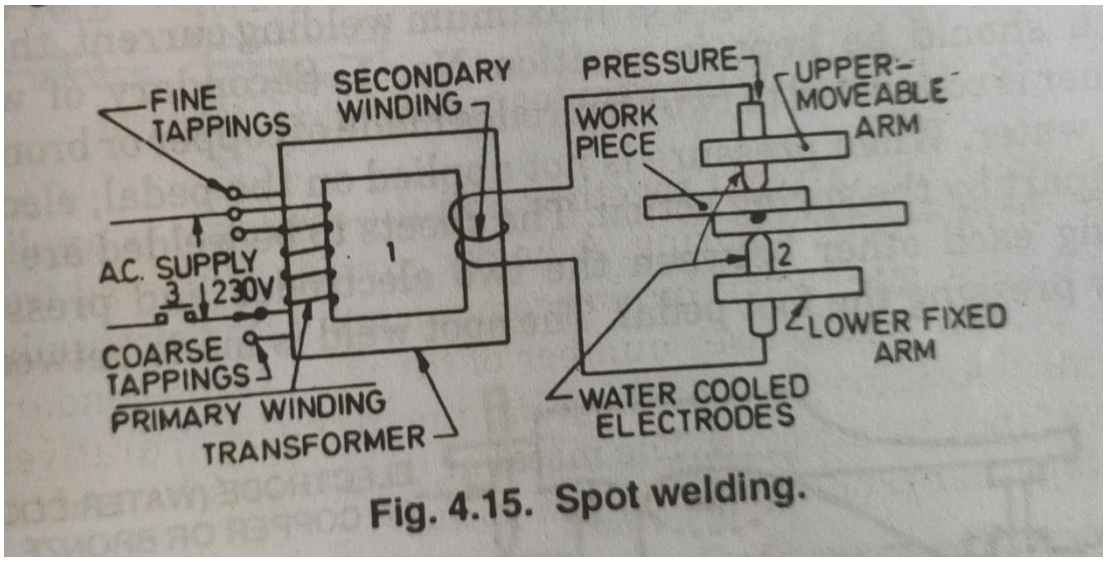


Fig. 4.15. Spot welding.

Application:-

1. It is applied to welding of sheets.

2. It is used for fabricating all types of sheets metal structure where mechanical strength rather than water or air tightness is required.

3. It may be applied to all types of boxes, cores and enclosing cases etc.

(D)SEAM WELDING:-

- It is similar to spot welding except that series of spots are produced by roller electrodes instead of tipped electrodes.
- As these rollers travel over the metal the pieces are under pressure and the current passing between them heats the two pieces of metal to the fusion point. This might be called as Seam spot weld method.
- The spaces can be timed to overlap or timed to have space between the spots. The main object of the overlapped spots is to produce gas and liquid leak proof lap joints.
- The intermittent overlap spot used technique is used for metals that are critical to heat treatment.

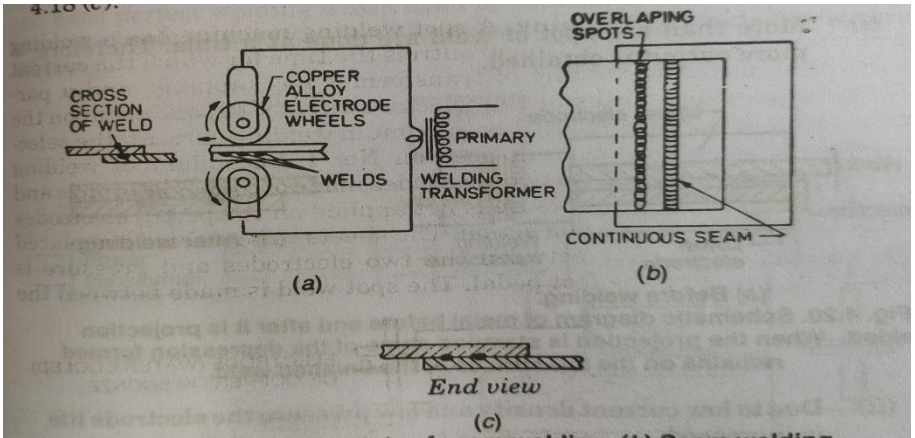


Fig. 4.18. (a) Principle of seam welding, (b) Seam welding.

Applications:-

1. It is used for making lap and butt welds.

2. It is quicker than spot welding operation.

3. It is used pressure tight or leak proof tanks transformer radiator units.

(E) Projection Welding:-

- Projection welding consists of forming & light projection on the sheets of metal & light projection are accurately formed in precise locations on the metal by a special set of dies.
- After the projection are formed, the raised portions on one piece are pressed into contact with another piece. While at the same time a heavy current is passed through the two pieces.
- When these raised protections touch the second sheet of steel, as they are damped by the electrodes in a projection welder and the current is applied, current flows at the points, heats and

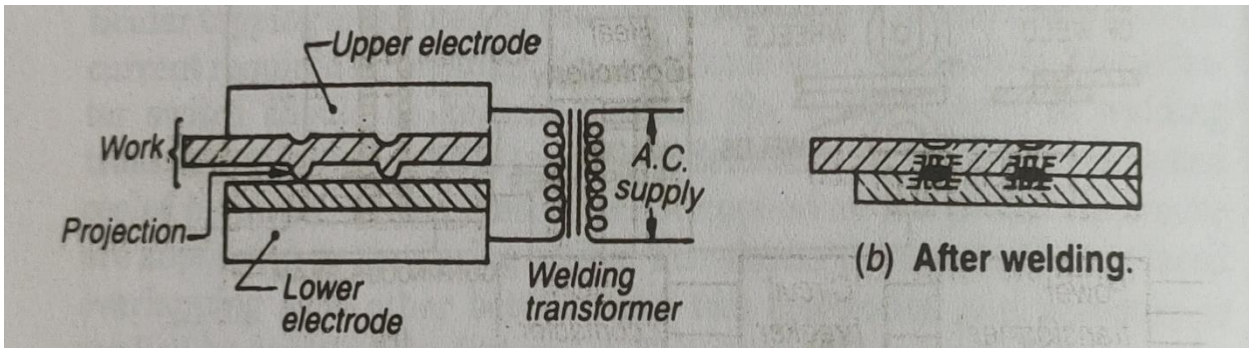


Fig. 4.20. Schematic diagram of metal before and after it is projection welded. When the projection is stamped some of the depression formed remains on the top surface of the finished weld.

fuses the two pieces together.

Application:-

1. It is advantages in assembling parts made by punching or stamping and for welding studs, nuts to plates.

Advantages of over spot welding:-

- More than one spot or weld are done at a time, therefore more output is obtained.
- Due to low current density and low pressure the electrode life is increased.
- Good, finished appearance is obtained because surface remains unidented by the electrodes.
- It locates the welds automatically at certain desired points by the position of Projection.

CHAPTER-4
ILLUMINATION

- Illumination is different from light, light is cause of illumination is theresult of surface on which it falls.
- Thus the illumination makes the surface look more or less bright with certain colour and it is this brighters and colour which the eye seen.

DEFINITION:-

- It is defined as the number of lumens falling on the surface per unit area.
- It is denoted by symbol 'E' and is measured in lumens per meter or Lux or meter candle.
- **E= Φ/ A lumens per M^2**
- Bigger unit of illumination is phot . 1 phot= 10^4 Lux

TERMS USED IN ILLUMINATION:-

I. **LIGHT:-**

Light is defined as the radiation energy from a hot body causing visualsensation upon the human eye.

II. **FLUX**:-

- It is known as luminous flux.
- It is defined as the total quantity of light energy radiated.
- It is measured in lumens and it is denoted by F and Φ
- It is defined as the rate of luminous energy.
- Flux Φ= Φ/t lumens.

Light energy:-

- It is the energy obtained in visual radiations in a given time and isexpressed in lumen hours and it is denoted by Φ.

Plane angle:-

- Plane angle is substended at a point in the some plane by twoconverging lines.
- This angle is measured in radiations or degrees.

Φ = Area/radians

= L/r radian

And one radians = (180/π) degree.

Solid angle:-

- Solid angle is the angle generated by the line passing through the pointin space and the periphery of the area.
- It is measured in steradians and is denoted by 'W' and

W= area/(radious)^2

Luminous intensity :-

- It is the defined as the output in lumens per watt of the power consumedby the source of light.
- It is measured in lumens per wattage.Lumen :-
- Lumen is defined as the amount of luminous flux

Given out in space represented by one unit of solid angle by a sourceHaving an intensity of one candle power in all directions

Lumens= Candle power x Solid angle = C.P. X wOr

Total lumens given out by the source of one candla is 4 n lumens.

Candle Power (C.P.) :-

- It is defined as number of Lumens given out by the source in a unít solidangle in a given direction.

It is denoted by symbol C.P.

i.e. C.P. =lumens/w

Illumination :-

- When the light falls upon any surface, the Phenomenon is calledillumination.
- It is defined as the number of Lumens, falling on the surface per unitarea.

- **It is denoted by symbol E And is measured in lumens per square metre orlux or metre Candle.**
- Bigger unit of illumination is phot. One phot = 10^4 lux

Metre Candle :-

- It is also known as lux.
- it is the illumination produced by a source of one candle power on theinner

Surface of a sphere of one metre radius.

Mean spherical Candle power (M.S.C.P.) :-

- It is defined as The áverage of candle powers in all directions and in allplans from the Source of light.

M.S.C.P. =total flux in lumens / 4π

Mean hemi spherical Candle power (M.H.S.C.P.) :-

- It is defined as the average of candle powers in all directions above orbelow the

horizontal plane passing through the source of light.

Mean horizontal Candle power (M.H.C.P.):-

- It is average Of all the candle powers in all direction is in the horizontalplane contain-Ing the source of light.

Reduction factor :-

- Reduction factor of a source of light is Defined as the ratio of its meanspherical candle power to its mean Horizontal candle power.

Reduction factor: M.S.C.P/M.H.C.P.!

Reflection factor:-

- **It is defined** as the ratio of reflected light To incident light. It is alwaysless than unity.
- R.F. =Reflected light/Incident light

Lamp efficiency :-

- It is defined as the ratio of luminous flux To the power input. It isexpressed as lumens/watt or watts/candle Power.
- Lamp efficiency = Lumens emitted by source/Wattage of source of light.

Space height ratio :-

- It is defined as the ratio of horizontal Distance between two adjacentlamps and height of lamps from the Working plane.

Space height ratio=Horizontal distance between two adjacent lamps/Heightof lamps above working plane

Depreciation factor.:-

- Due to accumulation of dirt,dust,and smoke on lamp they emit less light.
- It is defined as the ratio of illumination under everything is perfectly

clean to the illumination under normally working condition is known as

depreciation factor.

Depreciation factor=Illumination when everything is clean/Illuminationunder normal working condition

- It is more than unity.

Maintenance factor :-

- It is merely reverse of the depreciation Factor. So it is always less than unity.

Co-efficient of utilisation :-

- Co-efficient of utilisation is defined as the ratio of Lumens reaching theworking plane to the total lumens given out by the lamp.
- Co-efficient of utilisation= lumens reaching on working plane/totallumens

emitted by source of light

LAWS OF ILLUMINATION :-

- There are two laws of illumination
    1. Inverse square law
    2. Lambert's cosine law

INVERSE SQUARE LAW :-

- The illumination of a surface is Inversely proportional to square of distance - between the source and surface provided that the distancebetween the surface and the source is sufficiently large so that the source can be regarded as a point source.
- Consider a point source S having an intensity I lumens/steradian.
- Let two surfaces having areas A1 and A2 be placed at distances r and 2r metres always respectively from the source.
- The two surfaces are enclosed in the same solid angle 'w'.
- Since the source gives I lumens per steradian, any surface enclosed bysolid angle 'w' will receive a total flux =I x w lumens.

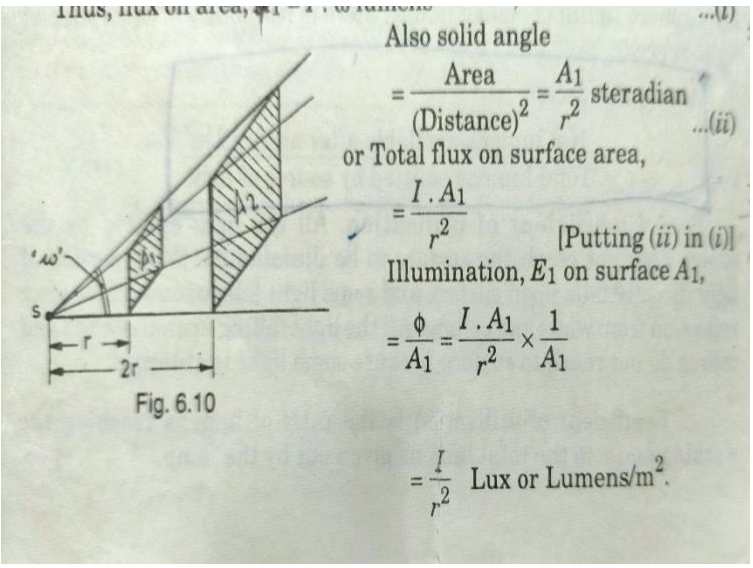
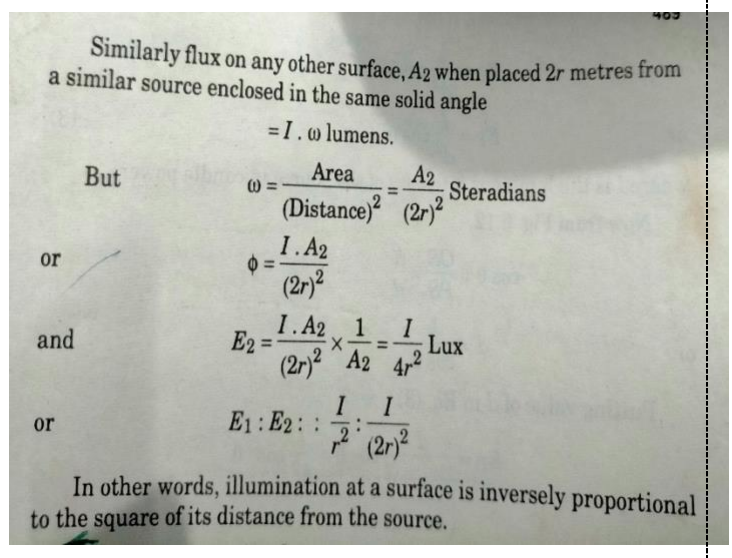


Fig. 6.10


Similarly flux on any other surface, A_2 when placed $2r$ metres from a similar source enclosed in the same solid angle

$= I \cdot \omega$ lumens.

But $\omega = \frac{\text{Area}}{(\text{Distance})^2} = \frac{A_2}{(2r)^2}$ Steradians

or $\phi = \frac{I \cdot A_2}{(2r)^2}$

and $E_2 = \frac{I \cdot A_2}{(2r)^2} \times \frac{1}{A_2} = \frac{I}{4r^2}$ Lux

or $E_1 : E_2 :: \frac{I}{r^2} : \frac{I}{(2r)^2}$

In other words, illumination at a surface is inversely proportional to the square of its distance from the source.

LAMBERT'S COSINE LAW :-

- The illumination of a surface is directly proportional to the cosine of theangel between the normal to the surface and direction of incident light.
- In the normal surface case, E= Φ/Area
- In the incident surface case, E= Φ/Area × cosθ

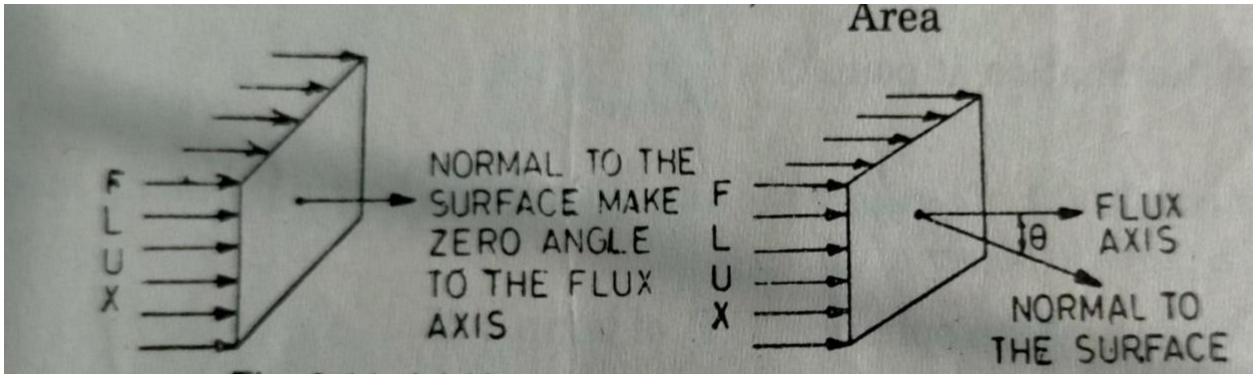


Fig. 6.11. (*a*) Normal surface. (*b*) Inclined surface.

SOURCES OF LIGHT :-

Various sources of light can be divided into two groups.

i. Natural sources.
ii. Artificial sources.

Artificial sources can be further divided into two groups

(i) Non-electrical sources of light.
(ii) Electrical sources of light

Natural sources of light are sun, stars. Main sources of light inNature is sun.

Non electric sources of light :-

- The non-electric sources of light are candles kerosive lamps , petromax,lamps etc..

Electrical sources of light

- The electrical sources of light are incandescent lamps mercury vapourlamps. Florescent tubes sodium vapour lamps etc…..
- The quantity, colour, and quality of light emitted by above various indifferent.

ELECTRICAL SOURCES OF LIGHT:-

Incandescent-Lamps :-

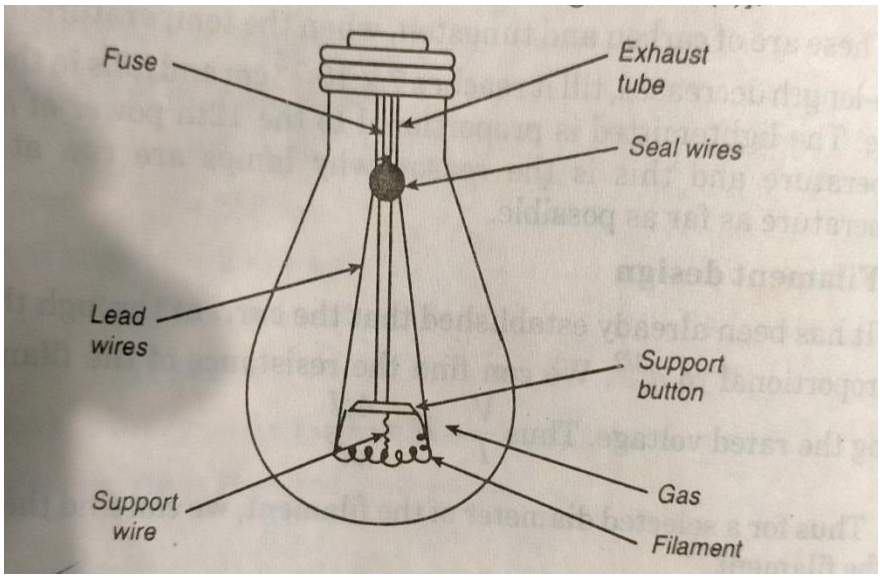
- **Filament materials**
  - These are of carbon and tungsten, when the temperature increases Wave-length decreases, till it reaches 7×10^{-5} cm and falls in the visibleRange.
  - The light emitted is proportional to the 12th power of absolute Temperature and this is the reason why lamps are run at a highTemperature as far as possible.
- **Filament design**
  - It has been already established that the current through the lamp Isproportional to d3/2.
  - We can find the resistance of the filament by Using the rated voltage.
  - Thus = $v/R = 4pl/\pi d^2$
  - Thus for a selected diameter of the filament, we can find the length Ofthe filament.

Construction features and working of filament lamps :-

- If the space in the lamp is replaced with an inert gas, tungsten Filamentcan reach a temperature of 2400 K without evaporation.
- Due To higher temperatures, loss of heat due to higher temperaturesoccurs. So the heat is reduced by gases like nitrogen or argon.
    - **The convection loss is minimised by coiled coil filament.**
- **SpiralFilaments are used now to prevent heat losses The case of tungstenfilament, light output α E^n**

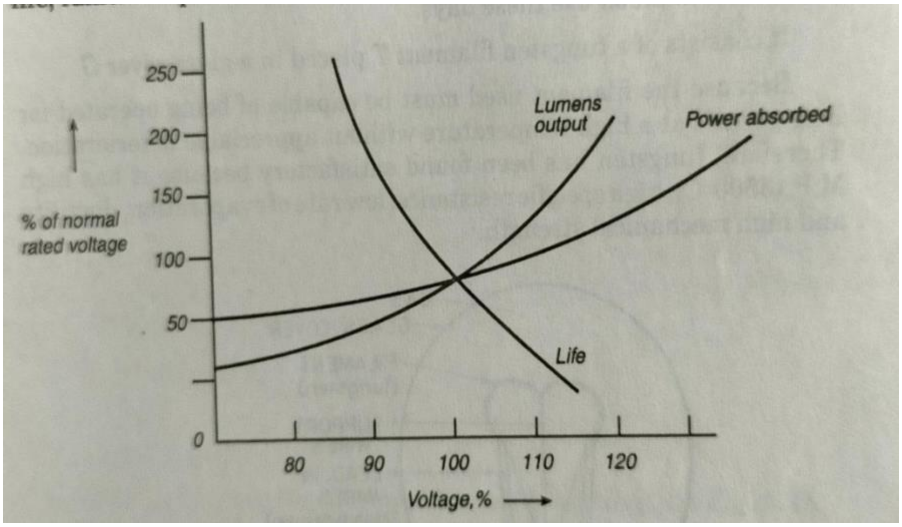
where n =4 or 5 and Power input α E^n

When, n = 1.8 and E is the voltage



Working :-

- During manufacture, all air is pumped out of glass envelope toPrevent filament burning up when operating.
- Lamps larger than 40 Watts are filled with inert gas (argon and nitrogen)to retard evaporation of tungsten.
- However, gradual evaporation causes a dark deposit On the inner side ofthe bulb blocking light.
- Now-a-days luminous Efficiency of 10-30 lumen/watt is achieved.Effect of voltage variation on the life of the lamp :-
- The filament lamps are under operation under constant supply voltages.



- But a variation of +- 6% voltage of consumers terminals is permitted under the Indian Electricity Rules. Further drop of voltage in the electricalwiring may occur.
- Thus a voltage variation from +6% to -8.5% may result.
- Hence the operating voltage varies from 212 to 224 V on a 230 V supplymains.
- A study of the behaviour of a 100 W filament gives the characteristiccurves shown In Figure] for its life, lumen output and power absurbed.

Incandescent lamps :-

- These are also known as filament lamps. These lamps work on theprincipal of Incandescence, hence known as Incandescent lamps.
- According to which, when current is passed Through the wire, both heatand light are produced.
- When wire in red Hot it emits more heat as compare to light.
- At white hot position, the Amount of light radiations being much morethan heat energy.

The material used for filament of filament lamp must have following properties :-

a) It should have high melting point.
b) It should have high resistivity.
c) It should have low temperature co-efficient.
d) It should have low vapour pressure.
e) It should be strong mechanically to withstand vibrations During normaluse.
f) It should be ductile so that it can be drawn into very thin Wires.

The material used for filament is carbon, osmium, tantalum and Tungsten.

- Now a day tungsten is mostly commonly used metal filament because if fulfills above all properties more over lamps with tungsten filament has higher efficiency than carbon, osmiom and tantalum filament lamps.

Gaseous discharge lamps :fluorescent tube:-

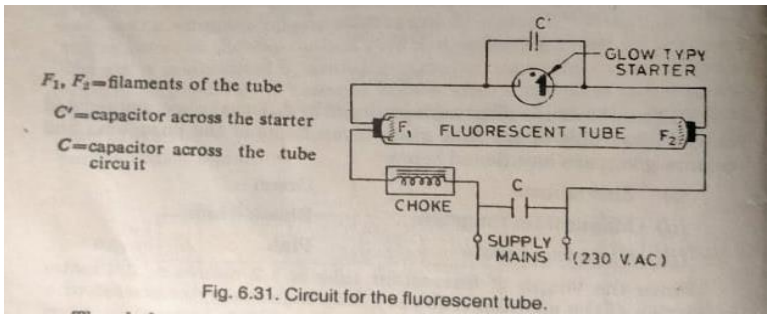


Fig. 6.31. Circuit for the fluorescent tube.

Construction :-

- The fluorescent tube consist of a long tube with an electrode at each endwhich has in the form of wiled coil filament coated with an electron emitting material like, oxide of barrium and scandium.
- The inside of the tube is coated with fluorescent power. A choke of high resistance is connected in series with the filament and starter as shownin the figure.
- A starter connected between two filament f1 and F2 as shown in abovefigure.
- There is also capacitor is inside the starter. A capacitor c is connected across the supply terminal in order to improve power Factor.

Operation :-

- When supply is given to the circuit nearly full supply to voltage across thestarter terminal due to low resistance of filament and negligible currentthrough the choke. The starter is fielled with some argon gas. At this voltage the gas inside and a glow appears inside the starter. This warm of the bimetallic strip carrying moving contacts and the strip bends and short circuited the starter terminal this gives a circulating of strong current through the filament f1,f2 and the choke coil.
- As the filament is coated with oxide of barium and strontium resulting inthermionic emission which can ionise the argon gas in side the tube. In the mean while the bimetallic strip of the starter cools down and break and per the starter circuit. The sudden opening of starter contacts result in an about change of current linking with the choke coil and whichmakes on filament f1 at high potential with respect to the other filamentf2.
- This momentary high p.d. is enough to ionise the gas medium that is mercury and argon present inside the tube this resulting paseg of currentbetween two electrodes inside the tube. This results in passage of current between two collision between electrodes and mercury atoms continue further emission from filament giving secondary the starter circuit due to the low resistance path between the filament f1 and f2 anda large voltage drop across the choke circuit.
- The choke also help in keeping the current through the ionised mediumwith in saft limit

the radiation from emitted mercury atoms falling or thephosphor cutting results in white colour of light the average life of the fluorescent lamp is also 4000 hours and its efficieny is about 40 lumesper watt.

Function of capacitor :-

- The capacitor across the starter terminal is to avoid introduction of noise,signals in the reception of radio or transister recever being operated nearthe tube the capacitor is connected across the supply inorder to improve the power factor which becomes law due to the presence of high reactance chock coil.

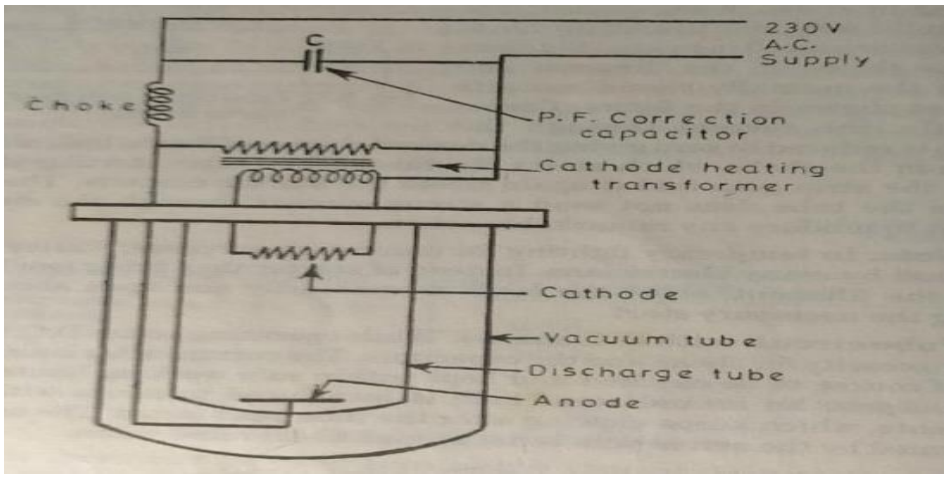
State basic idea about excitation in gas discharge lamp :-

- Discharge lamps are the lamp in which electrons are emitted from cathode when cathode is heated and due to passage of electric currentthrough it. This process is called as theromic ionic emission.

❖ Basic idea about discharge lamps are as follows:-

- In the gas discharge lamps due to closeness of the atoms of gas underpressure, energy transfers are not free during collision and consecequency osscilation, electrons are not free.
- Therefore instead of characteristic of radiation of particular wave length ,we get bands which get wider and wider as pressure characteristic wave length of that gas will be in abunace. The table below gives the colour oflight and efficiency lumen/watt for various gasses or vapours.

Vapour or gas	Coulor	efficiency
Sodium	yeiiow	40-50
Hg under Lp	Blue greeen	15-20
Hg under h.p	Blue white	20-30
Neon	Red	15-40
Co_2	White	2-4
c.d. vapour	Blue	0.5-1
he	Yellow white	4-10



.Sodium vapour lamp :-

- It has the highest theoretical luminous efficiency ad gives mono-cromaticorange yellow light the mono-cromatic light makes objectes appears grew such lamps on factor account of this are use only for strect and high coal lighting.
- The lamp consist of discharge tube having a special composition of glaswithstand the high temperature of the electric discharge.
- Thee discharge tube surrounded by an outer tube as shown in figure forheating the cathode aa transformer is included.
- Sodium below 60^0 c is solid state for starting the lamp thee electricdischarge is allow to take place neon gas.
- The temperature inside the discharge tube rises and vapourise sodium.
- Operating temperature is around 300^0c.
- it takes about lomin for sodium the sodium vapour to displace the recolure of Ne by its own yellow colour.
- The lamp takes about half an hour to reach full output.

- A chock is provided for stabilizing the electric discharge.
- The light output is 30-50 lumens per watt.
- The rating of bulb 40 watt, 80w, 60w, 140w.
- The lamps takes about 5-6 minutes for starting and takes about 15minutes for coming in full brilliancy.
- Its average life about 3000 working hours.
- It emits a light of yellow colour of wave length 5900 A^0.
- It can be only street light(out door) and arc only ac used.

Mercury vapour lamp (high pressure) :-

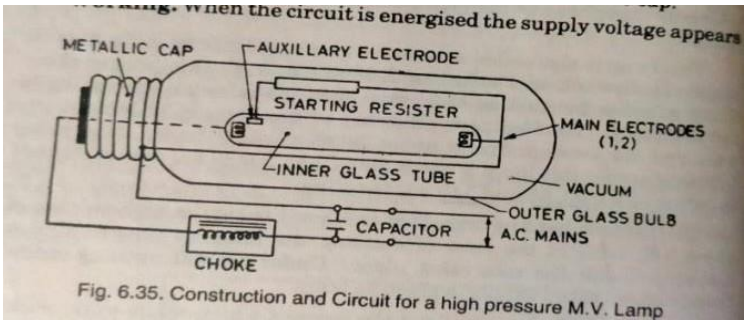


Fig. 6.35. Construction and Circuit for a high pressure M.V. Lamp

Construction :-

- It was observed that Hg discharge at low pressure gives mainly ultra- violet radiation. How ever if pressure is increased to one or two atmospheres the radiation of light in a visible spectrum. The inner tube content neon or argon gas under low pressure. The two main electrodes in the form of oxides coated coil and starting on auxiliary electrode neon,the cap and side of main electrode choke is used as usually with discharge with discharge lamps to limit the discharge current condenser is used to improve power factor.
- The inner discharge tube is made up of hard glass. It is obtained in an evacuated chamber which maintained high operating temperature of theinner arc tube.

Working :-

- When supply is given electric field is step up between starting electrodeand the adjacent main electrode. This causes discharge first to take place between them through argon gas produces enough heat to vapourise Hg drops in the inner tube for full discharge it requires 1-8 mm.

- The arc then shift to main electrodes and electron are emitted from the starting electrode and high resistance path becomes inactive.

Neon lamps and tubes :-

- Neon lamp consist of a glass both filled with neon gas with a small percentage of helium.
- The two electrodes in the glass bulb are of pure iron spaced few mm apart.
- These lamps are operated on 110v AC or 150v DC supply.
- Neon lamps give average pink coloured light and it size is very small as compared to incandescent lamp.
- Its luminous efficiency is 15-40 lumens per watt and power consumption is about 5w.
- These lamps are used an indicator lamp and night lamps.

CHAPTER-5
INDUSTRIAL DRIVES

- An electric drive is defined as a form of machine equipment designed to convertElectric energy into mechanical energy & provide electrical control.

Types of electric drive :-

Electric drive used in industries may be of two types :-

1. Group Drive.
2. Industrial Drive.

1. **Group Drive :-**

- In this case one motor is used for driving two or more then two machine.
- Motor is connected to a long shaft on which belt , pulley , gears are connectedTo run other machine.
- This type of electric drive is economical because single motor has very large capacityWhose cost is very less than the cost of a number of small motors.

Drawback of Group drives :-

- In case of any fault in the motor all the connected machines to the motor will ceaseTo operate.
- If at certain instance all the machines are not in operation then the machine will beWorking at low capacity.
- It is not possible to install a machine at a far distance.

2. **Individual Drive** :-

- In this type of electric drive a single electric motor is used to drive one individual machine.
- It will cost more than Group Drive but is operation has complete control on his machine.
- Machine can be operated at convenient places.

Advantages of Individual Industrial Drive :-

- Cost is low as compared to other system of drive.

- The system is more simple & operated smoothly.
- The control is very easy and operated is smooth.
- Flexible for remote control.
- Maintenance cost is quit low.
- It can be started any time without delay.

Disadvantages of Individual Drive :-

- Electric Drive can only be accepted in electric field area.
- Failure in supply may affected in the system.

Choice of Electric Drives :-

The important factor to choose an Electric Drives are :-

- Requirement related to source :-

  The main type of source and it's capacity , magnitude of voltage ,voltage Fluctuation , power factor & harmonics.

- Steady state operation requirements :-

  Nature of speed torque characteristics , speed regulation ,

  speed range efficiency ,Duty cycle , quadrant of operation.

- Transient requirement :-

  Starting , breaking , value of acceleration & de-acceleration , reversing performance.
- Capital & running cost maintenance.
- Environment & location.
- Reliability.
- Space and weight restriction.

Specification of commonly used motors :-

- Rating of motors.
- Whether the rating is continuous or short time or intermediate.
- Type of supply AC or DC.

- In case of AC 1 phase or 3 phase.
- Frequency.
- Method of

starting. Other essentials

specification

Types of motors whether DC or AC necessary with starting operating characteristics.

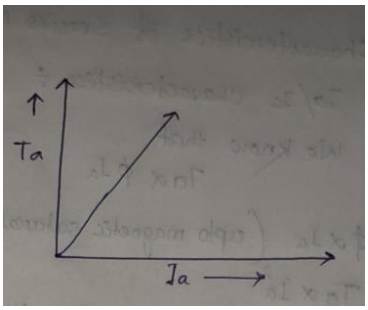
- Types of bearing & encloser :-

  Whether the drive is one or more machine.

- Types of Transmission :-

  Transmission of force or mechanical force from main to other by gear/ belt or chain.

Characteristics of DC motor :-



Characteristics of shunt motor:-

(a) Ta/Ia

characteristics :- We

know that in a DC

motor Ta α ϕ Ia

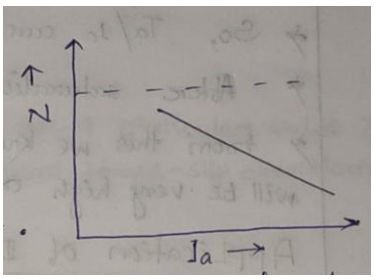
φis

constant

Ta α Ia

- Hence Ta/ Ia characteristics is a straight line passing through the origin.
- They are used only on light load.
- So a very large current is required to start a heavy load there for a shunt motor could not bestart in heavy load.

(ii) N/Ia characteristics:



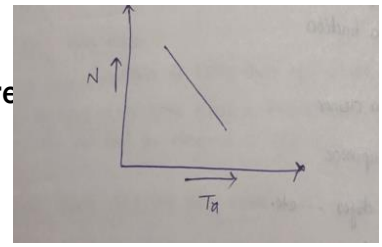
In shunt motor

N α Eb/Φ & Φ is

constant N α Eb

- The speed of a DC motor is given by N α Eb/Φ.
- The flux & black emf (Eb) in A shunt motor are almost constant under normal condition.
- So the speed of a shunt motor will remain constant.

(iii) N/Ta characteristics :



The speed of a shunt motor falls slidely as the load torque incre

Characteristics of Series Motor :

(iii) Ta/ Ia characteristics:

We

know thatTa

α ϕIa

ϕ α Ia (up to magnetic

saturation)Ta α Ia X Ia

After magnetic saturation

flux is constantTa α Ia

Up to magnetic saturation armature torque is directly proportional to the square of armature current.
So, Ta/Ia curve is portable up to

magnetic saturation.After saturation Ta/

Ia Curve is straight line.

From this we know that the straight torque of a D.C. Series motor will be very high as compared to shunt motor.

Application of DC motor:

(i) Shunt Motor

It is used in lathe machine, drill machine, waving machine

(ii) Series motor :

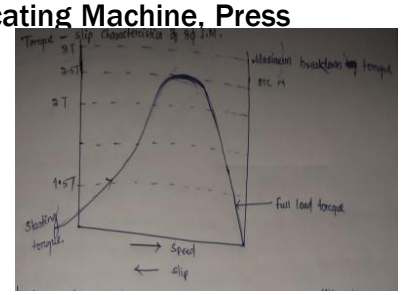
The machine having high starting torque so that these motor are used in : Elevator, electric traction, vacuum tube , Air compressor, Hair dryer —etc.

(iii) Compound Motor:-

These motor are used in : Surge machine, Reciprocating Machine, Press Machine

AC motor characteristics :

Torque slip characteristics of 3 ϕ IM



We know that the induction motor torque under runningcondition is given by The carve drawn between the torque & slip for a particularvalue of rotor resistance (R2) the graph thus obtain is called torque-slip characteristics curve.

Characteristics of 1 ϕ Induction Motor

- Split phase Induction Motor
- It is a constant speed motor.
- The motor has less cost.
- The starting torque is 1.5 to 2 times the full load torque, the starting torque 6-8 times the fullload current.
- The power ratting of the motor is in between Bow - 250 w.

Capacitor start Motor :

- Starting characteristics is better than split phase motor.
- This can be used where more starting torque is required.
- It produce less heat as compared split motor.

Capacitor Start Capacitor run motor :

- This motor is similar to the capacitor start motor
- The motor produces constant torque & not pulsating to torque, due to when the motor isvibration free.

CHAPTER-6
ELECTRIC TRACTION

- Electric traction means a locomotion in which the driving force is obtained from electric motor.
- There are many advantage of electric traction over other method of location.
- The most important requirement of the driving equipment for traction are –
  1. Maximum tractive force should be required at starting.
  2. The equipment should be capable to take over load for a short period.
  3. The wear caused on the tank should be minimum.
  4. The train should be self control and able to run or any route.
  5. The breaking should be possible without excessive wear on break shoes and the energy forbreaking should be negative.

ADVANTAGES –

1. **Cheapness-**
   It is cheapest method of all the other method of traction.
2. **Acceleration & Breaking-**
   These are smooth and rapid.
3. **Cleanliness-**

   It is free from smoke and flue gas and hence it is most suitable type of traction system to be used forunderground and tubular required.
4. **Maintenance cost-**

   Maintenance cost and repair cost of electric traction is about 50% less than steam traction system.
5. **Starting time-**

   It can be started without any loss of time where steam traction require minimum two hour's to start thelocomotive.
6. **Breaking-**

   In electric traction regenerative breaking is used which feedback about 40% of the energy.
7. **Shaving in high grade coal-**
   - Steam locomotive requires high grade coal which is different in our country.
   - Electric energy required for running electric locomotive is taken either from hydropower stationor from a thermal power station which run from load grade coal.
   - It has great passenger carrying capacity at high speed as compared to steam locomotive.
   - The far and Light in train can be connected directly to the supply lines and there is no need forproviding extra generator and batteries.

DISADVANTAGES –

1. Higher mutual expenditure is involved on electric traction.
2. Failure of supply is a problem to be faced in electric traction.
3. This vehicle can only for on electric field track.
4. When Ac energy utilized extra precaution should be taken to prevent interface with the adjacent telegram and telephone line.

SYSTEM OF TRACK ELECTRIC FICATION-

There are two types of vehicles are used for electric traction.

- The 1st type of vehicles receive power from a distribution network while the second type ofvehicles generate their own power.
- The first type of vehicles used AC or DC power from overhead line but second type of vehiclesdisel engine electric drive.
- Accordingly there are two main system of electric traction are used they are –

  1 Dc system

  2 AC system

1. DC system-

***The DC traction in India only exsit in Mumbai and some part of Madras . In this system the electricmotors are used in DC series motor.**
*** The operation voltage is about 600 v for sub urban railway and main line railway etc ranges from1500v to 300v.**
***The motor receive Power from an overhead line with the help of a Pentagram and the railway steeltrack act as return conductor.**
***The overhead wire is fed from various substation these substation receive power from 3 phase 11 kV or3 phase 33 kV or 3 phasy66 kV transmission line**
***Then this AC is converted into DC power by using mercury are rectifiers or rotary converter.**

* Now a day's the converter is semi converter rectifier distanced between substation depends upon thefactor i.e voltage drop, density, traffic.

* For urban railway the distance between substation is 3 to 50 km and for main line railway 40-50 km.

2. AC SYSTEM –

In modern days AC system are basically used in traction. Further Ac system can be divided into 4 types.

(a) 3 phase AC system –

***In this system 3 phase slipring induction motor is used to speed control can be achieved by thecombination of pole changing method and rotor resistance method.**
***The main advantage of this system is regenerative breaking is obtained immediately.**

* The voltage and frequency at which the motor operate are about 3600v &16 2/3HZ.

***The Major disadvantages is used two over head conductor.**
***So this method is almost out of use.**

(b) **1 phase standard frequency system-**

*This system is also known as composite system.
*This is most used in India.
*It consists of one overhead wire supply kv50Hz.
*A T/F is mounted on the locomotive and it stepdown the voltage which is further rectifier and fed to DCseries motor.
*The substation are supplied at high voltage up to 132kv which is stepdown to 25kv by T/F installed insubstation.
*With the development of semiconductor rectifier this system is more popular and more developedmethod.
*This system is more reliable more efficient.
*The driving force is obtain by DC series motor.

(c) **Single phase low frequency system –**

*1 phase 15kv 16 2/3HZ system is used in west Germany sweeden Australia for the main line service.
*A stepdown T/F is carried by a locomotive to get a voltage about 400v for the use of traction motoreach substation is supplied at high voltage at standard frequency.

* The voltage is stepdown and frequency is converted by set.

*Series motor are used for this traction.
*The main disadvantages of this system a special low frequency power distribution network is required.

(d) **1 phase to 3 phase system –**

*In this system 1 phase high voltage AC system is employed for distribution network.
*The locomotive carry phase converter which convert 1 phase into 3 phase. The 3 phase is corrected to a 3 phase induction motor to get the necessary driving force.
*The disadvantages of this system is low cost distribution and cheap in construction.
*The voltage of distribution network is 16kv 50HZ.

METHOD OF SUPPLY POWER TO RAILWAY TRAIN –

There are two system for supplying power to railway train.

1. Over head system

2. Conductor rail

system

Over head system

This system is addopted usually when distribution network is fed at high voltage.

- The current is collected from the overhead network with the help of collector.
- The rail track used as return path of conductor.

2. Conductor rail system –

- It is addopted for heavy electric traction.
- High conductivity steel are used for supplying power, these conductor rails are properlyinsulated,the Curtis collected with the help of collector shoe.
- The used of this yis restricted up to 0.8kv only.

***ADVANTAGES OF 25kv AC SYSTEM COVER DC SYSTEM –**

1. Light over head catenary-

- Use of high voltage in the overhead system reduces the current in the line which make the useof small size conductor.
- The small size conductor is light and easy to support,so supporting structure required are quitelight.

2. Saving in sub_stations-

- In high voltage AC system since the current drawn is less so voltage drops which one mainly due to reactance of the line are also quite less. This will provide longer distancebetween two substation.
- AC substation have less equipment and easy to maintain.
- Efficiency of AC locomotive is high than DC locomotive.
- 25kv AC is much deeper.