BALASORE SCHOOL OF ENGINEERING

SUB – U.E.T

THEORY – 03

CODE – EET – 602

BRANCH – ELECTRICAL

SEM- 6TH

Submitted by

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CHAPTER -1

Short type question - 2 marks

1. What is electro-plating?[2015 Q6(a),2017 Q4/a,2019 Q7(iii)]

Electroplating is an art of depositing superior or more Nobel metal over an inferior metal by means of electrolysis of a suitable electrolyte.

2. Define current efficiency. [2018 Q3(a)]

Current efficiency is defined as the ratio of the actual quantity of the substance liberated or deposited to the theoretical quantity, i.e.

$$\text{Current efficiency} = \frac{\text{Actual quantity of substance liberated or deposited}}{\text{Theoritical quantity of substance liberated or deposited}}$$

4. What is polarization? [2015 Q1/a]

Use of current density beyond certain limit makes the substance blacken due to formation of hydrogen gas at cathode. This phenomena is called polarization.

5. What is faradays law of electrolysis? [2016 (W) 1/a]

Faraday's First Law of Electrolysis states that the weight of the substance deposited or liberated is directly proportional to the quantity of electricity (coulombs) passed through it.

Faraday's second law of electrolysis states that, when the same quantity of electricity is passed through several electrolytes, the mass of the substances deposited are proportional to their respective chemical equivalent or equivalent weight.

Medium type question - 5 marks

1. Explain faradays law of electrolysis. [2015 Q2(b),2017 Q1/b,2016 Q1(b),2019 Q2(b)]

Faraday's laws of electrolysis combine two laws and these are described as follow.

Faraday's First Law of Electrolysis states that the wt of the substance deposited or liberated is directly proportional to the quantity of electricity (coulombs) passed through it.

i.e. mass of chemical deposition,

$$m \propto Quantity\ of\ electricity,\ Q \Rightarrow m = Z \cdot Q$$

m = Zit [as Q = It]

Where Z is a constant of proportionality and is known as electrochemical equivalent of the substance.

Faraday's second law of electrolysis states that, when the same quantity of electricity is passed through several electrolytes, the mass of the substances deposited are proportional to their respective chemical equivalent or equivalent weight.

$$\text{Thus chemical equivalent} = \frac{\text{Atomic weight}}{\text{Valency}}$$

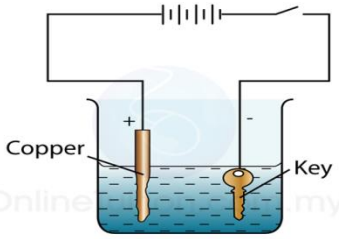
.

$$\frac{W_1}{W_2} = \frac{E_1}{E_2} \text{ or } \frac{Z_1 It}{Z_2 It} = \frac{E_1}{E_2} \text{ or } \frac{Z_1}{Z_2} = \frac{E_1}{E_2} \quad (\because W = ZIt)$$

Thus the electrochemical equivalent (Z) of an element is directly proportional to its equivalent weight (E), i.e.,

2. Explain electroplating. [2018 Q6(b),2019 Q7(iii)] or Write basic principle of electro deposition. [2015 Q2(b),2018 Q1(b)]

- Electroplating is the process of depositing a superior metal (ex. silver) over an inferior metal (ex. iron) by means of electrolysis'
- Electroplating is used to give metal objects a better appearance or to protect them from corrosion, wear, or rust, decorative pieces and jewelry are plated with gold or silver to make them more attractive.
- Copper is coated with chromium to protect it from corrosion. For the same reason iron and steel are plated with nickel, chromium, tin, zinc, or cadmium.



- First, a container is filled with a solution of a salt of the metal that is to form the coating. For example, if copper is to form the coating, the solution will consist of copper sulfate (a salt of copper) mixed with water. This solution is called the electrolytic bath. The object to be plated is immersed in the bath.
- The object to be coated is connected to the negative terminal of an electric battery or other source of direct current, and becomes the. The metal bar is connected to the positive terminal of the electric power source and becomes the anode.
- When electric power is applied, electrolysis of the electrolytic bath occurs. The bath gives up its metal content to the surface of the cathode. This coating forms an alloy with the metal of the cathode.
- If the anode is made of another metal, salts of the coating metal must be added to the bath as metal becomes deposited on the cathode.
- The longer the process continues, the greater the thickness of the coating on the cathode.

Preparation for electroplating

- Before electroplating the all the organic compound like oil , grease should be removed.
- All inorganic compounds like rust, oxide should be cleaned from the metal to be electroplated.
- Surface of the metal should be mechanically prepared for better deposition.

4. What are the applications of electrolysis? [2015 Q5(a),2018 Q1(c)]

Application of electrolysis are

- Extraction of metal from their ores – By the process of electrolysis metal can be extracted from their ores
- Extraction of Zinc –Zinc can be extracted from Zinc ore by electrolysis
- Extraction of Aluminium – Aluminium can be extracted from its ore by electrolysis process.
- Refining of metal – Pure metal can be obtained by reefing with the process of electrolysis
- Production of chemical – Many chemical can be obtained by the process of electrolysis process.
- Electrotyping – woodcut are reproduced in copper by the process of electroplating
- Electroplating – Process of depositing one metal over another by the process of electrolysis called electroplating
- Electroforming – New article can be produce by this process.

5.Explain briefly the factors affecting the amount of electro-deposition.[2019 Q1(b)]

The factor governing electro depositions are

Current density – At low value of current density, the ions are released at slow rate & the deposition is not uniform. At higher value of current density the quality of deposition become more uniform & fine.

Electrolytic concentration – These factors depend upon the current density, because by increasing the concentration higher current density achieved.

Temperature –The temp. of the electrolyte is different for different metals to have better deposition

Addition of agent – The quality of deposited is improved by the presence of an additional agent which may be organic compound as rubber , gums, sugar etc

Nature of the electrolyte – the smoothness of the deposited largely depends upon the nature of electrolyte.

Distance between the plates – Increasing the distance between electrodes increases the resistance, which affect adversely.

CHAPTER -2

Short type question - 2 marks

1. What are the different modes of heat transfer.[2016 Q1(a)]

Conduction, convection & radiation are the three modes of transfer of heat.

2. Give the name of one high frequency heating method. [2015 Q2/a,2018 Q2(a)]

High frequency heating are

- Induction heating
- Dielectric heating

3.What is skin effect?

Skin effect is the tendency of an alternating electric current to become distributed within a conductor such that the current density is largest near the surface of the conductor, and decreases with greater depths in the conductor.

Medium type question - 5 marks

1.State advantages of electric heating. [2016 Q2(c),2017 Q1(b),2019 Q1(c)] or Why electric heating is preferred over other form of heating.

Advantages of Electric 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. Moreover, the material to be heated does not get contaminated.
(ii) No Pollution. Since no 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 do not require big space for installation or for storage of coal and wood. Moreover, 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.

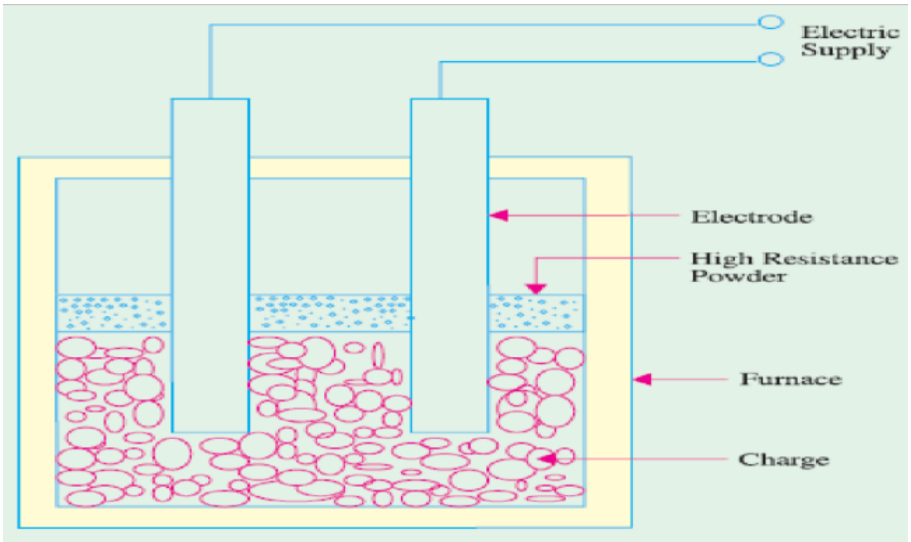
(vii) Better Working Conditions. Since electric heating produces no irritating noises and also the radiation losses are low, it results in low ambient temperature. Hence, working with electric furnaces is convenient and cool.

(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.

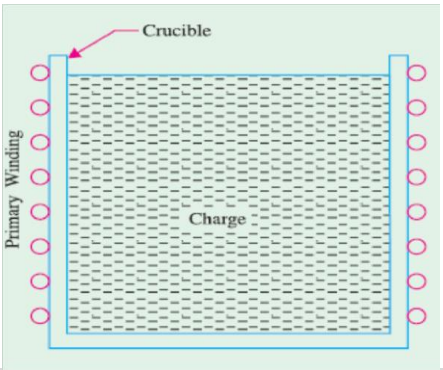
(*x*) Lower Attention and Maintenance Cost. Electric heating equipment generally will not require much attention and low maintenance cost.

2. Explain direct resistance heating. [2016 Q6(c),2019 Q6(c)]



- In this method the material (or charge) to be heated is treated as aresistance and current is passed through it.
- The charge may be in the form of powder, small solid pieces orliquid.
- The two electrodes are inserted in the charge and connected to either a.c. or d.c. supply (Fig).Obviously, two electrodes will be required in the case of d.c. or single-phase a.c. supply but there wouldbe three electrodes in the case of 3-phase supply.
- When the charge is in the form of small pieces, a powderof high resistivity material is sprinkled over the surface of the charge to avoid direct short circuit.
- In this method material have direct contact to the electrode. Ex – Resistance welding, melting of metal etc.

3. Explain coreless type induction furnace. [2015 Q7(b),2017 Q1(c)]



- As shown in Fig., 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 charge is put into the crucible and primary winding is connected to a high frequency a.c. supply The flux produce by the primary sets up eddy-currents in the charge and heats it up to the melting point
- 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
- The primary winding is not made of Cu wire but consists of hollow Cu tubes which are cooled by water circulating through them.
- Such furnaces are commonly used for steel production and for melting of non-ferrous metals like brass, bronze, copper and aluminium etc., along with various alloys of these elements.

Advantages

- They are fast in operation.
- They produce most uniform quality of product.
- They can be operated intermittently.
- Their operation is free from smoke, dirt, dust and noises.
- They can be used for all industrial applications requiring heating and melting.
- They have low erection and operating costs.
- Their charging and pouring is simple.

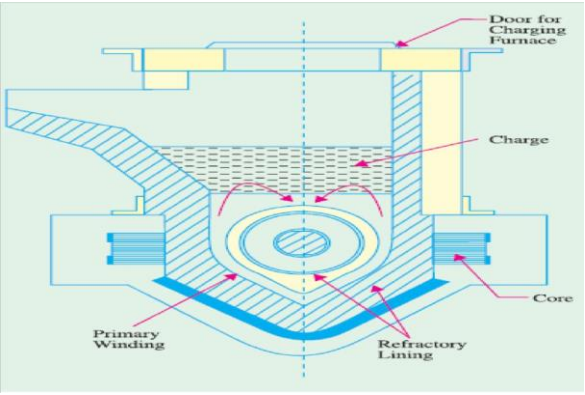
4. Explain briefly the principle of resistance furnace. [2016 Q 2/b,2018 Q2(b)]

- 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.,
- Temperatures upto 1000°C can be obtained by using heating elements made of nickel, chromium and iron.
- Ovens using heating elements made of graphite can produce temperatures upto 3000°C. Heating elements may consist of circular wires or rectangular ribbons. The ovens are usually made of a metal framework having an internal lining of fire bricks.
- The heating element may be located on thetop, bottom or sides of the oven.
- The nature of the insulating material is determined by themaximum temperature required in the oven.

- An enclosure for charge which is heated by radiation or convection or both is called a ***heating chamber***.

Long type question - 7 marks

1**. Explain vertical core type induction furnace with neat sketch. [2015 Q1(b),2017 Q4/c,2018 Q5(b)]**



- It is also known as Ajax-Wyatt furnace and represents an improvement over the core-type furnace. As shown in Fig., 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 shown in Fig. As Vee channel is narrow, even a small quantity of charge is sufficient to keep the secondary circuit closed.
- However, Vee channel must be kept full of charge in order to maintain continuity of secondary circuit. This fact makes this furnace suitable for continuous operation.
- The top of the furnace is covered with an insulated cover which can be removed for charging. The furnace can be tilted by the suitable hydraulic arrangement for taking out the molten metal.
- This furnace is widely used for melting and refining of brass and other non-ferrous metals. As said earlier, it is suitable for continuous operation. It has a p.f. of 0.8-0.85. With normal supply frequency, its efficiency is about 75% and its standard size varies from 60-300 kW, all single phase.

2. Write down the application of dielectric heating. [2015 Q1(c),2018 Q1(a)]

Dielectric heating used in

- It is used in wood processing industry
- Its is used for food processing
- It is used for baking foundary cores
- It is used for book binding
- It is used in textile industry
- It is used in sterilization of bandage and gauge
- It is used in pasturing of milk and beer

3. Explain mode of heat transfer. [2017 Q3/a,2016 Q2(b)]

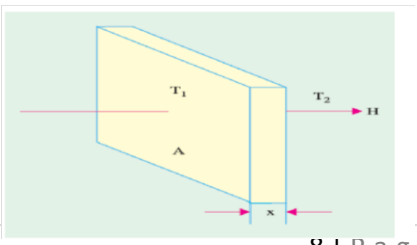
The different methods by which heat is transferred from a hot body to a cold body are as under:

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. If *T*1 and *T*2 are the temperatures of the two sides of the slab in °*K*, then heat conducted between the twoopposite faces in time *t* seconds is given by:

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



Where K is thermal conductivity of the material

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
$H = a\,(T1 - T2)$, where a and b are constants and $T1$ and $T2$ are the temperatures of the heating surface and the fluid in °K respectively.
In electric furnaces, heat transferred by convection is negligible

Convection
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 where K is radiating efficiency and e is known as emissivity of the heating element.

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

4.What is the principle of microwave heating.Explain its advantages,disadvantages and application.[2017 Q7/c,2019 Q4(b)]

The Microwave Heating Principle

Microwave heating is a multiphysics phenomenon that involves electromagnetic waves and heat transfer; any material that is exposed to electromagnetic radiation will be heated up. The rapidly varying electric and magnetic fields lead to four sources of heating. Any electric field applied to a conductive material will cause current to flow. In addition, a time-varying electric field will cause dipolar molecules, such as water, to oscillate back and forth. A time-varying magnetic field applied to a conductive material will also induce current flow. There can also be hysteresis losses in certain types of magnetic materials.

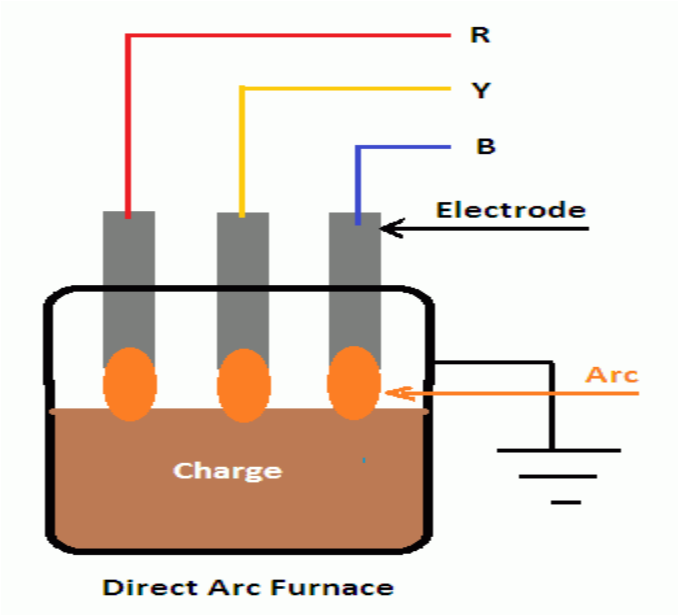
Applications of Microwave Heating

Heating Food

One obvious example of microwave heating is in a microwave oven. When you place food in a microwave oven and press the "start" button, electromagnetic 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 microwave heating depends upon the material properties. For example, if you place foods with varying water content in a microwave oven, they will heat up at different rates. A dinner plate may come out with some food on it that is very hot while the rest of it is still cold. Furthermore, the position of food relative to each other will also affect the electromagnetic field within the oven. That is why most microwave ovens have turntables to rotate the food and promote even heating.

5.Explain working principle of Direct Arc Furnace. [2019 Q2(c)]



The diagram shows a **direct electric arc furnace**. The chamber of the furnace is lined with refractory material. The arc is struck between the electrode and the charge. Three electrodes made of carbon or graphite are projected from the top of the furnace and three phase supply is given. The current passes through them via the charge. Since the arc is in direct contact with the charge so it is possible to produce highest temperatures by direct electric arc furnace. As the arc passes through the charge, it will produce automatic stirring action. The arc has a negative resistance characteristic i.e. resistance falls with the increase in temperature. Thus some sort of current limiting device is required in the circuit to prevent short circuits. This may be in the form of reactor. The *direct electric arc furnace* is very commonly used for the production of steel. There is a charging door from where the charge is supplied and also there is an outlet for molten metal. The usual size of direct electric arc furnace is 5 to 10 tons capacity. For melting 1 ton of steel 1000 units of energy are consumed.

6.Explain working of direct core type induction furnace.[2019 Q6(c)]

The direct core type induction furnace is shown in fig.

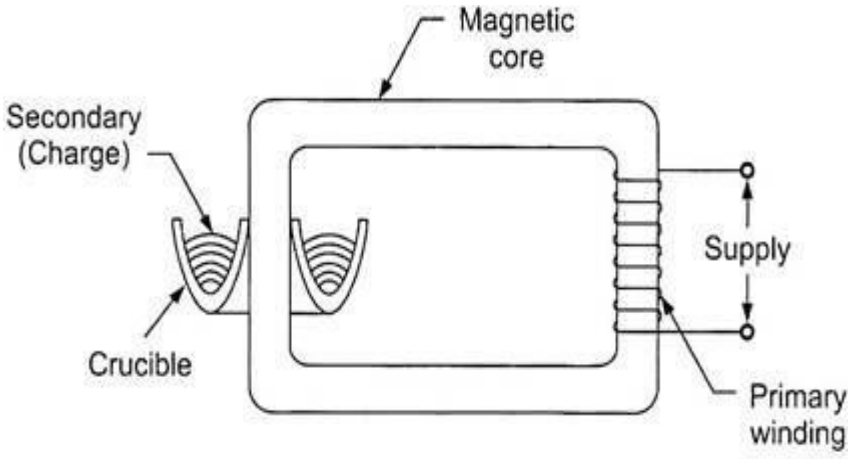


Fig. 3.12 *Core type furnace*

It consist of an iron core, crucible and primary winding connected to an a.c supply.The charge is kept in the cruicible, which forms a single turn short circuited secondary circuit.The current in the charge is very high in the order of several thousand amperes. The charge is magnetically coupled to the primary winding.The change is melted because of high current induced in it. When there is no molten metal, no current will flow in the secondary.To start the furnace molten metal is poured in the oven from the previous charge.

This type of furnace has the following drawbacks:

The magnetic coupling between the primary and secondary is very weak, therefore the leakage reactance is very high. This causes low power factor.Low frequency supply is necessary because normal frequency causes turbulence of the charge.If current density exceeds about 5 amps/mm2 the electromagnetic force produced by this current density causes interruption of secondary current.Hence the heating of the metal is interrupted. It is called pinch effect.The crucible for the charge id of odd shape and inconvenient from the metallurgical point of view.The furnace cannot function if the secondary circuit is open. It must be closed. For starting the furnace either molten metal is poured into the crucible or sufficient molten metal is allowed to remain in the crucible from the previous operation.Such furnace is not suitable for intermittent services.

CHAPTER -3

Short type question - 2 marks

1. Why AC is most suitable for resistance welding? [2015 Q1(a)]

AC is most suitable because it can provide any desired combination of current & voltage by means of transformer.

2. Why arc welding is better suitable for construction work? [2017 Q2(a)]

Most of the arc welding is done by hand process. The operator can took the electrode holder any where 7 the welding machine can be placed at one place. As construction work need welding in different place like above the ground or a few meters away from the machine , hence arc welding is suitable.

4. What is arc blow ? [2015 Q3(a)]

The space around the arc and the adjacent metal is always affected by magnetic fields which tend to deflect the arc. The phenomena of arc known as arc blow

Medium type question - 5 marks

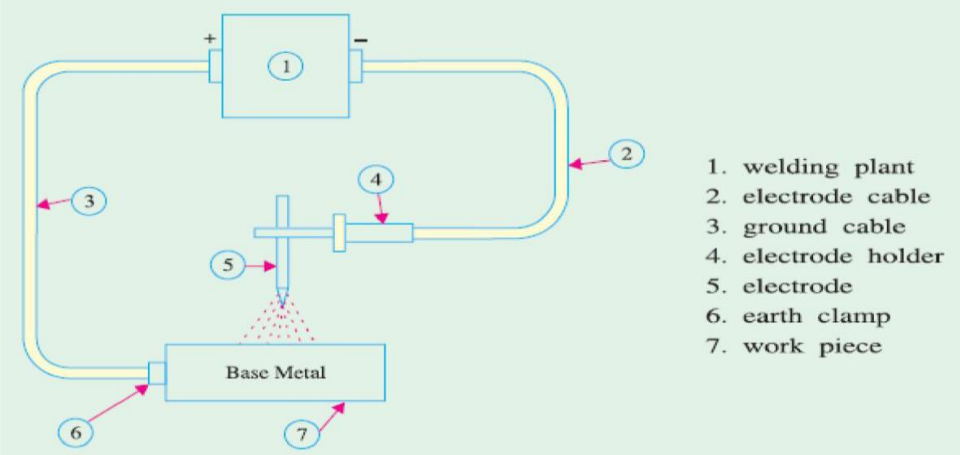
1. Explain DC & AC arc phenomena. [2018 Q3(c)]

D.C. & A.C. phenomena

- Both D.C. & A.C. can be used in arc welding, each having merits, demerits & application.
- The main advantages of D.C. welding are its higher arc stability & degree to which the work is heated. It is best suited for thinner sheet metal & non ferrous metal.
- In A.C. welding there is no arc blow, which considered superior for production welding.
- In D.C. welding more heat is produce at anode & less at cathode where in A.C. welding heat is developed equally at both electrodes.
- D.C. welding needs a motor generator set or rectifier for power supply where in A.C. welding only transformer is required.
- Operating cost of A.C. equipment is less as compared to D.C. equipment.
- Maintenance of transformer is easier than D.C. generator.
- A.C. welding system have lower power factor, which need extra capacitor for improving.
- In D.C. welding system bare electrode can be used where in A.C. coated electrode is used.

2. Explain the principle of arc welding. [2015 Q3(b) ,2017 Q5/b,2018 Q3(b),2019 Q6(b)]

- 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-circuits 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 negative electrons and positive ions. Consequently, air becomes conducting and current is able to flow Across the gap in the form of an arc.
- Current from A.C. or D.C. is obtained. On terminal is connected to electrode & other to work piece & the circuit is completed through air gap.
- The temperature attend varies from 3700 to 4000 degree centigrade.



4. What is resistance welding ? Explain different types of resistance welding.[2017 Q2(b),2019 Q4(c)]

- It is fundamentally 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 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
- The various types of resistance welding processes may be divided into the following four main groups :
    - Butt welding
    - Flash welding
    - Spot welding
    - Seam welding
    - projection welding

Advantages

Some of the advantages of resistance welding are as under:

- Heat is localized where required
- Welding Action is rapid
- No filler material is needed
- Requires comparatively lesser skill
- Is suitable for large quantity production
- Both similar and dissimilar metals can be welded

Type # 1. Spot Welding:

It is used for joining two or more sheets of metal. The sheets to be welded are held overlapping between the two electrodes, one moveable and the other fixed. Heavy current is passed through the electrodes. Pressure

is applied from the top electrode by moving it downward.The fusion of material takes place at the spot. The sheet is then moved to have another spot weld at the desired place. The time period for each weld may be 1/100th of a second or more. The current may be of the order of 5000 amperes or more. The voltage between electrodes about 2 volts. The open circuit voltage is less than 12 volts.Fig. 4.4 shows how spot welding is done. Rods, wires and small pieces can also be welded by this method. For the sheets the time required is about 1/50sec. for each 0.25 mm of total thickness of the two sheets to be welded.

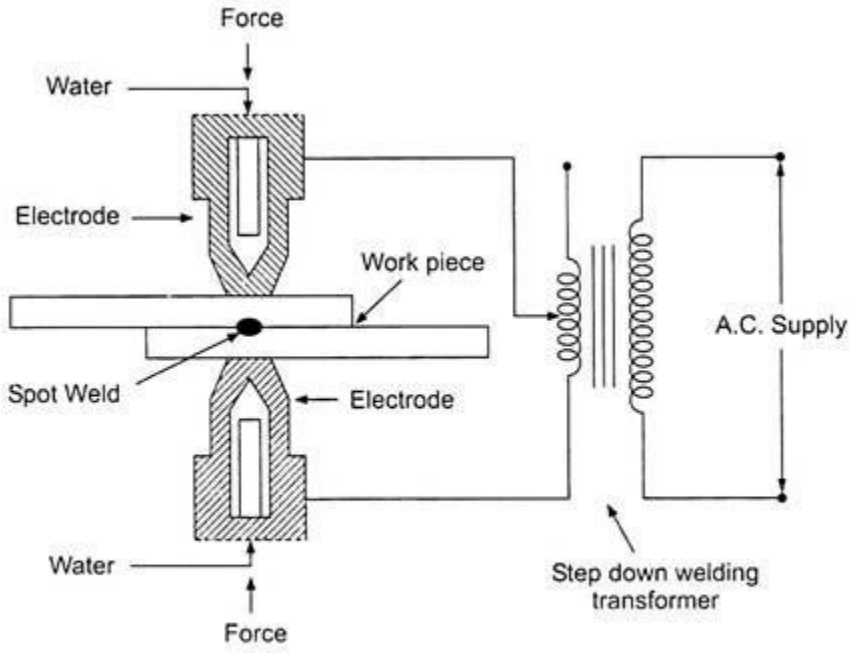


Fig. 4.4 *Principle of Spot Welding*

Spot Welding Machine:

A spot welding machine is shown in Fig. 4.5 AC supply is given to the primary of the welding transformer through the timer which controls the time for which the current flows. The primary has got tappings and a particular tapping is selected by the selector switch S depending upon the current required for welding.For maximum welding current the selector switch should be kept in position No. 1. The secondary is connected to the two electrodes made of copper or bronze and they are cooled by water. When pressure is not applied on the foot pedal, the electrodes are kept apart by the spring.The sheets to be welded are placed over-lapping each other between the two electrodes and pressure is applied by pressing the foot pedal. The spot weld is made between the sheets. Thickness and composition of the plates determine the duration and magnitude of the current. It varies from 1000 to 10,000 amperes and may flow for a fraction of a second to some seconds. Spot welding is mostly employed in the manufacture of automobiles, refrigerators and other metal stamping assemblies.

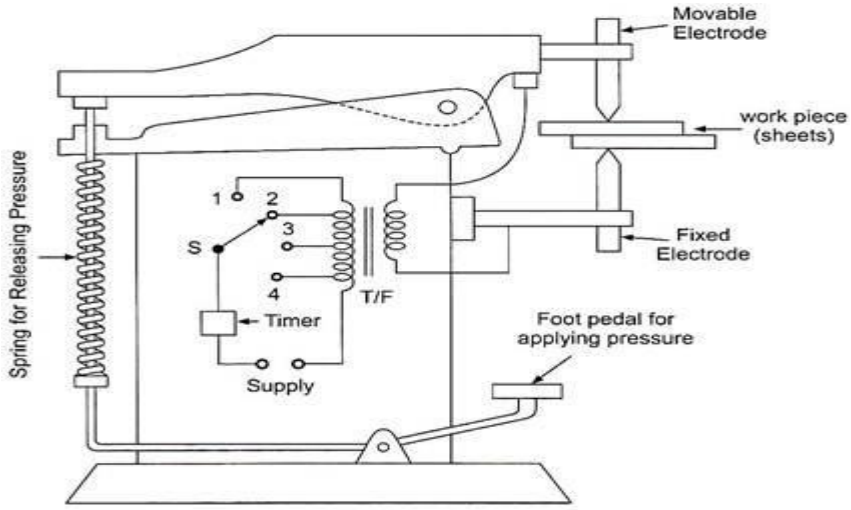


Fig. 4.5 *Spot Welding Machine*

Type # 2. Projection Welding:

It is infact a modified form of the spot welding. One of the pieces to be welded this way has projections produced by pressure. The electrodes are flat. The electrodes are placed on work piece and current passed between them. Heat is produced at the contacts and work piece gets welded at these points.It is easy to weld certain parts which cannot be welded by spot welding. When two plates to be welded are of different cross-section then in order to obtain desirable strength it is necessary to have the projections on the thicker plate.

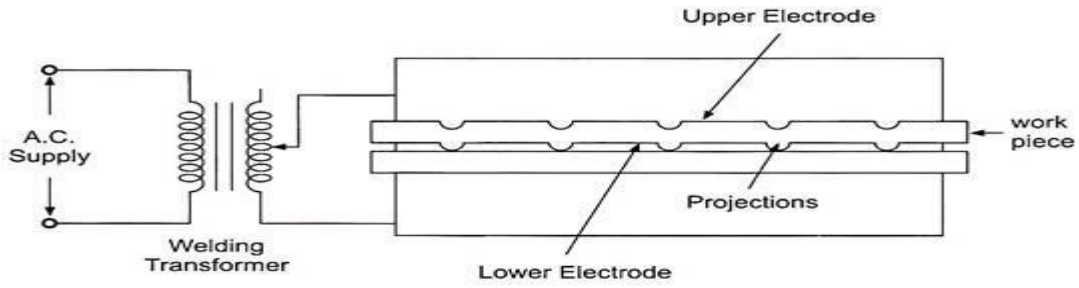


Fig. 4.6 *Principle of Projection Welding*

Type # 3. Seam Welding:

In Fig. 4.7 shows how seam welding is carried out. In this case wheel or roller type electrodes are used and the pressure between them remains constant. The seam welding is done in order to produce a continuous joint which may be required for the construction of tanks, transformer's refrigerators, gasoline tanks, air craft, containers and cylindrical pieces. Seam weld is actually a series of overlapping spot welds. Usually numbers of spots obtained per meter of the joint are between 200 to 400.The two sheets on which seam welding is required are placed overlapping each other. The current is passed between the two moving electrodes as shown in Fig. 4.7. The electrodes are to be shape of continuously rotating wheel which also applies pressure on the job. It is used when a continuous joint required between two overlapping metal sheets.

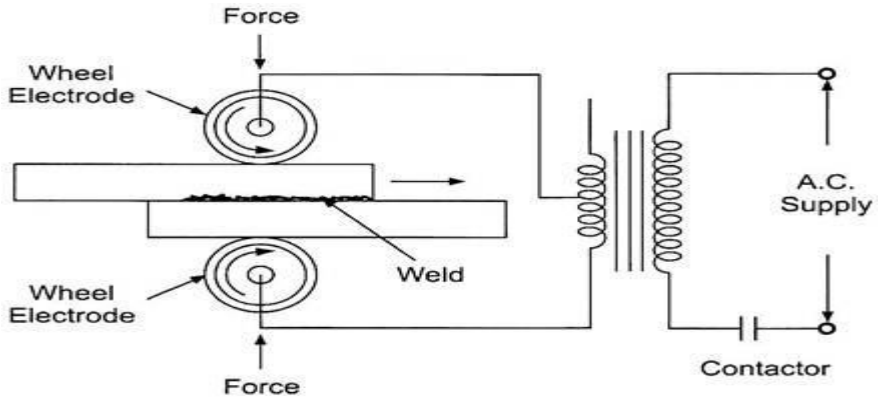


Fig. 4.7 *Principle of Seam Welding*

Type # 4. Butt Welding:

In Fig.4.8 shows how butt welding is done. The welding transformer has a comparatively larger number of turns on the primary and lesser number of turns on the secondary because heavy current is required on the secondary side. The two parts to be welded together are placed touching each other end to end so as to form a butt joint.A pressure is also applied in the axial direction of weld. The jobs are securely clamped and heavy current is passed through them. The heat produced is sufficient to raise the temperature of material to plastic state and fusion takes place at the points of contact when pressure is applied on both sides.

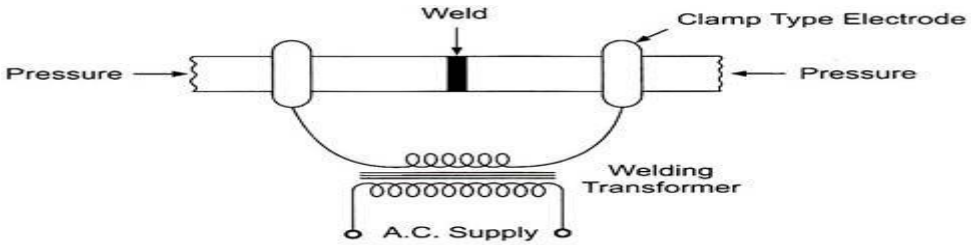


Fig. 4.8 *Butt Welding*

This method is used for welding pipes, wires and rods etc. The voltage required for welding is 2 to 10 volts and current varies from 50 A to several hundred amperes, depending upon the material and the area to be welded at a time.

Type # 5. Flash Butt Welding:

This is similar to butt welding except that the parts to be welded are joined together under light pressure and a heavy current passed through the joint. Due to poor contact at the joint arcing takes place. When sufficient heat has been produced the two parts are suddenly pressed together and the current is simultaneously stopped. A thin film is produced around the joint which is subsequently removed to give a weld of this type. It is used for welding chains, rail ends, shaft axles etc.

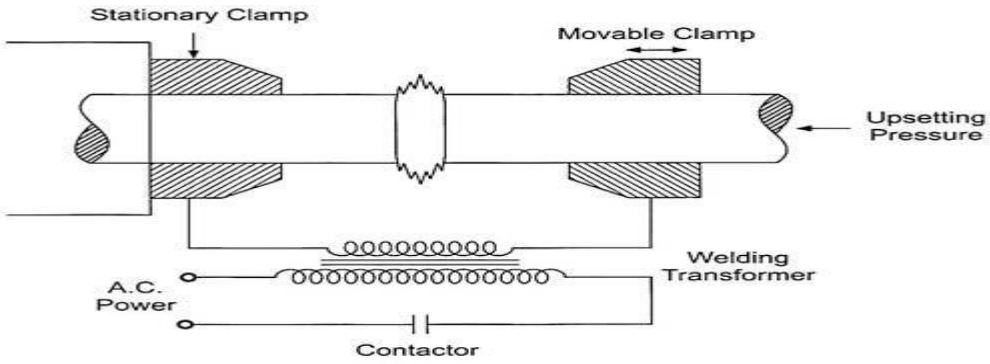


Fig. 4.9 *Flash Butt Welding*

CHAPTER -4

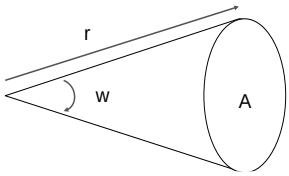
Short type question - 2 marks

1. Define luminous intensity. [2016 Q3(a).2019 Q4(a)]

Luminous intensity may be defined as the luminous flux emitted by a light source per unit solid angle. i.e. luminous intensity = lumens emitted by solid angle.It is denoted by I. (I = φ / w)

2. Define solid angle. [2015 Q2(a),2016 Q6(a),2018 Q5(a)]

The angle sustained at a point in the space by an area is known as solid angle
It is measured in steradians & is denoted by w
w = area / $(\text{radius})^2$



3. Define M.S.C.P. [2015 Q5(a),2016 Q4(a),2018 Q4(a)]

It is defined as the average candle power in all direction and in all planes from the source of light.
M.S.C.P. = Total flux in lumen / 4π.

4. Define M.H.S.C.P. [2014 Q5(a),2017 Q3(a)]

M.H.S.C.P. (Mean hemi spherical candle power):- It is defined as the average candle power in all direction above or below the horizontal planes from the source of light.

5. Define M.H.C.P.[2017 Q3(a),2015 Q3(a),2019 Q3(a)]

M.H.C.P. (Mean horizontal candle power):- It is defined as the average candle power in all direction in the horizontal planes from the source of light.

6. Define depreciation factor. [2016 Q 5/a]

The ratio of illumination when everything is perfectly clean to the illumination under normal working condition is known as depreciation factor.

$$\text{Depreciation factor} = \frac{\text{illumination when every thing is clean}}{\text{illumination under normal working condition}}$$

8. What is luminous efficiency ? [2016 Q3/a,2017 Q6/a]

Luminous efficiency can be defined as the ratio between energy radiated in the form of light to the total energy radiated in all other forms.

9. What is brightness? [2016 Q 5/a]

Brightness is an attribute of visual perception in which a source appears to be radiating or reflecting light. In other words, brightness is the perception elicited by the luminance of a visual target.

10.Define utilization factor.[2019 Q6(a)]

Ans: Utilization Factor may be defined as "the ratio of total lumens received on the working plane to the total lumens emitted by the light source". i.e. It may be defined as "the ratio of illumination under normal working condition to the illumination when everything is clean or new".

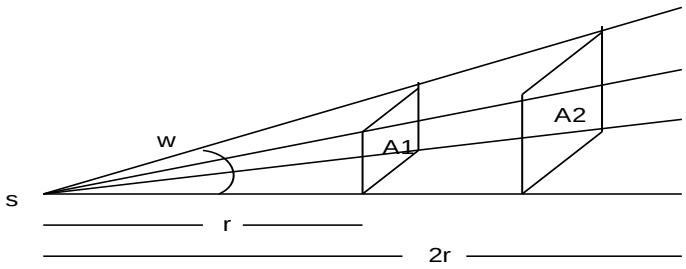
Medium type question - 5 marks

1. State & explain law of illumination. [2015 Q5(b), 2016 Q3(b),2017 Q3(b),2018 Q4(c),2019 Q3(b)]

There are two laws of illumination

Inverse Square Law. The illumination of a surface is inversely proportional to the square of the distance of the surface from the source. In other words, E α 1/r2

Consider a point source S having intensity I lumen / steradian.



Let two surface A1 & A2 placed at a distance r & 2r from the source. The two surface are enclosed in the same solid angle w.

- The total flux received by the surface = I x w lumens
- Thus flux on area A1 = I x w lumens

= I . A1 / r^2 (as w = area / $(\text{radius})^2$

- Illumination E1 on the surface A1

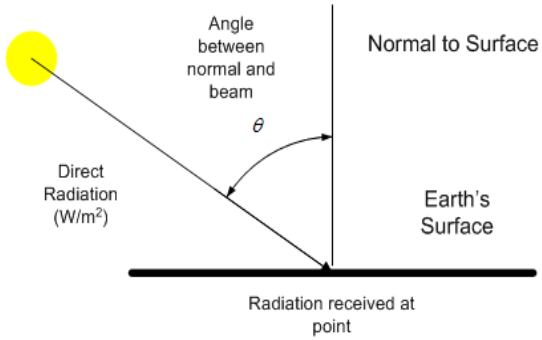
$$E1 = \varphi / A1 = \frac{I.A1}{r^2} \times \frac{1}{A1} = \frac{I}{r^2} \text{ lux}$$

- Similarly Illumination E2 on the surface A2

$$E2 = \varphi / A2 = \frac{I.A2}{(2r)^2} \times \frac{1}{A2} = \frac{I}{(2r)^2} \text{ lux}$$

Hence from the above equation it is concluded that illumination at a surface is inversely proportional to the square of its distance from the source.

(ii) *Lambert's Cosine Law.* According to this law, illumination *E* is directly proportional to the cosine of the *angle made by the normal to the illuminated surface with the direction of the incident flux*.



i.e E α cos θ

- In the normal surface case , E = φ / Area
- In the inclined surface case , E = φ cosθ / area

2. Polar curve. [2016 Q3/c,2015 Q3(b),2018 Q7(ii),2019 Q5(a)]

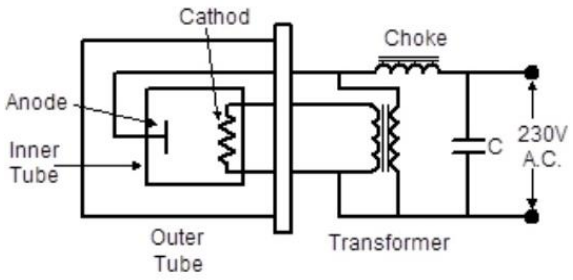
- The luminous intensity or candle power of any practical lamp is not uniform in all direction due to its unsymmetrical shape.
- The distribution of light is given by polar curve. The polar curve helps to find out C.P. of a light source in different direction.
- The luminous intensity in all direction is represented by polar curve.
- If the luminous intensity is measured in a horizontal plane about a vertical axis & curve is plotted between candle power (CP) & the angular position the curve is called horizontal polar curve
- Similarly vertical polar curve gives the relation of candle power in vertical plane passing through the lamp at various angles.
- Polar curve is used to measure MSCP & MHCP. it is also used to measure the actual illumination of a surface in particular direction.

Long type question - 7 marks

1. Explain sodium vapour lamp. [2016 Q7(a),2017 Q2/c]

Sodium Vapour Lamp

Diagram



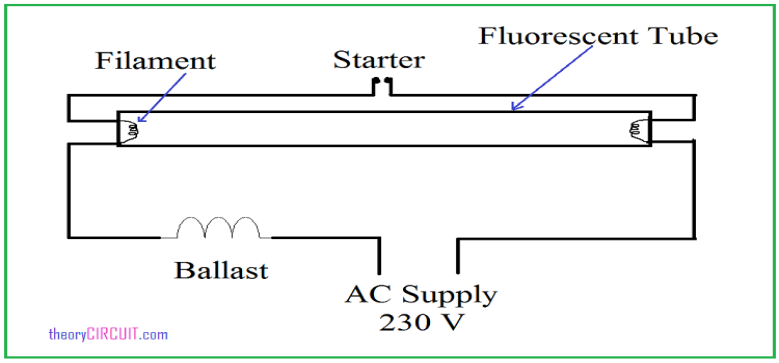
Construction

- This lamp consists of discharge tube made from special heat resistance glass, containing a small amount of metallic sodium, neon gas and two electrodes. Neon gas is added to start the discharge and to develop enough heat to vaporised sodium.
- A long tube is required to get lighter. To reduce overall dimensions of the lamp, the tube is generally bent into U-shape.
- A cathode heating transformer is used to generate high voltage at the time of starting.
- Choke is used to limit the current under normal working condition.
- Capacitor is used to improve power factor.

Working Principle:

- Electric discharge lamps require a high voltage at staring and low voltage during operation. So at starting a voltage of 480 V is applied across the lamp to start the discharge.
- Initially neon gas is discharged by producing a colour of red orange glow.
- After that neon gas discharge the metallic sodium. When metallic sodium vaporised fully the lamp will glow yellow light.
- After 10 to 15 minutes, the voltage falls to 150 V because of low power factor. To improve the power factor a capacitor is connected across the supply.
- Luminous efficiency of the lamp is 50 lumen/ watt. Operating temp is about 300̊ C.
- This lamp is always placed horizontally for proper distribution of sodium.

3. Explain fluorescent lamp with glow type starter.[2017 Q7(c)]



Construction

- It consists of a glass tube coated with fluorescent power in its inner side.
- Two tungsten electrodes coated with electron emissive material are placed both side of the tube.
- A glow type of starter & a ballast choke for boosting voltage .

- A capacitor used for power factor correction.
- The tube contains argon gas at low pressure and about 2.5 mm of mercury.

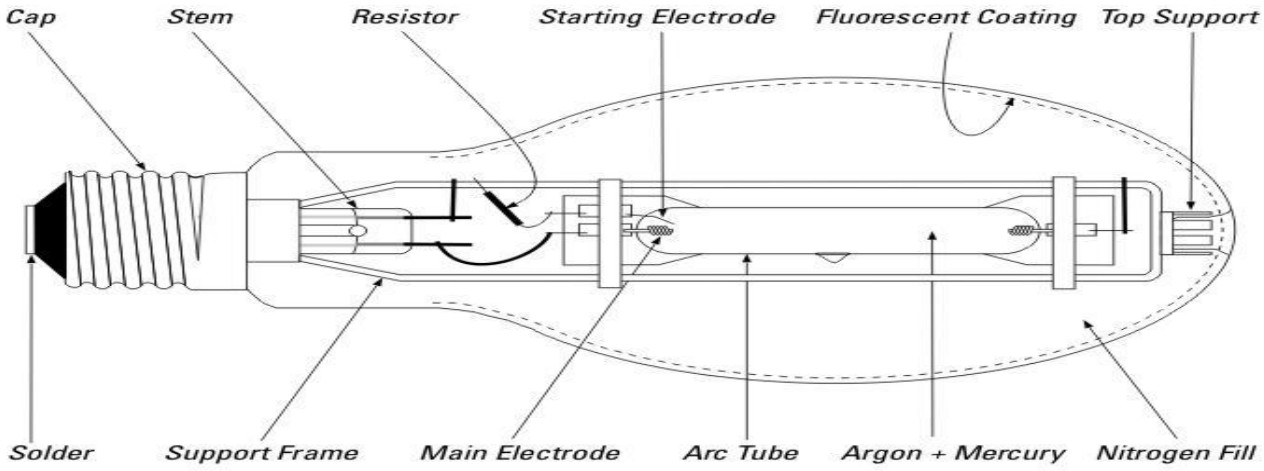
Working:

- When the supply is switched on all the input voltage appear across the starter. Two bimetallic strip of the starter are joined to make the ckt. complete.
- After a short while bimetallic strip opened, which create a high potential difference at the choke. This high voltage is enough to discharge the argon gas inside the tube.
- Argon again discharges the mercury, which produce ultraviolet ray. This ultraviolet ray when radiated at the fluorescent coating visible light is generated.
- Under normal working condition choke is used to limit the current flow.
- Capacitor is used to improve the power factor.

4.Write short notes on High pressure mercury vapour lamp.[2019 Q7(i)]

Ans:On the basis of pressure inside the discharge tube, the mercury vapor lamps are classified as high pressure Mercury Vapor Lamp and low pressure Mercury Vapor Lamp. High pressure M.V. Lamps are of following types :

1. M.A. type : these are operated at 220 -250 V A.C. main and made in 250 W and 400 W.
2. M.A.T. type : these are made in 300 and 500 W and operated at 200 -250 V A.C. as well as D.C.
3. M.B. type : This is operated at 200 – 250 V A.C. and made in 80 W and 125 W.



Construction :

- It consists of hard glass tube enclosed in outer bulb of ordinary glass.
- The spaces between two bulbs are completely evacuated to prevent heat loss by convection from inner bulb. The outer bulb absorbs harmful ultra violet rays.
- The inner bulb contains argon gas with certain quantity of mercury. In addition with two electrodes on starting electrode having high resistance in series also provided.
- The main electrodes are made of tungsten wire in helical shape. The lamp has screwed cap and connected to supply with choke.

- A capacitor is connected across supply to improve power factor.

Working Principle:

When the supply is switched ON, full voltage is applied across main and starting electrodes. This voltage breaks down the gap and discharge through argon gas takes place. As the lamp warms up, mercury is vaporized , which increase the vapor pressure. This discharge takes the shape of intense arc. After 5 minutes, the lamp gives full light. It gives greenish blue color light. This lamp is always suspended vertically, other wise inner glass tube may break due to excessive heat.

CHAPTER -5

Medium type question - 5 marks

1. Differentiate between group drive & individual drive. [2015 Q4(b) , 2016 Q4(b),2018 Q34(b),2019 Q3(c)]

Group drive

If several group of mechanisms or machines are organized on one shaft and driven or actuated by one motor, the system is called a group drive or shaft drive

Individual drive

If a single motor is used to drive or actuate a given mechanism and it does all the jobs connected with this load , the drive is called individual drive.

	Individual Drive	Group Drive
Initial Cost	Low	High
Speed	More Variation Possible	Wider Variation not possible
Running Cost	Low	High
Machine Attached	One	More than one
On Time of Breakdown	Only one machine get affected	All machine connected to group drive get affected
More Likely used	For Job Production	For Mass Production
Efficiency	High	Less
Power Required	Less	More

2. Write the applications of DC & AC motors. [2016 Q4/c]

Dc series motor	Line shaft , conveyors, elevator, crane , hoist , electric traction
DC shunt motor	Lathe , milling machine , electric fan , blower , pumps
DC compound motor	Mining work , Rolling mill , Paper mill, Rubber mill , conveyors
AC motor	
3 phase induction motor Squirrel cage	Electric fan , blower, pumps , line shaft , paper ill , floor mill , hoist
Slipring type	Elevator , large crane , hoist , Grinder , conveyor etc..
1 Phase induction motor	
Universal motor	Vacuum cleaner , portable tool , hair dryer , kitchen appliance

Repulsion type	Small compressor , garage equipment , shoe machinery , wood working
Shaded pole	Electric clocks , photography , hair dryers

3. State factors governing choice of electric motor. [2016 Q5(b)]

While selecting a motor for a given drive it depend upon the several factor described below,

(i) Electrical characteristics
- Starting characteristics
- Running characteristics
- Speed control
- Braking characteristics

(ii) Mechanical Characteristics
- Type of enclosure
- Type of bearing
- Transmission of drive
- Noise level

(iii) Size & rating of machine
- Rating of motor
- Whether the motor is to be used continuously ,intermittently or for variable load.

(iv) Cost
- Capital cost
- Running cost.

4.Explain group drive and its advantages.[2017 Q6/b]

If several group of mechanisms or machines are organized on one shaft and driven or actuated by one motor, the system is called a group drive or shaft drive.

Advantages: a. Initial cost: Initial cost of group drive is less as compared to that of theindividual drive.

b. Sequence of operation: Group drive system is useful because all the operations are stopped simultaneously.

c. Space requirement: Less space is required in group drive as compared to individual drive.

d. Low maintenance cost: It requires little maintenance as compared to individual drive.

Long type

1. Explain starting & running characteristics of DC series motor. [2015 Q6(b), 2016 Q 4/c,2017 Q5(c),2019 Q5(c)]

Characteristics of DC Series Motors

Torque Vs. Armature Current (T_a-I_a)

We know that torque is directly proportional to the product of armature current and field flux, $T_a \propto \phi.I_a$. In DC series motors, field winding is connected in series with the armature, i.e. $I_a = I_f$. Therefore, before magnetic saturation of the field, flux ϕ is directly proportional to Ia. Hence, before magnetic saturation Ta α Ia^2. Therefore, the Ta-Ia curve is parabola for smaller values of Ia.

After magnetic saturation of the field poles, flux ϕ is independent of armature current Ia. Therefore, the torque varies proportionally to Ia only, T ∝ Ia.Therefore, after magnetic saturation, Ta-Ia curve becomes a straight line.

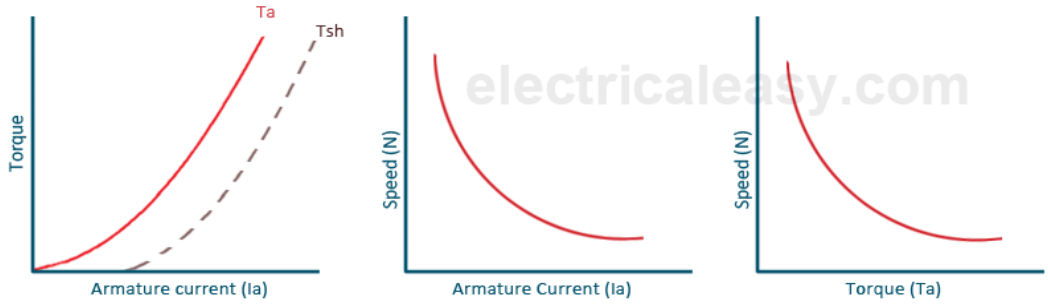
Speed Vs. Armature Current (N-Ia)

We know the relation, $N \propto E_b/\phi$

For small load current (and hence for small armature current) change in back emf Eb is small and it may be neglected. Hence, for small currents speed is inversely proportional to ϕ. As we know, flux is directly proportional to Ia, speed is inversely proportional to Ia. Therefore, when armature current is very small the speed becomes dangerously high. That is why a series motor should never be started without some mechanical load.

Speed Vs. Torque (N-Ta)

This characteristic is also called as mechanical characteristic. From the above two characteristics of DC series motor, it can be found that when speed is high, torque is low and vice versa.



Characteristics of DC series motor

CHAPTER -6

Short type question - 2 marks

1. What is traction ? [2016 Q 6/a]

Traction means a driving force which moves a locomotive. The driving force may be mechanical or electrical.

Medium type question - 5 marks

1. Explain magnetic track breaking. [2016 Q6(b),2017 Q7/b]

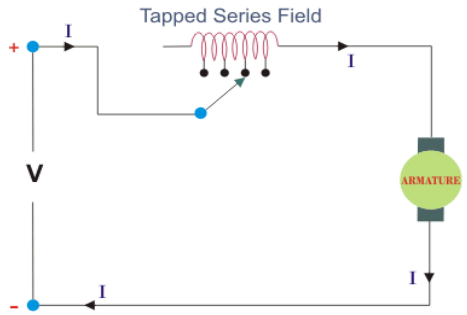
- The power of electromagnetic track brakes comes from electromagnetic attraction between the brake and the track. They are intended to provide retardation beyond the adhesion limit of the wheels alone, which ultimately is limited by the weight of the vehicle.
- Track brakes are fitted on the bogies between each pair of wheels and in line with the running rails. In operation they are first dropped into position on the rails, using air actuators, and then current is applied to strong electromagnet coils within the shoes. This pulls the brake shoes hard against the track with a force that can exceed the vehicle's weight, and strong braking forces result.
- Because of the risk of damage to the track work at points, etc., track brakes are typically recommended for use only in emergency situations, typically if the tram loses control and sanding is ineffective, or the disc brakes have failed.
- In practice, some rail systems use them much more frequently, to compensate for rails made slippery by weather conditions, or as a roll-back prevention measure on hills.
- Track brakes are usually operated by a driver's emergency stop button mounted separately to the normal traction/brake controller, or by the release of the "dead man's handle".
- Systems which use them frequently may have a separate switch to actuate the track brake without activating other emergency stopping measures.
- On some systems, permanent magnet track brakes are used as parking brakes.

2. Explain tapped field control for traction motor. [2015 Q5(c), 2016 Q5(c),2018 Q7(a)]

In this method increasing the speed by reducing the flux and it is done by lowering number of turns of field winding through which current flows.

In this method a number of tapping from field winding are brought outside.

This method is employed in electric traction.



3. Explain DC & AC traction motor. [2016 Q6/b]

Characteristics of DC Series Motors

Torque Vs. Armature Current (T_a-I_a)

We know that torque is directly proportional to the product of armature current and field flux, $T_a \propto \phi.I_a$. In DC series motors, field winding is connected in series with the armature, i.e. $I_a = I_f$. Therefore, before magnetic saturation of the field, flux ϕ is directly proportional to Ia. Hence, before magnetic saturation Ta α Ia^2. Therefore, the Ta-Ia curve is parabola for smaller values of Ia.

After magnetic saturation of the field poles, flux ϕ is independent of armature current Ia. Therefore, the torque varies proportionally to Ia only, T ∝ Ia. Therefore, after magnetic saturation, Ta-Ia curve becomes a straight line.

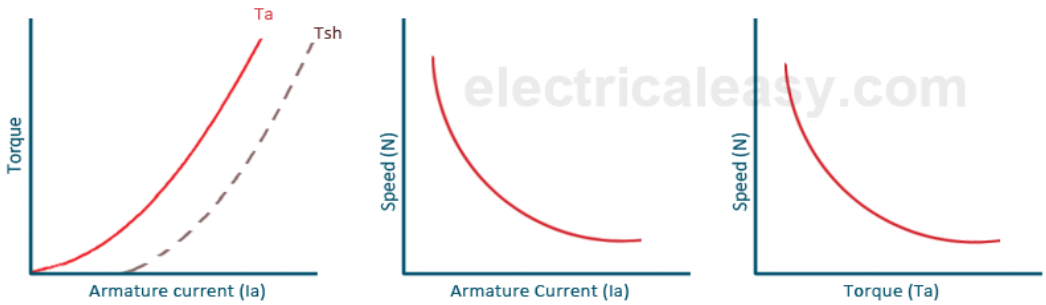
Speed Vs. Armature Current (N-Ia)

We know the relation, $N \propto E_b/\phi$

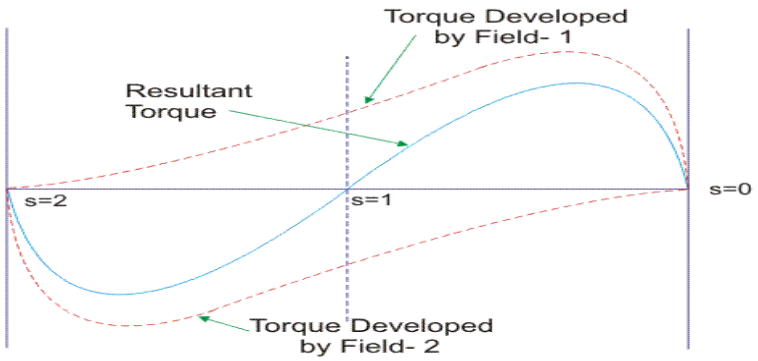
For small load current (and hence for small armature current) change in back emf Eb is small and it may be neglected. Hence, for small currents speed is inversely proportional to ϕ. As we know, flux is directly proportional to Ia, speed is inversely proportional to Ia. Therefore, when armature current is very small the speed becomes dangerously high. That is why a series motor should never be started without some mechanical load.

Speed Vs. Torque (N-Ta)

This characteristic is also called as mechanical characteristic. From the above two characteristics of DC series motor, it can be found that when speed is high, torque is low and vice versa.



Torque Slip Characteristics of Single Phase Induction Motor



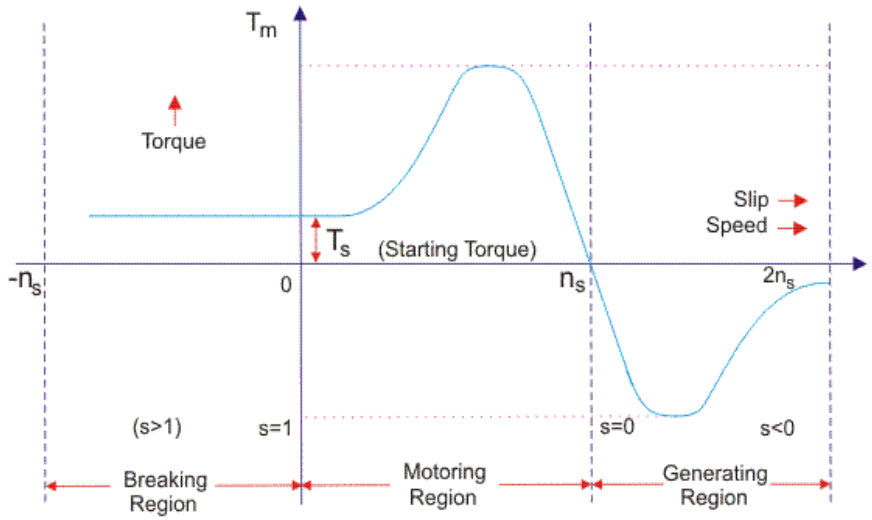
Torque Slip Characteristics of Single Phase Induction Motor

From the figure, we see that at a slip of unity, both forward and backward field develops equal torque but the direction of which are opposite to each other so the net torque produced is zero hence the motor fails to start. From here we can say that these motors are not self starting unlike the case of three phase induction motor. There must be some means to provide the starting torque

If the forward field torque is larger than the backward field than the motor rotates in forward or anti clockwise direction. If the torque due to backward field is larger compared to other, then the motor rotates in backward or clockwise direction.

Torque Slip Characteristics of Three Phase Induction Motor

The variation of slip can be obtained with the variation of speed that is when speed varies the slip will also vary and the torque corresponding to that speed will also vary. The curve can be described in three modes of operation-



Torque Slip Curve for Three Phase Induction Motor

The induction motor torque varies from zero to full load torque as the slip varies. The slip varies from zero to one. It is zero at no load and one at standstill. From the curve it is seen that the torque is directly proportional to the slip. That is, more is the slip, more will be the torque produced and vice-versa.

In this mode of operation induction motor runs above the synchronous speed and it should be driven by a prime mover. in this case, the torque and slip both are negative so the motor receives mechanical energy and delivers electrical energy.

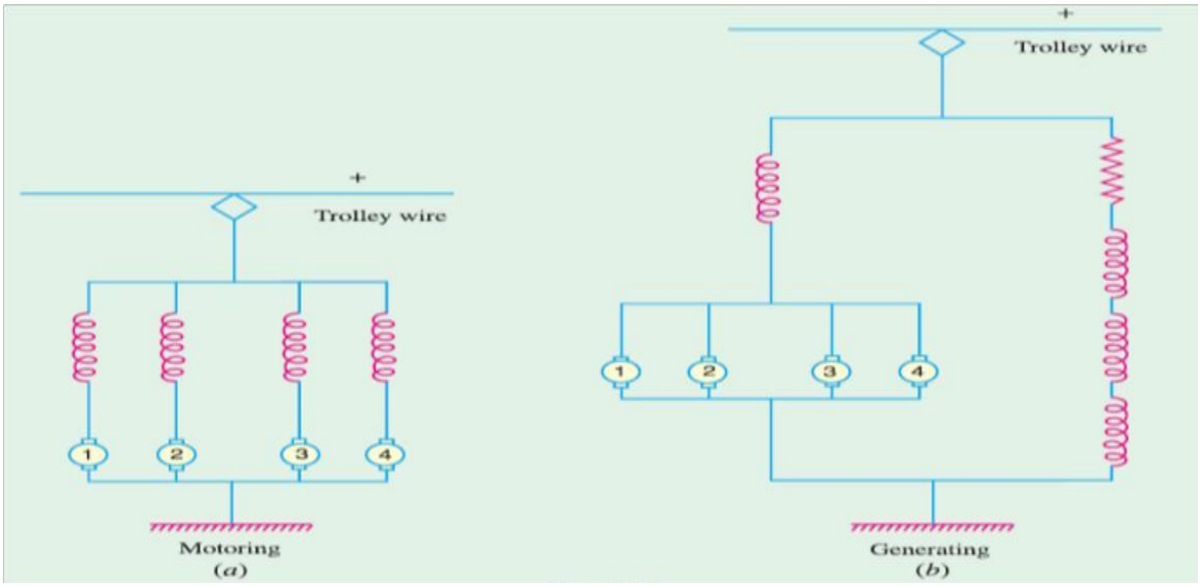
In the Braking mode, the two leads or the polarity of the supply voltage is changed so that the motor starts to rotate in the reverse direction and as a result the motor stops. This method of braking is known as plugging.

4. Explain regenerative braking with three phase induction motor . [2015 Q3(c),2019 Q5(b)]

In order to achieve the regenerative braking, it is essential that (*i*) the voltage generated by the machine should exceed the supply voltage and (*ii*) the voltage should bez kept at this value, irrespective of machine speed. Fig. 43.34 (*a*) shows the case of 4 series motors connected in parallel during normal running *i.e.* motoring. One method of connection

during regenerative braking is to arrange the machines as shunt machines, with series fields of 3 machines connected across the supply in series with suitable resistance.

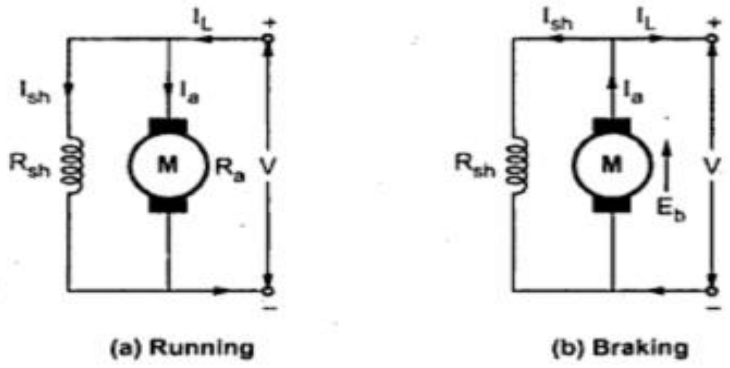
One of the field winding is still kept in series across the 4 parallel armatures as shown in figure (*b*). The machine acts as a compound generator. (with slight differential compounding) Such an arrangement is quiet stable; any change in line voltage produces a change in excitation which produces corresponding change in e.m.f. of motors, so that inherent compensation is provided *e.g.* let the line voltage tends to increase beyond the e.m.f. of generators. The increased voltage across the shunt circuit increases the excitation thereby increasing the generated voltage. Vice-versa is also true. The arrangement is therefore self compensating.



Long type question - 7 marks

1. Explain regenerative breaking for a D.C. motor. [2017 Q6/c]

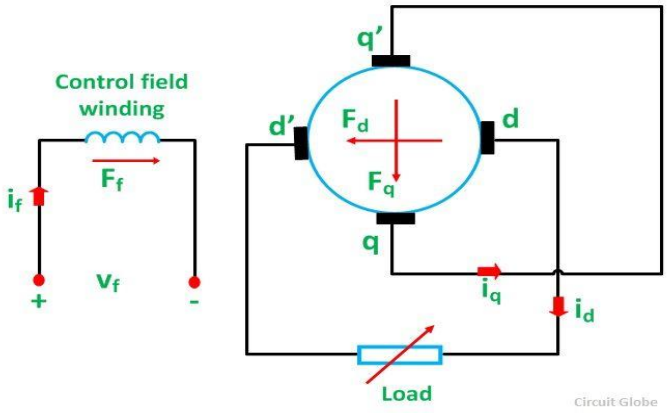
- Regenerative braking takes place whenever the speed of the motor exceeds the synchronous speed.
- This baking method is called regenerative braking because here the motor works as generator and supply itself is given power from the load, i.e. motors.
- The main criteria for regenerative braking is that the rotor has to rotate at a speed higher than synchronous speed, only then the motor will act as a generator and the direction of current flow through the circuit and direction of the torque reverses and braking takes place.
- The only disadvantage of this type of braking is that the motor has to run at super synchronous speed which may damage the motor mechanically and electrically, but regenerative braking can be done at sub synchronous speed if the variable frequency source is available.



(Shunt Motor)

2. Explain metadyne speed control of DC traction motor. [2015 Q4(c) ,2016 Q7(c)]

Metadyne is a special machine which consists of two pairs of brushes or has an additional set of brushes on the d axis. This arrangement enables the armature MMF to provide most of the excitation and achieve higher power gains. In this, the brushes of the quadrature axis (q axis) are short-circuited, and direct axis (d axis) brushes give the output.



A stator of the machine has a control field winding. A current i_f flows through the control field winding. The generator is rotating at a constant speed; an EMF e_{aq} is induced between the quadrature axis brushes qq' because of the control field winding MMF.

$$e_{aq} = K_{af} i_f \dots\dots\dots (1)$$

Where, K_{af} is a constant and i_f is the field current.

The brushes qq' are short-circuited, a quadrature axis armature current i_q flows and establish an MMF F_q if the quadrature axis. Since the impedance of the short-circuited path is low, a small change in control field current produces a greater armature current in the q axis.

The magnetic field is stationary in space because of the commutator action. Rotation in the q axis flux produces an EMF in the armature. This EMF appears across the direct axis brushes dd' and is given by the equation shown below.

$$e_{ad} = K_{dq} i_q \dots\dots\dots (2)$$

Where, K_{dq} is a constant and i_q is the quadrature axis armature current.

If the load resistance R_L is connected across the direct axis brushes, the direct axis armature current i_d will flow through the load. A direct axis flux F_d is produced by this current and according to Lenz's law, it opposes its main cause, i.e., the control field MMF F_f.

The magnetic field of the current produced is 90 degrees ahead of the flux wave producing the voltage. Since, there are two stages of voltage generation, the MMF of the direct axis output current is shifted twice by 90 degrees. As a result, it opposes the control field MMF.

The voltage generated in the quadrature axis is given as

$$e_{aq} = K_{qf} i_f - K_{qd} i_d \dots\dots\dots (3)$$

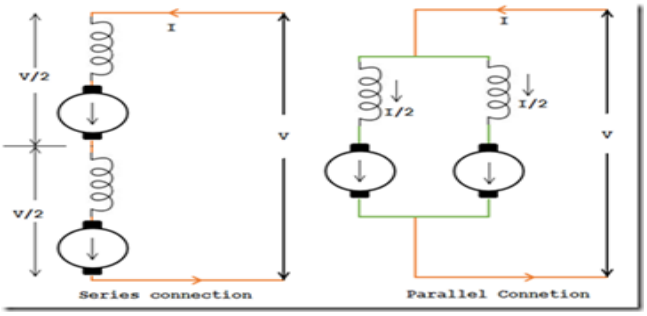
Where K_{qd} is a constant if the magnetic saturation is neglected and speed is assumed to be constant.

An increase in i_d decreases e_{aq} and as a result, i_q is reduced. Hence, e_{ad} and i_d are reduced. Thus, over a wide range of load variation the value of field excitation current i_f and the output current i_d remains constant. A Metadyne acts as a constant current generator.

3 Explain series parallel control of traction motor. [2016 Q6/c,2019 Q7(ii)]

To control the DC series motor this is another way called series parallel technique. This is the method normally used in traction by connecting two or more than that of the series motor are couple mechanically at the same load.

Whenever the series motors are connected in sequence (series) like shown in the figure, each and every armature of the motor receive the one-half of the rated voltage. Thus the speed will be less. If the series motors are connected in parallel, each and every armature of the motor receives the full normal voltage and hence the speed is also high. Thus we can achieve the two speeds (low or high) by connecting the motor either in series or parallel. Note for the same load on the pair of motors, the speed of the system would run nearly 4 times once motors are in parallel as while they are in series.


V/2
V/2
I
V
Series connection
I
I/2
I/2
V
Parallel Connetion