DIPLOMA - BOARD EXAMINATION -APRIL 2024

ANSWER KEY FOR THE QUESTION CODE: 309

SUBJECT NAME: DISTRIBUTION & UTILIZATION / 4030610 **BRANCH: EEE**

SCHEME: N **MAXIMUM MARK: 100** **SEMESTER: 6th**

PART-A 10×3=30 (Each Question Carries 3 marks)

Q.NO:1. Classify Substations. (ANY 3 TYPES) (3 marks)

The substations can be classified in several ways including the following:

1. **Classification based on service requirement**
   a) Transformer substation
   b) Switching substation
   c) Industrial / Factory substation
   d) Converting substation
   e) Frequency changer substation
   f) Power factor correction substation
2. **Classification on constructional features**
   a) Indoor substation
   b) Outdoor substation
   c) Underground substation
3. **Classification based on configuration**
   Conventional air insulated outdoor substation of SF6 Gas insulated substation (GIS)
   Composite substation having combination of the above two.
4. **Classification based on voltage levels**
   A.C. Substation: EHV, HV, MV, LV, HVDC Substation

Q.NO:2. State the different types of connection schemes of distribution system (3 marks)

According to scheme of connection the distribution system was classified as:
i) Radial system
ii) Ring main system
iii) Interconnected system.

Q.NO:3. Mention any one application area of group drive system. (Any One Application) (3 marks)

1. Paper mill 2. Textile mill
3.Workshops 4. Food Grinding mills

Q.NO:4. What are the features of good braking system? (3 marks)

The main features of a braking system are,

1. The braking should be quick and reliable in action.
2. The Braking Torque must be controllable.
3. Some suitable means must be provided for dissipation of kinetic energy of the rotating parts of the motor and its driving machines.

Q.NO:5. Define Average Speed (3 marks)

The Average speed is defined as the ratio of the distance covered between the stops to the actual time of run.

$$\text{Average speed} = \frac{\text{Distance between the stops}}{\text{Actual time of run}}$$

Q.NO:6. State the types of Traction Systems. (ANY 3 TYPES) (3 marks)

Presently, following four types of track electrification systems are available:

1. Direct current system—600 V, 750 V, 1500 V, 3000 V
2. Single-phase Low frequency ac system —15-25 kV, 16 2/3, 25 and 50 Hz
3.Single-phase High frequency ac system
4. Three-phase ac system—3000-3500 V at 16 2/3 Hz
5. Composite system—involving conversion of single-phase ac into 3-phase ac or dc.

Q.NO:7. What is Flood Lighting? (3 marks)

It means 'flooding' of large surfaces with the help of light from powerful projectors. Flooding is employed for the following purposes.

- For aesthetic purposes as for enhancing the beauties of building by night i.e. flood lighting of ancient monuments, religious buildings on important festive occasions etc.
- For advertising purposes i.e. flood lighting, huge hoardings and commercial buildings.
- For industrial and commercial purposes as in the case of railway yards, sports stadiums and quarries etc.
- For flood lighting it is necessary to concentrate the light from the lamp into a relatively narrow beam. Lamp is accurately controlled and covered into a narrow beam by means of projector.

Q.NO:8. Write the precautions in erecting lighting installations. (ANY 3 POINTS) (3 marks)

1.Selection of fittings

2.Location of fittings

3.Rating of conductors

4. Heating of Lamp Holders

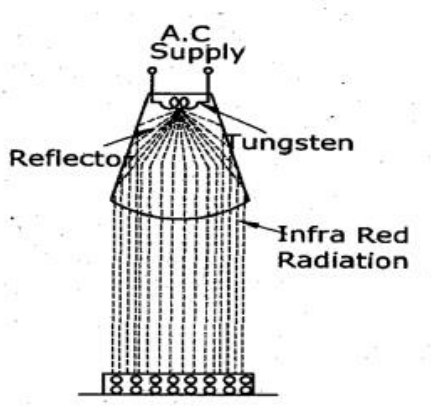
Q.NO:9. What is infrared heating? (3 marks)

This type if heating is used for low and medium temperatures. In this method a special tungsten filament lamp is operated at the temperature of 2300°C. The lamp at this temperature emits a large amount of infra red radiation. Operating the lamp at this temperature also increases the life of the filament.

In comparison to other resistance heater, this lamp emits a large amount of heat, which is being reflected to the charge. In this method, heat emission about 7500 watts/m^2 can be obtained. The temperature of charge obtained will be 200 to 300°C.

This type of heating is employed in drying paint and foundry moulds and plastic heating at low temperatures.

Diagram for Infrared Heating:



Q.NO:10. List the types of radiation welding. (3 marks)

The following are the 3 types of radiation welding.

a. Ultrasonic welding
b. Electron beam welding
c. LASER beam welding

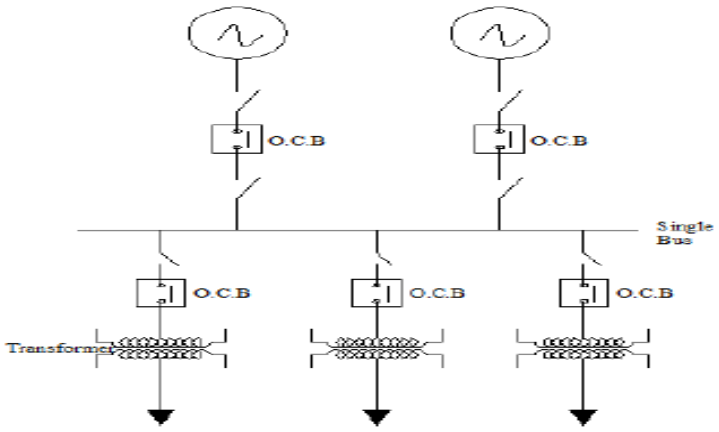
PART-B 5×14=70 (Each Question Carries 14 marks)

Q.NO: 11.(a) Discuss the different types of bus bar arrangements. (ANY 3 TYPES)

1.Single bus bar Arrangement **(Diagram =7 marks + Explanation =7 marks)**
2. Single bus bar system with sectionalisation
3. Double bus bar Arrangement
4. Double bus bar system with sectionalisation.
5. Ring bus bar system.(Mesh Scheme)

1. SINGLE BUS BAR ARRANGEMENT.

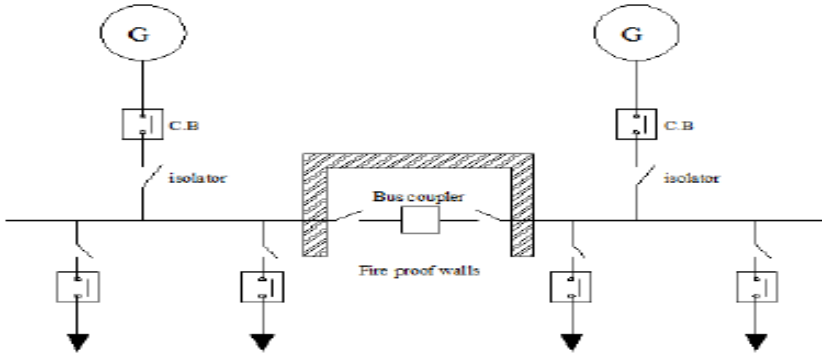
- The single bus bar scheme has only one three phase bus to which the various incoming and outgoing circuits are connected Single bus bar scheme is not preferred for major substations
- In the event of a bus fault a breaker failure the entire bus has to be de energized and a major outage occurs. Dependence on only one main bus gives lack of operational flexibility.
- For maintenance of the main bus or while providing extension to the main bus the entire station shall be de-energized. Although the protective relaying is relatively simple it lacks flexibility and during a bus fault the entire bus is switched off resulting in a major outage.
- Single bus bar scheme is used for DC switchboards and very small AC Substations or generating stations. They are used for low voltage medium voltage bus bars up to 33kv in the form of open outdoors switch yard of indoor metal clad switchgear



Single Bus Bar arrangement

2. SINGLE BUS BAR WITH SECTIONALISATION.

- In a sectional bus bar the main bus is divided into two of more sections with a circuit breaker and isolators in between the adjoining sections.
- One section can be completely shut down for the purpose of bus maintenance repairs of extension without disturbing without disturbing the continuity of the other bus section

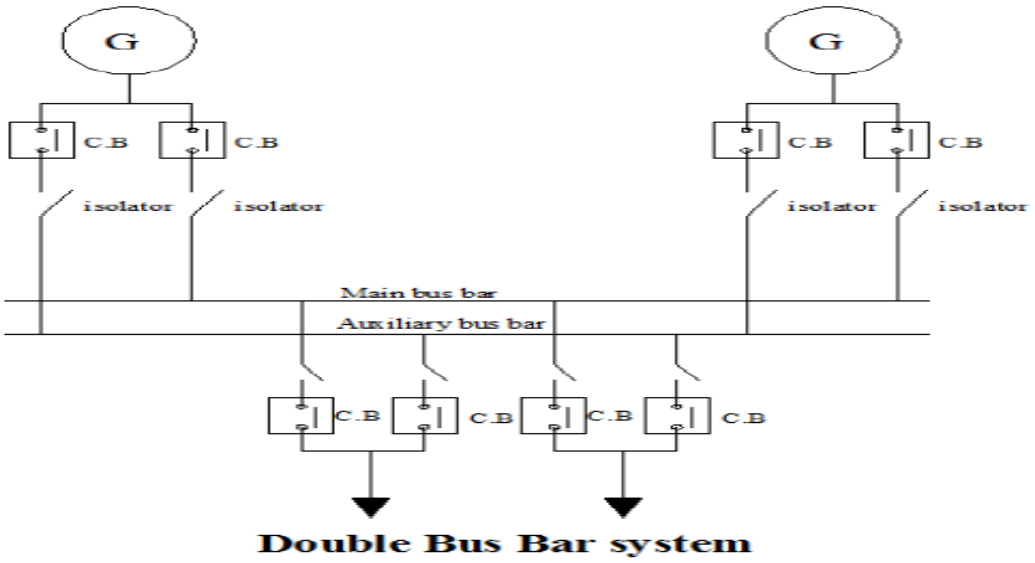


Sectionalized Single Bus Bar system

- Single Sectionalized Bus bar the number of sections depends up to the importance of the station and local switching requirements. The fault level of each bus can be reduced by installing a current limiting reactor in between the two adjoining sections.
- When two parallel feeders are taken from the same bus to one load point they are connected to different bus sections so that even if one feeder is dead during maintenance of one bus section the other feeder continue to serve. Bus sectionalizing should be through a circuit breaker so that the bus transfer can be carried out under full load conditions.
- Two isolators should be provided with each sectionalizing circuit breaker to enable the maintenance of the circuit breaker.
- If only isolator is used a sectionalizing switch the opening and closing of the same should be under no load condition. In case each section is supplied from a different source there should be a provision of synchronizing the two bus sections. Before closing the circuit breaker, the conditions for synchronism shall be satisfied.

3. DOUBLE BUS BAR ARRANGEMENT

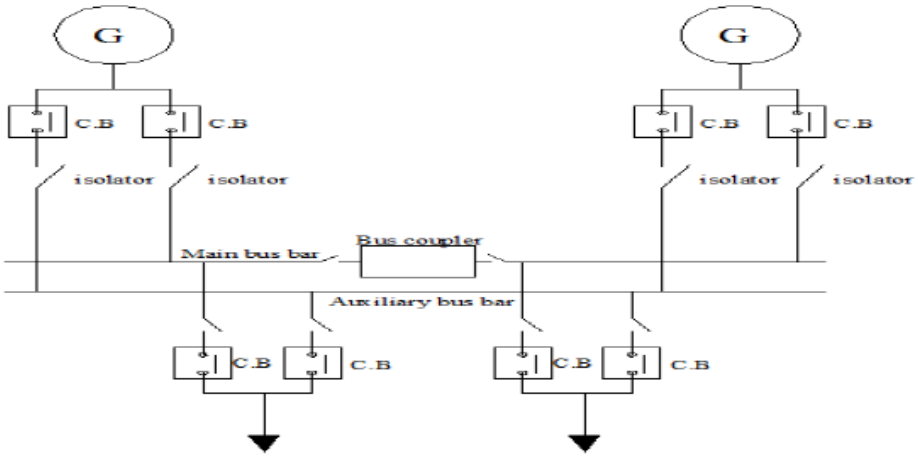
Double Bus bar Scheme is used universally for important EHV substations (110kv and above). The Double bus bar scheme is costlier than the single bus bar scheme is costlier than the single bus bar scheme but it gives higher operational flexibility and permits bus bar maintenance repairs or extension without shutdown.



- Double Bus bar Scheme have two three phase bus bars called main bus and reserve bus or bus no 1 and bus no 2.
- The main bus is for normal us and the reserve bus is available in case of maintenance or fault on the main bus. The Reserve Bus can also be used for testing a new feeder charging a feeder at higher voltage for test purposes for commissioning tests on a new plant. All these activities can be carried out without disturbing the main bus.
- During normal service only one of the buses is energized the other bus is in reserve. If both the buses are to be simultaneously in service, the protective relaying becomes complex.
- The connection between each incoming and outgoing circuits and the duplicate bus is through either one circuit breaker or two bus selecting isolators one for each bus bar through two circuit breakers and two insulators one circuit breaker one isolator for each bus bar.

4. SECTIONALIZED DOUBLE BUS BAR SCHEME

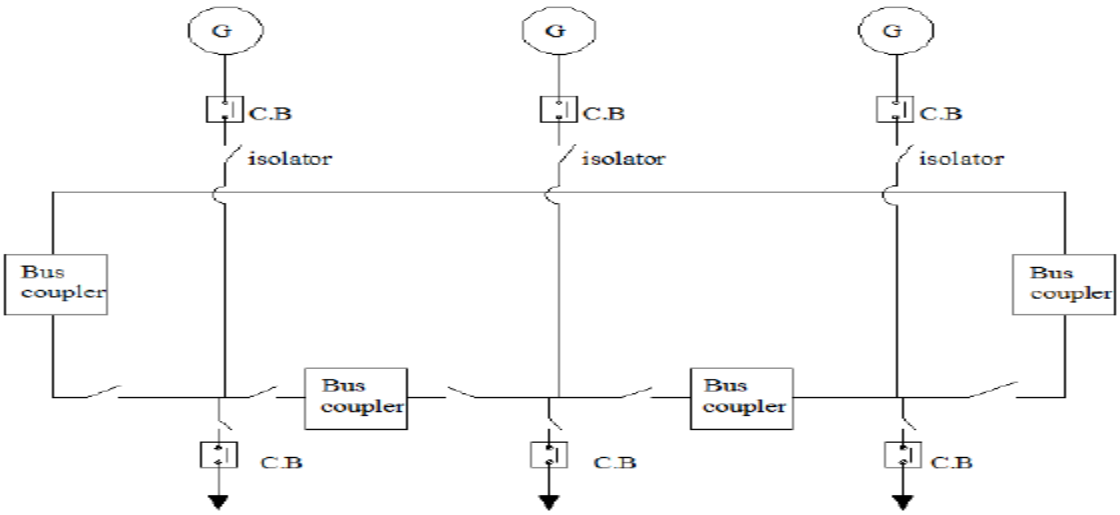
- In this scheme the auxiliary bus bars are used with the sectionalized main bus bar. In this method, any section of the bus bar can be isolated for maintenance work.
- The auxiliary bus is not sectionalized because of avoiding un necessary expenses.



Sectionalised Double Bus Bar system

4. RING BUS (MESH SCHEME)

- In the ring bus scheme the bus bars and the breakers are in series to form a ring. The circuits are connected between the breakers.
- The number of breakers is equal to the number of circuits. During the normal operation all the circuit breakers are closed. During a circuit fault two breakers in the associated bus bar are tripped.
- If one of these breakers fails to clear the fault an additional circuit will be tripped by breaker stuck up back up relay. During the breaker maintenance the faint is opened but all the circuits continue to serve.
- In the ring scheme sources and circuits are connected alternately. During breaker maintenance no change in protective relay is required.
- The ring bus is economical in cost as it requires only one breaker per circuit. Ring bus has good reliability good flexibility and is safe to operate.



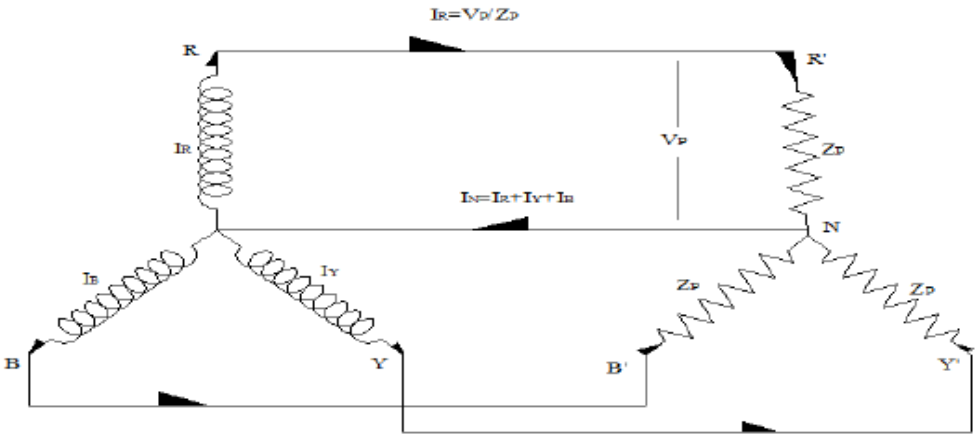
- The Ring bus is considered to be suitable for important 220kv and 400kv substations having up to five circuits.
- For more than five circuits breaker and half scheme is preferred Ring bus gives a better security than simple single bus because alternative route is available around the bus to the outgoing circuit.
- In case of bus bar fault the immediate result is similar to that of single bus bar scheme that all circuits are lost. However, the fault can be isolated by opening the bus bar isolators on either sides or most of the circuit can be reenergized Mesh scheme is called Ring Scheme in USA and Mesh scheme in England.
- In mesh scheme the bus forms a ring and circuit breakers are in the closed ring instead of Bing in outgoing or incoming circuits Ring bus has low cost. It is flexible for breaker maintenance.

Q.No :11.(b) Explain three phase ,four wire star connected unbalance load circuit.

Diagram=7 marks + Theory Explanation =7 marks

- In 3-phase 4-wire star-connected load circuits the star points of load and the generator are tied together through neutral wire of zero impedance.
- Therefore the neutrals are at the same potential and voltage across each impedance is same and equal to phase voltage whether the circuit is balanced or unbalanced.
- The three phase currents or line currents can be determined by dividing the phase voltage by the impedance of the concerned phase.

IR=VR/ZR ;
IY=VY/ZY ;
IB=VB/ZB



STAR CONNECTED UNBALANCED CIRCUITS

- The current in neutral wire can be determined by applying Kirchhoff's first law at star point N are shown in above figure.
- According to which **IR+IY+IB+IN=0** or current in neutral wire **IN=-(IR+IY+IB)**
- In balanced load circuits the line currents are equal and have the same phase angles with their respective phase voltages so their vector sum is zero and current in neutral wire is zero. In unbalanced load circuits the neutral wire Carries currents.

Q.No: 12 (a) Explain the different types of electric drives used in industrial loads .

(Diagram =7 marks + Explanation =7 marks)

Electric drives may be grouped into three categories:

1. Group drive
2. Individual drive and
3. Multi motor drive.

1. GROUP DRIVE

In group drive, a single motor drives a number of machines through belts from a common shaft. It is also called line shaft drive.

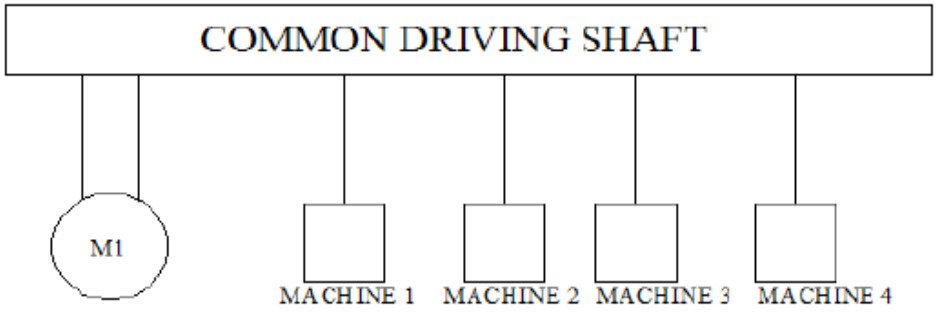


Fig 2.1.The group drive

Advantages:

1. It leads to saving in initial cost because one 150-kW motor costs much less than ten 15-kW motors needed for driving 10 separate machines.

2. Since all ten motors will seldomly be required to work simultaneously, a single motor of even 100- kW will be sufficient to drive the main shaft. This diversity in load reduces the initial cost still further.

3. Since a single large motor will always run at full-load, it will have higher efficiency and power factor in case it is an induction motor. 4. Group drive can be used with advantage in those industrial processes where there is a

sequence of continuity in the operation and where it is desirable to stop these processes simultaneously as in a flour mill.

Disadvantages:

1. Any fault in the driving motor renders all the driven equipment idle. Hence, this system is unreliable
2. If all the machines driven by the line shaft do not work together, the main motor runs
At reduced load. Consequently, it runs with low efficiency and with poor power factor.
3. Considerable amount of power is lost in the energy transmitting mechanism.
4. Flexibility of layout of different machines is lost since they have to be so located as to suit the position of the line shaft.
5. The use of line shaft, pulleys and belts etc. making the drive look quite untidy and less safe to operate.
6. It cannot be used where constant speed is required as in paper and textile industry.
7. Noise level at the worksite is quite high.

2. INDIVIDUAL DRIVE

In the case of an individual drive, each machine is driven by its own separate motor with the help of gears, pulley etc.

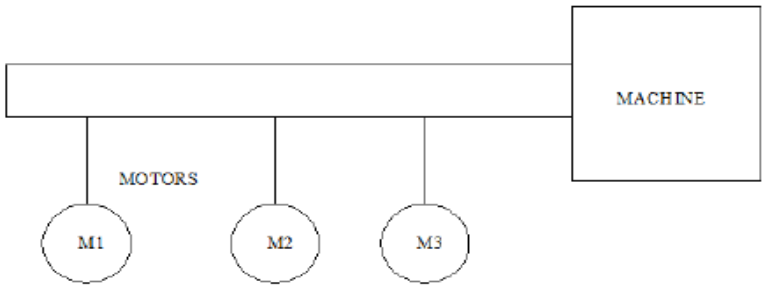


Fig 2.2. Individual Drive

Advantages

1. Since each machine is driven by a separate motor, it can be run and stopped as desired.
2. Machines not required can be shut down and also replaced with a minimum of dislocation.
3. There is flexibility in the installation of different machines.
4. In the case of motor fault, only its connected machine will stop whereas others will continue working undisturbed.
5. The absence of belts and line shafts greatly reduces the risk of accidents to the operating personnel.
6. Ach operator has full control of the machine which can be quickly stopped if an accident occurs.
7. Maintenance of line shafts, bearings, pulleys and belts etc. is eliminated. Similarly there is no

danger of oil falling on articles being manufactured–something very important in textile industry.

- The only disadvantage of individual drive is its initial high cost. However, the use of individual drives and multi motor drives has led to the introduction of automation in production processes which, apart from increasing the productivity of various undertakings, has increased the reliability and safety of operation.

3. MULTI MOTOR DRIVE.

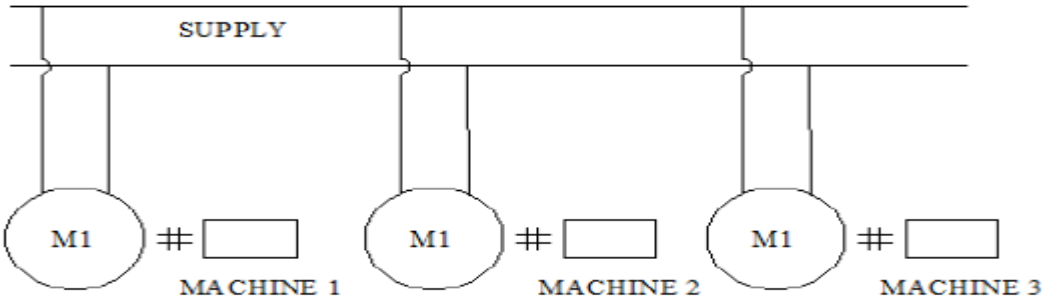


Fig 2.3 Multi motor drive

- In multi-motor drives separate motors are provided for actuating different parts of the driven mechanism. For example, in travelling cranes, three motors are used: one for hoisting, another for long travel motion and the third for cross travel motion.
- Multi motor drives are commonly used in paper mills, rolling mills, rotary printing presses and metal working machines etc

Q.No: 12 (b) Explain the necessary mechanical characteristics needed for the selection of motor.

The selection of a driving motor depends primarily on the conditions under which it has to operate and the type of load it has to handle. Main mechanical characteristics for such a selection are as follows:

Mechanical characteristics
a). Types of enclosures
b). Type of bearing
c). Noise level
d). Transmission of drive

(a) TYPES OF ENCLOSURES (Explanation =4 marks)

The main function of an enclosure is to provide protection not only to the working personnel but also to the motor itself against the harmful ingress of dirt, abrasive dust, vapors and liquids and solid foreign bodies such as a spanner or screw driver etc. At the same time, it should not adversely affect the proper cooling of the motor. Hence, different types of enclosures are used for different motors depending upon the environmental conditions. Some of the commonly used motor enclosures are as under:

1. **Open Type:**

In this case, the machine is open at both ends with its rotor being supported on pedestal bearings or end brackets. There is free ventilation, since the stator and rotor ends are in free contact with the surrounding air. Such, machines are housed in a separate neat and clean room. This type of enclosure is used for large machines such as d.c. motors and generators.

2. **Screen Protected Type:**

In this case, the enclosure has large openings for free ventilation. However, these openings are fitted with screen covers, which safeguard against accidental contacts and rats entering the machine but afford no protection from dirt, dust and falling water. Screen-protected type motors are installed, where dry and neat conditions prevail without any gases or fumes.

3. **Drip Proof Type:**

This enclosure is used in very damp conditions *i.e.* for pumping sets. Since motor openings are protected by over-hanging cowls, vertically falling water and dust are not able to enter the machine.

4. **Splash-proof Type:**

In such machines, the ventilating openings are so designed that liquid or dust particles at an angle between vertical and 100° from it cannot enter the machine. Such type of motors can be safely used in rain.

5. **Totally Enclosed (TE) Type:**

In this case, the motor is completely enclosed and no openings are left for ventilation. All the heat generated due to losses is dissipated from the outer surface which is finned to increase the cooling area. Such motors are used for dusty atmosphere *i.e.* sawmills, coal-handling plants and stone-crushing quarries etc.

6. **Totally-enclosed Fan-cooled (TEFC) Type:**

In this case, a fan is mounted on the shaft external to the totally enclosed casing and air is blown over the ribbed outer surfaces of the stator and end shields . Such motors are commonly used in flour mills, cement works and sawmills etc. They require little maintenance apart from lubrication and are capable of giving years of useful service without any interruption of production.

7. **Pipe-ventilated Type:**

Such an A Enclosure is used for very dusty surroundings. three-phase motor The motor is totally enclosed but it is cooled by neat and clean air brought through a separate pipe from outside the dust-laden area. The extra cost of the piping is offset by the use of a smaller size motor on account of better cooling.

8. **Flame-proof (FLP) Type:**

Such motors are employed in atmospheres which contain in-flammable gases and vapors *i.e.* in coal mines and chemical plants. They are totally enclosed but their enclosures are so constructed that any explosion within the motor due to any spark does not ignite the gases outside. The maximum operating temperature at the surface of the motor is much less than the ignition temperature of the surrounding gases.

(b) BEARINGS (Explanation =4 marks)

These are used for supporting the rotating parts of the machines and are of two types:

1. Ball or roller bearings

2. Sleeve or bush bearing

(*a*) Ball Bearings Up to about 75kW motors, ball bearings are preferred to other bearings , because of their following advantages :

1. They have low friction loss

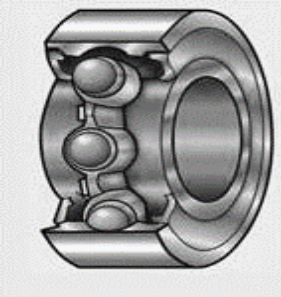
2. They occupy less space

3. They require less maintenance

4. Their life is long.

5. Their use allows much smaller air-gap between the stator and rotor of an induction motor.

Their main disadvantages are with regard to cost and noise particularly at high motor speeds.



(*b*) Sleeve Bearings

These are in the form of self-aligning porous bronze bushes for fractional kW motors and in the
Form of journal bearings for larger motors. Since they run very silently, they are fitted on super-silent motors used for driving fans and lifts in offices or other applications where noise must be reduced to the absolute minimum.

(c) NOISE LEVEL : (Explanation =4 marks)

- The noise produced by a motor could be magnetic noise, windage noise and mechanical noise. Noise level must be kept to the minimum in order to avoid fatigue to the workers in a workshop.
- Similarly, motors used for domestic, hospital appliances; offices and theatres must be almost noiseless. Transmission of noise from the building, where the motor is installed to another building can be reduced if motor foundation is flexible *i.e.* has rubber pads and spring.
- To reduce noise, journal bearing may be used in place of ball bearings. The motor should be mounted on a heavy concrete or cast iron block. The electrical connections should be made through flexible conduits.

(d) TRANSMISSION OF DRIVES (Explanation =2 marks)

For transmit power from driving machine to driven machine, below are the types of transmission drives commonly used.

1. Direct drive
2. Belt drive
3. Rope drive
4. Chain drive
5. Gear drive

Q.No: 13 (a) Write Short notes on Booster Transformer connection in Electric Traction and Neutral Sectioning.

In a.c. traction system, return current which flows from the locomotive to the track soon leaks to the ground with in short distance and returns to the substation through its earth. These ground current causes heavy interference with the communication lines. His current can be minimized by using booster transformers. It consists of two windings of1: 1 ratio. The primary winding is connected in series with contact wire. Any amount of current flowing through primary requires to be balanced by equal current in secondary and so the tendency of current flowing through stray path is reduced.

There are **two methods** of connecting booster transformer.

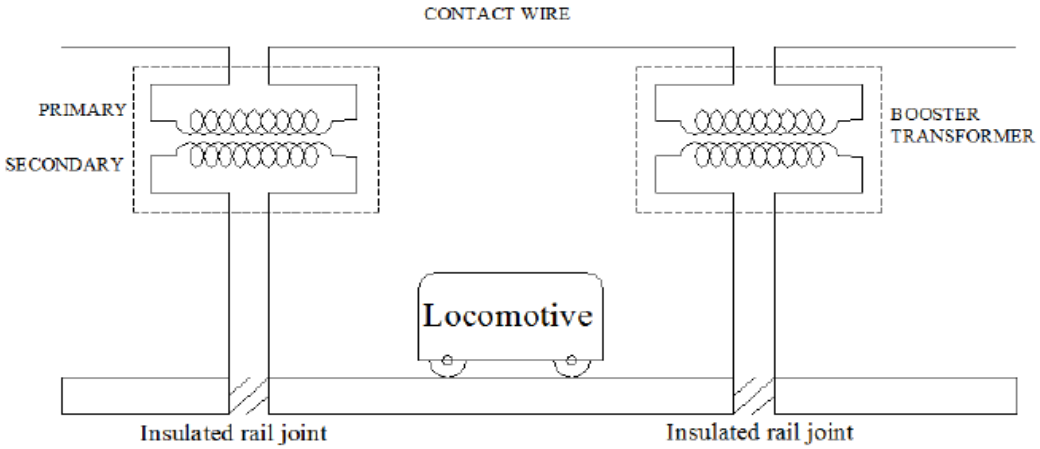
1. Rail connected booster transformer.
2. Booster transformer with return feeder.

1. <u>Rail Connected Booster Transformer</u>. <u>(Diagram – 2.5 mark + Explanation = 2.5 mark)</u>

- As in below figure primary is connected in series with the contact line and secondary in series with rails.
- Induced voltage in the secondary constraints the return current to flow through rails. This method of connecting booster transformer has the following drawbacks.

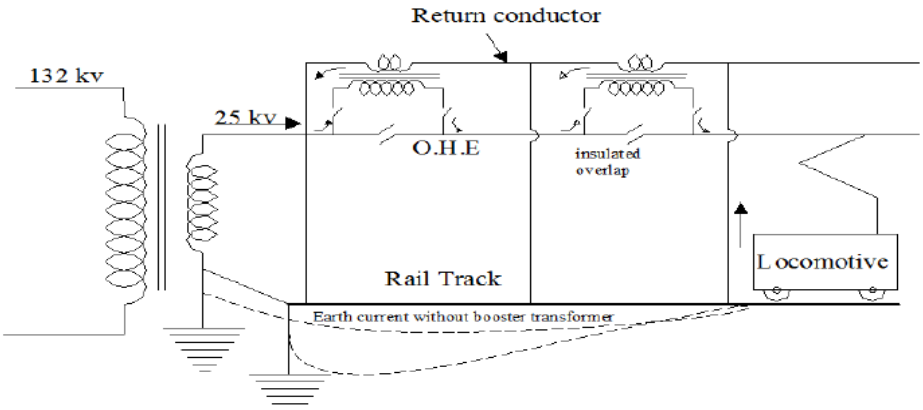
1. Need insulated rail joint with small neutral sectioning.
2. Insulation puncture between rails of insulated joins may cause short circuiting the secondary and make the booster transformer ineffective.
3. Voltage rises of 200v between rails and 100v between rail and earth may cause danger.

4. Requires close spacing of booster transformer.



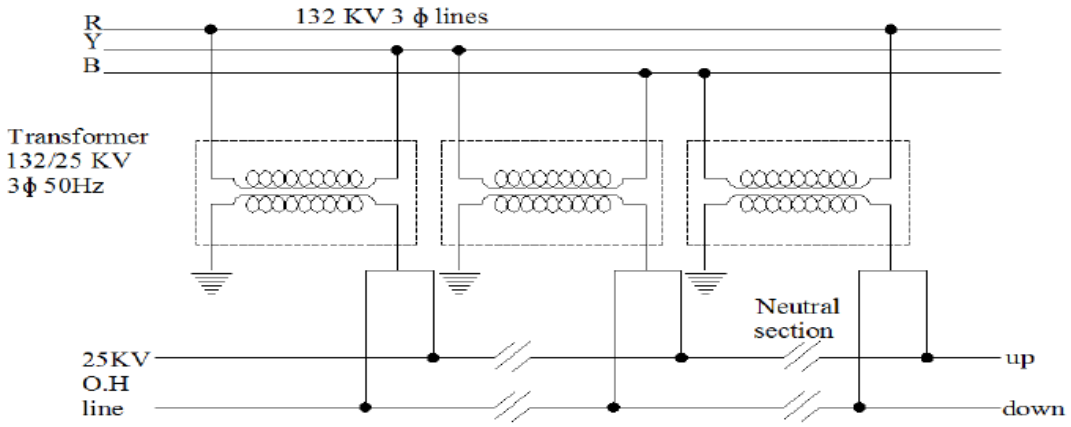
2. <u>Booster Transformer With Return Feeder</u> <u>(Diagram – 2.5 mark + Explanation = 2.5 mark)</u>

- This method is more effective than others. Fig shows the connection of booster transformer with return feeder.
- In this system rails are connected midway between booster transformers. The return current now flows through the return feeder back to substation.
- Running the return feeder very close to the contact wire reduces the tendency of magnetic coupling between power line and telecommunication line.
- The turns of the booster transformer should be 1:1 so as to enables the secondary to suck out the current from rails equal in magnitude to that flows in primary



NEUTRAL SECTIONING (Diagram – 2 mark + Explanation = 2 mark)

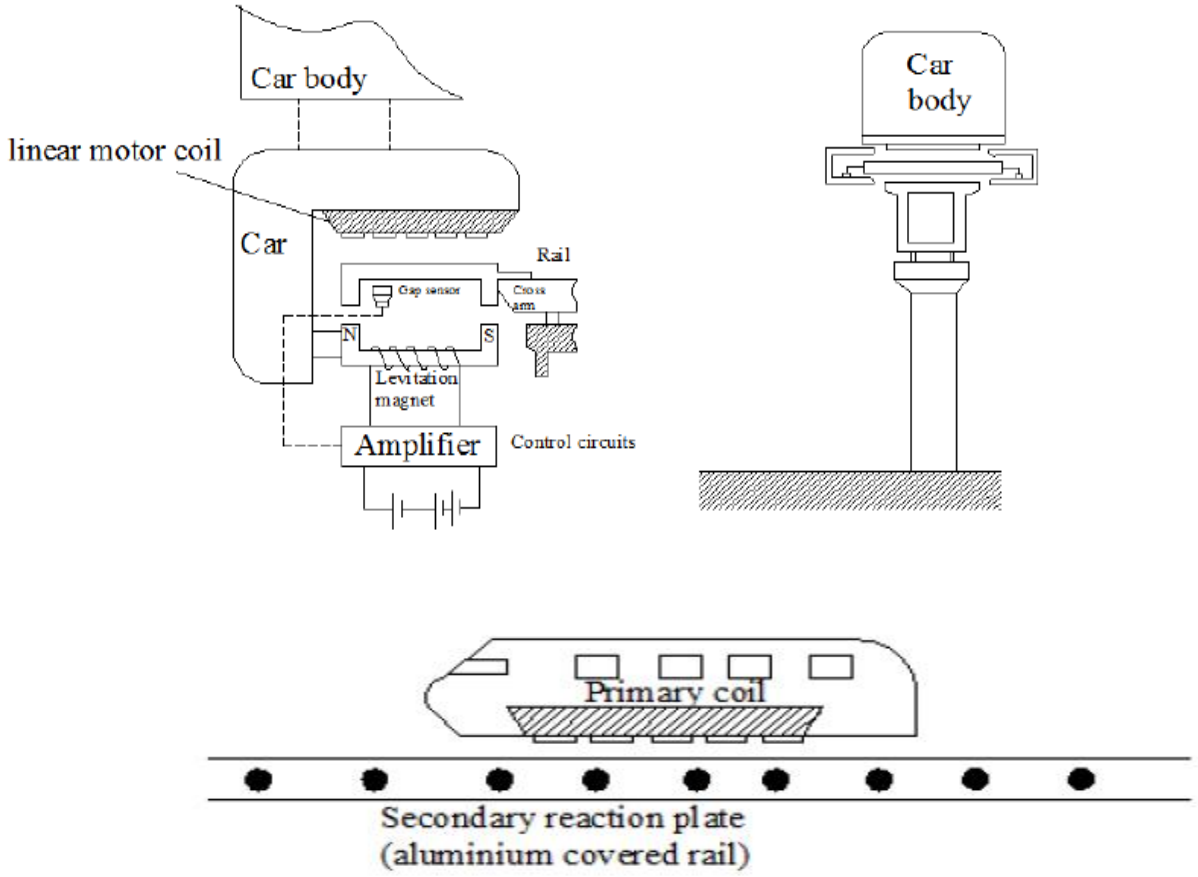
- Power generation and transmission systems of supply are three phase system. For traction it needs single phase system. If all he traction loads are put on one phase alone, it will causes unbalancing in three phase system.
- For this the adjacent substations tap different phases of three phases in order to achieve even loading of the lines. For that it must have boundary of supply between two substations which have insulated over lap.
- Therefore Momentary passing of pantograph under insulated overlap will cause short circuit between two phases, thereby damaging the OHE equipments.
- In order to prevent bridging of two different phases a small insulation called neutral section is provided. It is insulated from both sides and is not connected to any source of supply. Its main function is to permit physically smooth and electrically sparkless passage of pantograph from one section to and the other. Neutral sections are indicated in displays for the drivers of an electric train to switch off before approaching neutral section and coast it to other zone. For these warning boards are placed to draw the attention of the driver.



Q.No:13 (b) Explain about the Magnetic Levitation .

Diagram=7 marks + Explanation =7 marks

MAGNETIC LEVITATION (MEGLEV) :



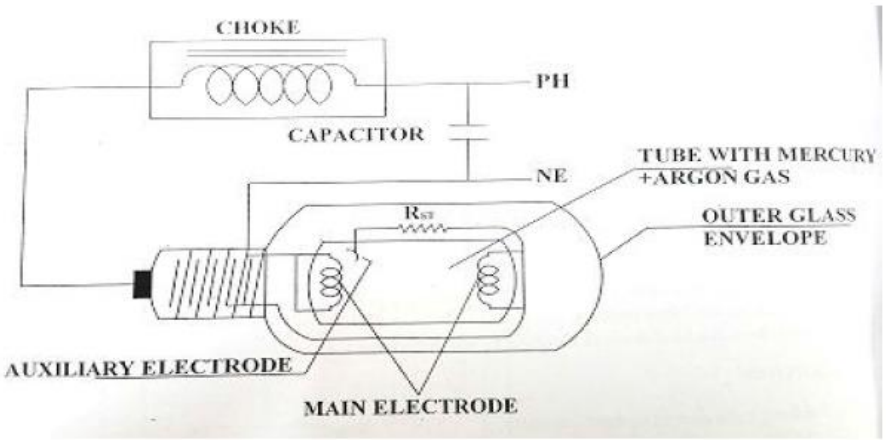
- In levitation system, ordinary electromagnets are used .These magnets produce an attractive force and levitate the vehicle i.e., to rise and float the vehicle in the air with no physical support.
- The electromagnets are attached to the car. These magnets are placed such that they are facing the underside of the rail as shown in fig.below figure .
- They produce an attractive force and levitate the car. The attractive force is controlled by a gap sensor. The gap sensor measures the distance between the rails and electromagnets.
- A control circuit continuously regulates the gap at a fixed distance of about 8mm.If the gap increases beyond 8mm, the current to the electromagnet is increased, to create more attraction (i.e., Now the gap is reduced).If the gap become less than 8mm,the current is decreased, to create less attraction(i.e., Now the gap is increased).
- The levitation magnets are 'U' shaped and the rails are inverted 'U' shaped as shown in fig. In this system the electromagnetic attractive forces levitate and guide the car. In this system linear induction motor is used.
- The linear induction motor is just like ordinary induction motor, but it has been split open and flattened. The primary side coils of the motor are attached to the car body.
- The secondary side reaction plates are installed along the guide way of the rail as shown in fig. The secondary plate is made of aluminum or copper plate.

Advantages

1. The vehicle is designed so that it interlocks with the guide way. So there is no risk of derailment.
2. When the vehicle is running, there is no physical contact between the carriages and guide way which minimize the noise and vibration.
3. There are less moving and rolling parts. So wear and tearis less. Hence low maintenance is required.

Q.No: 14 (a) Explain with a sketch the working of High Pressure mercury vapour lamp.

Diagram=7 marks + Explanation =7 marks



CONSTRUCTION & WORKING:

- The construction of high pressure mercury vapour lamp. This lamp consists of two tubes. The inner discharge tube is made of hard glass.
- This tube contains small quantity of neon or argon gas under low pressure in addition to mercury.
- There are two main electrodes and a starting electrode which is placed quite close to one of the main electrodes.
- The inner tube is contained in an evacuated outer tube. This tube protects the inner tube from coming into direct contact with atmospheric temperature changes. The lamp has a screwed cap and is connected to the supply mains through a choke.
- To improve the power factor of the tube a condenser is connected across the mains.
- During connections to the supply mains, the auxiliary electrode is connected through a high resistance. The second main electrode is connected to neutral of the supply. The phase comes to the first main electrode through the insulated part of the metallic cap.
- When the tube is switched on, an arc starts between the first main electrode and starting electrode. The argon gas is ionized and a glow appears between these two electrodes.
- A small amount of current is flowing through starting resistor. This results in building up of pressure due to heating up of mercury which is originally in the condensed form.
- Therefore the medium between the main electrodes is ionised and current starts flowing between the two main electrodes. The discharge is of a pale blue glow and is limited by the choke in the main circuit. This lamp is M.A. type and is rated at 250 to 400 watts for 230V A.C.

- The lamp should always be mounted vertically, otherwise the inner tube can be damaged by the striking arc. The time taken during starting of the lamp is 5 to 6 minutes.
- The temperature inside the bulb is about 650^0C and efficiency of the lamp is about 40 lumens/watt.
- This lamp is unsuitable for indoor lighting and is suitable for A.C mains only.

Typical mercury-vapour lamp applications are :
1. High-bay industrial lighting — where high level illumination is required and colour rendition is not important.
2. Flood-lighting and street-lighting
3. Photochemical applications — where ultra-violet output is useful as in chlorination, water sterilization and photocopying etc.
4. For a wide range of inspection techniques by ultra-violet activation of fluorescent and phosphorescent dyes and pigments.
5. Sun-tan lamps — for utilizing the spectrum lines in the region of ultra-violet energy for producing sun-tan.

Q.No: 14 (b) Define (i) MSCP (ii) MHSCP (iii) Space height ratio (iv) Utilisation Factor (v) Solid angle (vi) Beam factor (vii) Glare lamp efficiency.

(Each Definition = 2 mark)

(i) MSCP- MEAN SPHERICAL CANDLE POWER :

Generally, the luminous intensity or candle power of a source is different in different directions. The average candle-power of a source is the average value of its candle power in all the directions. Obviously, it is given by flux (in lumen) emitted in all directions in all planes divided by 4π. **This average candle-power is also known as mean spherical candle-power (MSCP).**

$$MSCP = \frac{total\ flux\ in\ lumens}{4\pi}$$

(ii) MHSCP-MEAN SEMI-SPHERICAL CANDLE POWER :

It is the mean or average of the candle powers in all directions below the horizontal. It is given by the total flux emitted in a hemisphere (usually the lower one) divided by the solid angle subtended at the point source by the hemisphere.

$$MHSCP = \frac{flux\ emitted\ in\ a\ hemisphere}{2\pi}$$

(iii) SPACE HEIGHT RATIO

Spacing Height Ratio is defined as the ratio of the distance between adjacent luminaries (center to center) to their height above the working plane.

SHR (Nominal) = (1/Hm) x (Square root (Area/N))

Where

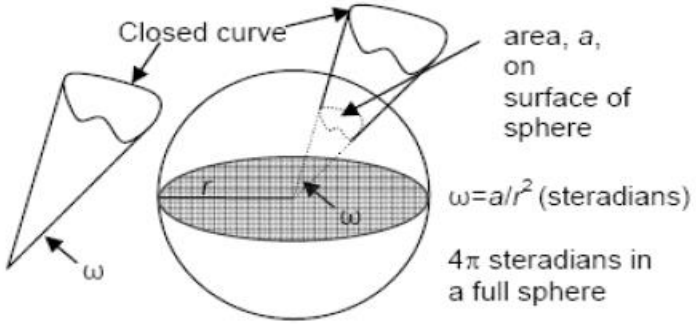
Hm is mounting height,
N is number of luminaries

iv) UTILISATION FACTOR

Utilization factor or coefficient of utilization is defined as the ratio of total lumens reaching the working plane to the total lumens given out by the lamp.

(v) SOLID ANGLE

A solid angle, ω, made up of all the lines from a closed curve meeting at a vertex, is defined by the surface area of a sphere subtended by the lines and by the radius of that sphere, as shown below. The dimensionless unit of solid angle is the steradian, with 4π steradians in a full sphere.



$$\text{solid angle } \omega = \frac{\text{Area}}{(\text{Radius})^2}$$

(vi) BEAM FACTOR

The Beam factor is the ratio between lumens in the beam of a projector to the lumens given out by lamps

$$\text{Beam factor} = \frac{\text{Lumens in the beam of a projector}}{\text{Lamp Lumens}}$$

(vii) GLARE LAMP EFFICIENCY:

The ratio of total luminous flux over total power input, expressed in **lumens per watt**.

For Example: An Electric Lamp

$$\text{Lamp Efficiency} = \frac{\text{Lumens emitted by source}}{\text{Wattage of source of light}}$$

Q.No :15 (a) Explain dielectric heating with a sketch. State its application.

(Diagram=6 marks + Explanation =6 marks & Application =2 marks)

- Dielectric heating is also sometimes called as high frequency capacitance heating.

- If nonmetallic materials i.e, insulators such as wood, plastics, china clay, glass ceramics etc are subjected to high voltage A.C current, their temperature will increase after some time. The increase in temperature is due to the conversion of dielectric loss into heat.
- The dielectric loss is dependent upon the frequency and high voltage. There fore for obtaining high heating effect high voltage at high frequency is usually employed. The metal to be heated is placed between two sheet type electrodes which form a capacitor.
- When A.C supply is connected across the two electrodes, the current drawn by it is leading the voltage exactly 90°. The angle between voltage and current is slightly less than 90°, with the result that capacitor.
- At normal supply frequency the power loss may be small. But at high frequencies, the loss becomes large which is sufficient to heat the dielectric. Rate of heat production can also be increased by applying high potential but it is also limited because of the following considerations:

(a) Possibility of formation of standing waves between the surface of two electrodes having wavelength nearly equal to or more than one quarter of the wavelength of the particular frequency used.

(b) Necessity of employing special matching circuit at higher frequencies due to the fact that maximum power transfer takes place when the oscillator impedance equals the load impedance.

(c) At higher frequencies it is difficult for tuning inductance to resonate with the charge capacitance.

(d) At higher frequencies, it is almost impossible to get uniform voltage distribution.

Fig.5.8.a. Dielectric Heating

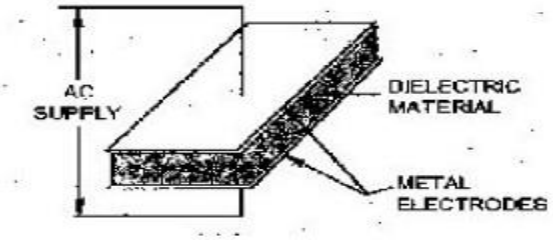
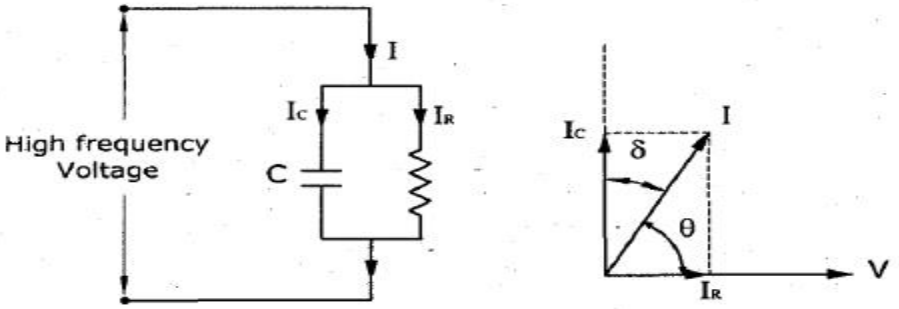


Fig.5.8.b. Equivalent circuit & Vector diagram



Advantages

1. Uniform heat
2. Simple
3. Low running cost
4. Heat generated can be controlled accurately
5. Better Working conditions
6. Less Time of Operation
7. Also called as Capacitance Heating

8. For heating non metallic materials Eg. Wood, Plastic, China Clay, Glass, Ceramics

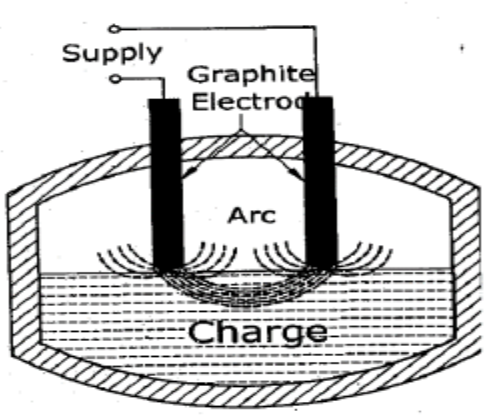
Applications
1. Manufacturing of synthetics
2. Wood processing
3.Foundry course baking
4. Food processing

Q.No: 15 (b) Draw and explain direct and indirect arc furnaces with suitable sketches.

(Diagram =7 marks + Explanation =7 marks)

TYPES OF ARC FURNACES
1. Direct arc furnace
2. Indirect arc furnace

1. DIRECT ARC FURNACE



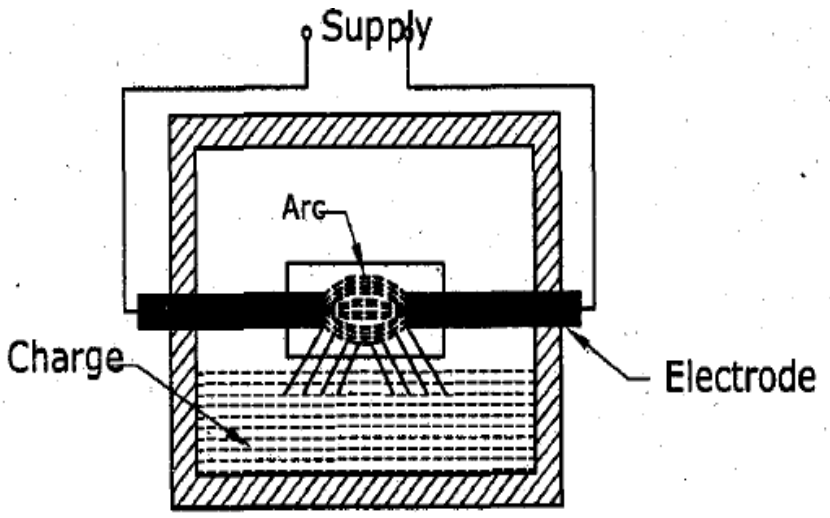
Working principle:

- In this type the charge acts as another electrode. There are two carbon or graphite electrodes and the arc is developed at two places.
- The arc is directly in contact with the charge and the arc is due to the current in the charge, therefore the charge is heated to very high temperature. Single arc or 2/3 arcs are established between electrodes.
- Current flows through the body of charge, develops heat due to electric resistance.

Advantages

1. Very high temperature is obtained
2. More uniform in composition
3. Stirring action takes place.
4. Used for steel production
5. Power factor is 0.8
6. Size of the furnace is from 5 to 10 tones (small), from 50 to 100 tones (large)

2. INDIRECT ARC FURNACE



Working principle:

- The arc is produced between two electrodes and the heat is transmitted to the charge by radiation. Current flows through electrodes & Arc Exists between two electrodes.
- Heat is radiated from arc to the charge. It is only of single phase type, because of limitation of number of electrode.
- The current does not flow through the charge; hence there is no automatic stirring. So the furnace is required to be rocked mechanically.
- Indirect arc furnaces are used for melting non ferrous metals. Maximum temperature attained by charge is low. Used in iron industries, where intermittent supply of molten metal is required.

Advantages

1.Flexibility
2. High melting speed
3. Economy
4. Low metal losses
5. Sound castings

Applications

i). To make castings of alloy iron for heat resisting, abrasion resisting & similar special purposes
ii). Suited for non- ferrous castings of copper, bronze, nickel alloy etc, Hydraulic & other pressure fittings.

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