1728

October 2024

DISTRIBUTION AND UTILIZATION

PART-A

1. What are the types of bus bar arrangements? **[3 marks]**
(Any Three Point)

1. Single bus bar system
2. Single sectionalized bus bar system
3. Duplicate bus bar system with one breaker per circuit
4. Duplicate bus bar system with two breakers per circuit
5. Main and transfer bus bar
6. Ring bus bar
7. Breaker and a half bus bar system
8. Mesh bus bar scheme
9. Hybrid system

2. List the advantages of ring main distribution system. **[3 marks]**
(Any Three Point)

- It increases the service reliability
- reduced power losses
- Ring main distribution can extend the life of electrical equipment.
- Lower installation costs.
- Improve voltage regulation.

3. What is plugging? **[3 marks]**

Plugging means phase reversal. It is a simple method of electrical braking. During the braking period reverse torque produces on the motor. A special device is required to cut off the supply as soon as the motor comes to rest. This method can be applied to both AC and DC motors.

4. Write the advantage of electric drives. **[3 marks]**
(Any Three Point)

1. It is simple in construction and has less maintenance cost
2. Its speed control is easy and smooth
3. It is neat, clean and free from any smoke or flue gases
4. It can be installed at any desired convenient place thus affording more flexibility in the Layout.
5. It can be remotely controlled
6. Being compact, it requires less space

7. It can be started immediately without any loss of time
8. It has comparatively longer life.

5. Mention the methods of feeding power to locomotives. **[3 marks]**

1. Rail conductor system.
2. Overhead line system.
3. Pantograph collector.

6. What is meant by transition in series-parallel control connection? **[3 marks]**

1) In first step the motors run with full resistance in series' **First Series** After whole of the external resistance has been cut out now motors are now in series without resistance. This is known as **Full Series.**

2) Second step is to short circuit one motor. This is known as **First Transition**

3) Third step is open one end of the short circuit motor this is known as **Second Transition** and some of the resistance is connected and also known as **First Parallel.** Fourth step is to connect this open end of the motor with corresponding terminal of the other motor. The external resistance is gradually reduced and now the motor runs at **Full Parallel.** It will be observed that during shunt transition steps from 1 to 4 one motor is actually short circuited and then disconnected from supply and afterwards reconnected in parallel. This therefore results in the loss of tractive effort during this period till motor is reconnected in parallel.

7. Define luminous intensity. **[3 marks]**

Luminous intensity in a given direction is the quotient of the luminous flux emitted by a source (or by an element of a source), in an infinitesimal cone containing the given direction by the solid angle of that cone. Hence it is the luminous flux / unit solid angle.

8. What are the advantages of LED lamps? **[3 marks]**
(Any Three Point)

1. In keeping with the long life claimed for LED lamps, long warranties are offered.
2. Reduces energy costs — uses at least 75% less energy than incandescent lighting, saving on operating expenses.
3. Reduces maintenance costs — lasts 35 to 50 times longer than incandescent lighting and about 2 to 5 times longer than fluorescent lighting. No lamp-replacements, no ladders, no ongoing disposal program.
4. Reduces cooling costs — LEDs produce very little heat.

5. Is guaranteed — comes with a minimum three-year warranty — far beyond the industry standard.
6. Offers convenient features — available with dimming on some indoor models and automatic daylight shut-off and motion sensors on some outdoor models.
7. Is durable — won't break like a bulb.

9. Give the advantages of electric heating. **[3 marks]**
(Any Three Point)

1. Economical
2. High η (75 to 100%)
3. Cleanliness
4. Absence of flue gases
5. Ease of control
6. Automatic protection
7. Localized application
8. Uniform heating
9. Low attention & low maintenance cost
10. Better working conditions

10. List out any three electric welding equipment. **[3 marks]**
(Any Three Points)

1. AC welding equipment's
2. DC welding equipment's
3. Other equipment's

a) Welding Holder
b) Welding Leads
c) Ground Connection
d) Hand Shields

PART-B

11. (a) Discuss about various substation in electrical power system. **[14 marks]**

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

1. Classification based on voltage levels :

A.C.Substation:

- EHV, HV, MV, LV, HVDC Substation.

2. Classification on constructional features:
   - Outdoor or Indoor
   - Outdoor substation is under open sky. Indoor substation is inside a building
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 application :
   - Switchyard in generating station
   - Switching substation
   - Sending end substation
   - Receiving end substation
   - Distribution substation
   - Factory substation
   - Compensating substation
   - Load substation eg: Arc furnace substation.

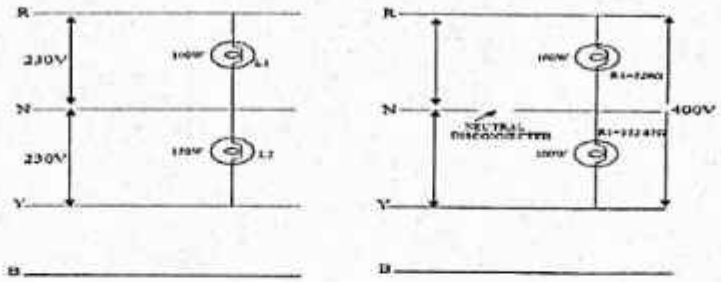
(Or)

(b) Explain the consequences of disconnection of neutral in 3 phase 4 wire AC distribution system with an example. **(Explain 7 marks, Example 7 marks)**

In a balanced three phased four wire system when the neutral is disconnected no change is produced but in case of unbalanced 3-phase 4-wire system when the neutral is disconnected the loads which are connected between any two conductors and the neutral are connected in series and potential difference across the combined load becomes equal to line voltage. The potential difference across each load is thus changed as per rating of the load. The effect of disconnecting the neutral in a 3- phase 4- wire unbalanced system will be clear from the following solved example.

The lamp L1 of 100 Watts is connected between phase R and neutral Lamp L2 of 150

watts is connected between phase Y and the neutral.



Resistance of Lamp L_1, $R1 = \frac{(230)^2}{100} = 529\ \Omega$

Resistance of Lamp L_2, $R2 = \frac{(230)^2}{150} = 352.67\ \Omega$

When the neutral wire is disconnected as shown in fig the two lamps are connected in series. Therefore the potential difference across the combination becomes equal to the line voltage E_L(400V)

Now current through lamps = $\frac{EL}{R1+R2} = \frac{400}{529+352.67} = 0.454$ A

Voltage across lamp L1 = IR_1= 0.454 x 529 = 240.17 V

Voltage across lamp L2 = IR_2 = 0.454 x 352.67 = 160.11V

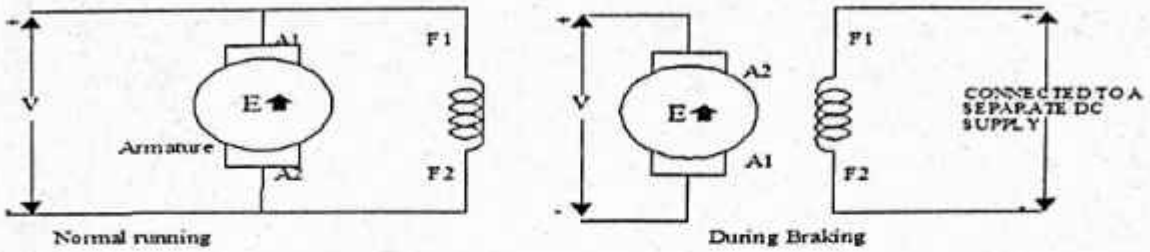
From the above the voltage across 100 watt lamp is increased to 24 V whereas voltage across 150 watt lamp is decreased to 160V. Therefore 100 W lamps become brighter and 150W becomes dim.

12 . (a) Explain about regenerative braking as applied to various motors.

(Diagram 7 marks, Explain 7 marks)

In this method of braking, motor is not disconnected from the supply but is made to run as a generator by utilizing the Kinetic energy .Electrical energy is fed back to the supply. The magnetic drag produced on account of generator action offers the braking torque. It is the most efficient method of braking.

a) Regenerative Braking applied to D.C. Shunt motor:



Take the case of a shunt motor. It will run as a generator whenever its E_b be-comes greater than V.

Can exceed V in two ways:

1. By increasing field excitation :
2. By increasing motor speed beyond its nor-mal value, field current remaining the same. It happens when load on the motor has overhauling characteristics as in the lowering of the cage or a hoist or the down- gradient movement of an electric train. Regenerative braking can be easily applied to D.C. shunt motors though not down to very low speeds because it is not possible to increase field current sufficiently.

b) Regenerative Braking applied to D.C. Series motor:

In the case of D.C. series motors, reversal of current necessary to produce regeneration would cause reversal of the field and hence of E_b. Consequently, modifications are necessary if regenerative braking is to be employed with D.C. series motors. It may, however, be clearly understood that regenerative braking cannot be used for stopping a motor. Its main advantages are (*i*) reduced energy consumption (*ii*) reduced wear of brake shoes and wheel (*iii*) lower maintenance cost.

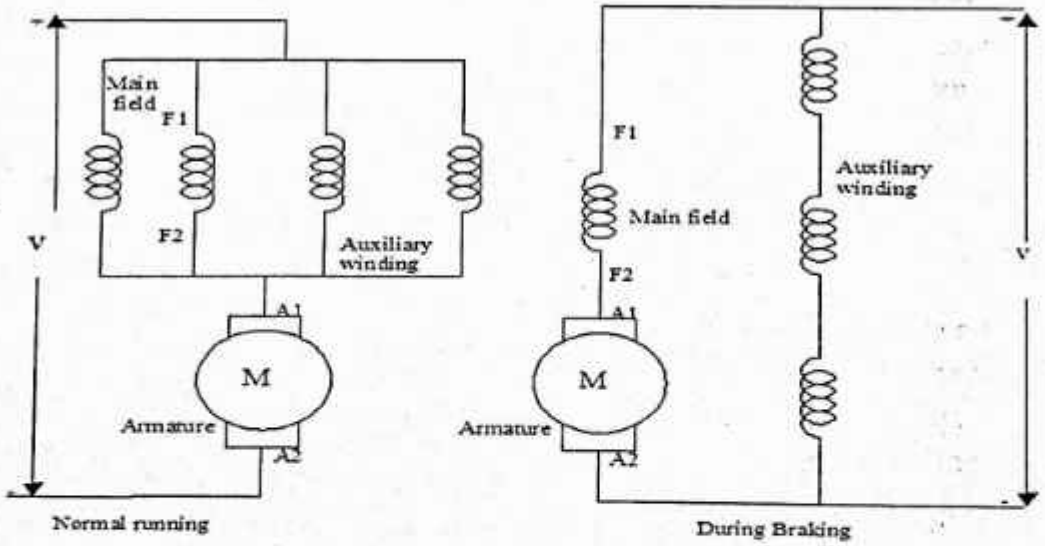


Fig shows the connection of a D.C. series motor for Regenerative Braking using French

method. It is provided with a main series winding and auxiliary field winding connected in parallel with the main series winding in a D.C series motor. During braking period, the auxiliary windings are put in series with each other and switched across the supply as in fig. the motor acts as a differentially compound generator.

c) Regenerative Braking applied to induction motor:

When an induction motor runs above synchronous speed the emf induced in the rotor is greater than the supply voltage. Hence the motor works acts as an induction generator and feed power back to the supply line. No extras auxiliaries are needed for this purpose. Its application is very useful to lift and hoist for a descending load at a speed slightly above synchronous speed.

(Or)

(b) Discuss about the factors governing the selection of motors.

(Types 4 marks, Explain 10 marks)

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 guiding factors for such a selection are as follows:

(a) Electrical characteristics:

1. Running characteristics
2. Starting characteristics
3. Speed control
4. Braking

(b) Mechanical considerations:

1. Types of enclosures
2. Transmission of drive
3. Type of cooling
4. Noise level
5. Type of bearing

(c) Size and rating of motors

1. Requirement for continuous, intermittent or variable load cycle
2. Overload capacity

(d) Cost

1. Capital cost
2. Running cost

In addition to the above factors, one has to take into consideration the type of current available whether alternating or direct. However, the basic problem is one of matching the mechanical output of the motor with the load requirement i.e. to select a motor with the correct speed/torque characteristics as demanded by the load. In fact, the complete selection process requires the analysis and synthesis of not only the load and the proposed motor but the complete drive assembly and the control equipment which may include rectification or frequency changing.

I). Electrical characteristics:

a) Running characteristics:

The Running characteristics of a motor include the speed- torque or the speed- current characteristics,

Losses, magnetizing current, efficiency and power factor at various loads. The magnetizing current and power factor are to be considered in case of AC motors only.

b) Starting characteristics:

The starting torque developed by a motor should be sufficient to start and accelerate the motor at its load to the rated speed in a reasonable time. Some motors may have to start against full load torque example: motors driving grinding mills or oil expellers, traction work.

c) Speed control:

i) In a DC motor the speed can be controlled by the following methods:

1. Armature control method
2. Field control method

ii) In AC motor the speed can be controlled by the following methods

1. By changing the supply voltage
2. By changing the supply frequency
3. By changing the number of poles of motor
4. By injecting emf in the rotor circuit.
5. By cascading of motors.
6. By injecting resistance in the rotor circuit.

d) Braking

If the load is removed from an electric motor and even the supply is disconnected, the motor will run for some time due to its inertia. To avoid danger to the worker or to stop the motor immediately braking is applied. The braking should be reliable and quick in action. The braking torque is applied to stop the motor. There are two types of braking i0Mechanical Braking ii) Electrical braking.

II. Mechanical characteristics:

a) Types of Enclosures

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.

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.

13. (a) Discuss about various current collector used in electric traction.

(Types 2 marks, Diagram 6 marks, Explain 6 marks)

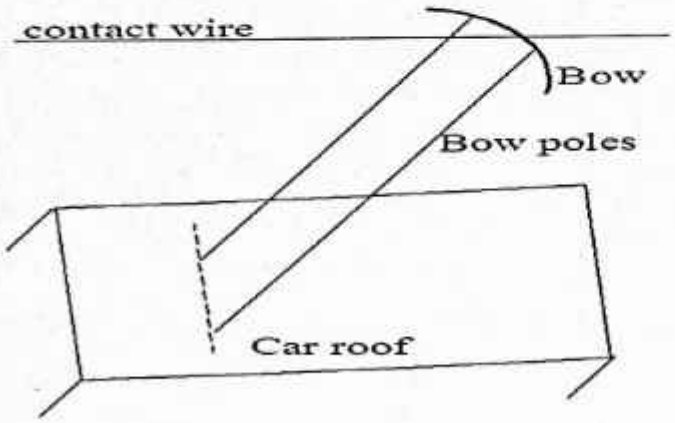
Main requirement of a collection gear is that it should, under no circumstances leave the contact of OHE. Contact wire in all practical installation is never perfectly horizontal. It rises and falls depending upon the weight of the contact wire and distance between droppers. Depending upon the speed of the electric vehicle collection gear has to rise and fall in order to main train the contact with OHE. The various types of current collection gears are Bow collector, Pantograph collectors, Pole collector, Cable collector...

a) Pole Collector

For tramways grooved gun metal wheel trolley collector of grooved slider shoe with carbon insert attached to the end of long pole provided on the top of the car is used. Collector is held in contact with the wire by means of spring the force of contact being 10kg.for wheel collector 17kg for carbon insert slider. The pole can swivel about its support so that it is not necessary for trolley wire to run exactly in the center of the track. It is universally used for trolley buses to enable them to maneuver in traffic up to a distance of 4 to 5 meters from the contact wire.

Trolley collector has to operate in trailing position. Main drawback of trolley collector is that it has to be rotated by 180°before tramcar can have motion in the reverse direction. Trolley collector is suitable for low speeds up to 22 to 30kmph beyond which it runs the risk of jumping off the contact wire. Another drawback particularly with trolley wheel pole collector is that there is poor contact between the wheel and trolley wire. This gives rise to high current density which results in heavy arcing. Its use is therefore prohibited in gassy mines where pole collector with grooved slider shoe is preferred.

b) Bow Collector



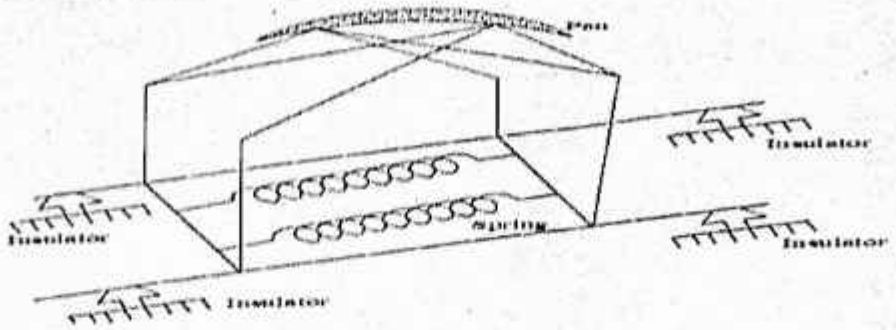
Main advantage of bow collector is that it can be used for higher speeds. Bow collector consists of two trolley collector poles at the end of which is placed a light metal strip up to one meter long for current collection. Although provision of metal strip enables the contact of trolley wire its maneuverability is lost. It is as such not suitable for trolley buses. On tramway services trolley wire is hung at the center line of the track with about 15cm.stagger to hive uniform wear of the strips and prevent formation of groove on it. Collection strip is of soft material such as copper aluminum or carbon so that it should wear instead of trolley wire as it is easy to replace wrong out collection strip than trolley wire. Bow collector has always to run trailing just like trolley collector. It therefore requires either provision of duplicate bows or an arrangement of reversing the bows for motion in the reverse direction.

Disadvantages:

- Poor current collecting capacity
- Irreversible operation is not possible

) Pantograph collector:

The disadvantages of bow collectors are overcome by this type of collectors. Pantograph collectors always maintain the link between the overhead lines.



Its function is to maintain link between overhead contact wire and power circuit of the electric locomotive at different speeds under all wind conditions and stiffness of OHE. It means that positive pressure has to be maintained at all times to avoid loss of contact and sparking but the pressure must be as low as possible in order to minimize wear of OH contact wire.

A 'diamond' type single-pan pantograph is shown in Fig. It consists of a pentagonal framework of high- tensile alloy-steel tubing. It has a copper strip which acts as contact surface. The contact portion consists of a pressed steel pan fitted with renewable copper wearing strips which are forced against the OH contact wire by the upward action of pantograph springs. The pantograph can be raised or lowered from cabin by air cylinders. It is used in the vehicles run at high speeds and current to be collected is 2000 to 3000 A.

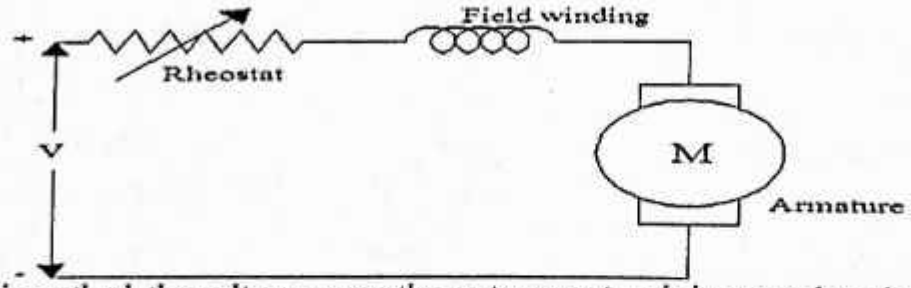
(Or)

(b) Explain about the different starting methods of DC traction motors.

(Types 3 marks, Diagram 6 marks, Explain 5 marks)

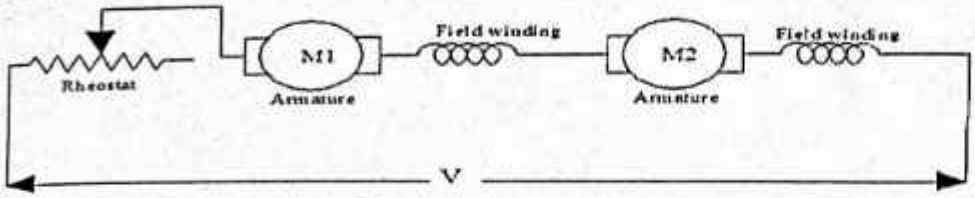
1. Plain Rheostatic starting
2. Series – parallel starting
3. Metadyne control

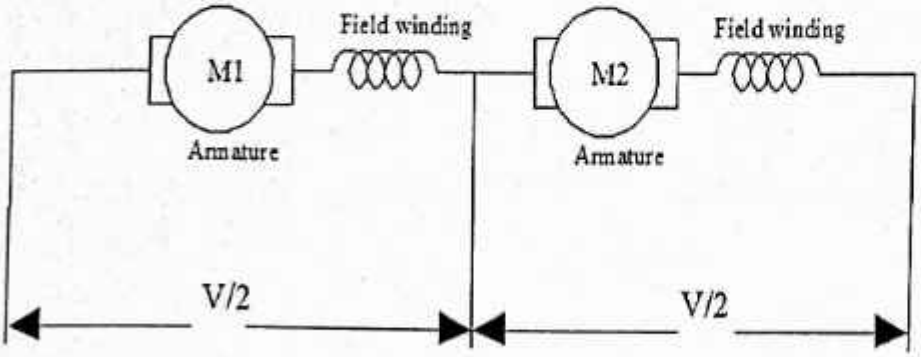
1. Plain Rheostatic starting:

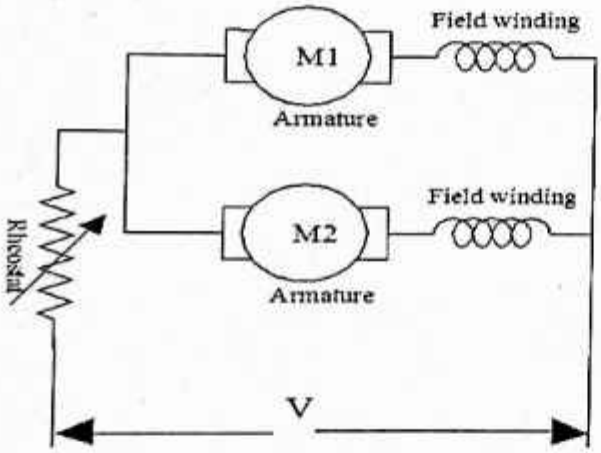


In this method, the voltage across the motor armature is increased gradually from zero o full voltage. This is obtained by connecting an external series resistance as shown in fig. This external resistance helps to limit the starting current and suitable of the DC motors. When the supply is switched ON, the back emf is zero. As the motor accelerates and speed increases, motor current will go on reducing with the development of back emf in the motor armature. When certain values of minimum motor current are reached, a portion of external resistance is cut out. As a result of this motor current again reaches its maximum value.

2. SERIES PARALLEL CONTROL:



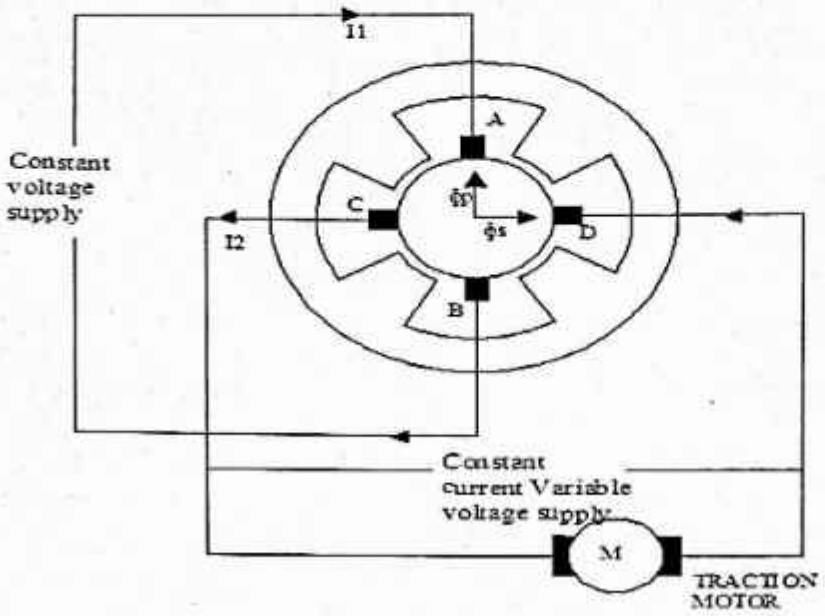




It is usual to have at a time more than one traction motor. In that case it is economical to have combined rheostatic and series parallel control of traction motors. Accordingly two traction motors are connected in series and supply to them is given through the starting resistance in series which is progressively cut out until only two motors remain in series when the motors are left running in this position voltage across each will be nearly half of the supply voltage and motors will be running nearly at half the full speed. For full speed motors are disconnected and then reconnected in parallel again supplied through starting resistance. This resistance is then progressively cut out leaving motors in parallel running condition.

Both series motors are connected in series through full starting resistance across supply. Starting resistance is gradually cut out step by step till both series motors are in series across supply it should be noted here that the starting resistance always divided into two separate sections each connected motor. This makes it possible to employ same resistance in both series and parallel for either connection. Both the motors are put in parallel along with their respective external resistances across supply.

3. Metadyne control:



Metadyne converter is a machine which takes power at constant voltage and variable current and delivers at constant current and variable voltage. The main advantages of this is that the loss is much, lower than resistance starting method. Since the current throughout the starting period is maintained constant, uniform tractive effort is produced and so jerks are avoided. This type of control gives very smooth drive and high coefficient of adhesion. The metadyne consists of a d.c. armature wound for two poles, and provided with two pairs of brushes and a 4 –pole field magnet as shown in fig. One pair of brushes A,B is connected across a constant voltage d.c. supply whereas the other pair C,D is connected to load ie series traction motor. The metadyne converts constant voltage supply in to a constant current, variable voltage supply for feeding the load. The machine acts as a motor as far as brushes AB are concerned and as a generator as far as brushes CD are concerned. With metadyne converter, a regenerative braking can be obtained by reversing the field of traction motor and also the magnitude of regenerative braking can be controlled by controlling the magnitude of reverse excitation.

14. (a) State and explain the laws of illumination.

(Each law 7 marks, Total 14 marks)

A) **COSINE LAW:**

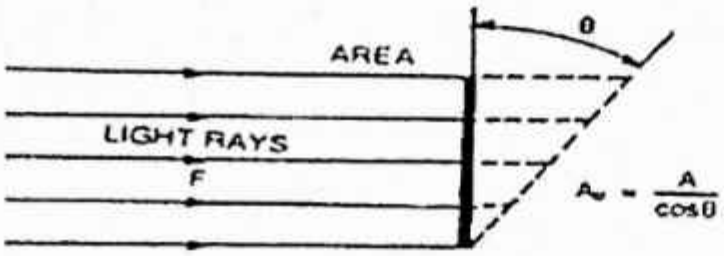
The illumination received on a surface is proportional to the cosine of the angle between the direction of the incident light rays and the normal to the surface at the point of incidence. This is mainly due to the reduction of the projected area as the angle of incidence increases.

Thus

$E_h = E_n \cos 0 (I \cos 0) / D^2$

Where

E_h = illumination on a horizontal plane,
E_n = illumination due to light normally incident,
0 = the angle of incidence,
D = distance from the source.



B) **INVERSE SQUARE LAW:**

The illumination upon a surface varies inversely as the square of the distance of the surface from the source. Thus if the illumination at a surface one meter from the source is X units, then the illumination at 2 meters will be X/4 at 3 meters will be X/9 and so on.

Strictly the inverse square law operates only when the light rays are from a point source and are incident normally upon the surface.

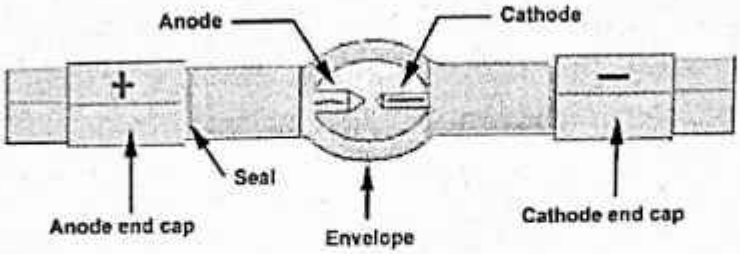
Thus illumination in lamberts/metre^2 on a normal place= Candle power / (Distance in meters) 2

(Or)

(b) Explain about the working of Arc lamp and Halogen lamp with necessary diagrams.
(Diagram 7 Marks, Explain 7 Marks)

I. ARC LAMP:

Parts of a short arc lamp



The carbon arc lamp is now obsolete for all of these purposes and is only still made for very specialized purposes where a high intensity UV source is needed. The term is now used for gas discharge lamps, which produce light by an arc between metal electrodes through an inert gas in a glass bulb.

The common fluorescent lamp is a low- pressure mercury arc lamp. The xenon arc lamp, which produces a high intensity white light, is now used in many of the applications which formerly used the carbon arc, such as movie projectors and searchlights.

An *arc* is the discharge that occurs when a gas is ionized. A high voltage is pulsed across the lamp to "ignite" or "strike" the arc, after which the discharge can be maintained at a lower voltage. The "strike" requires an electrical circuit with an *igniter* and a ballast. The ballast is wired in series with the lamp and performs two functions.

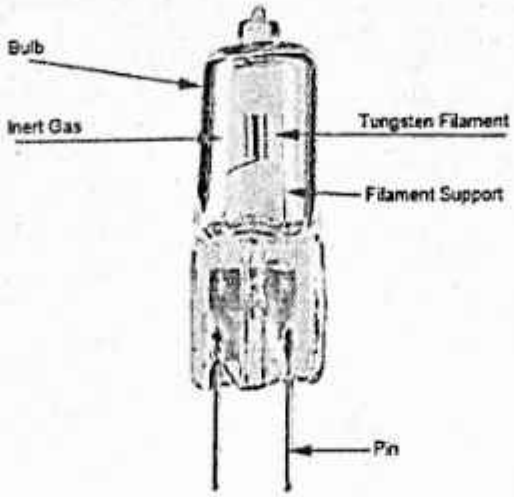
First, when the power is first switched on, the igniter/starter (which is wired in parallel across the lamp) sets up a small current through the ballast and starter. This creates a small magnetic field within the ballast windings. A moment later the starter interrupts the current flow from the ballast, which has a high inductance and therefore tries to maintain the current flow (the ballast opposes any change in current through it); it cannot, as there is no longer a 'circuit'. As a result, a high voltage appears across the ballast momentarily - to which the lamp is connected, therefore the lamp receives this high voltage across it which 'strikes' the arc within the tube/lamp. The circuit will repeat this action until the lamp is ionized enough to sustain the arc.

When the lamp sustains the arc, the ballast performs its second function, to limit the current to that needed to operate the lamp. The lamp, ballast and igniter are rated matched to each other; these parts must be replaced with the same rating as the failed component or the lamp will not work.

The temperature of the arc in an arc lamp can reach several thousand degrees Celsius. The outer glass envelope can reach 500 degrees Celsius, therefore before servicing one must ensure the bulb has cooled sufficiently to handle. Often, if these types of lamps are turned off or lose their power supply, one cannot restrike the lamp again for several minutes (called cold restrike lamps). However, some lamps (mainly fluorescent tubes/energy saving lamps) can be restruck as soon as they are turned off.

II. HALOGEN LAMP:

Tungsten-Halogen Lamp



In incandescent lamps, the life and efficiency is reduced due to slow evaporation of filament and also due to black deposits formed on inner side of the bulb. The addition of a small amount of halogen vapor to the iodine gas restores part of the evaporated tungsten back to the filament by means of chemical reaction. This eliminated blackening which is normally caused by a deposit of evaporated tungsten on the walls of the envelope and a high luminous efficiency is maintained throughout the life of the lamp. The life of the halogen lamp is nearly double the tungsten filament lamp as the small envelope is used with resultant high gas filling pressure.

15. (a) Explain direct and indirect resistance heating with suitable sketches.
(Diagram 7 Marks, Explain 7 Marks)

Direct Resistance Heating

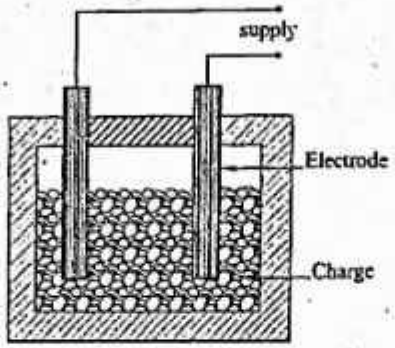
Working principle:

In this method the material (or charge) to be heated is treated as a resistance and current is passed through it. The charge may be in the form of powder, small solid pieces or liquid. The two electrodes are inserted in the charge and connected to either A.C. or D.C. supply. Obviously, two electrodes will be required in the case of D.C. or single-phase A.C. supply but there would be three electrodes in the case of 3-phase supply.

When metal pieces are to be heated, a powder of high resistivity material is sprinkled over the surface of the charge to avoid direct short circuit. Heat is produced when current passes through it. This method of heating has high efficiency because the heat is produced in the charge itself.

- Material to be heated is called as Charge
- Non- metal Charges are in the forms of Powder, Pieces or liquid
- They form a resistance for the current flow

- For heating Metal Charges, High resistance powder is sprinkled, to avoid short circuit
- DC & 1 Ø AC supplies – 2 Electrodes



ADVANTAGES

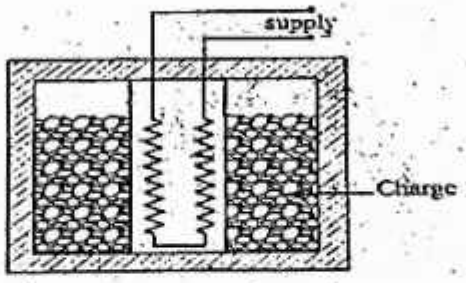
- High η
- Gives uniform heat

DISADVANTAGES

- Current is not easily variable
- Automatic temperature control is not possible.

Indirect Resistance Heating:

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



ADVANTAGES

1. Gives uniform heat.
2. Automatic temperature control possible.

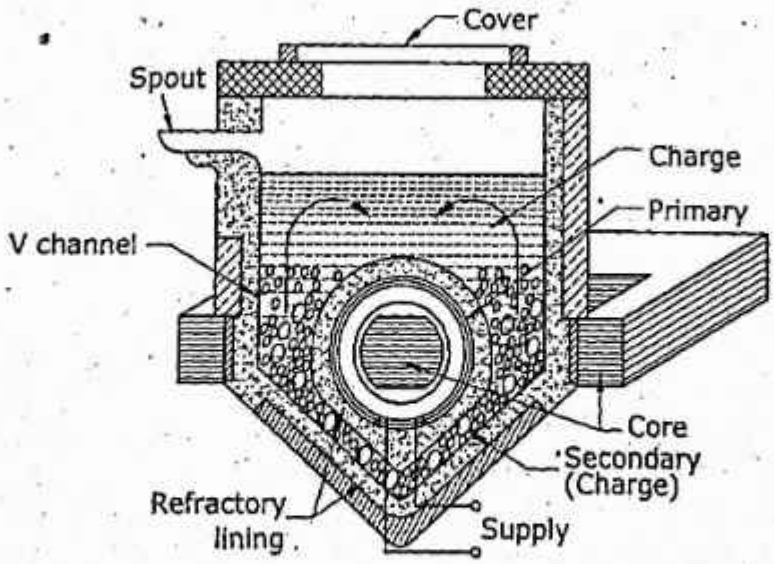
DISADVANTAGES

1. Lower efficiency.

(Or)

(b) Explain about the Vertical Core (AJAX WYATT) induction furnace with a neat sketch. (Diagram 7 Marks, Explain 7 Marks)

Improved type of core type induction furnace. It has a vertical channel for the charge, so the crucible used is also vertical. The principle of operation is that of a transformer in which the secondary turns are replaced by a closed loop of molten metal. The primary winding is placed on the central limb of the core. Hence leakage reactance is comparatively low and power factor is high. An inner wall of furnace is coated with refractory lining of suitable material. The top of the furnace is covered with an insulated cover which can be removed for charging. Arrangements are made for tilting the furnace. The molten metal in the 'V' portion acts as a short circuited secondary. When primary is connected to the A.C supply, high current will be induced in the short circuited secondary. This current melts the charge. As the furnace is having a narrow V-shape at the bottom, the molten will be accumulated at the bottom and even a small amount of charge will keep the secondary completed. Hence chances of discontinuity of the circuit are less.



ADVANTAGES

- Magnetic coupling between primary and secondary is better
- Low leakage reactance. So power factor is better
- Discontinuity of circuit is less. (Can used for intermittent services)
- Energy consumption for melting non- ferrous metal is about 300-500 units per tone
- Can be operated with normal frequency

APPLICATIONS

- To melt
- Brass
- Bronze
- Copper
- Zinc
- Tin

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