Important suggestions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skills)
4) While assessing figures, examiner may give credit for principle components indicated in a figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case some questions credit may be given by judgment on part of examiner of relevant answer based on candidate understands.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q.1 A) Attempt any three of the following: ----------12 Marks

a) Define the following terms w.r.t. illumination: (Each Definition- 1 Mark)

1) Luminous Intensity 2) Lux 3) Utilization factor 4) Maintenance factor

1) Luminous intensity:-

The Luminous flux emitted per unit solid angle is called the luminous intensity of the source. And its **unit is Candela**

2) Lux :-

It is unit of illumination and it is defined as luminous flux falling per unit area

OR

It is defined as the luminous flux falling per square meter on the surface which is perpendicular to the rays of light from the source of one candle power and one meter away from it.

OR

It is defined as the illumination of the inside of a sphere of radius 1 m and a source of 1 C.P is fitted at the centre of sphere.

3) Utilization factor:-

It is defined as the ratio of total lumens reaching the working plane to the total lumens given out by the lamp.

4) Maintenance factor:-

It is defined as the ratio of illumination under normal working conditions to the illumination when everything is clean. **OR**

$$Maintenace factor = \frac{Illumination\ under\ normal\ \ working\ condition}{Illumination\ under\ every\ thing\ is\ clean}$$

b) Give the classification of various electric heating methods. Write down brief working principle of each. (Classification -3 Marks & any one working principle explain-1 Marks)

➢ **The classification of various electric heating methods:**

1) Power frequency electric heating:

i) Resistance heating:

a) Direct resistance heating

b) Indirect resistance heating

ii) Arc Heating:

a) Direct arc heating (furnace)

b) Indirect arc heating

2) High frequency electric heating:

iii) Induction Heating:

a) Direct core type induction heating (furnace)

b) Vertical core type induction heating or Ajax Wyatt induction heating

c) Indirect core type induction heating

d) Core loss induction heating

iv) Eddy Current heating furnace

v) Dielectric heating

Explanation: -

i) Principle of Resistance heating:

When the current pass through the heating element/material than heat is developed duet to I^2R losses.

ii) Principle of Arc heating:

Arc contains the heat therefore by producing the arc the material or charge is heated i.e known as arc heating.

iii) Principle of Induction heating:

The basic principle of induction heating is that supply is given to primary winding of furnace transformer & heat is produced in the secondary (charge) due to electromagnetic action.

iv) Principle of Eddy current heating:

When high voltage and high frequency supply is given coil wound to the job to be heated then eddy currents are induced in the job and due to eddy current loss job get heated.

v) Principle of Dielectric heating:

When non metallic parts such as wood, plastic, glass are subjected to alternating field high voltage and high frequency supply dielectric loss will occur in the job due to which job gets heated.

c) What are the facors governing selection of electric motors?

- **Following Factors governing electric drive (Motor):**

(Any four points are expected-1 Mark each)

i) **Nature of supply:** Whether supply available is AC, pure DC or rectified DC.

ii) **Nature of Drive (Motor):** Whether motor is used to drive individual machine or group of machines.

iii) **Nature of load:** Whether load required light or heavy starting torque or load having high inertia ,require starting torque for long duration. **OR** Whether load torque increases with speed ($T \propto N$) or decreases with speed ($T \propto 1/N$) **or** remains constant with speed (T = N) or increases with square of speed ($T \propto N^2$)

iv) Electric Characteristics of drive: Starting, running, speed control and braking characteristics of electric drive should be studied and it should be matched with load.

v) Size and rating of motor: Whether motor is short time or continuously or intermittently running or used for variable load cycle. Whether overload capacity, pull out torque is sufficient.

vi) Mechanical Considerations: Types of enclosure, Types of bearing, Transmission of mechanical power, Noise and load equalization etc.

vii) Cost: Capital, running and maintenance cost should be less.

d) What are the requirements of an ideal traction system?

(Write Any Four points from requirements – 1 Mark to each point)

Ideal Traction system should processes following requirement:-

i) It should have low capital, Running, maintenance cost.

ii) Quick starting time.

iii) It should have high rate of acceleration & retardation.

iv) Highest speeds are possible.

v) Easy speed control method.

vi) Braking system should be reliable.

vii) Absence of unbalance forces i.e coefficient of adhesion should be more.

viii) Centre of gravity should be lower.

ix) Better riding quality (less vibration)

x) Traction system should be clean & long life.

xi) It should be self contained.

xii) No standby losses.(it should processes high efficiency)

xiii) Regenerative braking should be possible.

B) Attempt any one of the following: ---------- 06 Marks

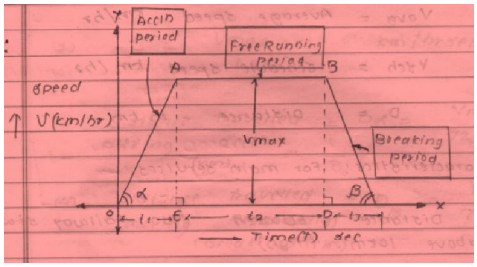
a) An electric train has an average speed of 42 kmph on a level track between stops 1400 m apart. It is accelerated at 1.7 kmphps and is braked at 3.3 kmphps. Draw a speed –time curve and determine i) Maximum speed ii) Acceleration and braking periods.

ii) Given Data:-

D = 1400 M, average speed (V_{av}) = 42KM / Hr,

Acceleration (α) = 1.7 Km/Hr/sec; Retardation (β) = 3.3 Km/Hr/sec.

Trapezoidal speed time curve :-



or Equivalent fig. (1/2 Mark)

➢ $V_{av} = \dfrac{3600\,D}{Actual\ Time\ of\ run}$ ---------- **(1/2 Mark)**

$\therefore\ Actual\ Time\ of\ run = \dfrac{3600\,D}{V_{av}}$, $Actual\ Time\ of\ run = \dfrac{3600 \times 1.4}{42}$

$\therefore\ Actual\ Time\ of\ run = \dfrac{5040}{42}$

$\therefore\ Actual\ Time\ of\ run = 120$ sec. ---------- **(1 Mark)**

➢ Maximum Speed =

$$V_{max} = \frac{T - \sqrt{T^2 - 4K3600D}}{2K}$$ ---------- **(1/2 Mark)**

But, $K = \dfrac{\alpha + \beta}{2(\alpha \times \beta)}$

$K = \dfrac{1.7 + 3.3}{2(1.7 \times 3.3)}$

$K = 0.4456$ ---------- **(1/2 Mark)**

Now, $V_{max} = \dfrac{T - \sqrt{T^2 - 4K3600D}}{2K}$

$$V_{max} = \frac{120 - \sqrt{120^2 - 4 \times 0.4456 \times 3600 \times 1.4}}{2 \times 0.4456}$$

$V_{max} = 52.066$ kmph ----------Answer---------- **(1 Mark)**

- Period during Acceleration (t_1) =

$$\alpha = \frac{V_{max}}{t_1} \qquad \therefore t_1 = \frac{52.066}{1.7}$$ ---------- (**1/2 Mark)**

$t_1 = 30.6275$sec ----------Answer---------- **(1/2 Mark)**

- Period during Retardation (t_3) =

$$\beta = \frac{V_{max}}{t_3} \qquad t_3 = \frac{V_{max}}{\beta}$$ ---------- (**1/2 Mark)**

$$t_3 = \frac{52.066}{3.3}$$

$t_3 = 15.7775$ sec----------Answer-------- **(1/2 Mark)**

b) A 400V, 50Hz, 3-Ph line delivers 200 kw at 0.8 P.f lagging. It is desired to raise the line power factor to 0.99 by installing shunt capacitor. Calculate the capacitance of each unit if they are connected in i) Star and ii) Delta

Volt : line volts V = 400V, f= 50 Hz P= 200kW $\cos\phi_1 = 0.8$ $\cos\phi_2 = 0.99$

$Cos\varphi_1 = 0.8 \quad \therefore \phi_1 = Cos^{-1}0.8 = 36.8698^0 \quad \therefore \tan\phi_1 = 0.75$

$Cos\varphi_2 = 0.99 \quad \therefore \phi_2 = Cos^{-1}0.99 = 8.1096^0 \quad \therefore \tan\phi_2 = 0.1424$

$Q_1 = P \tan\phi_1$

$= 200 \times 0.75$

$= 150$ KVAR

$Q_2 = P \tan\phi_2$

$= 200 \times 0.1424$

$= 28.48$ KVAR

KVAR = $P (\tan\phi_1 - \tan\phi_2)$ ---------- **(1 Mark)**

$Q_C = P \tan\phi_1 - P \tan\phi_2$

$= 150 - 28.48$

$= 121.52$ KVAR ---------- **(1 Mark)**

∴ **1) Capacitor when connected in Star :-**

$$C \text{ per phase} = \frac{QC}{\omega V^2}$$ ---------- **(1 Mark)**

$$C \text{ per phase} = \frac{121.52 \times 10^3}{2\pi \times 50 \times 400^2}$$

$$C \text{ per phase} = \frac{121.52 \times 10^3}{50.265 \times 10^6}$$

$C \text{ per phase} = 2.4175 \times 10^{-3}$ F ---------- **(1 Mark)**

∴ **2) Capacitor when connected in Delta:-**

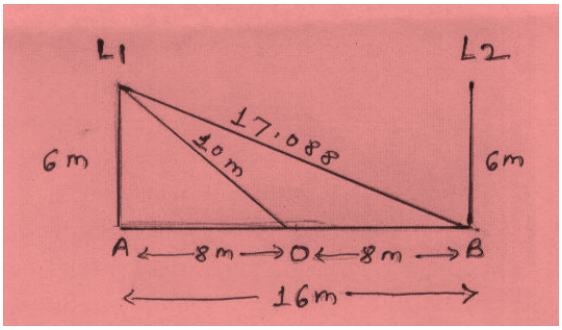
$$C \text{ per phase} = \frac{QC}{3\omega V^2}$$ ---------- (**1 Mark)**

$$C \text{ per phase} = \frac{121.52 \times 10^3}{3 \times 2\pi \times 50 \times 400^2} \quad C \text{ per phase} = \frac{121.52 \times 10^3}{3 \times 50.265 \times 10^6}$$

$C \text{ per phase} = 8.0586 \times 10^{-4}$ F ---------- **(1 Mark)**

Q.2 Attempt any Four of the following: ----------16 Marks

a) Two lamp posts are 16 m apart and fitted with a 100 cp lamp each at a height of 6 m above ground . Calculate the illumination on a ground : a) Under each lamp b) Midway between the lamps.



Illumination at point A due to L_1 =

$$E = \frac{I}{d^2}$$

$$E = \frac{100}{6^2} \qquad \therefore \quad E = \frac{100}{36}$$

$E = 2.78 \ lux$ ---------- **(1/2 Mark)**

Illumination at point A due to L_2 =

$$E = \frac{I}{d^2} \times \cos\phi$$ ---------- **(1/2 Mark)**

$$E = \frac{I}{(AL_2)^2} \times \cos\phi \qquad \therefore \quad E = \frac{100}{(17..088)^2} \times \frac{6}{17.088}$$

$E = 0.12 \ lux$ ---------- **(1/2 Mark)**

Illumination at point A due to L_1 and L_2 =

$E = 2.78 \ lux + 0.12 \ lux$

$E = 2.90 \ lux$ ---------- **(1/2 Mark)**

Similarly illumination at point B due to L_1 and L_2 = 2.90 Lux

$\therefore$ a) under each lamp : 2.90 Lux ---------- **(1/2 Mark)**

b) Midway between the lamps:

illumination at point 'O' due to L_1 =

$$E = \frac{I}{d^2} \times \cos\phi$$

$$E = \frac{I}{(OL_2)^2} \times \cos\phi \qquad \therefore \quad E = \frac{100}{(10)^2} \times \frac{6}{10}$$

$E = 0.6 \ lux$ ---------- **(1/2 Mark)**

Illumination at point 'O' due to L_2 =

$$E = \frac{I}{d^2} \times \cos\phi$$

$$E = \frac{I}{(OL_2)^2} \times \cos\phi \qquad \therefore \quad E = \frac{100}{(10)^2} \times \frac{6}{10}$$

$E = 0.6 \ lux$ ---------- **(1/2 Mark)**

Illumination at point 'O' due to L_1 and L_2 =

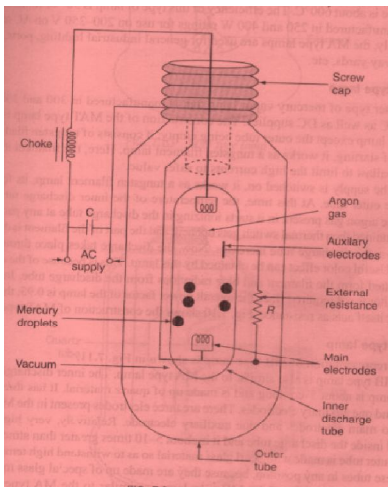
$E = 0.6 \, lux + 0.6 \ lux$

$E = 1.20 \ lux$ ---------- **(1/2 Mark)**

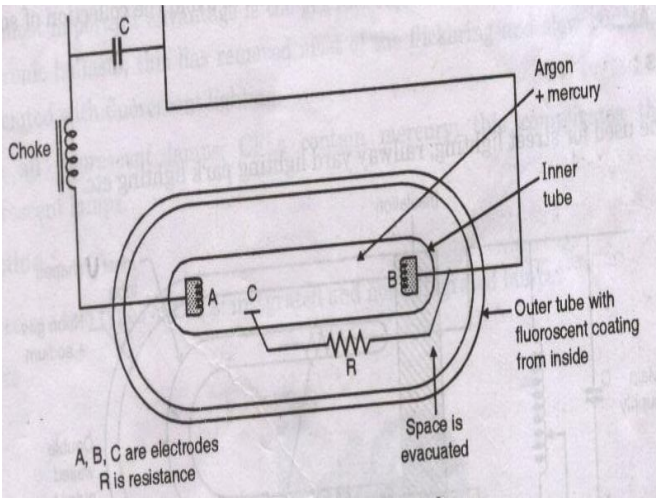
b) Explain construction of high-pressure mercury vapour discharge lamp with neat sketch.

(Figure-1 Mark & Explain Construction-3 Mark)

- **Figure mercury vapour discharge lamp :-**



OR



Construction:-

- It consists of an inner bulb generally of silicon, to withstand high temperatures.
- The bulb contains a small quantity of mercury and argon.
- It is protected by outer glass, this may be cylindrical or elliptical.
- The space between the two bulbs is filled with nitrogen at a pressure of half atmosphere.
- The discharge tube has three electrodes, namely two main electrodes A and B and one starting electrode.

- The starting electrodes are connected through a resistance of about 10-30 k ohm to the main electrode, located at the far end.
- The electrodes are of tungsten wire helise filled with electron emissive materials, usually barium and strontium carbonates mixed with thoria.

OR Student may be write

The construction & connection diagram is as shown in figure. As per this construction there are following components.

- **Choke:** The choke is acting as the ballast. At the time of supply voltage variation current flowing through the inner tube is maintained constant to keep uniform light intensity. Sometimes choke can be designed for to get the higher voltages & to apply the inner tube of mercury vapour lmap.
- **Starting resistance/limiting resistance:** Whenever current flows through the starting resistance there is a I^2R loss which is converted into heat. If the temperature of this heat goes near about 600^0C then there will be heating effect & inert gases ionization will be start.
- **Auxiliary electrode & Main electrode:** It is made by high resistive element. The ionization is taking place through the inert gases whenever current flows from auxiliary electrode to main electrode.
- **Inner Tube:** The various inert gases e.g. Argon, Nitrogen etc with mercury powder are filled in the inner tube at low pressure or high pressure.
- **Outer Tube:** The function of outer tube is to make the vacuum surrounding the inner tube to avoid thermal dissipation or to maintain 6000C surrounding the inner tube.
- **Power factor improvement Capacitor:** The function of power factor improvement capacitor is to improve the power factor 0.5 to 0.95

c) What factors should we consider while designing the lighting scheme?

(Any four point are expected – 1 Mark to each point)

List Factors designing a lighting scheme:

1) Area of the working plane.
2) Decided lux level on working plane.
3) Waste light Factor
4) Utilization Factor
5) Deprecation Factor
6) Wattage of lamp
7) Illumination Efficiency of the lamp.

d) A hall 30m x 15m x 5m (h) size is to be provided with a general illumination of 150 lumens/m^2. Taking a coefficient of utilization of 0.6 and depreciation factor of 1.4, determine number of fluorescent tubes required and their spacing. Assume luminous efficiency of fluorescent tube as 75 lumens per Watt for 40 watt tube.

Given Data :- Note As per Assumption Final Answer may change so give marks for correct steps and don't stickup with Final Answer

Hall Dimension : 30 m x 15m x 5m (h) = 4500 Sqft

U.F = 0.6, Assumption :- Let, waste light factor = 1, Wattage of each lamp = 100 watt

- Total No. of on working plan =

$$\frac{\textit{Area of Working plane} \times \text{Lux level required on working plane} \times \text{Waste light factor} \times \text{D.F}}{\text{UF}}$$

(1 Mark)

$$= \frac{(30 \times 15) \times 150 \times 1 \times 1.4}{0.6}$$

$$= \frac{94500}{0.6}$$

= 157500 Lumens----------

(1 Mark)

$$\text{Total No. of Lamps} = \frac{\textit{Total Lux level required on working plan}}{\text{Wattage of each lamp} \times \text{output (lumen efficiency)}}$$ **(1 Mark)**

$$= \frac{157500}{40 \times 75}$$

$$= 52.5 \cong 53 \textit{ tubes}$$

Total No. of Lamps = 53 Nos. Say----------Answer---------- **(1 Mark)**

e) A building frontage of 50m x 15m is to be illuminated by flood lighting projectors, situated 25m away. If the illumination is 100 lux, coefficient of utilization is 0.5, depreciation factor 1.5, waste light factor 1.2, estimate the number and size of projector. Assume a lamp of 500 watt having luminous efficiency of 45 lumens/ watt.

Here:

$$\frac{\textit{Area of Working plan} \times \text{Lux level required on working plan} \times \text{Waste light factor} \times \text{DF}}{\text{coefficent of utilization}}$$

A=Area I= Illumination in level w= waste light factor and D= depreciation factor

➢ Total Lumens on Building frontage = $\frac{AIWD}{C}$ ---------- **(1 Mark)**

$$= \frac{(50\times15)\times100\times1.2\times1.5}{0.5} = \frac{13500}{0.5}$$

= 270000 Lumens---------- **(1 Mark)**

Total No. of Projector Lamps = $\frac{Total\ \text{Lux level required on working plan}}{\text{Wattage of each lamp} \times \text{output (lumen efficiency)}}$ **(1 Mark)**

$$= \frac{270000}{500\times45}$$

= 12 Lamps---------- **(1/2 Mark)**

According to distance –wide angle projector is used

According to wattage – Medium angle projector is used ---------- **(1/2 Mark)**

f) What are the requirements of heating materials? Give minimum four names of heating materials. (Requirements any four point-1/2 mark each point and Name of material any four-1/2 mark each name)

➢ **Following Requirements of good heating material:- (Any four points expected)**

i) **High resistivity:** It should have high resistivity. So that is becomes compact in size and produces more heat with small input current.

ii) **High melting point:** It should have high melting point to withstand at high temperature.

iii) **High Oxidizing temperature:** It should have high oxidizing temperature or it should not oxidize even at high temperature**.**

iv) **High Resistance to corrosion:** It should have high resistance to corrosion to avoid rusting.

v) **Mechanical Strength:** It should have high mechanical strength to withstand from mechanical injury.

vi) **Ductile:** It should be ductile so that it can be manufactured into different size & shape.

vii) **Long Life:** It should have long life.

viii) **Less Costly:** It should be less costly and easily available.

ix) Low temperature co-efficient of resistance: For accurate temperature control, it should have low temperature co-efficient of resistance.

x) It should not be brittle.

- **Names of heating materials: (Any four points expected)**

i) Nichrome ii) Constantan or Eureka iii) Nickel-chromium iv) Iron-chromium-Aluminimum v) Silicon carbonite vi) Tungsten vii) Platinum viii) Carbon

Q.3 Attempt any Four of the following: ----------16 Marks

a) Explain with neat sketch principle of operation of indirect arc furnace.

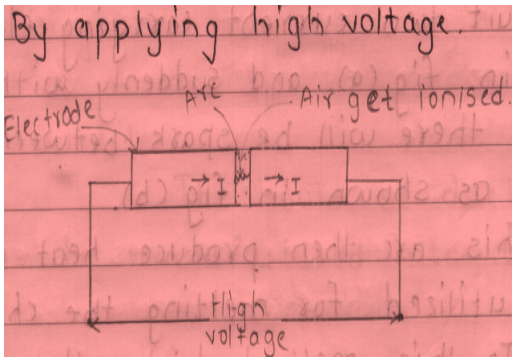
(2- Marks to fig. & 2-Marks for Operation total 4 Marks)

- **Principle of operation of indirect Arc furnace can be explained by any one of the following method. (Any one method is expected to explain)**

a) By applying High Voltage
b) By separation of two current carrying electrodes suddenly

Explanation:-

a) By applying High Voltage:- Figure:



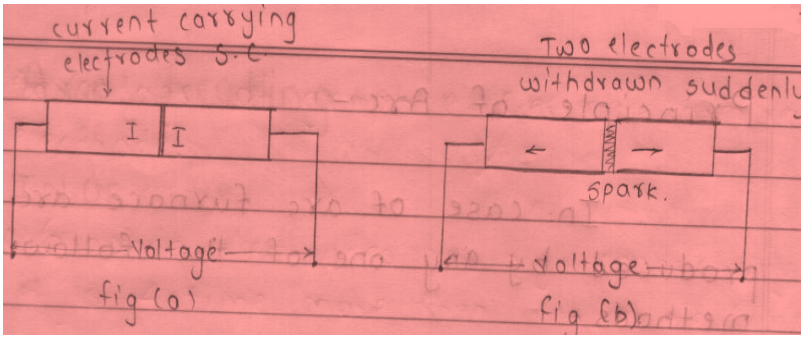
Equivalent fig

Operation:

When very high voltage is applied across any two electrodes separated by small air gap then air between two electrodes gets ionized and ionized air is conducting, so current starts flowing from one electrode to another electrode in the form of spark (arc).

This arc produces heat energy which is utilized for melting the charge. Once arc is struck between two electrodes then low voltage is sufficient to maintain the arc.

b) By Separation of two current carrying electrodes suddenly:- Figure:



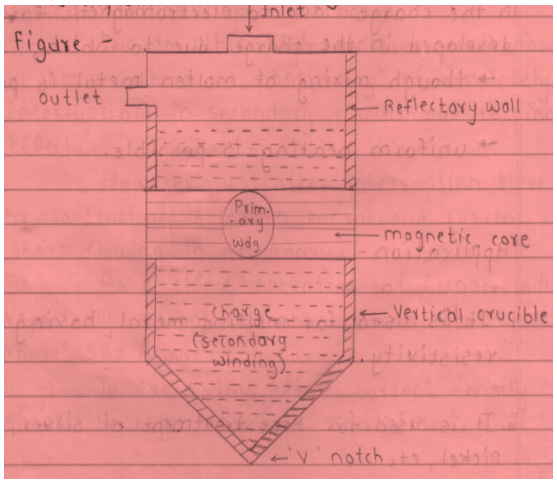
Equivalent fig.

Operation:-

Another way to produce arc is to short circuit two current carrying electrodes as shown in fig (a) and suddenly withdraw them, then there will be spark between two electrodes as shown in figure (b) This arc then produce heat energy which is utilized for melting the charge. In this method high voltage is not necessary to produce the arc.

b) Explain with neat sketch construction of 'Ajax Wyatt' vertical core furnace. List any two applications of it. (Figure-1 Mark, Construction-2 Mark and any two application-1)

- **Neat sketch of 'Ajax Wyatt' vertical core furnace:**



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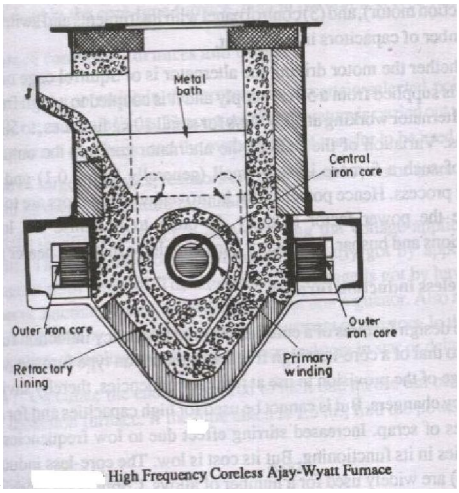


or Equivalent fig.

Construction of 'Ajax Wyatt' vertical core furnace:

Vertical core type induction heating furnace is nothing but transformer. It consists of

- **Magnetic Core:** Magnetic core consists of low magnetic loss silicon steel stampings and high permeability material. So that it will not saturate even at high magnitude of primary current.
- **Primary winding:** Primary winding is as usual wound around central timb magnetic core and it is made from Cu.
- **Secondary Winding:** Secondary winding consists of vertical shape crucible and narrow 'V' notch at bottom crucible is made from insulating material which provides a housing for metal scrap charge which is to be melted. The material used for crusiable is of ceramic type so that it will withstand even at high temperature of molten metal. Also it has heat insulating property.
- **Refractory Wall:** Refractory lining is used along the wall of furnace chamber (crursible) to withstand heating chamber at high temperature. And to reduce heat loss.
- **Opening:** There are two opening to the furnace. One opening is for pouring the charge is called as inlet and another opening is for taking out molten metal is called as outlet. Both openings are closed during furnace operation to avoid heat loss.
- **Cooling arrangement:** Cooling arrangement for transformer is made either by providing forced fan arrangement or water cooled.
- **Tilting arrangement:** The tilting arrangement is provided to tilt the crucible to take out molten metal from furnace. Tilting arrangement is either by haydraulic for large furnace or by means of rope for small furnace.
- **Control panel:** It consists of various types of protective equipments, temperature control switchgear, tap changer, various meter etc

Application of 'Ajax Wyatt' vertical core furnace: (Any two applications expected)

- It is used for melting metal having low resistivity.
- It is used for heat treatment of silver, Copper, nickel etc.
- Such type of furnace are used for continuous operations only and not used for intermittent services.

c) Explain the principle of resistance welding and state its advantages.

(Explanation-2 Mark and any four advantages expected-1/2 each advantages)

Working principle of resistance welding:

In resistance welding, sufficiently heavy current at low voltage is passed directly through two metals in contact to be welded. Heat is produced due to I^2R losses where 'R' is the contact resistance. The heat is utilized to obtain welding temperature (to become a plastic state)

When welding temperature is reached supply is cut down and external pressure is applied simultaneously across the job to complete weld.

- **Advantages of resistance welding: (Any Four advantages expected)**

i) No external filler material is required at the time of welding.

ii) Thin material can be welded satisfactorily.

iii) Energy consumption is less (3-4 kwatt/kg of deposited material)

iv) Since A.C supply is used, it is more economical.

v) Welding transformer is used, so no load losses, initial, running and maintenance cost are less.

vi) Non- consumable electrodes are used.

vii) Difficult shapes and sections can be welded satisfactorily.

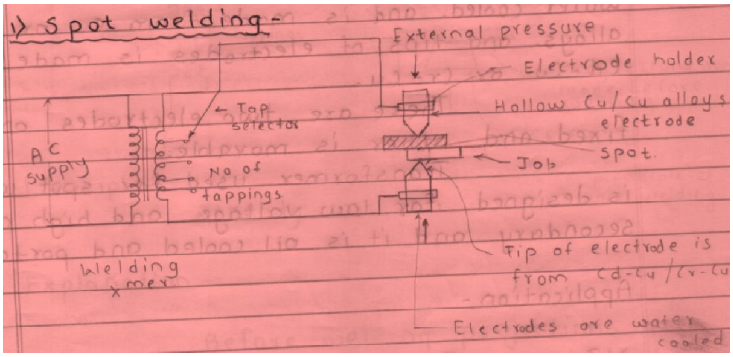
viii) Heat is localized where required.

ix) It is more reliable.

x) Working condition is more safe as no arc is produced.

d) Explain the principle of electric spot welding and state its applications.

(Explanation-2 Mark and any four advantages expected-1/2 each application)



or Equivalent fig.

Spot welding means the joining of two metal sheets at suitable spaced interval. As shown in fig. Job to be welded is placed one over the other between two electrodes under pressure.

When heavy current passed through the job through electrode. Current varies from 1000A to 10000A.and the voltage between electrodes is usually less than 2V.

The period of flow of current and magnitude of current depends upon thickness of sheet (job) to be welded. The electrodes are hallow and water cooled. And is made from copper or copper alloys and tips of electrodes is made from Cd-Cu or Cr-Cu.

There are two electrodes one is fixed and other is movable and transformer used for spot welding.

OR STUDENT MAY WRITE IN THIS WAY

In spot welding, sufficiently heavy current at low voltage is passed directly through two metals in contact to be welded. Heat is produced due to I^2R losses where 'R' is the contact resistance. The heat is utilized to obtain welding temperature (to become a plastic state)

When welding temperature is reached supply is cut down and external pressure is applied simultaneously across the job to complete weld.

- **Applications of spot welding: (Any Four applications expected)**

i) Joining of automobiles body section.

ii) Joining and fabricating sheet metal structure.

iii) It is used for automatic welding process.

iv) for spot welding to GI sheets, MS sheet, tined, lead-coated sheets.

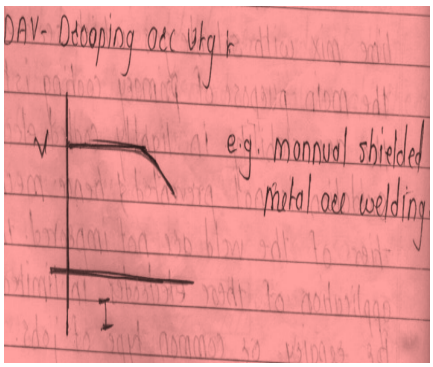
v) For spot welding to non-ferrous material such as brass, bronze, nickel, Cu,Al,etc.

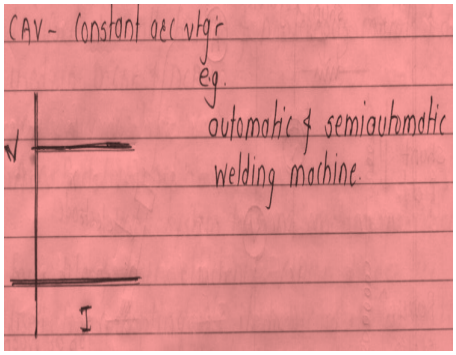
vi) In fabrication workshop for different applications.

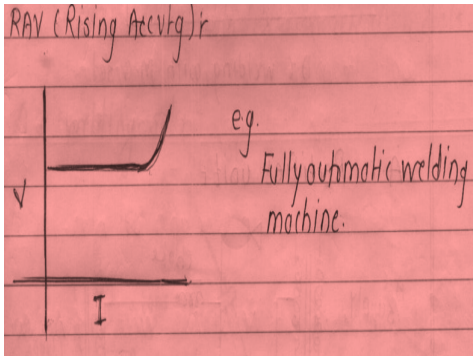
e) Explain V-I characteristics of arc welding D.C. machines.

(Characteristics -2 Mark & explanation-2 Mark)

- **V-I characteristics of arc welding D.C. machines:-**







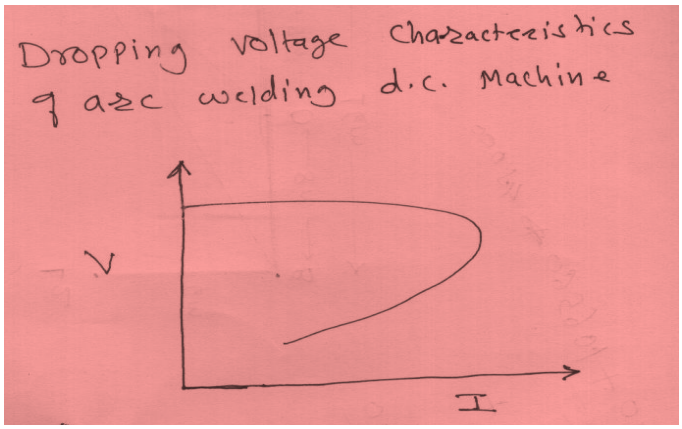
OR Equivalent figure

Explanation:

During welding operation large fluctuations in current & arc voltage result in less mechanical strength & the metal transfer & the other factor the welding machine must compensate for such changers in arc voltage in order to maintain even arc column. There arc main three voltages current characteristics of the welding machines are used which are shown in above.

OR STUDENT MAY WRITE IN THIS WAY

- **V-I characteristics of arc welding D.C. machines**



OR Equivalent figure

Explanation:

- **Characteristics of Arc:** Arc is conducting and it has negative temperature co-efficient of resistance. i.e its resistance decreases as temperature increases.
- **Effect of characteristics**: This decreasing resistance will increase current further due to this arc blow increases i.e arc does not remain steady. It goes on increasing and increasing. Due to this job may burn.
- **D.C Machine**: To stabilized arc D.C differential compound generator is used. It has dropping voltage characteristics, i.e as load increases voltage suddenly decreases. Due to this characteristics arc remains steady.

f) Why coated electrodes are preferred welding? (Any four point expected-1 Mark each)

Due to following advantages of coated electrodes are preferred welding:

- It avoids rapid cooling.
- Thermal losses are reduced.
- It reduces welding time.
- It prevents oxidation action.
- It prevents weld to become brittle.
- It increases arc stability because it contains ionizing agent.
- Provide smoother surface of welding.
- It protects from atmospheric contamination.
- Weld obtained is perfect, due to additional covering component.
- In case of metal arc welding AC supply is used so coated electrode are compulsory to obtain sound weld.

Q.4 Attempt any three of the following: ----------12 Marks

a) What are the different safety and protective devices used in elevators? Also state functions of each device. (List of Safety device- 1.5 Mark, Function 1/2 Mark & List of Protective device-1.5 Mark & Function 1/2 Mark)

- **Safety Devices used in elevators & its function:- (Any three safety devices expected to write)**

S.No	Safety Devices	function
1	Door safety switch	Door will not open when elevator is in operating condition.
2	Over travel switch	It avoids over travel
3	Over speed control switch	It controls the speed
4	Car safety switch	It protects the car
5	Car operating switch	It operates the car
6	Emergency STOP Switch	In case of emergency this switch is operated

- **Protective Devices used in elevators & its function:- (Any three protective devices expected to write)**

S.No	**Safety Devices**	**function**
1	Main line service switch (main switch and fuse)	for a ON-OFF purpose
2	CB and overload relay	for protection against over current fault
3	Phase failure protective relay.(1-ph preventer)	It as good as single phase preventer, It protects motor to run on single phasing
4	Phase reversal protective relay	It avoids motor to run in reverse direction
5	Over speed, slow down relay	It avoids to run motor in over speed

b) What are factors that decide the size and shape of elevator car? **(4 Mark)**

The size and shape of elevator car depends are following two factors:

i) No. of passenger to be carried: While selecting the size of car it is a usual practice to allow.

- A Space of 2 Sq.fit/ person.
- Average weight of passenger is assumed 68 kg/person.
- Thus the maximum load capacity of elevator is considered 34 kg/sq.ft
- There should be wide frontage and shallow depth

ii) Limitation in the building design:

- Shape of elevator depends on space available in building

c) State the Bombay lift Act. **(4 Mark)**

The Bombay lift Act: (Any Similar Acts may be consider & Any four expected)

Manufacturing, erection and maintenance of lift shall be done as per “Bombay Lift Act”.1939. The Chief engineer electrical is the authority who will give:

- Permission to install lift.
- License to operate lift.
- Permission for making addition or alternation to lift installation. For e.g. i) Change in speed of lift ii) Change in capacity of lift iii) Change in number of landing. Iv) Type of drive
- Observing the condition of lift two times in one year in view of safety.

- In case of accidents in lift owner should give intimation to lift inspector.
- Only license holder is authorized to install, to do maintenance of lift.

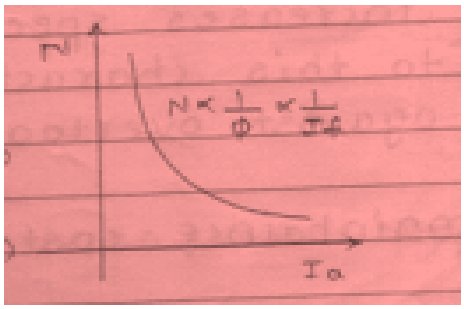
d) Compare group drive with individual drive.(Any Four point expected- 1 Mark each point)

S.No.	Point	Group Drive	Individual Drive
1.	Initial Cost	Less	High
2.	Flexibility	Less Flexibility	More Flexibility
3	Safety	It is less Safe	It is more safe
4	Reliability	It has less reliability	It has high reliability
5	Space required	Less	More
6	Overload Capacity	Higher	Less
7	Maintenance cost	Less	More
8	Speed control	Difficult	Easily possible
9	Mechanical Power transmission losses	More Losses	Less losses
10	Addition/Alternation	Easily not possible	Easily possible

B) Attempt any one of the following: ---------- 06 Marks

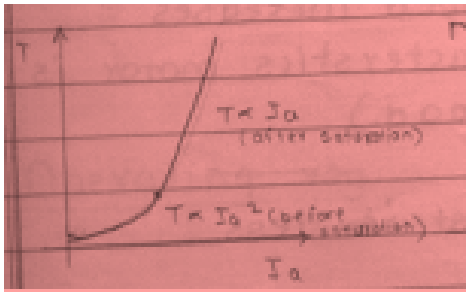
a) Explain the following characteristics of D.C. series motor: 1) Speed-current characteristics 2) Torque-Current characteristics 3) Speed-Torque characteristics

1) Speed-current characteristics: (Explanation-1/2 Mark & Characteristics -1.5 Mark)



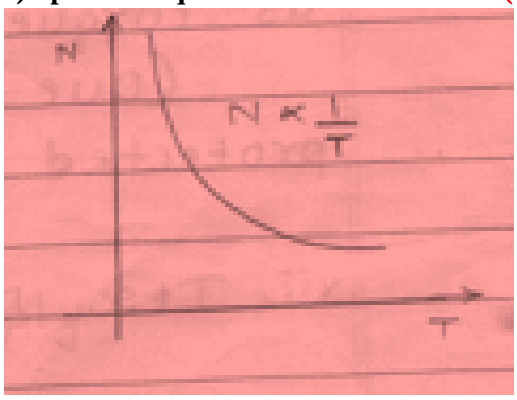
Explanation: As load increases (Armature current) speed decreases.

2) Torque-Current characteristics: **(Explanation-1/2 Mark & Characteristics -1.5 Mark)**



Explanation: Initially (before saturation of series field winding) torque is directly proportional to the square of the armature current. And after saturation of series field winding torque is directly proportional to armature current.

3) Speed-Torque characteristics: **(Explanation-1/2 Mark & Characteristics -1.5 Mark)**

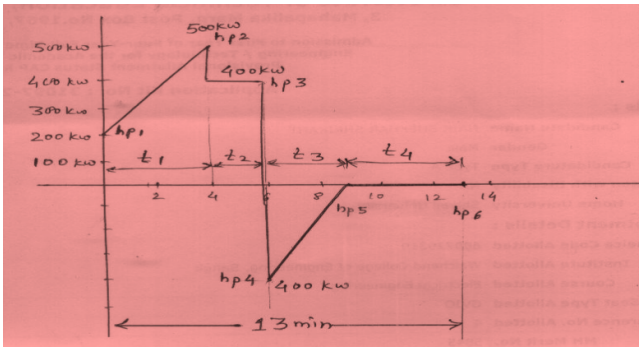


Explanation: As Torque increases speed decreases.

OR Equivalent fig.

b) A constant speed motor has the following duty cycle: i) load rising linearly from 200 kw to 500 kw in 4 minutes. ii) uniform load of 400 kw for 2 minutes. iii) regenerative power returned to supply reducing linearly from 400 kw to zero in 3 minutes. iv) Remains idle for 4 minutes. Determine power factor rating of motor, assuming losses to be proportional to (power)^2.

- Load rising from 200 to 500 kw :- 4 min
- Uniform load of 400 kw : - 2 min
- Regenerative braking from 400 to zero : 3 min
- idle for : 4 min



or Equivalent fig

Rating of Motor in KW =

$$KW = \sqrt{\frac{1/3\left(KW_1^2 + KW_1\,KW_2 + KW_2^2\right)\times t_1 + KW_3^2 t_2 + 1/3\;\; KW_4^2 t_3 + KW_5^2 t_4}{T}}$$ ---------- **(1Mark)**

Where, T = $t_1 + t_2 + t_3 + t_4$

T = 4 + 2 + 3 + 4

T = 13 min. ---------- ---------- **(2 Mark)**

$$KW = \sqrt{\frac{1/3\left(KW_1^2 + KW_1\,KW_2 + KW_2^2\right)\times t_1 + KW_3^2 t_2 + 1/3\;\; KW_4^2 t_3 + KW_5^2 t_4}{13}}$$

$$KW = \sqrt{\frac{1/3\left(200^2 + 200\times 500 + 500^2\right)\times 4 \;+ 400^2\times 2 + 1/3\;\; (-400)^2\times 3 + 0^2\times 4}{13}}$$ -------- **(1 Mark)**

$$KW = \sqrt{\frac{1000000}{13}}$$

$$KW = \sqrt{76923.07692}$$

$KW = 277.35\,KW$ ----------Answer---------- **(2 Mark)**

So, Select nearest standard rating of motor available in the market.

Q.5 Attempt any Four of the following: ----------16 Marks

a) What are the requirements of the motors used in following applications? Also suggest suitable motor for the same. 1) Stone crushing machine. 2) Paper mills. **(for stone crushing Machine Any one Requirements- 1 Mark & Any one Name of motor -1 mark and for Paper Mill Machine Any one Requirements- 1 Mark & Any one Name of motor -1 mark)**

1) Stone crushing machine: i) Squirrel double cage Induction Motor ii) Slip ring I.M

Requirements: (Any one requirement are expected)

i) High starting torque ii) High overload capacity iii) totally enclosed the motor or totally enclosed type enclosure

2) Paper Mills: - i) Synchronous Motor ii) Shunt Motor iii) Squirrel cage Motor

Requirements: (Any one requirement are expected)

The paper making machine has to perform the job of forming sheets, removing water from sheets, drying of sheets, pressing of sheets and reeling up of sheets. The basic requirements of paper mill machines drive are

i) For the actual formation and production of sheets and from the point of view of economy, constancy of the speed of the drive is necessary.

ii) For the paper machine to be multi-purpose, its speed should be adjustable over a range as large 10:1

iii) In the calendar section and reel section, variations in tension in sheet can occur even if the correct relative speeds are maintained due to uneven drying and other factors. It is therefore, imperative to augment the speed control circuit by an overriding control.

iv) While cleaning the wire, it has to be moved forward a few cms at a time for its proper cleaning and inspection, hence the motor employed should be capable of running at inching speeds of 10-25 m/minute as long as a particular button in pressed.

v) Each section should be able to run at the crawling speed of 10-25 m/minute for running in felts, wire and heating up of dryer cylinders.

vi) Smooth and quick starting of the sections, without causing excessive starting current are required.

vii) Control system employed should be flexible.

b) State the advantages of single phase A.C system of track electrification.

Advantages of Single phase AC System :- **(Any Four advantages, 1 Mark for each)**

i) As system voltage is high (25KV) as compared to DC supply system (3000V) so current drawn by overhead conductor is less because. ($I \alpha 1/V$)

ii) Due to low current cross section of overhead conductor reduces. So its weight reduces.

iii) As weight of overhead conductor reduces design of supporting structure becomes lighter.

iv) Due to low current copper losses in transmission line reduces, so transmission efficiency increases.

v) Due to low current voltage drop in transmission line decreases. Due to this distance between two substation increases. So number of substation required is less than DC track electrification system for same track distance. eg.

S.No.	Voltage level	Distance between 2 substation
1	1-ph AC, 25KV	50 to 80 KM
2	3000V DC	12 to 30 KM
3	1500V DC	5 to 12 KM
4	750/600V DC	2 to 5 KM

vi) Due to low current size (capacity) of AC substation is more than DC substation. So number of substation required is less than DC track electrification system for same track distance.

S.No.	Supply System	Size of Substation
1	1-ph AC, 25KV	10 to 15 MW
2	3000V DC	2 to 6 MW

vii) Due to all above advantages cost of track electrification less as compared to DC track electrification system.

viii) Starting efficiency is high in case of AC supply system as voltage is reduced with the help of transformer.

c) Define the following terms w.r.t. traction machines : i) Average speed ii) Schedule speed, Also state the factors affecting the schedule speed.

(1 Mark for each definition & 2 Mark for any two reasons for factors affecting the schedule speed

1) **Average Speed: -** It is defined as distance covered between two stops divided by actual time of run is known as average speed. **OR**

$$V_{av} = \frac{3600D}{T}$$

Where T = is actual time of run in sec **OR**

$$Average\ Speed = \frac{Distance\ between\ stops\ or\ stations}{Actual\ time\ of\ run}$$

2) **Schedule Speed: -** It is defined as distance covered between two stops divided by schedule time is known as schedule speed. OR

$$Schedule\ Speed = \frac{Distance\ between\ stops\ or\ stations}{(Actual\ time\ of\ run) + (Stop\ time)}$$ **OR**

$$Schedule\ Speed = \frac{Distance\ between\ stops\ or\ stations}{Schedule\ time}$$

- **The following factors affect the schedule speed: (Any two points expected)**

i.) By increasing Acceleration.

ii) By increasing Retardation.

iii) By increasing both Acceleration and Retardation.

iv) By increasing maximum speed

v) By increasing stop time

vi) By reducing coasting period.

d) What is specific energy consumption of a train? State various factors affecting it.
(Definition of SEC-2 Mark & factors affecting any two point-1 Mark each point)

- **Specific Energy consumption of a train:**

It is the energy consumed by train in watt-hr. The energy input to the tonne-km. motor is called energy consumption **OR** To Calculate specific energy consumption we will first find out specific energy output of train and when it is divided by efficiency of traction motor & efficiency of transmission gear then we will get specific energy consumption. **OR**

$$Specific\ Energy\ consumption = \frac{Specific\ energy\ o/p\ of\ driving\ wheel\ (train)}{\eta_m \times \eta_{gear}}$$

- **Factors Affecting Specific Energy Consumption:**

Following factor affect specific energy consumption (SEC):

i) Distance between stop: Greater the distance between two stop less will be the SEC

ii) Train Resistance: Lesser the value of train resistance lower will be the SEC.

iii) Gradient: Specific energy consumption will be less for level track then up gradient track and for down gradient SEC will be less.

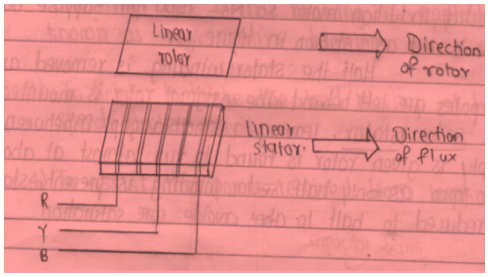
iv) Variation in track Level: SEC will more when there is variation in cross and longitudinal level of track then plan level track.

v) Coasting period: More the coasting period less will be the SEC.

vi) Efficiency of equipments: Greater the efficency of equipments (η of traction motor & η of transmission gear) etc. less will be the specific energy consumption.

e) Explain linear induction motor as traction motor. List any two advantages and disadvantages of each. (Explanation-1 Marks, Three advantages are expected each Advantage -1/2 Mark each & three disadvantages are expected each disadvantages - 1/2 Mark each)

➢ **Explanation of Linear induction Motor:**



In a sector IM, if sector is made flat and squirrel cage winding is brought to it we get linear I.M. In practice instead of a flat squirrel cage winding, aluminum or copper or iron plate is used as rotor.

The flat stator produces a flux that moves in a straight line from its one end to other at a linear synchronous speed given by Vs = 2 wf

Where, Vs = linear synchronous speed in m/sec

w = width of one pitch in m. f = supply frequency (Hz)

The speed does not depends on number of poles but only on the poles pitch and supply frequency. As the flux move linearly it drags the rotor plate along with it in same direction. However in much practical application the rotor is stationary while stator moves.

➢ **Advantages of Linear Induction Motor: (Any three points expected)**

i) It is robust in construction.

ii) High starting torque and it is independent on speed.

iii) As motion is linear centrifugal forces are absent so there is no limitation on maximum speed.

iv) Higher power weight ratio.

v) Overheating of rotor is eliminated.

vi) low maintenance cost.

vii) low initial cost.

- **Disadvantages of Linear Induction Motor: (Any three points expected)**

i) Low power factor.

ii) Efficiency is low.

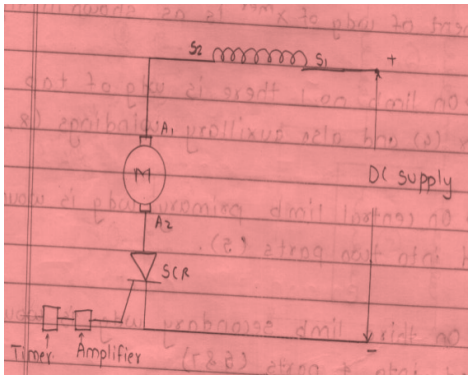
iii) 3-ph, overhead system is complicated and costly.

iv) Cost of track electrification is high due to reaction rail.

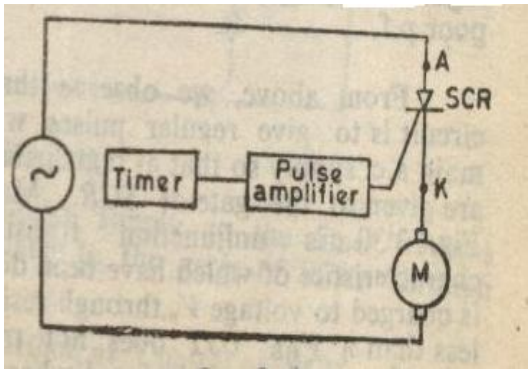
f) Explain chopper control of traction motors with suitable schematic diagram.

(Figure -2 Marks & Explanation – 2 Marks)

Chopper Control Method:-



OR



or Equivalent fig.

Explanation:-

Speed of DC motor is directly proportional to supply voltage. And variable voltage to the armature can be obtained chopper control method.

Chopper control method can be used either on AC supply side or on DC supply side. When it is used on DC supply side then it is called chopper control method.

Q.6 Attempt any two of the following: ----------16 Marks

a) State the condition under which regenerative braking with D.C series motor is possible. Also explain regenerative braking with neat schematic diagram.

(Condition- 2 Mark, Explanation- 4 Mark & Figure-2 Mark)

➢ **Condition to achieve regenerative braking: (Any four condition are expected)**

Following are the different conditions or requirements necessary to achieve electric regenerative braking.

i) Electric regenerative braking is possible for service track having long down gradient exceeding 0.6%.

ii) At the time of braking generated emf must be greater then supply voltage even when speed of train is reducing.

iii) The D.C machines required in case of regenerative braking are to be selected of large size (rating)

iv) When generated energy happens to be surplus over and above demand then there must be provision in substation to waste this surplus energy otherwise electric regenerative braking.

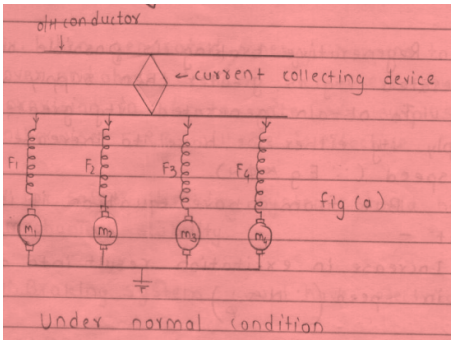
v) For safety braking system should have mechanical stability.

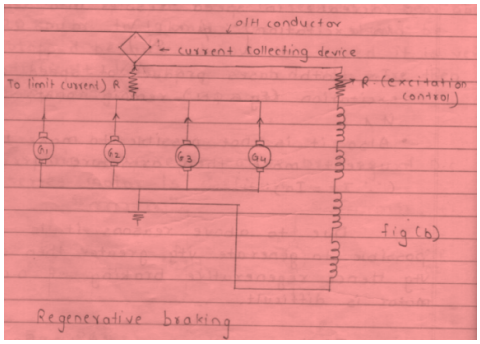
vi) When speed of train is reduced to near about 20km/hr. to 16km/hr the ERB should be stopped because below this speed it is very difficult to keep generated voltage more than supply voltage.

OR Student may write following condition

i) It is possible to generated voltage greater then supply voltage only when D.C series motor field winding is separately excited and extra care must be taken to make it more stable.

➢ **Schematic diagram of regenerative braking**





➢ **Explanation of regenerative braking:**

- During normal running motors are connected in parallel with field winding in series w.r.t. armature as shown in figure 1.
- At the time of regenerating braking all the armature are connected in parallel without series field winding and all series field winding are connected in series with external resistance & are separately excited as shown in fig.2
- At this time motor acts as a generator and excitation current is so adjusted that generated voltage (Eg) is greater than supply voltage (V), so that power will be fed back to supply.
- This process is continued upto the speed of train reaches up to 20 to 16 km/hr. after that it is difficult to maintain generated voltage greater than supply voltage.
- So, electric regenerative braking is stopped for final stoop mechanical braking is applied.

b) 1) what are causes of low power factor.

1) Causes of low power factor: - **(Any Four point expected-1 Mark each point)**

i) Magnitude of Magnetizing Current (I μ):- As magnetizing current increases, power factor reduces.

ii) Due to use of Induction Motor:- Most of industrial drives, agriculture pumps, lift, irrigation pump set uses I.M. which works at lagging power factor, So power factor reduces.

iii) Due to use of Transformer: - All transformers works at lagging power factor, so power factor of system reduces.

iv) Due to welding transformer: - Welding transformers are operated at low p.f. which reduces p.f. of the system.

v) Due to inductance of transmission & distribution Line: - In case of AC transmission & distribution lines, inductance is present which is the main cause of low power factor.

vi) Series Reactor:- Series reactor is used in substation to minimize fault current causes low power factor.

vii) Industrial electrical heating furnaces:- Induction and arc furnace used in steel manufacturing industry works at low p.f. which reduces p.f. of the system.

viii) Arc Lamp:- Arc lamp & electric discharge lamps operates at low p.f.so p.f. of the system reduces.

ix) Equipments operated at light load:- P.f. falls if equipments like alternator, transformer, I.M etc are not operated at full load.

x) Improper repairs and maintenance:- P.f. falls if proper maintenance or repairs of equipments are not done.

b) 2) What are the different tariffs used by electricity supply authority? Explain any one of them in brief. (1/2 Mark to one method state any four of the following total 2 Mark & for any one Explanation -2 Mark)

Types of Tariff:- (Any four types are expected)

i) Flat-demand Tariff

ii) Simple-demand Tariff or Uniform Tariff

iii) Flat-rate Tariff

iv) Step-rate Tariff

v) Block-rate Tariff

vi) Two-part Tariff:

vii) Maximum demand Tariff

viii) Three-part Tariff

ix) Power factor Tariff :- a) KVA maximum demand Tariff

b) Sliding Scale Tariff or Average P.F. Tariff

c) KW and KVAR Tariff

x) TOD (Time of Day) Tariff

Explanation: Any one type of tariff explanation is expected

i) Flat Demand Tariff:

- It is used where energy consumption is fixed per day i.e where load is fixed and is used for fixed hours.
- E.g. Street lighting, Road Signal system and advertising board.
- In this type no energy meter is connected, so meter reading, billing, accounting, Stationary, bill distribution and collection etc expenses are eliminated and also save time for billing.

ii) Simple or uniform demand tariff:-

- In this type of tariff cost of energy charges is calculated on the basis of actual energy consume energy meter is connected in consumer premises.

iii) Flat Rate Tariff:-

- In this type of tariff there are two energy meter in one premises.
- One energy meter is for lighting circuit load and another meter is for power circuit load.
- Tariff rate for lighting and power load are different.
- Tariff rate for lighting is higher than tariff for power load.

iv) Step rate Tariff:-

- In this tariff there are steps for unit's consumption and cost/unit is less for more consumption of unit.
- The main disadvantage of this tariff is that the consumer unnecessary wastes the power to enter the next stage.
- For example 1) Step- I- Rs.2/KWH :- If consumption not to exceed 50 unit

  2) Step-II – Rs. 1.75/KWh:- If consumption not to exceed 200 unit.

  1) Step-II- Rs. 1.50/KWh:- If consumption exceeds above 200 units.

v) Block Rate Tariff:-

- In case of block rate tariff there are blocks of units consumed and each block tariff rate/unit (KWH) is different.
- If generation is less than utilization than tariff rate/unit in each block goes on increasing and vice versa.

vi) Two Part Tariff:-

- In this type of tariff energy bill is split into two parts.
- Only one energy meter is used to measure no. of units consumed it recovers a fixed charge which depends on load (KW).
- This type of tariff system is used for residential and commercial consumers.(up to 20 KW
- This type of tariff is not used for industrial consumers.
  ENERGY BILL= FIXED CHARGE +RUNNING CHARGE

vii) Maximum Demand Tariff/KVA MD Tariff:-

- It is similar to two part tariff except that maximum demand (KVA) is actually measured by installing maximum demand (in KVA)
- M.D. Meter is installed in the premises of consumer, in addition to energy meter.
- Industrial consumer is trying to improve power factor to reduce maximum demand charges.
- This type of tariff is applicable to industrial consumer/H.T. consumer.

viii) Three part Tariff:-

- Fixed charges per month depend on connected load.
- This type tariff is used for HT consumer.
  ENERGY BILL= FIXED CHARGE+SEMI-FIXED CHARGE+RUNNING CHARGE

ix) Power Factor Tariff:-

- The tariff in which P.f. of industrial consumer is taken into consideration.
- Power factor tariff is used for industrial consumer /H.T. consumer.
- If the P.F. of consumer is less than P.F.declar by Supply Company (say below .92iag.) than penalty will be charged in energy bill.
- If The P.F. of consumer is more than P.F.declar by supply company (say above .96 iag.) than discount will be given in energy bill.

x) Time of Day (TOD) Tariff or OFF-load Tariff:-

- TOD energy meter is installed in the HT consumer premises.
- If the P.F. of consumer is less than P.F.declar by supply company (say below .92iag.) than penalty will be charged in energy bill.
- This meter is specially designed to measure energy consumption w.r.t time.
- This type of tariff is such that energy consumption charges/unit are less during OFF-load period
- There is a higher tariff rate energy consumption charge during peak-load period.
- This type of tariff is introduced to encourage industrial consumers to run their maximum load during OFF-load period.

c) What are the measures to be taken for energy conservation in the field of 1) Refrigeration and air-conditioning 2) illumination?

1) Refrigeration and Air-conditioning: (Any Four point Expected -1/2 to each point total 2 Marks)

➢ **Measures for energy conservation in the field of Refrigeration :**

(Any similar points other than below should be consider)

- Remove internal shelf lights to reduce refrigeration and lighting energy use.
- Remove all, or at least every other incandescent bulb over refrigerated meat displays.
- Maintain display fixtures and freezers at the following temperatures for maximum energy savings:

Frozen food cases, -8 degrees F, Ice cream cases/chests, -14 degrees F
Deli cases, 35 degrees F, Beer cases, 40 degrees F
Soda/dairy cases, 40 degrees F

- Keep products below market load lines in freezers and coolers.

- Overloaded displays decrease product quality and increase energy use by as much as 10 to 20% per unit.
- Follow the manufacturer's recommendations for shelf positions and sizes to prevent increased refrigeration loads.
- Keep doors on refrigerated units open as little as necessary when unloading or re-stocking.
- Use recommended night covers on low-temperature fixtures, and keep covers below load lines to reduce compressor run time and save energy.
- Clean condensing fins and plates monthly, and inspect for ice build-up and bent fins.
- Check door latches and gaskets on refrigeration and freezer units regularly; adjust latches and replace worn door gaskets as needed.
- When purchasing new refrigeration systems select the higher energy efficiency rating (EER) the greater the cooling capacity for each kWh of energy input, the greater the efficiency of the system.
- Brush condenser coils weekly with a non-metallic brush, and clean coils monthly if dust build-up is extensive.

- Check refrigerant monthly for correct charge.
- Clean meat and dairy cases monthly.
- Clean produce and freezer cases every three months.

- Perform annual checks on refrigeration and freezer units to determine whether units are level; upright doors should close automatically from an open position.
- Have automatic defrost cycles checked annually and adjusted if necessary by a trained service technician.

➢ **Measures for energy conservation in the field of Air-conditioning:**

(Any similar points other than below should be consider)

- Keep vents closed in unoccupied areas to prevent heating or cooling of storage areas and closets.
- Reduce fresh air intake to the minimum necessary for the type of business.
- Treat water in evaporative condensers regularly.
- Replace old HVAC systems with new energy-efficient systems.

- Install paddle fans, stratotherm fans, or other re-circulating systems to create air movement. Ceiling temperatures can often be 30 to 40 degrees higher than floor temperatures, and air movement from fans can enhance the cooling ability of air conditioning systems.
- Install air conditioner economizers to use outside air to cool buildings when outdoor air is lower than indoor temperatures.
- Install time clocks, set-back thermostats, and microprocessor thermostats to monitor HVAC systems when buildings are unoccupied.
- Install intermittent ignition devices on gas furnaces to save gas.
- Modify flue dampers on gas furnaces to increase burner efficiency.

- Check air filters monthly and clean or change as needed.
- Check air intake screens monthly, and clean as required.
- Inspect air dampers monthly, and keep them as airtight as possible.
- Check V-belts (fan belts) monthly for frays, cracks, and nicks, and replace as necessary.
- Check heat recovery devices monthly for proper operation.
- Brush off air conditioner condenser coils monthly.

- Check motors, bearings, and blower fans every 3 months, and lubricate as required.

- Check heating and cooling coils every 3 months, and clean as needed.
- Check vacuum blower compartments every 3 months.
- Check ducts, vents,

- Check cooling systems in the spring before the cooling season begins.
- Check pulleys and sheaves in the spring and fall for alignment and proper belt tension.
- During the summer, open windows and use only the fan portion of cooling systems when outdoor air is cooler than indoor temperatures.
- Keep doors and windows closed when air conditioning systems are operating.

- Check cabinets and brackets once a year, and tighten all bolts and screws as necessary.
- Check housings yearly, and remove rust and re-paint as required.

2) Measures for energy conservation in the field of illuminations: (Any Four point Expected - 1/2 to each point total 2 Marks)

(Any similar points other than below should be consider)

- Turn off non-essential and decorative lighting, especially in unoccupied areas.
- Replace flickering, dim and burned-out lamps.
- Clean fixtures and diffusers (at least annually).
- Color-code or mark light switches and circuit breakers that can be turned off when not needed.

- Use task lighting to directly illuminate work areas.
- Lower the height of light fixtures if possible to increase usable light.
- Replace burned out lamps with lower wattage lamps or energy-saving lamps wherever possible.
- replacing incandescent lighting systems with compact fluorescent and/or LED Lamps.
- Install more efficient security and parking lot lighting. High-pressure sodium fixtures are more efficient than metal halide, mercury vapor, fluorescent or incandescent fixtures.
- Install time clocks or photoelectric cells to control exterior lighting, advertising sign lighting and some interior lighting.
- Paint dark walls and ceilings with lighter colors to maximize the effect of existing light sources.
- Maximize natural lighting by installing skylights or windows.
- Install dimmer or occupancy switches where appropriate to lower energy use such as in stairwells, copy rooms, restrooms.
- Color-code switches that should remain off when crews are cleaning.
- Proper and timely maintenance is required for the efficient lighting.