Hall Ticket Number:

IV/IV B.Tech (Regular / Supplementary) DEGREE EXAMINATION

January, 2021 **Electrical and Electronics Engineering**

Seventh Semester **Utilization of Electrical Power**

Time: Three Hours **Maximum :** 60 Marks

Answer ALL Questions from PART-A. (1X12 = 12 Marks)

Answer ***ANY FOUR*** *questions from PART-B.* (4X12=48 Marks)

Part - A

1 Answer all questions (1X12=12 Marks)

a) Define the short time rating of motor
b) Explain the term heating time constant
c) Write the advantages of electric braking.
d) What do you mean by electric traction?
e) Define schedule speed
f) What is coefficient of adhesion?
g) What is meant by good weld?
h) For carbon-arc welding only dc can be used. Why?
i) What is pinch effect?
j) Define maintenance factor.
k) What is meant by glare?
l) Why is tungsten selected as the filament material?

Part - B

2 a) A motor has the following load cycle: Accelerating period 0-15 sec Load rising uniformly from 0 to 1000 h.p. Full speed period 15-85 sec Load constant at 600 h.p. Decelerating period 85-100 sec h.p. returned to line falls uniformly from 200 to zero Decking period 100-120 sec Motor stationary. Estimate the size of the motor. 6M

b) Write short notes on load equalisation. 6M

3 a) A 40 KW motor when run continuously on full load, attains a temperature of 35°C, above the surrounding air. Its heating time constant is 90 min. What would be the ½ hour rating of the motor for this temperature rise? Assume that the machine cools down completely between each load period and that the losses are proportional to square of the load. 6M

b) Explain the operation of dynamic braking applied to dc shunt motor with braking characteristics. 6M

4 a) State the system of track electrification employed for the main line services. 4M

b) Sketch the typical speed-time curve for the train movement of sub-urban service and from this derive a simplified speed-time curve. 8M

5 a) A 350-tonne electric train runs up gradient of 1 percent with the following speed-time curve: i) uniform acceleration of 1.6 kmphps for 25 seconds, ii) constant speed for 50 seconds, iii) coasting for 30 seconds, and braking at 2.56 kmphps to rest. Calculate the specific energy consumption if train resistance is 50 N/tonne, effect of rotational inertia 10 percent, overall efficiency of transmission gear and motor is 75%. 8M

b) Why plugging is most inefficient method of braking compared to other methods? 4M

6 a) What are the advantages of electrically produced heat? What are the properties to be possessed by the element used in resistance oven? 6M

b) Write short notes on design of heating element for electric furnace. 6M

7 a) Write short notes on arc welding 6M

b) What is resistance welding? What are its limitations? 6M

8 a) Explain the principle of operation of sodium vapour lamp and its advantages. 8M

b) State the functions of starter and choke in a fluorescent lamp. 4M

9 a) Two powerful street lamps of 1,000 candela and 800 candela (assumed uniform in all directions) are mounted 12.5 m above the road level and are spaced 25 metres apart. Find the illumination produced at a point on the ground in-between the lamp posts and just below the lamp posts. 6M

b) Short notes on incandescent lamp characteristics. 6M

1 a. Ans) A short time rating of an electric motor can be defined as the extrapolated overload rating of the motor which it can supply for the specified short time without getting overheated

b Ans) The heating time constant is the time taken by the machine to attain 63.2% of its final steady temperature raise (θf).

C Ans) Advantage of Electrical Braking :

- Electric braking is fast and cheap.
- In electric braking there is no maintenance cost like replaced brake shoes periodically.
- By using electic braking the capacity of the system(like higher speeds, heavy loads) can be increased.
- A part of energy is returned to the supply consequently the running cost is reduced.
- In electric braking negligible amount of heat is generated whereas in mechanical braking enormous heat is produced at brake shoes which leads to failure of brakes.

d Ans) The system which use electrical power for traction system i.e. for railways, trams, trolleys, etc. is called electrical traction. OR Electric traction means a locomotion in which the driving force is obtained from electric motors.

e Ans) Schedule speed:
The ratio of the distance covered between two stops to the total time of the run including the time for stop is known as schedule speed. It is denoted with the symbol 'V_S'.

f Ans) This is the ratio of the tractive effort force just necessary slip the wheels on the track to the adhesive weight. ... μ = tractive effort to slip

g Ans) Welding is the only way of joining two or more pieces of metal together to make them act as a single piece. The basic conditions of welding quality to achieve products of such high quality includes the following:

- No cracks or holes found in the bead.
- The finished product satisfies the design dimensions and has almost no distortion.
- The welding meets the required strength.

H Ans) The carbon electrode using as negative pole because of low temperature generated on the tip than work piece, and carbon electrode not fuse and mix up with the work piece. ... In this reason DC current used in carbon arc welding AC current not used in the welding because of fixed polarity can be maintained.

I Ans) The formation of bubbles & voids in the charge while heating.

J Ans) The ratio of illumination on a given area after a period of time to the initial illumination on the same area; used in lighting calculations to account for the depreciation of lamps or reflective surfaces.

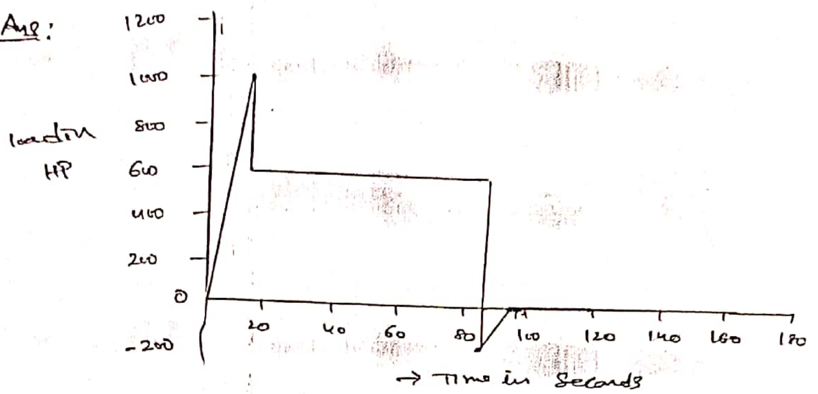
K Ans) Glare is the loss of visual performance or discomfort produced by an intensity of light in the visual field greater than the intensity of light to which the eyes are adapted. Glare may come directly from a light source or be reflected.

L Ans) Tungsten is used for making filament of an electric bulb due to the following reasons: Being an alloy it has a very high melting point. It has very high resistivity so it does not burn easily at room temperature. The lamp glows at high temperatures.

Essay Questions

6M

2. a. Ans:



3M

$$RMS\ H.P = \sqrt{\frac{\frac{1}{3}(1000)^2 \times 15 + 600^2 \times 70 + \frac{1}{3}\, 200^2 \times 15}{120}}$$

$= 503.3$

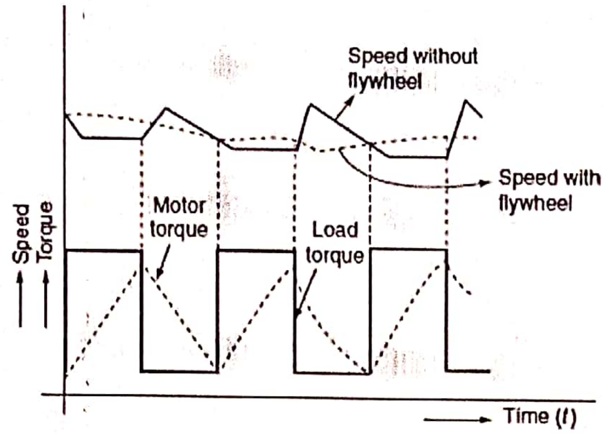
Rating of motor $\simeq$ 505 HP

3M

2 b Ans.

Load Equalization:

If the load fluctuates between wide limits in space of few seconds, then large peak demands ofcurrent will be taken from supply and produce heavy voltage drops in the system. Large size of conductor is also required for this. Process of smoothing out these fluctuating loads is commonly referred to as load equalization and involves storage of energy during light load periods which can be given out during the peak load period, so that demand from supply is approximately constant. Tariff is also affected as it is based on M.D. (Maximum Demand).



3M

The method of Load Eqalization most commonly employed is by means of a flywheel. During peak load period, the flywheel deccelarates and gives up its stored kinetic energy, thus reducing the load demanded from the supply. During light load periods, energy is taken from supply to accelerate flywheel, and replenish its stored energy ready for the next peak. Flywheel is mounted on the motor shaft near the motor. The motor must have drooping speed characteristics, that is, there should be a drop in speed as the load comes to enable flywheel to give up its stored energy. 3M.

3 a. Ans: let P kW be the 1/2 hour rating of motor

θ_f – Final temperature rise at P kW

θ_f' – final temperature rise at 40 kW

∴ losses at P kW $\propto P^2$

losses at 40 kW $\propto 40^2$

$$\Rightarrow \frac{\theta_f}{\theta_f'} = \frac{\text{Losses at P kW}}{\text{Losses at 40 kW}} = \left(\frac{P}{40}\right)^2$$ } 3M

$$\therefore \theta_f = \left(\frac{P}{40}\right)^2 \theta_f'$$

As the machine cools down completely for 'P' kW the equation will be

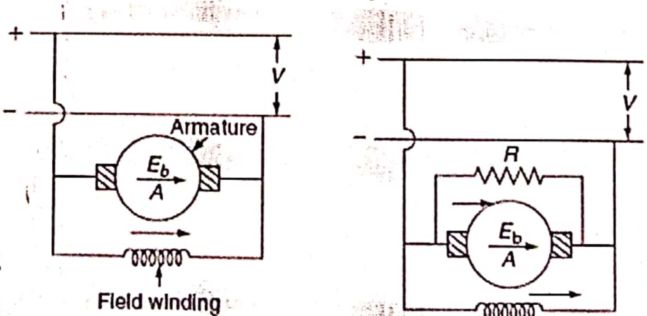
$$\theta = \theta_f\left(1 - e^{-t/T}\right) \text{ where } \theta_f = \left(\frac{P}{40}\right)^2 \times 35$$

$$\Rightarrow 35 = \left(\frac{P}{40}\right)^2 \times 35\left(1 - e^{-0.5/1.5}\right)$$ } 3M

$$\therefore P = 75.13 \text{ kW}$$

3 b Ans) **DYNAMIC BRAKING OF DC SHUNT MOTOR**

The connection diagram of the DC shunt motor during both normal and braking conditions. In case of DC shunt motor, both armature and field windings are connected across the DC supply, as shown in below fig.



(a) Normal running condition (b) Braking period

} 3M

During the braking period, the armature is disconnected from the supply and field winding is continuously excited by the supply in the same direction. The kinetic energy of all rotating parts is dissipated in the resistor '*R*' now the machine starts working as generator. Now, braking developed is proportional to the product of the field and the armature currents. But the shunt motor flux remains constant, so the braking torque is proportional to armature current at low-speeds braking torque is less and in order to maintain constant braking torque, the armature is gradually disconnected. Hence, the armature current remains same thereby maintaining the uniform braking torque.

4 a Ans) **System Of Track Electrification**

The system which use electrical power for traction system i.e. for railways, trams, trolleys, etc. is called electrical traction. The track electrification refers to the type of source supply system that is used while powering the electric locomotive systems. It can be AC or DC or a composite supply. Selecting the type of electrification depends on several factors like availability of supply, type of an application area, or on the services like urban, suburban and main line services, etc.

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

1. Direct current system—600 V, 750 V, 1500 V, 3000 V

2. Single-phase ac system—15-25 kV, 16 2/3,, 25 and 50 Hz

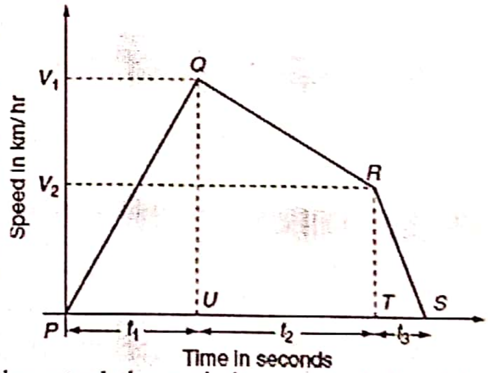
3. Three-phase ac system—3000-3500 V at 16 2/3Hz

4. Composite system—involving conversion of single-phase ac into 3-phase ac or dc.

4 b Ans.

QUADRILATERAL SPEED–TIME CURVE

Quadrilateral speed–time curve for urban and suburban services for which the distance between two stops is less. The assumption for simplified quadrilateral speed–time curve is the



initial acceleration and coasting retardation periods are extended, and there is no free-running

Let $V1$ be the speed at the end of accelerating period in km/h, $V2$ be the speed at the end of coasting retardation period in km/h, and βc be the coasting retardation in km/h/sec.

Time for acceleration, $t_1 = \frac{V_1 - 0}{\alpha} = \frac{V_1}{\alpha}$.

Time for coasting period, $t_2 = \frac{V_2 - V_1}{\beta}$.

Time period for braking retardation period, $t_3 = \frac{V_2 - 0}{\beta} = \frac{V_2}{\beta}$.

Total distance travelled during the running period D:

= the area of triangle PQU + the area of rectangle $UQRS$ + the area of triangle TRS.

= the distance travelled during acceleration + the distance travelled during coastingretardation + the distance travelled during breaking retardation.

But, the distance travelled during acceleration = average speed × time for acceleration

$$= \frac{0 + V_1}{2} \times t_1 \text{ km/h} \times \text{sec}$$

$$= \frac{V_1}{2} \times \frac{t_1}{3{,}600} \text{ km.}$$

The distance travelled during coasting retardation= $\frac{V_2 + V_1}{2} \times t_2$ km/h × sec

$$= \frac{V_2 + V_1}{2} \times \frac{t_2}{3{,}600} \text{ km.}$$

The distance travelled during breaking retardation = average speed × time for breaking retardation

BM

$$= \frac{0 + V_2}{2} \times t_3 \text{km/h} \times \text{sec}$$

$$= \frac{V_2}{2} \times \frac{t_3}{3{,}600} \text{ km.}$$

∴ Total distance travelled:

$$D=\frac{V_1}{2}\times\frac{t_1}{3,600}+\frac{(V_1+V_2)}{2}\frac{(t_2)}{3,600}+\frac{V_2}{2}\times\frac{t_3}{3,600}$$

$$=\frac{V_1t_1}{7,200}+\frac{(V_1+V_2)t_2}{7,200}+\frac{V_2t_3}{7,200}$$

$$=\frac{V_1}{7,200}(t_1+t_2)+\frac{V_2}{7,200}(t_2+t_3)$$

$$=\frac{V_1}{7,200}(T-t_3)+\frac{V_2}{7,200}(T-t_1)$$

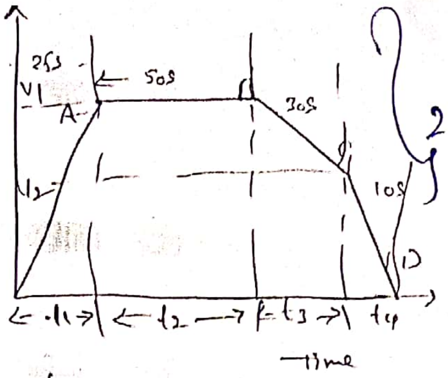
$$=\frac{(V_1+V_2)T}{7,200}-\frac{V_1t_3}{7,200}-\frac{V_2t_1}{7,200}$$

$$=\frac{(V_1+V_2)T}{7,200}-\frac{V_1V_2}{7,200\beta}-\frac{V_1V_2}{7,200\alpha}$$

$$=\frac{\text{T}}{7,200}(V_1+V_2)-\frac{V_1V_2}{7,200}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right)$$

$$7,200D=(V_1+V_2)\text{T}-V_1V_2\left(\frac{1}{\alpha}+\frac{1}{\beta}\right).$$

5.a. Ans:



2M

From the fig

$V_1 = \alpha t_1 = 1.6 \times 25$

$= 40$ KMPH

Tractive force during coasting is

$F_t = (98 MG + M_r r)$

$= M(98 \times 1 + 50) = 148\,M$ newton

Also, $F_t = 277.8\, M_e \beta_c$ during coasting equating the two expressions we get $277.8\, M_e$

$\beta_c = 148\,M$

$\therefore \beta_c = \frac{148}{277.8} \times \frac{M}{M_e} = \frac{148}{277.8} \times \frac{1}{1.1}$, $\beta_c = 0.48$ KMPH

Now $V_2 = V_1 + \beta_c t_3$

$= 40 + (-0.48) \times 30 = 25.6$ KMPH

$t_4 = V_2/\beta = 25.6/2.56 = 10$ Second

Distance travelled during acceleration period $= \frac{1}{2} \times 40 \times \frac{25}{3600} = 0.139$ KM

Distance travelled during constant speed period is $= V_1 \times t_2 = 40 \times \frac{50}{3600}$

$= 0.555$ KM

Distance travelled during coasting

$= \left(\frac{V_1 + V_2}{2}\right) \times t_3 = \frac{40 + 25.6}{2} \times \frac{30}{3600} = 0.273$ KM

Distance travelled during braking $= \frac{1}{2} V_2 t_4 = \frac{1}{2} \times 25.6 \times \frac{10}{3600} = 0.035$ KM

3M

Total distance b/w stops $= 0.139 + 0.555 + 0.273 + 0.035 = 1.002$ KM

Distance travelled during acceleration & free running period is

$D' = 0.139 + 0.555 = 0.694$ KM

Specific energy consumption is

$= 0.01072 \frac{V_m^2}{\eta D} \cdot \frac{M_e}{M} + 27.25 \frac{G}{\eta} \cdot \frac{D'}{D} + 0.2778 \frac{r}{\eta} \frac{D'}{D}$ watt-KM

$= \frac{0.01072 \times 40^2}{0.75 \times 1.002} \times 1.1 + 27.25 \times \frac{1}{0.75} \times \frac{0.694}{1.002} + 0.2778 \times \frac{50}{0.75} \times \frac{0.694}{1.002}$

$= 63.1$ wh/tonne-KM

3M

5 b Ans. Plugging:

It is also known as reverse current braking. The armature terminals or supply polarity of a separately excited DC motor or shunt DC motor when running are reversed. Therefore, the supply voltage V and the induced voltage E_b i.e. back emf will act in the same direction. The effective voltage across the armature will be V + E_b which is almost twice the supply voltage.Thus, the armature current is reversed and a high braking torque is produced. Plugging is a highly inefficient method of braking because, in addition to the power supplied by the load, the power supplied by the source is wasted in resistances. 4M

6 a Ans.

Advantages of Electric Heating:

As compared to other methods of heating using gas, coal and fire etc., electric heating is far superior for the following reasons :

(*i*) **Cleanliness.** Since neither dust nor ash is produced in electric heating, it is a clean system of heating requiring minimum cost of cleaning. Moreover, the material to be heated does not get contaminated.

(*ii*) **No Pollution.** Since no flue gases are produced in electric heating, no provision has to be made for their exit.

(*iii*) **Economical.** Electric heating is economical because electric furnaces are cheaper in their initial cost as well as maintenance cost since they do not require big space for installation or for storage of coal and wood. Moreover, there is no need to construct any chimney or to provide extra heat installation.

(*iv*) **Ease of Control.** It is easy to control and regulate the temperature of an electric furnace with the help of manual or automatic devices. Temperature can be controlled within ± 5°C which is not possible in any other form of heating.

(*v*) **Special Heating Requirement.** Special heating requirements such as uniform heating of a material or heating one particular portion of the job without affecting its other parts or heating with no oxidation can be met only by electric heating. 8M

(*vi*) **Higher Efficiency.** Heat produced electrically does not go away waste through the chimney and other by products. Consequently, most of the heat produced is utilised for heating the material itself.

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

Requirement of a Good Heating Element:

A good heating element should have the following properties:

(1) High Specific Resistance. When specific resistance of the material of the wire is high, only short length of it will be required for a particular resistance (and hence heat) or for the same length of the wire and the currrent, heat produced will be more.

(2) High Melting Temperature. If the melting temperature of the heating element is high, it would be possible to obtain higher operating temperatures.

(3) Low Temperature Coefficient of Resistance. In case the material has low temperature coefficient of resistance, there would be only small variations in its resistance over its normal range of temperature. Hence, the current drawn by the heating element when cold (*i.e.*, at start) would be practically the same when it is hot.

(4) High Oxidising Temperature. Oxidisation temperature of the heating element should be high in order to ensure longer life.

3M

(5) Positive Temperature Coefficient of Resistance. If the temperature coefficient of the resistance of heating element is negative, its resistance will decrease with rise in temperature and it will draw more current which will produce more wattage and hence heat. With more heat, the resistance will decrease further resulting in instability of operation.

(6) Ductile. Since the material of the heating elements has to have convenient shapes and sizes, it should have high ductility and flexibility.

6 bAns. DESIGN OF HEATING ELEMENTS

By knowing the voltage and electrical energy input, the design of the heating element for an electric furnace is required to determine the size and length of the heating element. The wire employed may be circular or rectangular like a ribbon. The ribbon-type heating element permits the use of higher wattage per unit area compared to the circular-type element.

Circular-type heating element

Initially when the heating element is connected to the supply, the temperature goes on increasing and finally reaches high temperature.

Let V be the supply voltage of the system and R be the resistance of the element, then electric power input, $P = \frac{V^2}{R}$ W.

If ρ is the resistivity of the element, l is the length, 'a' is the area, and d is the diameter of the element, then:

$$R = \rho \frac{l}{a} = \frac{\rho l}{\frac{\pi d^2}{4}}.$$

Therefore, power input,

$$P = \frac{V^2 \pi d^2}{4 \rho l}. \tag{4.2}$$

By rearranging the above equation, we get:

$$\frac{l}{d^2} = \frac{V^2}{4P\rho}. \tag{4.3}$$

where P is the electrical power input per phase (watt), V is the operating voltage per phase (volts), R is the resistance of the element (Ω), l is the length of the element (m), a is the area of cross-section (m^2), d is the diameter of the element (m), and ρ is the specific resistance (Ω-m)

According to Stefan's law, heat dissipated per unit area is

$$H = 5.72 \times 10^4 \, k \, e \left[\left(\frac{T_1}{1,000} \right)^4 - \left(\frac{T_2}{1,000} \right)^4 \right] \text{W/m}^2, \tag{4.4}$$

where $T1$ is the absolute temperature of the element (K), $T2$ is the absolute temperature of the charge (K), e is the emissivity, and k is the radiant efficiency.

The surface area of the circular heating element:

$S = \pi dl.$

$\therefore$ Total heat dissipated = surface area × H

$= H\pi dl.$

Under thermal

equilibrium, Power

input = heat dissipated

$P = H \times \pi dl.$

Substituting P from Equation (4.2) in above equation

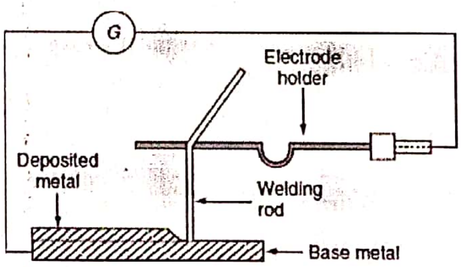
$$\frac{V^2}{\rho l}\left(\frac{\pi d^2}{4}\right) = H \times \pi dl$$

3M

By solving Equations (4.3) and (4.4), the length and diameter of the wire can be determined

7 a Ans. $\frac{l}{d^2} = \frac{\pi V^2}{4P\rho}$. ELECTRIC ARC WELDING (4.3)

Electric arc welding is the process of joining two metallic pieces or melting of metal is obtained due to the heat developed by an arc struck between an electrode and the metal to be welded or between the two electrodes as shown in below



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In this process, an electric arc is produced by bringing two conductors (electrode and metal piece) connected to a suitable source of electric current, momentarily in contact and then separated by a small gap, arc blows due to the ionization and give intense heat.

The heat so developed is utilized to melt the part of workpiece and filler metal and thus forms the weld.

In this method of welding, no mechanical pressure is employed; therefore, this type of welding is also known as *'non-pressure welding'*.

The length of the arc required for welding depends upon the following factors:

- The surface coating and the type of electrodes used.
- The position of welding.
- The amount of current used.

3M

7 b Ans.

Resistance welding is a thermo-electric process in which heat is generated at the interface of the parts to be joined by passing an electrical current through the parts for a precisely controlled time and under a controlled pressure (also called force).

Key advantages of the resistance welding process include:

- Very short process time
- No consumables, such as brazing materials, solder, or welding rods
- Operator safety because of low voltage
- Clean and environmentally friendly
- A reliable electro-mechanical joint is formed

3M

There are an abundance of resistance welding applications used within a variety of industries

- The most common applications of large-scale resistance welding can be found in the automotive industry, aerospace industry, railway industry, food and beverage industry, nuclear industry, solar industry, material handling industry, military/defense industry, and the industrial and manufacturing industry.
- Resistance welding in the automotive industry is probably the most common. During vehicle assembly there are three resistance welding processes that are typically leveraged: spot welding, projection welding (a variation of spot welding) and seam welding (a variation of spot welding).

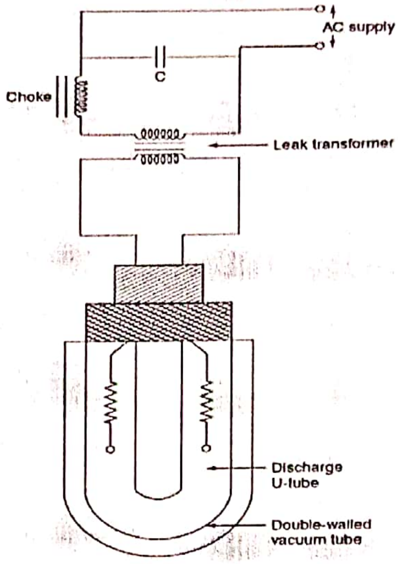
Limitations:

- Equipment complex, to be equipped with high technical level of maintenance personnel.
- Higher cost
- Large capacity and the majority of single-phase welder
- Unbalanced load on the grid causing serious damages
- Lack of simple and practical means of NDT
- Lap joints add weight and material
- Lower tensile and fatigue strength

3M

8a Ans. SODIUM VAPOR LAMP

A sodium vapor lamp is a cold cathode and low-pressure lamp. A sodium vapor discharge lamp consists of a *U*-shaped tube enclosed in a double-walled vacuum flask, to keep the temperature of the tube within the working region. The inner *U*-tube consists of two oxide-coated electrodes, which are sealed with the ends. These electrodes are connected to a pin type base construction of sodium vapor lamp is shown in Fig. .



4M

Working

Initially, the sodium is in the form of a solid, deposited on the walls of inner tube. When sufficient voltage is impressed across the electrodes, the discharge starts in the inert gas, i.e., neon; it operates as a low-pressure neon lamp with pink color. The temperature of the lamp.increases gradually and the metallic sodium vaporizes and then ionizes thereby producing the monochromatic yellow light. This lamp takes 10–15 min to give its full light output. The yellowish output of the lamp makes the object appears gray.

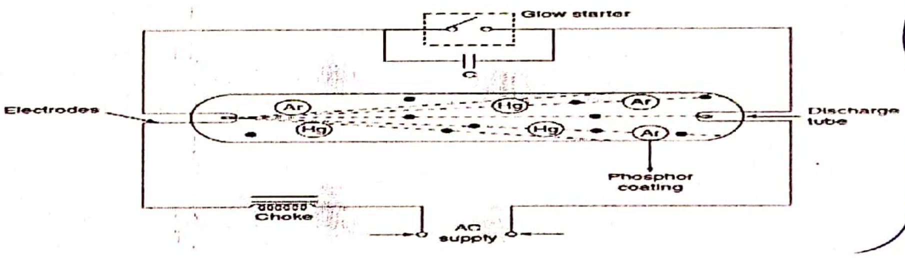
In order to start the lamp, 380 – 450 V of striking voltage required for 40- and 100-W lamps. These voltages can be obtained from a high reactance transformer or an auto transformer. The operating power factor of the lamp is very poor, so that a capacitor is placed to improve the power factor to above 0.8. More care should be taken while replacing the inner tube, if it is broken, then sodium comes in contact with the moisture; therefore, fire will result. The lamp must be operated horizontally or nearly so, to spread out the sodium well along the tube.

The efficiency of sodium vapor lamp is lies between 40 and 50 lumens/W. Normally, these lamps are manufactured in 45-, 60-, 85- and 140-W ratings. The normal operating temperatures of these lamps are 300°C. In general, the average life of the sodium vapor lamp is 3,000 hr and such bulbs are not affected by voltage variations.

8 bAns. Fluorescent Lamp

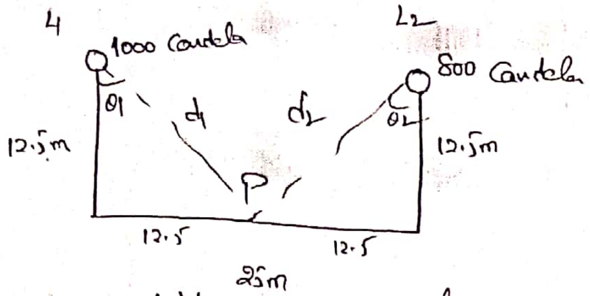
It consists of a long horizontal tube, due to low pressure maintained inside of the bulb; it is made in the form of a long tube.

The tube consists of two spiral tungsten electrode coated with electron emissive material and are placed at the two edges of long tube. The tube contains small quantity of argon gas and certain amount of mercury, at a pressure of 2.5 mm of mercury. The construction of fluorescent lamp is shown in below Normally, low-pressure mercury vapor lamps suffer from low efficiency and they produce an objectionable colored light. Such drawback is overcome by coating the inside of the tube with fluorescent powders. They are in the form of solids, which are usually knows as phosphors.



A glow starter switch contains small quantity of argon gas, having a small cathode glow lamp with bimetallic strip is connected in series with the electrodes, which puts the electrodes directly across the supply at the time of starting. A choke is connected in series that acts as ballast when the lamp is running, and it provides a voltage impulse for starting. A capacitor of 4μF is connected across the starter in order to improve the power factor.

9.a Ans.



Illumination at 'P' due to both Lamps

$E = E_1 + E_2$

$E_1 = \frac{I_1}{d_1^2}\cos\theta_1$, $\cos\theta_1 = \frac{12.5}{d_1}$ $\quad d_1 = \sqrt{12.5^2 + 12.5^2} = 17.67$

$= \frac{1000}{17.67^2} \times 0.707$ $\quad = \frac{12.5}{17.67} = 0.707$

$E_1 = 2.264$ Lux

$E_2 = \frac{I_2}{d_2^2}\cos\theta_2 =$ $\quad \cos\theta_2 = \frac{12.5}{d_2}$ $\quad d_2 = \sqrt{12.5^2 + 12.5^2} = 17.67$

$= \frac{800}{17.67^2} \times 0.707 = 1.8114$ Lux

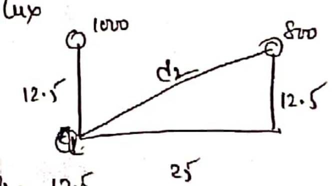
Total $E = E_1 + E_2 = 2.264 + 1.8114 = 4.075$ Lux

Illumination $E = 4.075$ Lux

3M

Illumination under the Lamps

$E_1 = \frac{I_1}{d^2}$ Lux at Q $= \frac{1000}{12.5^2} = 6.4$ Lux



at Q, $E_2 = \frac{I_2}{d_2^2}\cos\theta_2 =$

$= \frac{800}{27.95^2} \times 0.447$ $\quad \cos\theta_2 = \frac{12.5}{d_2} = \frac{12.5}{27.95} = 0.447$ $\quad d_2 = \sqrt{12.5^2 + 25^2}$, $d_2 = 27.95$

$E_2 = 0.457$ Lux

Total at Q, $E = E_1 + E_2$

$= 0.457 + 6.4$

$= 6.857$ Lux

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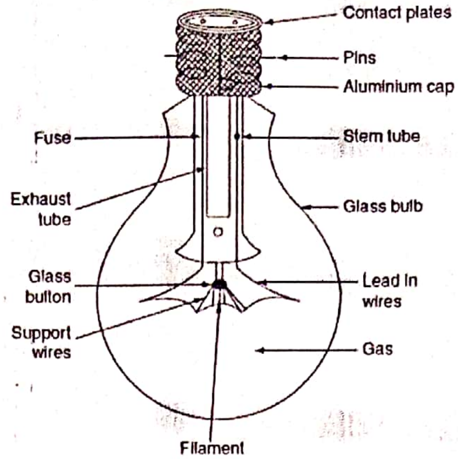
Scanned with CamScanner

• 9 b Ans. Incandescent Lamp



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These lamps are temperature-dependent sources. When electric current is made to flow through a fine metallic wire, which is known as *filament*, its temperature increases. At low temperatures, it emits only heat energy, but at very high temperature, the metallic wire emits both heat and light energy. These incandescent lamps are also known as *temperature radiators.*

Above fig_ shows the construction of the tungsten filament incandescent lamp. It consists of an evacuated glass bulb and an aluminum or brass cap is provided with two pins to insert the bulb into the socket. The inner side of the bulb consists of a tungsten filament and the support wires are made of molybdenum to hold the filament in proper position. A glass button is provided in which the support wires are inserted. A stem tube forms an air-tight seal around the filament whenever the glass is melted.

Operation:

When electric current is made to flow through the fine metallic tungsten filament, its temperature increases. At very high temperature, the filament emits both heat and light radiations, which fall in the visible region. The maximum temperature at which the filament can be worked without oxidization is 2,000°C, i.e., beyond this temperature, the tungsten filament blackens the inside of the bulb. The tungsten filament lamps can be operated efficiently beyond 2,000°C, it can be attained by inserting a small quantity of inert gas nitrogen with small quantity of organ. But if gas is inserted instead of vacuum in the inner side of the bulb, the heat of the lamp is conducted away and it reduces the efficiency of the lamp. To reduce this loss of heat by conduction and convection, as far as possible, the filament should be so wound that it takes very little space

3M

Usually, the tungsten filament lamp suffers from 'aging effect', the output of the light an incandescent lamp decreases as the lamp ages. The output of the light of the lamp decreases due to two reasons.

- At very high temperature, the vaporization of filament decreases the coil diameter so that resistance of the filament increases and hence its draws less current from the supply, so the temperature of the filament and the light output of the bulb decrease.
- The current drawn from the mains and the power consumed by the filament decrease, which decrease the efficiency of the lamp with the passage of time. In addition, the evaporation of the filament at high temperature blackens the inside of the bulb.

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