E-NOTES
FOR
UTILIZATION OF ELECTRICAL ENERGY(UEE)

Sem: 6th

Branch: EE

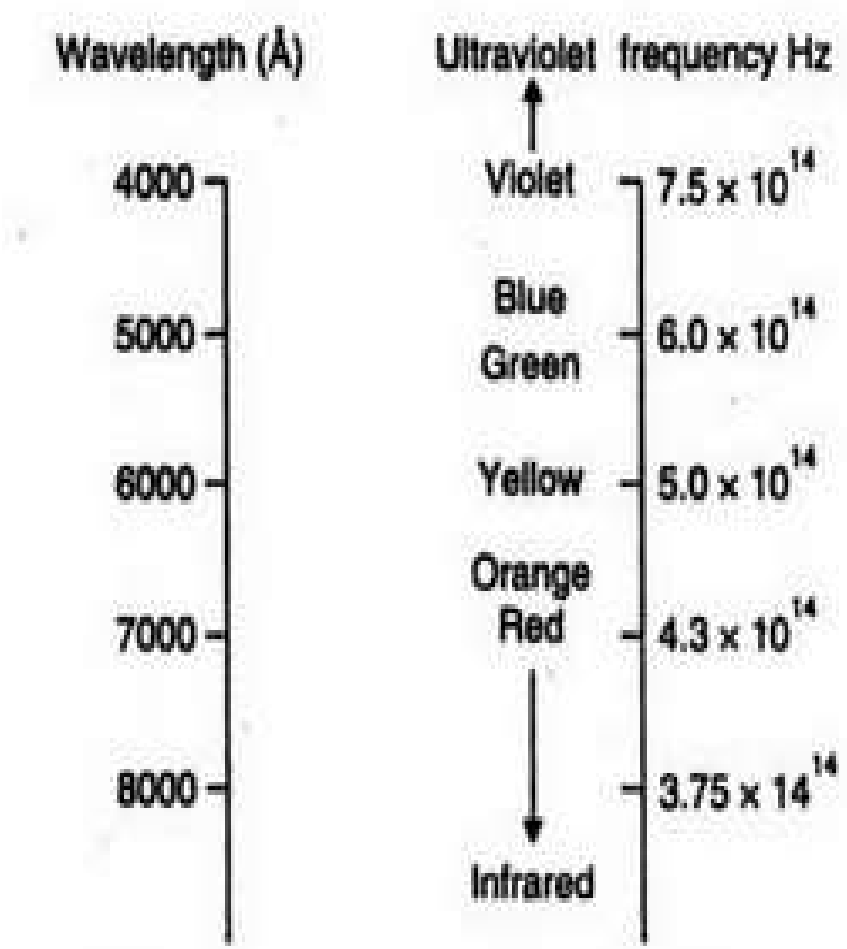
ELECTRICAL ENGINEERING DEPARTMENT

GOVT. POLYTECHNIC, HISAR

Nature of light

- Light is a form of radiant energy. Various forms of incandescent bodied are the sources of light and the light emitted by such bodies depend upon the temperature of bodies.
- Heat energy is radiated into the medium by a body which is hotter than the medium surrounding it.
- The heat of the body can be classified as red hot or white-hot.
- While the body is red-hot the wave length of radiated energy will be sufficiently large and the energy available is in the form of heat.
- When the temperature increases the body changes from red-hot to white-hot state, the wave length of the energy radiated becomes smaller and smaller and enter into the range of the wave length of the light.

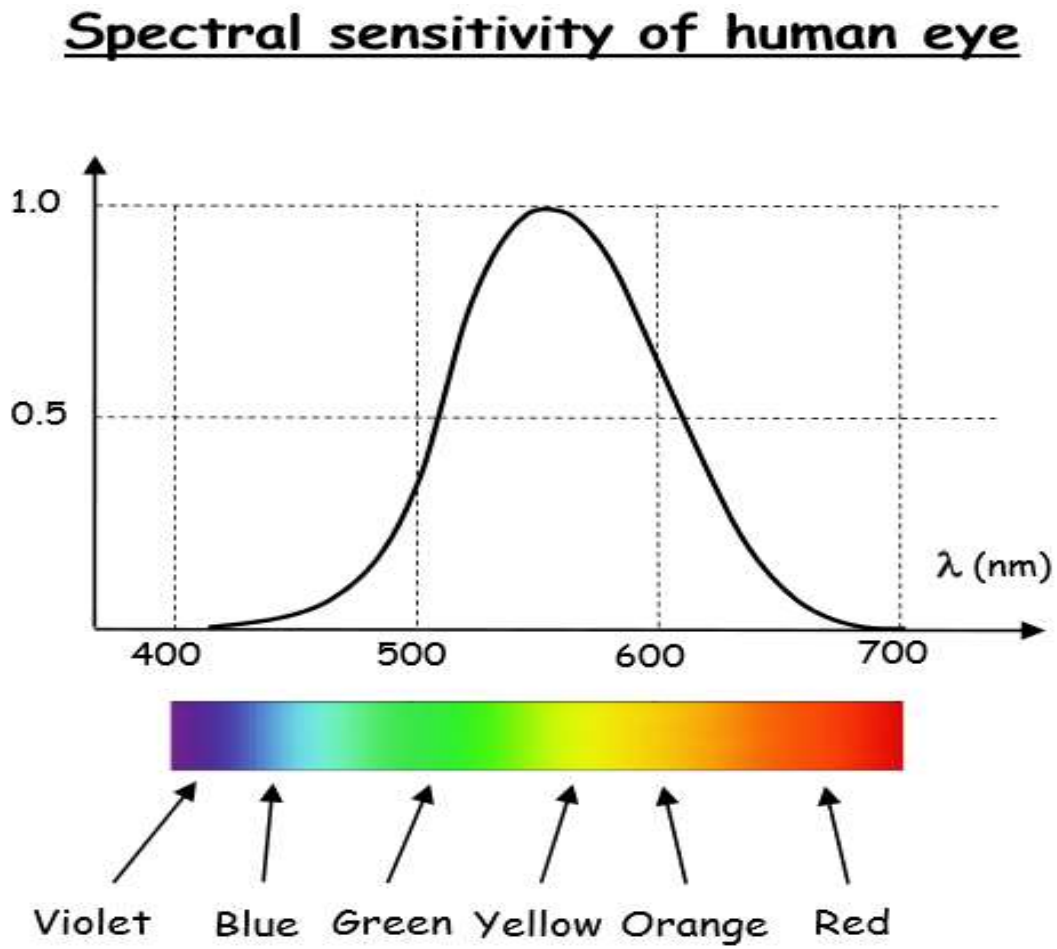
Wavelength & Colour of Light



Sensitivity of human eye

- The sensitivity of the eye to the lights of different wave lengths varies from person to person and according to the age.
- The average relative sensitivity is shown in the fallowing figure.
- The high have greatest sensitivity for wave lengths of about 5,500A: that is yellow-green can be seen under such poor conditions of illumination when blue or red can not be see under dim illumination

Sensitivity of human eye



Terms used in illumination

1. Luminous flux:

- It is defined as the total quantity of light energy emitted per second form a luminous body.
- It is represented by symbol F and is measured in lumens.
- The concept of luminous flux helps us to specify the output and efficiency of a given light source

2. Solid angle:

- Plane angle is subtended at a point in a plane by two converging straight lines and its magnitude is given by

$$\text{Solid angle } \Omega = \frac{A}{r^2}$$

Terms used in illumination

3. Luminous intensity:

- Luminous intensity in any given direction is the luminous flux emitted by the source per unit solid angle, measured in the direction in which the intensity is required.
- It is denoted by symbol I and is measured in candela(cd) or lumens/steradian.

4. Illumination:

- Illumination differs from light every much, though generally these terms are used more or less synonymously.
- light is the cause and illumination is the result of that light on surfaces on which it falls.
- Thus the illumination makes the surface look more or less bright with certain colour and it is this brightness and colour which the eye sees

Terms used in illumination

5. Luminous efficiency:

- **Luminous efficacy** is a measure of how well a **light** source produces visible **light**.
- It is the ratio of **luminous** flux to power, measured in lumens per watt in the International System of Units (SI).

6. Depreciation factor:

- This is merely reverse of the maintenance factor and is defined as the ratio of the initial meter-candles to the ultimate maintained metre-candles on the working plane.

Terms used in illumination

7. Coefficient of utilization:

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

8. Space to height ratio:

- Spacing Height Ratio is defined as the ratio of the distance between adjacent luminaires (centre to centre), to their height above the working plane.

9. Reflection factor:

- When a ray of light impinges on a surface it is reflected from the surface at an angle of incidence, as shown in the fallowing figure.
- A certain portion of incident light is absorbed by the surface.
- The ratio of reflected light to the incident light is called the reflection factor.
- It's value always less than unity.

Terms used in illumination

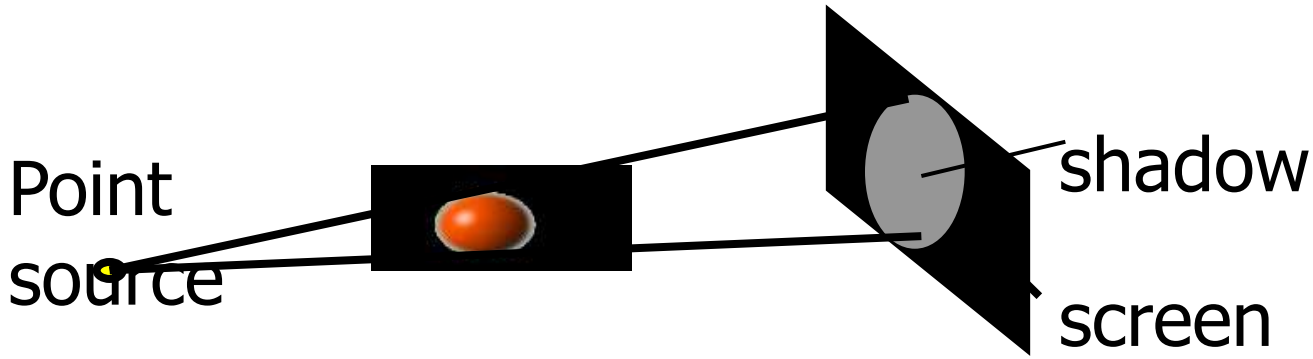
9. Glare:

- The size of the opening of the pupil in the human eye is controlled by its iris.
- If the eye is exposed to a very bright source of light the iris automatically contacts in order to produce the amount of light admitted and prevent damaged to retina this reduces the sensitivity, so that other objects within the field of vision can be only imperfectly seen.

10. Shadow:

- A certain amount of shadows is desirable in artificial lighting as it helps to give shape to the solid objects and makes them easily recognized.
- Objects illuminated by shadow less light appear flat and uninteresting, contours are lost and it is difficult for the eye to form a correct judgment of the shape of an object.

Terms used in illumination



11. Lux:

- Illumination of a surface is defined as the luminous flux received by the surface per unit area. It is represented by the symbol ‘E’ and is measured in lux (or lumen/m^2)

Laws of Illumination

There are two laws of illumination:

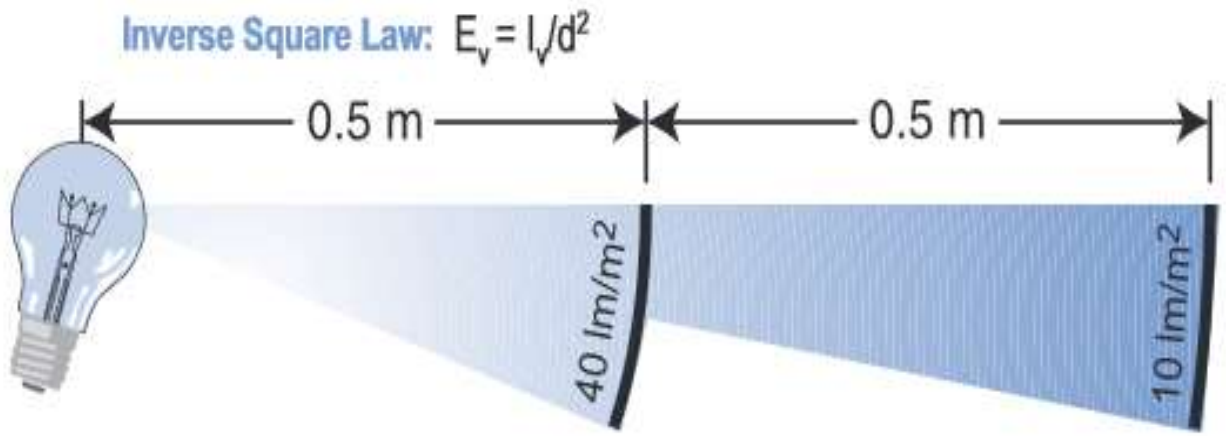
(a) Law of inverse squares

(b) lamberts cosine law

(a) Law of inverse squares

- As a surface that is illuminated by a light source moves away from the light source, the surface appears dimmer. In fact, it becomes dimmer much faster than it moves away from the source. The inverse square law, which quantifies this effect, relates illuminance (Ev) and intensity (Iv) as follows:
- $Ev = Iv/d^2$
- Where d = the distance from the light source

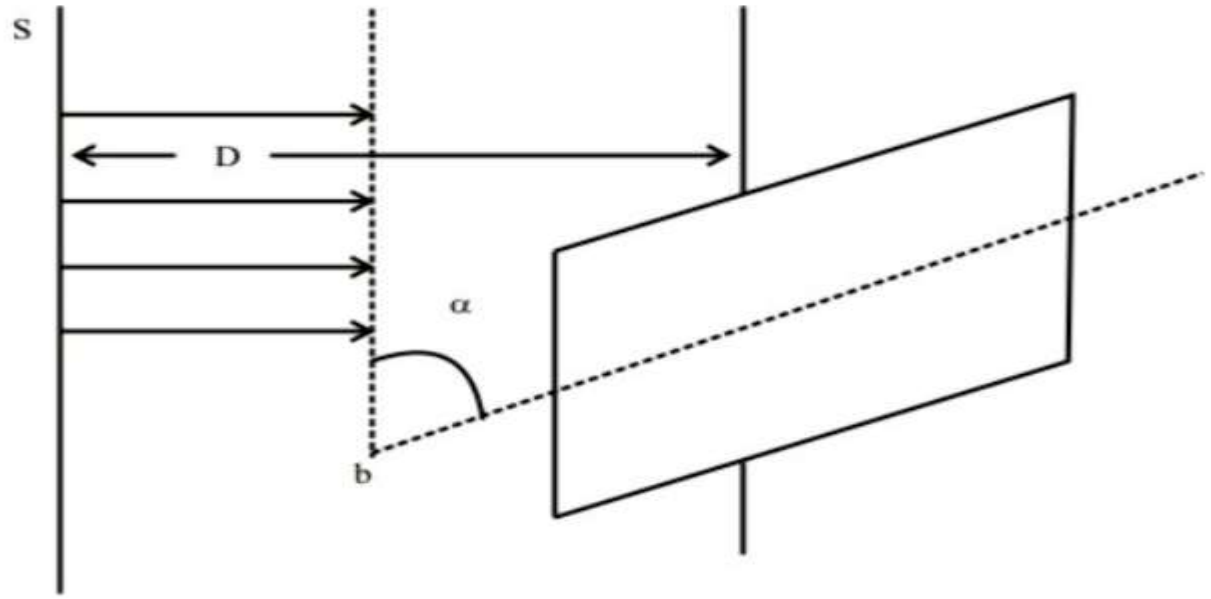
Laws of Illumination



(b) Lambert's Cosine Law:

- Lambert's cosine law states that the illumination falling on any surface depends on the cosine of the light's angle of incidence.

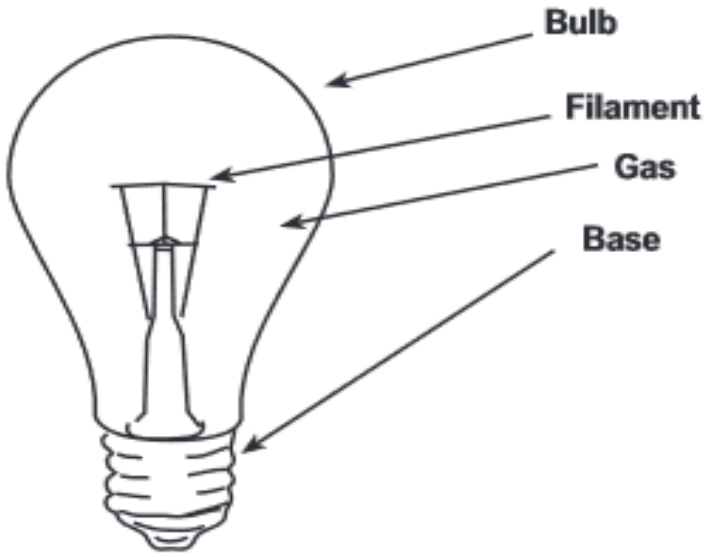
Laws of Illumination



As per lambert cosine law, $E = \frac{I \cos \propto}{D^2}$

Incandescent Lamp

- Incandescent lamp technology uses electric current to heat a coiled tungsten filament to incandescence.
- The glass envelope contains a mixture of nitrogen and a small amount of other inert gases such as argon.
- Below figure shows the construction of a typical incandescent lamp:



Discharge lamps

- Discharge lamps produce light by passing an electric current through a gas that emits light when ionized by the current.
- An auxiliary device known as a ballast supplies voltage to the lamp's electrodes, which have been coated with a mixture of alkaline earth oxides to enhance electron emission.

Discharge lamp:

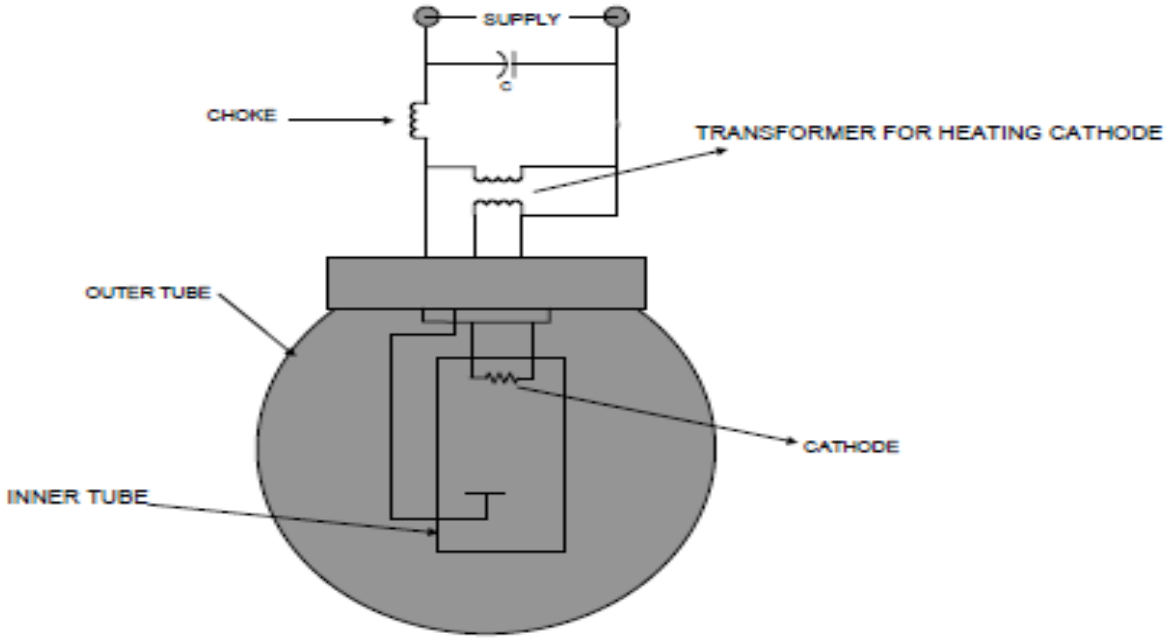
(a) Sodium vapour lamp

(b) Mercury Vapour lamps

Sodium vapour lamp

- The lamp consists of a discharge tube having special composition of glass to withstand the high temperature of the electric discharge.
- The discharge tube is surrounded by an outer tube as shown in fig.
- For heating the cathode a transformer is included.
- Sodium below 600C is in solid state.
- For starting the lamp the electric discharge is allowed to take place in neon gas.
- The temperature inside the discharge tube rises and vaporizes sodium.
- Sodium vapour has the highest theoretical luminous efficiency and gives monochromatic orange-yellow light.

Sodium vapour lamp



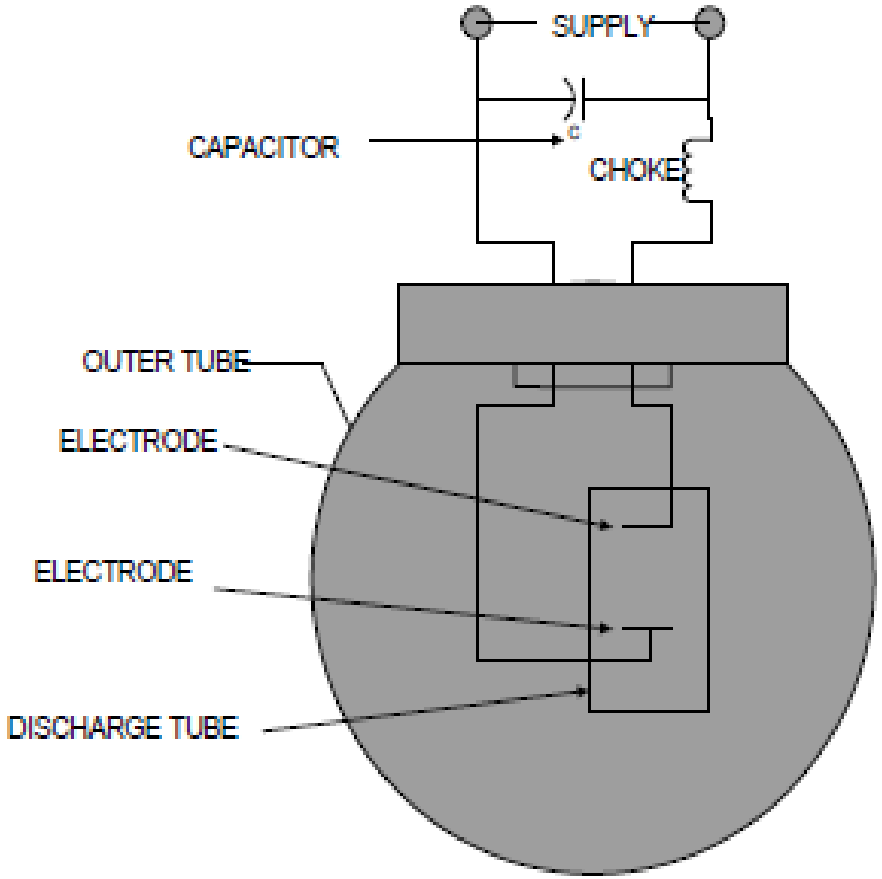
SODIUM VAPOUR LAMP

A choke is provided for stabilizing the electric discharge and a capacitor for power factor improvement.

Mercury Vapour lamps

- It is similar to construction of the sodium vapour lamp.
- The electrodes are tungsten coils containing an electron emitting material, which may be small piece of thorium or an oxide mixture.
- The electric discharge first takes place through argon and this vaporizes the mercury drops inside the discharge tube.
- The electron emitting material supplies electrons to maintain the arc.
- The space between two bulbs is filled with an inert gas.
- Mercury vapour lamps are used for lighting of secondary roads, car parking areas, parks and gardens, factory sheds, etc.

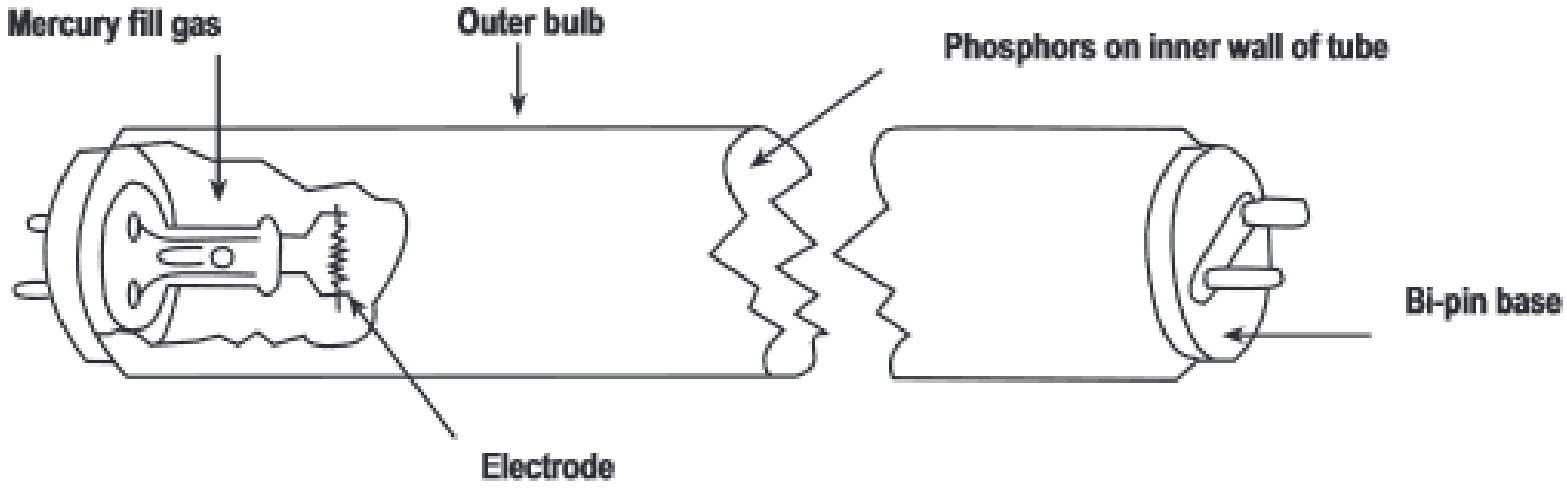
Mercury Vapour lamps



- Xenon may also be used in high-pressure mercury vapor lamps to aid starting time, and does not significantly change the visible spectrum of the lamp

Fluorescent lamp

- In the mercury vapour lamp considerable amount of radiation is in ultra-violate range.
- By coating the inside of the tube by phosphor, this ultra violate radiation is converted in visible light.
- Phosphors have definite characteristic colours, but when mixed together, they produce a large variety of colours.



Halogen lamp

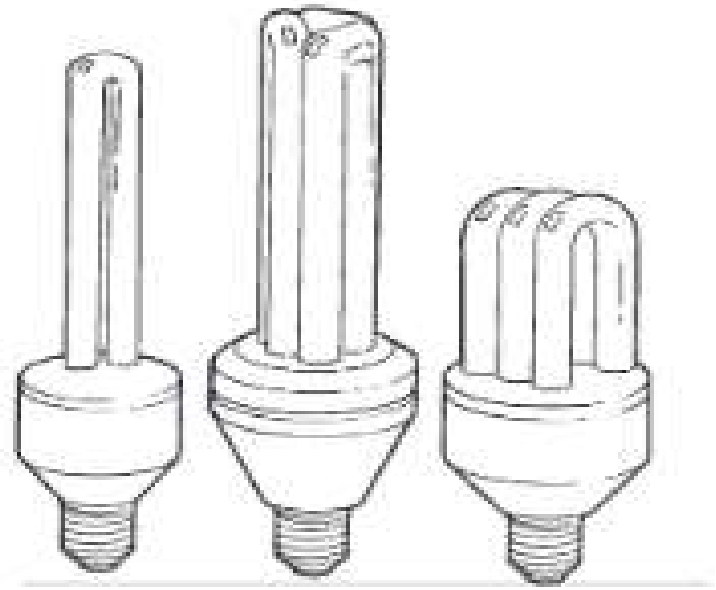
- Unlike incandescent lamps, halogen lamps use a halogen gas fill (typically iodine or bromine), to produce what is called a “halogen cycle” inside the lamp.
- In the halogen cycle, halogen gas combines with the tungsten that evaporates from the lamp.
- Halogen lamps are sometimes called “quartz” lamps because their higher temperature requires quartz envelopes instead of the softer glass used for other incandescent lamps.
- The bulb wall remains cleaner, because the evaporated tungsten is constantly re-deposited on the filament by the halogen cycle. This allows the lamp to maintain lumen output throughout its life

Neon lamp

- It is cold cathode lamp and consists of a gas bulb filled with a neon gas with a small percentage of helium.
- These lamps give to orange pink colored light.
- Electrodes are of pure iron and are spaced only few mm apart so that lamp can be made for voltages as low as 110 volts a.c. or 150 volts d.c.
- For use on a.c. the electrodes are of equal size. On d.c. the gas glows near the negative electrode, therefore negative electrode is larger in size.
- The efficiency of neon lamp lies between 15-40 lumens/watt.
- The lamp of this type is of the size of an ordinary incandescent lamp.
- The power consumption is of the order of 5watts.

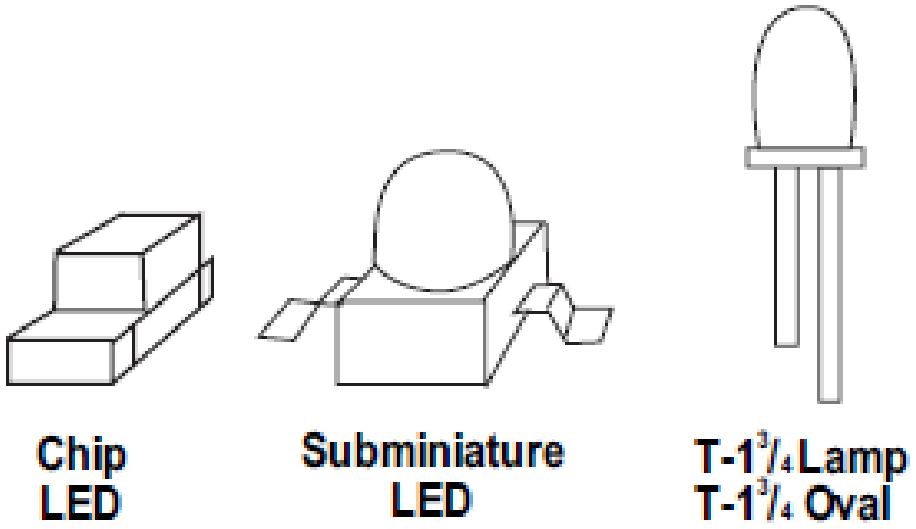
Compact Filament Lamp (CFL)

- CFLs produce light in the same manner as linear fluorescent lamps.
- Their tube diameter is usually 5/8 inch (T5) or smaller.
- CFL power ranges from 5 to 55 watts.
- Figure shows several styles of CFLs.



LED Lamp

- LEDs are solid-state semiconductor devices that convert electrical energy directly into light.
- LEDs can be extremely small and durable; some LEDs can provide much longer lamp life than other sources.



Comparison of fluorescent & incandescent lamps

Tungsten Filament Lamp	Fluorescent Tubes
Voltage fluctuation has comparatively more effect on the light output.	Voltage fluctuation has comparatively low effect on light output as the variations in voltage are absorbed in the choke.
Luminous efficiency increases with the increase in the voltage of the lamp.	Luminous efficiency increases with the increase in wattage and increase in length of tube.
It gives light close to natural light. Therefore objects are properly seen	It does not give light close to natural light, therefore, colour rendering is defective.
Due to comparatively high working temperature heat radiations are also present.	Due to low working temperature heat radiation is low.
Its brightness is more.	Its brightness is less.
The initial cost per lamp is quite low.	The initial cost per tube is more.

Calculation of number of light points for interior illumination

The number of lamps required in a particular place can be designed by following three methods:

1. **Watt per square meter:** This is a rough method. Watts per square meter are calculated on the basis of efficiency of lamp (lm/watt).
2. **Inverse square law:** This method is used in street light calculations. In this method law of illumination is used for this candle power of the lamps should be known.
3. **Lumen per square meter method:** This method is used for design of general lighting. In this method, lamp efficiency, Depreciation factor, utilization factor etc. are used.

Illumination schemes

The interior lighting schemes may be classified as (i) direct lighting (ii) semi-direct lighting (iii) semi-indirect lighting (iv) indirect lighting

(i) Direct lighting:

- It is most commonly used type of lighting scheme.
- In this lighting scheme more than 90 % of total light flux Is made to fall directly on the working plane with the help of deep reflectors.
- Though it is most efficient but causes hard shadows and glare.
- It is mainly used for industrial and general out door lighting.

(ii) Semi-direct lighting:

- In this lighting scheme 60-90 % if the total light flux is made to fall down wards directly with the help of semi-direct reflectors, remaining light is used to illuminate the ceiling and walls.

Illumination schemes

- Such a lighting system is best suited to rooms with high ceiling where a high level of uniformly distributed illumination is desirable.

(iii) Semi-indirect lighting:

- In the lighting scheme 60-90 % of total light flux is thrown upwards to the ceiling for defuse reflection and the rest reaches the working plane directly except for some absorption by the bowl.
- It is mainly used for indoor light decoration purposes.

(iv) Indirect lighting:

- In this light scheme more than 90% if total light flux is thrown upwards to the ceiling for diffuse reflection by using inverted or bowl reflectors.
- In such a system the ceiling acts as the light source, and the glare is reduced to minimum.

Main requirements of proper lighting

The following factors are required to be considered while designing the lighting schemes:

(I) Illumination Level :

- This is the most vital factor because a sufficient illumination is the basic means where by we are able to see our surroundings.
- For each type of work there is a range of brightness most favorable to output i.e which causes minimum fatigue and gives maximum output in terms of quality and quantity.

(ii) Uniformity of illumination :

- The human eye adjusts itself automatically to the brightness within the field of vision. If there is a lack of uniformity, pupil or iris of the eye has to adjust more frequently and thus fatigue is caused to the eye and productivity is reduced.

Main requirements of proper lighting

(iii) Colour of light :

- The appearance of the body colour entirely depends upon the colour of the incident light. In general the composition of the light should be such that the colour appears natural i. e . its appearance by artificial light is not appreciable different from that by day light.

(iv) Shadows:

- In lighting installations, formation of long and hard shadows causes faigue of eyes and therefore is considered to be a short-coming.
- Hard and long shadows can be avoided by (i) using large no of small luminaries mounted at height not less than 2.5 meters and (ii) by using wide surface sources of light using globes over filament lamps or by using indirect lighting system.

Main requirements of proper lighting

(v)Glare :

- It may be direct or reflected i.e it may come directly from the light source or it may be reflected brightness such as from a desk top, nickeled machine parts.
- Direct glare from a source of light is the more common, and is more often a hindrance to vision.

Street lighting

The main objectives of street lighting are

(i) To make the traffic and obstructions on the road clearly visible in order to promote safety and convenience.

(ii) To make the street more attractive.

(iii)To increase the community value of the street.

- The principle employed for street lighting is different from that of interior lighting. There are no walls and ceiling which reflect or diffuse light, hence only direct lighting scheme can be employed and hard shadows and high contrast can not be avoided.
- Mercury vapour and sodium discharge lamps have been found to have certain particular advantages for street lighting purposes. The most important of these low power consumption for a given amount of light.

Flood lighting

- Flood light means flooding of large surfaces with light from powerful projectors.
- It is employed to serve one or more of the following purposes.

I. For enhancing beauty of building at night such as public places, ancient buildings.

II. For illuminating railway yards, sports stadiums, car parks, constructions sites, quarries etc.

III. Flood lighting it is necessary to concentrate the light from the light source into a narrow beam. The particular type of reflector and its housing used for concentrating the light into narrow beam is known as flood light projection.

Advantages of electrical heating

The various advantages of electric heating over other the types of heating are:

(i) Economical: Electric heating equipment is cheaper; they do not require much skilled persons; therefore, maintenance cost is less.

(ii) Cleanliness: Since dust and ash are completely eliminated in the electric heating, it keeps Surroundings cleanly.

(iii) Pollution free: As there are no flue gases in the electric heating, atmosphere around is pollution free; no need of providing space for their exit.

(iv) Ease of control: In this heating, temperature can be controlled and regulated accurately either manually or automatically.

(v) Uniform heating: With electric heating, the substance can be heated uniformly, throughout whether it may be conducting or non-conducting material.

Advantages of electrical heating

(vi) High efficiency: In non -electric heating, only 40-60% of heat is utilized but in electric heating 75-100% of heat can be successfully utilized. So, overall efficiency of electric heating is very high.

(vii) Automatic protection: Protection against over current and overheating can be provided by using fast control devices.

(viii) Heating of non-conducting materials: The heat developed in the non-conducting materials such as wood and porcelain is possible only through the electric heating.

Resistance heating

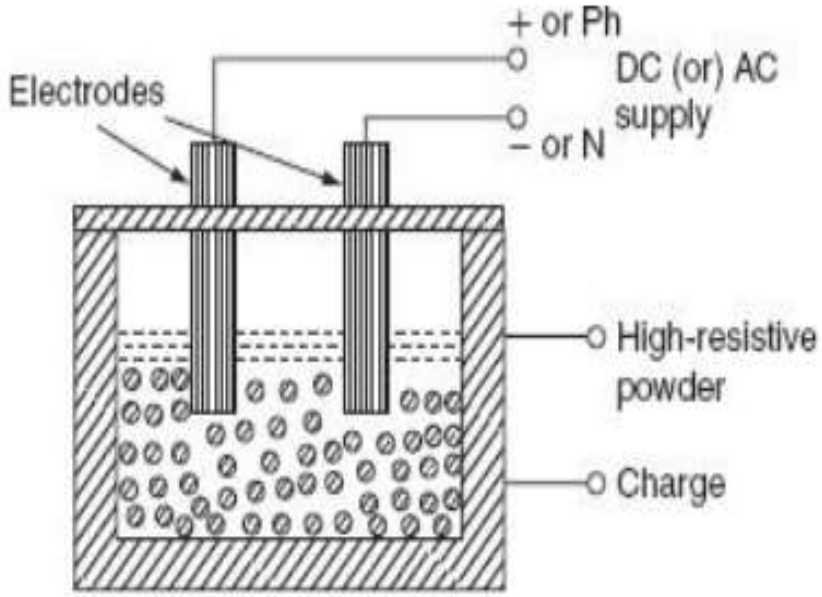
- This method is based upon the I^2R loss.
- Whenever current is passed through a resistive material heat is produced because of I^2R loss.
- There are two methods of resistance heating. They are:

(i) Direct Resistance heating and

(ii) Indirect Resistance Heating

(i) Direct Resistance heating:

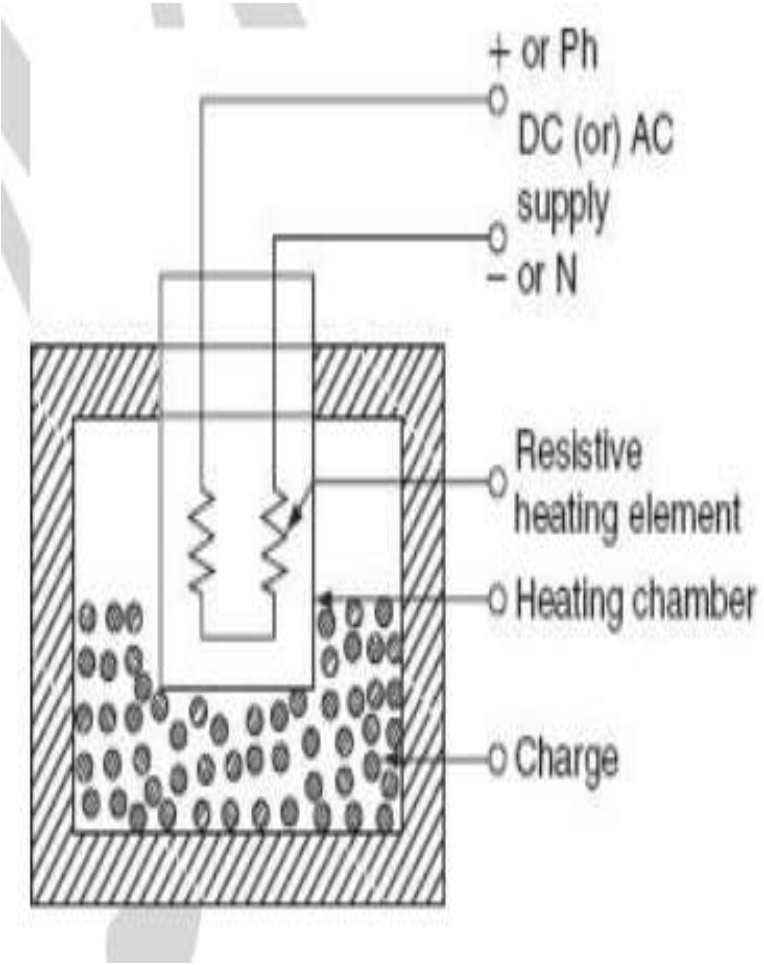
In this method, electrodes are immersed in a material or charge to be heated. The charge may be in the form of powder, pieces, or liquid. The electrodes are connected to AC or DC supply as shown in Fig.



Resistance heating

(ii) Indirect Resistance Heating:

In this method of heating, electric current is passed through a wire or other high resistance material forming a heating element. The heat proportional to I^2R loss produced in the heating element is delivered to the charge by one or more of the modes of transfer of heat i.e. conduction, convection and radiation. If the heat is transferred by conduction the resistor must be in contact with the charge.

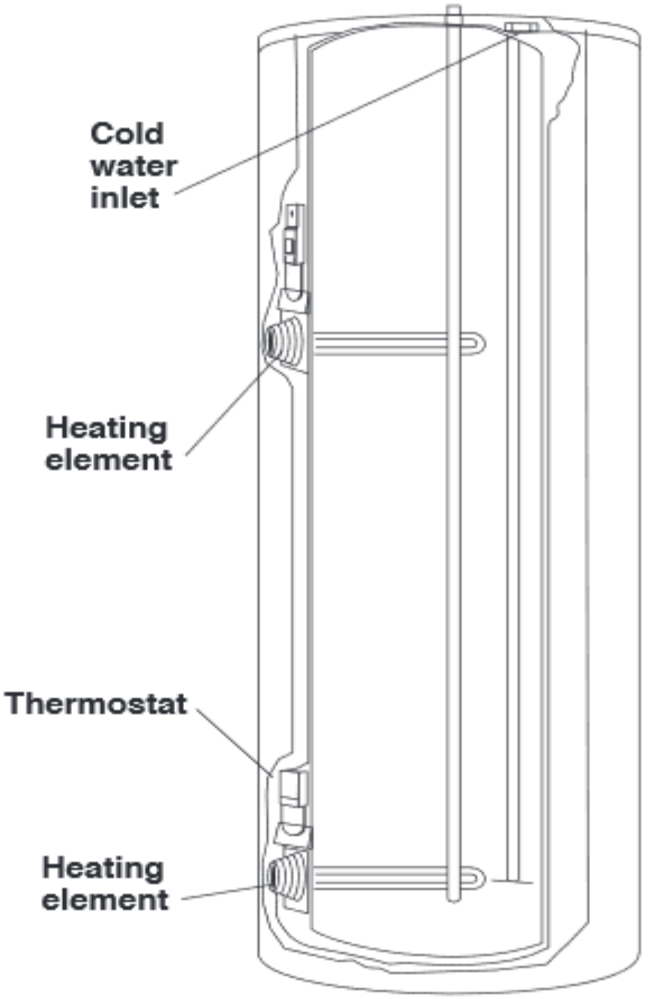


Electric ovens

- It essentially consists of a high resistive material through which an electric current is passed placed in a chamber made of heat insulating material.
- The element may be in the form of strip or wire and is placed on the top, bottom of the oven depending upon circumstances.
- Resistance ovens are used for various purposes such as heat treatment of metals, drying, backing of pottery materials, cooking of food e.t.c.
- The temperature of oven can be controlled by controlling (i) voltage or current (ii) time and (iii) resistance.
- The automatic control of temperature can be obtained by providing thermostat which will operate a switch to OFF or ON the circuit as soon as the temperature exceeds or fall below the adjusted value.

Domestic water heaters

- Most of electric water heating is done by immersion heaters which consists of resistance coils placed in slotted cylinders of ceramic material. The material used for resistance coils is nichrome wire coated with magnesium oxide for preventing oxidation of the element which heats up the water due to I^2R loss in it.



Properties of resistance heating elements

1. **Low temperature coefficient:** Heating element should have low temperature coefficient so that with change in temperature the resistance of heating element should not very too much. A material with high temperature coefficient will draw large starting current.
2. **High melting point:** Melting point of heating element should be high so that it can achieve high temperature in order to heat the charge.
3. **Free from oxidation:** The heating element should not oxidized at high temperature otherwise it will have to be changed frequently.
4. **High resistivity:** The heating element of high resistivity will be able to produce required amount of heat even with small length of wire.

Induction heating

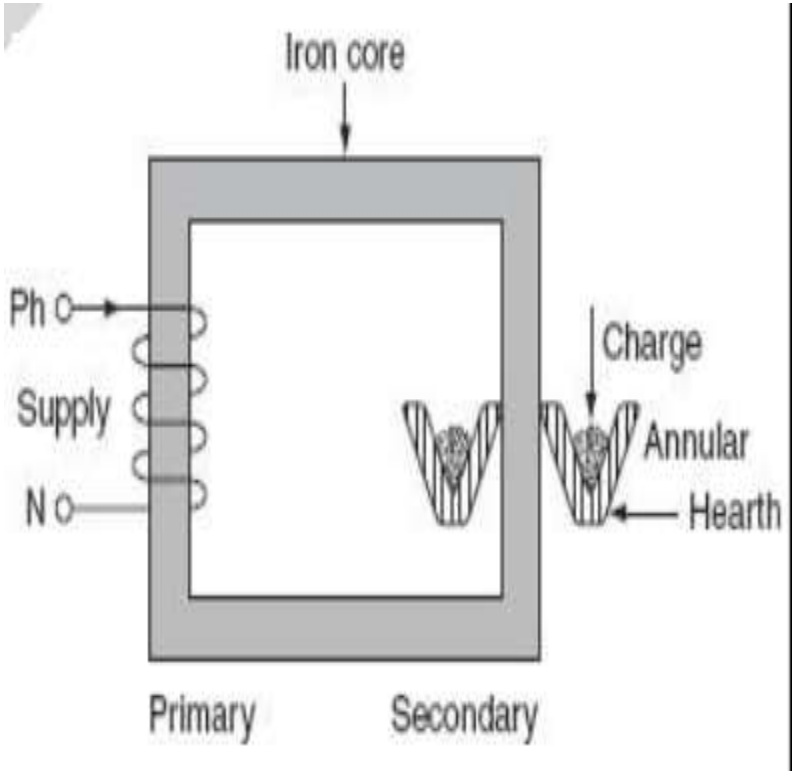
- Induction heating is based on the principle of transformers.
- There is a primary winding through which an a.c current is passed.
- The coil is magnetically coupled with the metal to be heated which acts as secondary.
- An electric current is induced in this metal when the a.c current is passed through the primary coil.
- The following are different types of induction furnaces:

1.Core type (low frequency) induction furnaces.

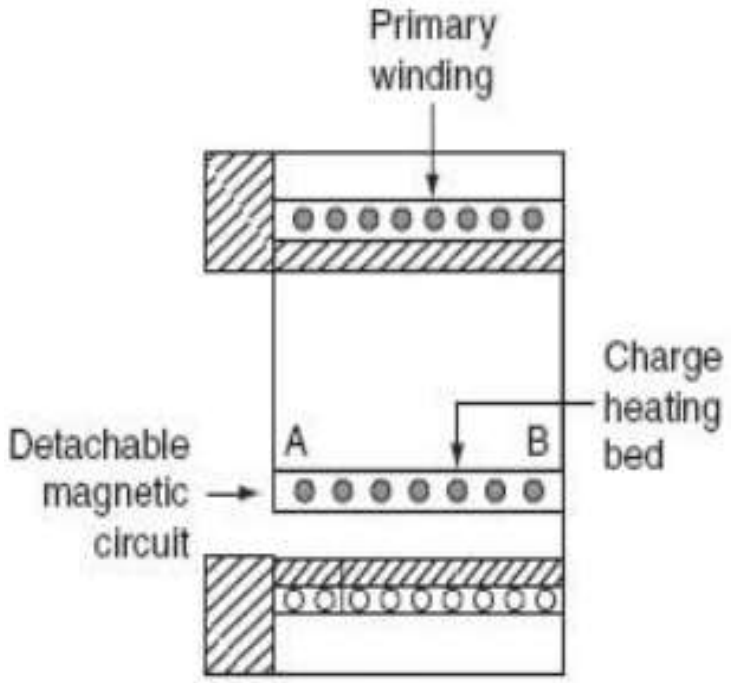
2.Coreless type (high frequency) induction furnaces

Core type (low frequency) induction furnaces

1. **Direct Core type induction furnaces:**

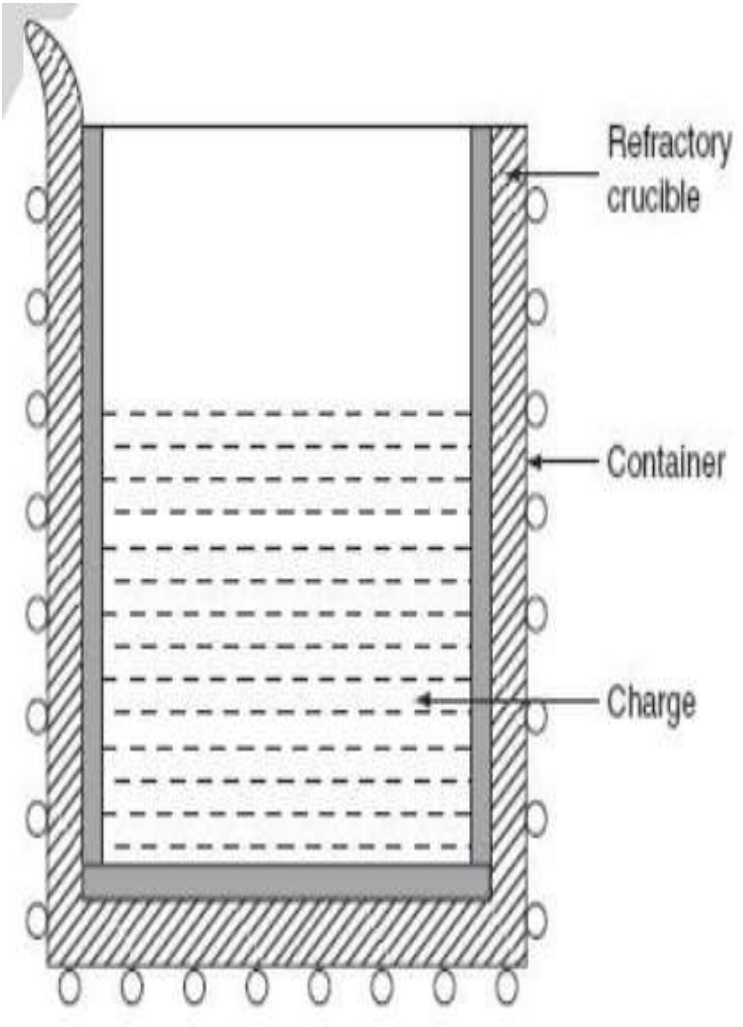


2. **Indirect Core type induction furnaces:**



Coreless type induction furnace

- In this furnace, heat developed in the charge due to eddy currents flowing through it.
- When primary coils are excited by an alternating source, the flux set up by these coils induce the eddy currents in the charge. The direction of the resultant eddy current is in a direction opposite to the current in the primary coil. These currents heat the charge to melting point and they also set up electromagnetic forces that produce a stirring action to the charge.



Electric arc heating

The heating of matter by an electric arc. The matter may be solid, liquid, or gaseous. When the heating is direct, the material to be heated is one electrode; for indirect heating, the heat is transferred from the arc by convection, or radiation.

Electrodes used in arc furnaces:

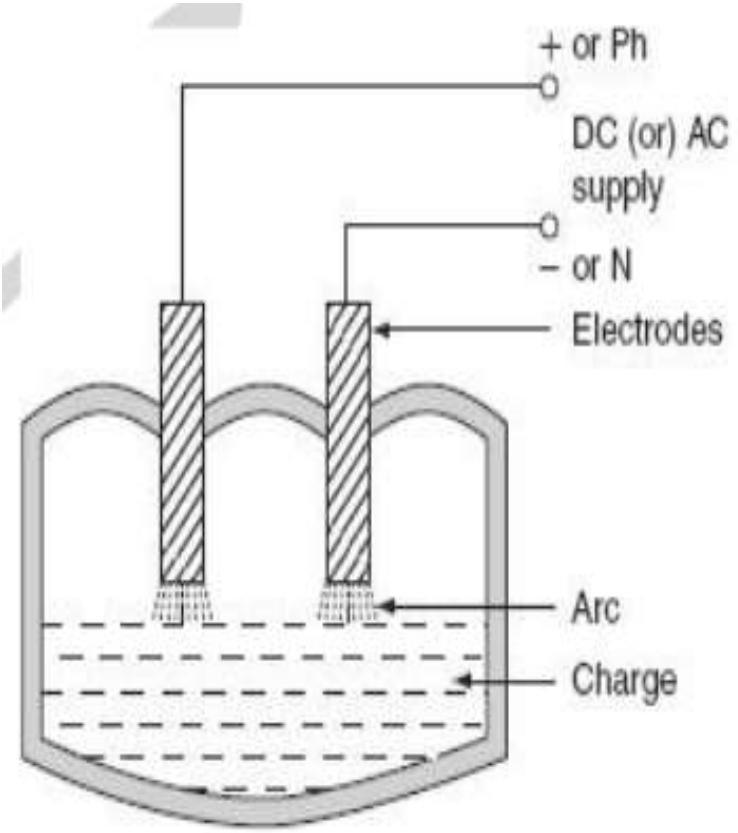
1. Carbon electrodes
2. Graphite electrodes
3. Self-baking electrodes

Types of arc heating furnaces:

1. Direct arc furnaces
2. Indirect arc furnaces

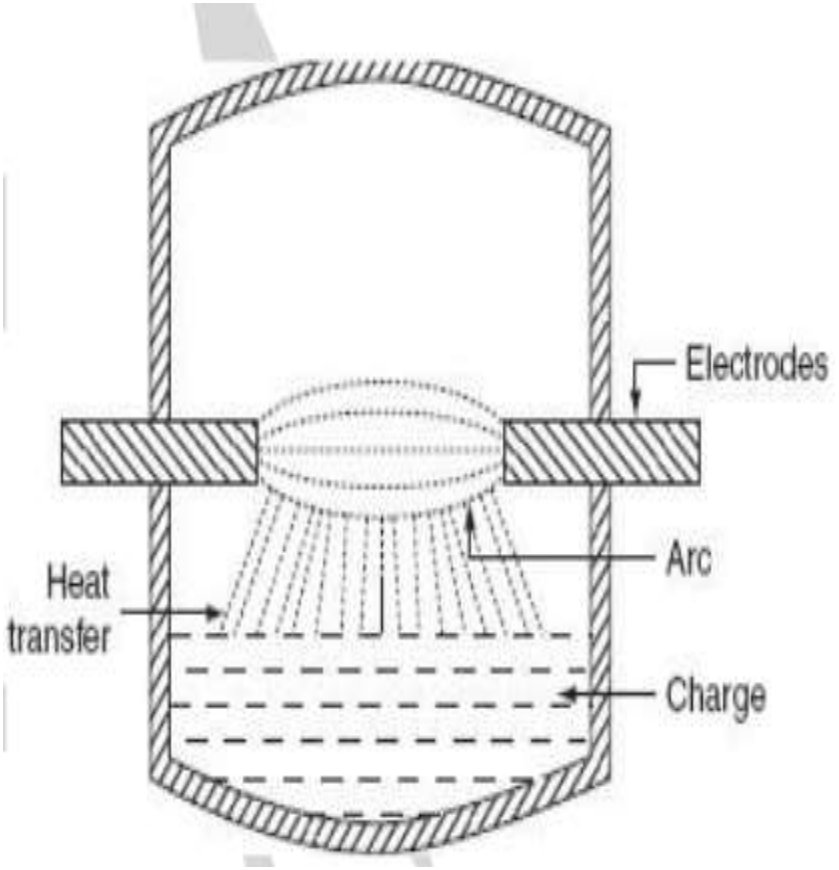
Direct arc furnaces

- When supply is given to the electrodes, two arcs are established and current passes through the charge, as shown in Fig. As the arc is in direct contact with the charge and heat is also produced by current flowing through the charge itself, it is known as direct arc furnace.
- The most important feature of the direct arc furnace is that the current flows through the charge



Indirect arc furnaces

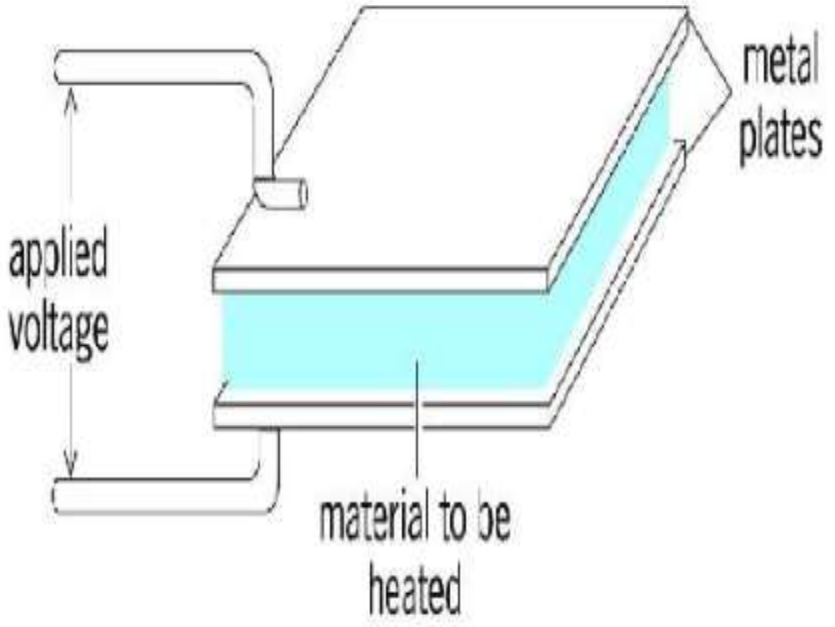
- In indirect arc furnace, the arc strikes between two electrodes by bringing momentarily in contact and then with drawing them heat so developed, due to the striking of arc across air gap is transferred to charge is purely by radiation. The
- charge in this furnace is heated not only by radiation from the arc between electrode tips but also by conduction from the heated refractory during rocking action; so, the efficiency of such furnace is high.



Dielectric heating

Principle of Dielectric heating:

- When a capacitor is subjected to a sinusoidal voltage, the current drawn by it is never leading the voltage by exactly 90º.
- The angle between the current and the voltage is slightly less with the result that there is a small in-phase component of the current which produces power loss in the dielectric of the capacitor.



Infra-red heating & Solar Heating

- In this method of heating, heating elements consist of tungsten filament lamps together with reflectors to direct the whole of heat emitted on to charge (material to be heated).
- The lamps are operated at 2300 degree celcius there by giving a large amount of infrared radiations and the reflectors are plated with rhodium which prevents the leakage of heat through the chamber. The lamps used are rated between 250-11,000 watts as 250V.

Solar Heating:

In solar water heating collectors capture and retain heat from the sun. This heat is then transferred to a liquid. Heating of the sun trapped using the green house effect. Solar radiation is energy in the form of electromagnetic radiations from the infrared to the ultraviolet.

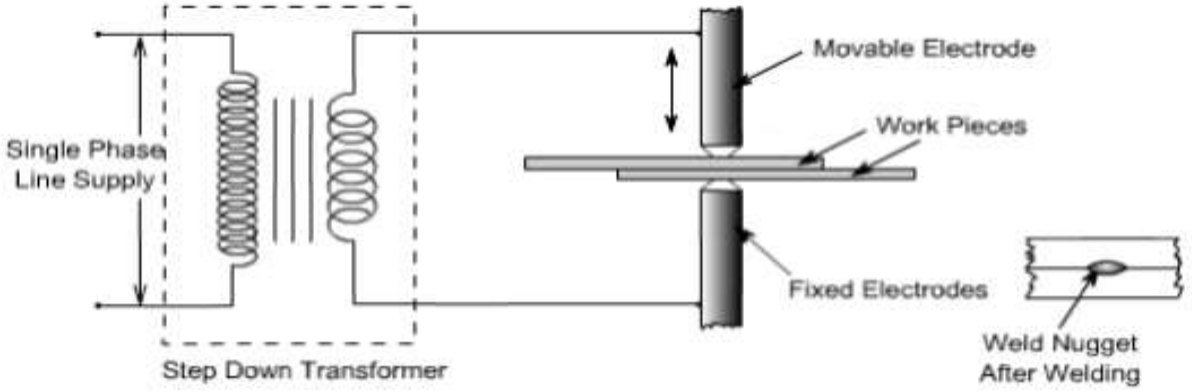
Electric Welding

Advantages of electric welding:

- **Uniform weld**: A uniform weld is obtained by using electric welding methods
- **Flexibility**: Electric welding can be carried out at any desired place.
- **Economical**: Losses are less in electric welding, hence it is cheaper and economical method.
- **Quick operation**: Electric welding can be started instantaneously and it does not require any waiting period.
- **High efficiency**: Efficiency of the electric equipment with no rotating parts is very high.

Resistance welding

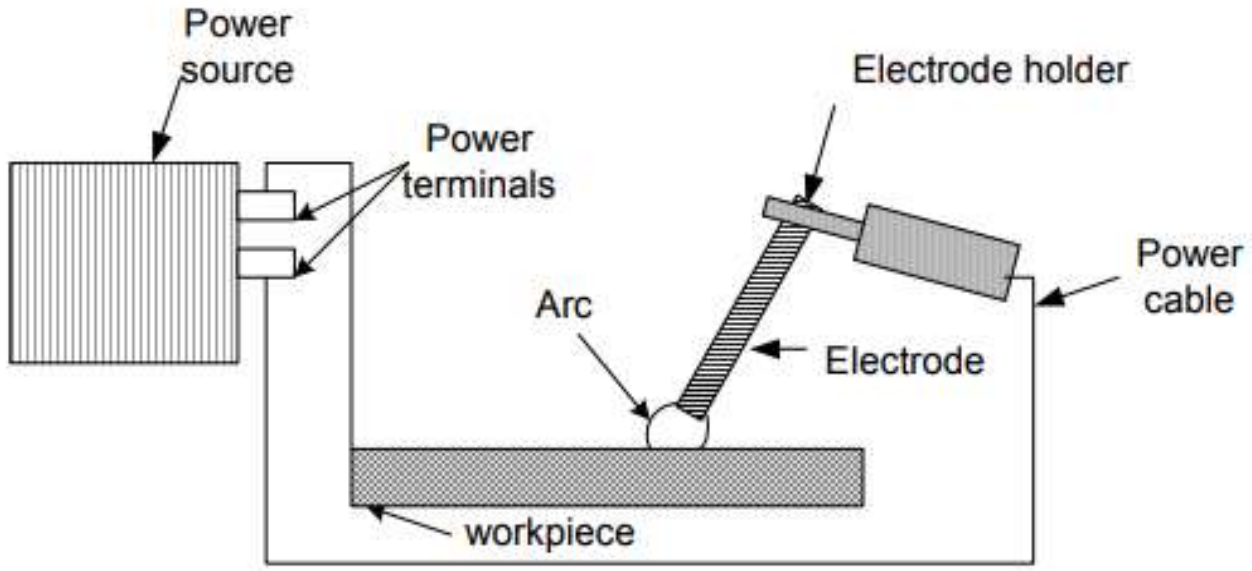
Resistance welding processes are pressure welding processes in which heavy current is passed for short time through the area of interface of metals to be joined. These processes differ from other welding processes in the respect that no fluxes are used, and filler metal rarely used. All resistance welding operations are automatic and, therefore, all process variables are preset and maintained constant. Heat is generated in localized area which is enough to heat the metal to sufficient temperature, so that the parts can be joined with the application of pressure. Pressure is applied through the electrodes.



Principle of Resistance spot Welding

Arc welding

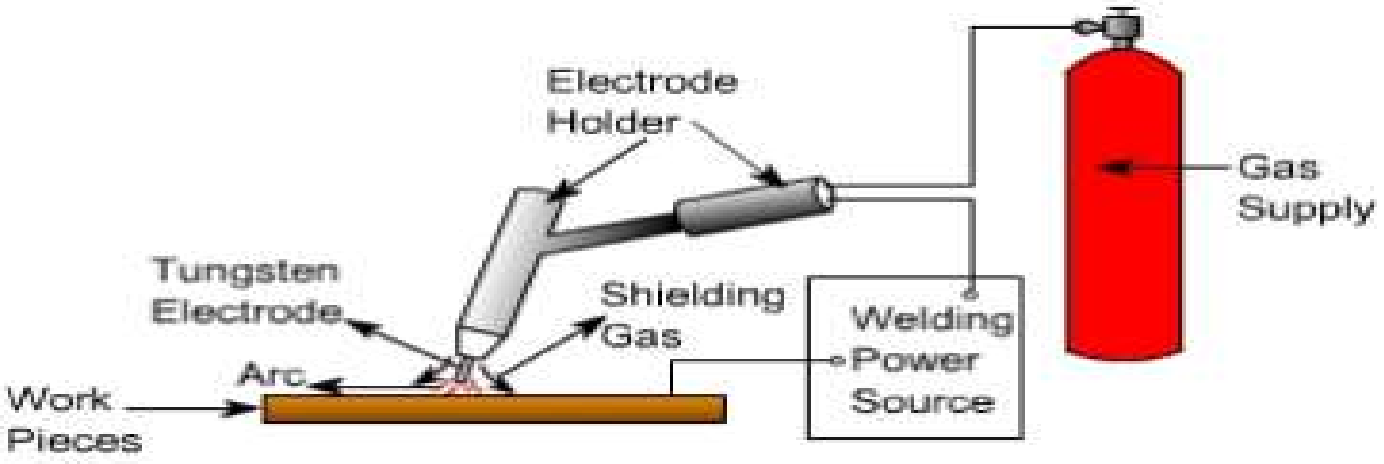
All arc welding processes apply heat generated by an electric arc for melting the faying surfaces of the base metal to develop a weld joint. Common arc welding processes are manual metal or shielded metal arc welding (MMA or SMA), metal inert gas arc (MIG), tungsten inert gas (TIG) etc.



Schematic diagram showing various elements of SMA welding system

TIG Welding

- Tungsten Inert Gas (TIG) or Gas Tungsten Arc (GTA) welding is the arc welding process in which arc is generated between non consumable tungsten electrode and work piece. The tungsten electrode and the weld pool are shielded by an inert gas normally argon and helium.



Schematic Diagram of TIG Welding System.

Advantages of using coated electrodes

- By using flux coated electrode, slag is formed on the surface of the weld which prevents rapid cooling of the weld and does not allow it to become weak and brittle.
- Remove impurities and oxides
- Stabilizing the arc
- Providing a protective atmosphere
- Providing slag of suitable of suitable qualities

Thank You