1.5 TYPES OF LAMPS

According to principle of operation the light sources may be grouped as follows.

- Arc Lamps
- High Temperature Lamps
- Gaseous discharge Lamps
- Fluorescent type Lamps.

1. Arc lamps

Electric discharge through air provides intense light. This principle is utilized in arc lamps.

2. High temperature lamps

Oil and gas and incandescent filament type lamps, which emit when heated to high temperature.

3. Gaseous Discharge lamps

Under certain conditions, it is possible to pass electric current through a gas or metal vapour, which is accompanied by visible radiations. Sodium and mercury vapours lamps operate on this principle.

4. Fluorescent type lamps:

Certain materials, when exposed to ultra violet rays, transform the absorbed energy into radiations of longer wavelength lying within the visible. This principle is employed in fluorescent lamps.

ARC LAMPS

a) Carbon arc lamp

b) Flame arc lamp

c) Magnetic arc lamp

FILAMENT LAMPS OR INCANDESCENT LAMPS

a) Halogen lamp

b) Cold lamp

FILAMENT DISCHARGE LAMPS

a) Sodium vapour discharge lamp

b) High pressure mercury vapour discharge lamp

c) Neon lamp and Neon tube lamp

FLUORESCENT LAMPS

a) Mercury Iodide lamp

b) Neon lamp

c) Neon tube

d) Fluorescent tube

INCANDESCENT LAMP

The electrical light source which works on the principle of incandescent phenomenon is called **Incandescent Lamp**. In other words, the lamp works due to glowing of the filament caused by electric current through it, is called **incandescent lamp**.

How do Incandescent Lamps Work?

When an object is made hot, the atoms inside the object become thermally excited. If the object is not melting the outer orbit electrons of the atoms jump to higher energy level due to the supplied energy. The electrons on these higher energy levels are not stable they again fall back to lower energy levels. During falling from higher to lower energy levels, the electrons release their extra energy in a form of photons. These photons then emitted from the surface of the object in the form of electromagnetic radiation. This radiation will have different wavelengths. A portion of the wavelengths is in the visible range of wavelengths, and a significant portion of wavelengths are in inferred range. The electromagnetic wave with wavelengths within the range of inferred is heat energy and the electromagnetic wave with wavelengths within visible range is light energy. Incandescent means producing visible light by heating an object. An incandescent lamp works in the same principle. The simplest form of the artificial source of light using electricity is an incandescent lamp. Here we use electric current to flow through a thin and fine filament to produce visible light. The current rises the temperature of the filament to such extent that it becomes luminous.

Working Principle and Construction of Incandescent Lamp

The filament is attached across two lead wires. One lead wire is connected to the foot contact and other is terminated on the metalic base of the bulb. Both of the lead wires pass through glass support mounted at the lower middle of the bulb. Two support wires also attached to glass support, are used to support filament at its middle portion. The foot contact is isolated frommetalic base by insulationmaterials. The entire system is

encapsulated by a colored or phasphare coated or transparent glass bulb. The glass bulb may be filled with insert gases or it is kept vacuum depending upon rating of the incandescent lamp. The filament of **incandescent lamps** is air-tightly evacuated with a glass bulb of suitable shape and size. This glass bulb is used to isolate the filament from surrounding air to prevent oxidation of filament and to minimize convention current surround the filament hence to keep the temperature of the filament high. The glass bulb is either kept vacuum or filled with inert gases like argon with a small percentage of nitrogen at low pressure. Inert gases are used to minimize the evaporation of filament during service of the lamps. But due to convection flow of inert gas inside the bulb, there will be greater chances of losing the heat of filament during operation. Again, vacuum is a great insulation of heat, but it accelerates the evaporation of filament during operation. In the case of gas-filled incandescent lamps, 85 % of argon mixed with 15 % of nitrogen is used. Occasionally krypton can be used to reduce filament evaporation because the molecular weight of krypton gas is quite higher. But it costs greater. At about 80 % of atmospheric pressure, the gasses are filled into the bulb. Gas is filled in the bulb with the rating more than 40 W. But for less than 40 W bulb; there is no gas used. The various parts of an incandescent lamp are shown below.

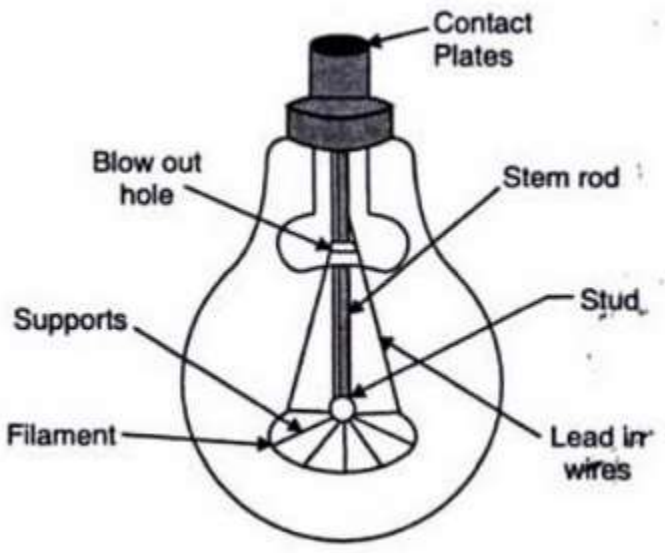

Figure 1.5.1 Incandescent lamp

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 26]

HIGH PRESSURE SODIUM LAMPS or (HPS LAMPS)

It is very difficult to get any material which is free from corrosion in presence of sodium vapour in high temperature and pressure. This was the main difficulty of producing high pressure sodium lamp shown in figure 1.5.2. In 1959, the development of polycrystalline alumina (PCA) opened a new path to introduce the high pressure sodium vapor Lamp. As this material is very rarely affected by high pressure and temperature sodium vapour. The first lamp with 400 W, 42000 initial lumens and 6000 hour life first came in the market in 1965. But afterward some improvements made this lamp with 50000 initial lumens with 24000 hours at 10 hours per start. We can get a lamp that has 2.4 times lumens output of its mercury counterpart with same rated life span.

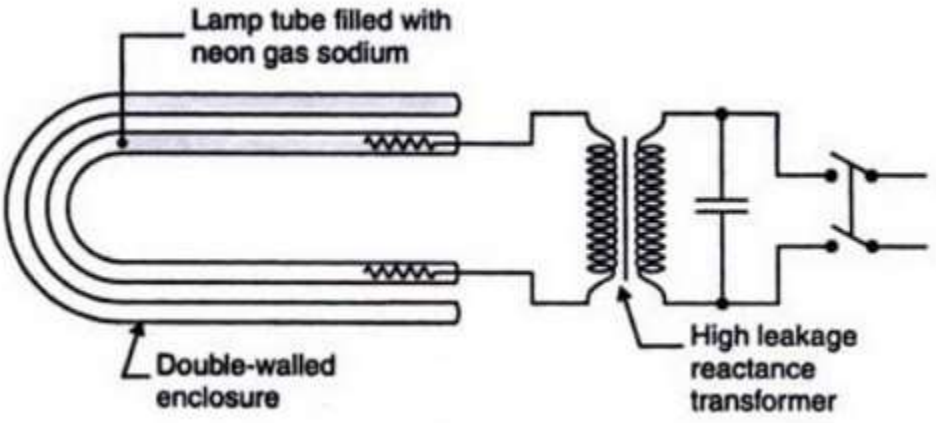

Figure 1.5.2 Sodium vapour lamp

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 32]

It has an inner PCA arc tube that is filled with xenon gas. This xenon gas is used for starting purpose of the lamp as ionization potential of xenon gas is lowest among all other inert gases used for this purpose. In addition to xenon gas sodium mercury amalgam is present in this arc tube, too. In each end, back wound and coated tungsten electrodes are mounted. To seal the tube monolithic seal is used instead of niobium end cap. The arc tube is inserted into a heat resistant outer bulb. It is supported by an end clamp that is floating. This end clamp permits the entire structure to expand contract without distorting. The space between the tube and the bulb is a vacuum space. This vacuum space is needed to insulate heat from the arc tube. Because it is necessary to keep the arc tube at required temperature to sustain arc during normal operation. High pressure sodium lamp has very small diameter (3/8 inch). So, there is no enough space to provide any starting electrode in the arc tube. So higher voltage is required to initiate arc. A ballast with ignitor is used

for this purpose. High voltage is fed to the lamp from the ballast by using the phenomenon of superimposing a low energy high voltage pulse. Generally, a typical pulse has a peak voltage of 2500 V and it has durability for only 1 microsecond only. This high voltage pulse makes the xenon gas ionized sufficiently. Then it initiates and maintains the xenon arc. The initial arc has sky blue color. Amalgam used in the reservoir formed inside the arc tube. It is in the back of one of the electrodes. It is normally vaporized during lamp operation. As the xenon arc has started temperature of arc tube is increased which first vaporizes mercury and the lamp start glowing with bluish white color. This color represents the effect of the xenon and mercury mixture at excitation. Gradually the temperature again rises, and sodium becomes vaporized lastly and becomes excited, a low pressure monochromatic yellow sodium spectrum result. During the period of sodium spectral line becomes at 589 nm.

MERCURY VAPOUR LAMP

In case of fluorescent lamp, mercury vapour pressure is maintained at lower level such that 60% of total input energy gets converted into 253.7 nm single line as shown in figure 1.5.3.

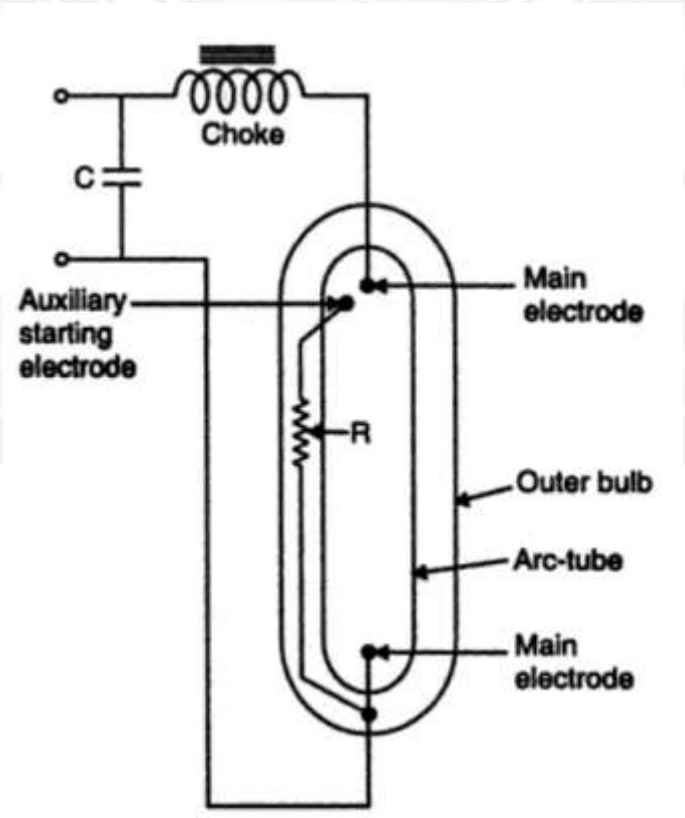

Figure 1.5.3 Mercury vapour lamp

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 33]

Again, transition of the electrons requires least amount of input energy from a colliding electron. As pressure increases the chance of multiple collisions gets increased. A schematic diagram of mercury lamp is shown below. This lamp is containing an inner quartz arc tube and outer borosilicate glass envelope. The quartz tube is able to withstand arc temperature 1300°K, whereas the outer tube withstands only 700°K. Between two tubes nitrogen gas is used to be filled to provide thermal insulation. This insulation is for to protect the metal parts from oxidation due to higher arc temperature. The arc tube contains the mercury and argon gas. Its operational function is same as the fluorescent lamp. Two main electrodes and a starting electrode are inside the arc tube. Each main electrode holds a tungsten rod and upon which a double layer of coiled tungsten wire is wound. Basically, the electrodes are dipped into a mixture of thorium, calcium and barium carbonates. They are heated to convert these compounds into oxides after dipping. Thus, they get thermally and chemically stable to produce electrons. The electrodes are connected through a quartz tube by molybdenum foil leads. Just when the main supply voltage is applied to the mercury lamp, this voltage comes across the starting electrode and the adjacent main electrode (bottom electrode) as well as across two main electrodes (bottom and top electrodes). As the gap between starting electrode and bottom main electrode is small the voltage gradient is high in this gap. Because of this high voltage gradient across the stating electrode and the adjacent main electrode (bottom) a local argon arc is created, but the current gets limited by using a starting resistor. This initial arc heats up the mercury and vaporizes it and this mercury vapor helps to strike the main arc soon. But the resistance for the main arc current control resistor is somewhat less than the resistance of the resistor used in the initial arc current control purpose. For this reason, initial arc stops and main arc continues to operate. It takes 5 to 7 minutes to make all of the mercury to be vaporized completely. The lamp gets its state of its operational stability. The mercury vapor arc gives visible spectra of green, yellow and violet. But there may be still some invisible ultraviolet radiation during discharging process of **mercury vapour** so phosphor coating may be provided on outer glass cover to improve efficiency of the mercury lamp. There are five lamps with phosphor coating to provide improved color performance. As the wattage increases the initial lumen ratings for the phosphor

coated lamps get available with 4200, 8600, 12100, 22500 and 63000. The average life of mercury lamp is 24000 hours i.e. 2 years 8 months.

FLUORESCENT LAMP

Tube shaped florescent lamp is termed as tube light. **Tube light** is a lamp that works on low pressure mercury vapor discharge phenomenon and converts ultra violet ray into visible ray with the help of phosphor coated inside glass tube.

Material Used Inside the Fluorescent Lamp

The materials used to build a tube light are given below.

1. Filament coils as electrodes
2. Phosphor coated glass bulb
3. Mercury drop
4. Inert gases (argon)
5. Electrode shield
6. End cap
7. Glass stem

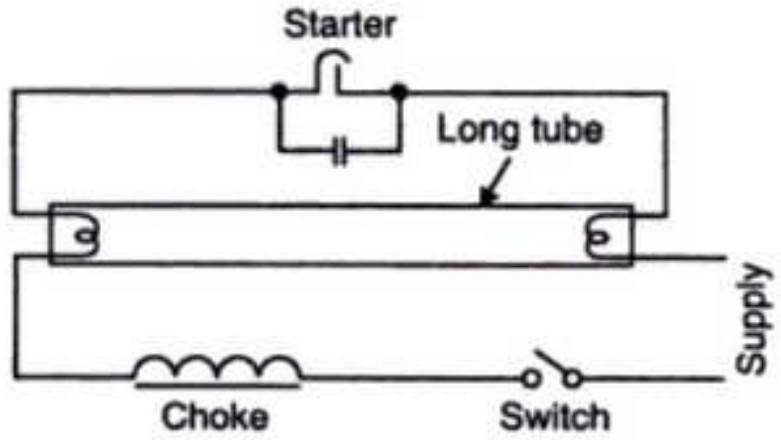

Figure 1.5.4 Fluorescent lamp

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 34]

Auxiliary Electrical Components along with Fluorescent Lamp

The tube light does not work directly on power supply. It needs some auxiliary components to work. They are-

Ballast: It may be electromagnetic ballast or electronic ballast.

Starter: The starter is a small neon glow up lamp that contains a fixed contact, a bimetallic strip and a small capacitor.

Working Principle of Fluorescent Lamp

When the switch is ON, full voltage will come across the tube light through ballast and fluorescent lamp starter. No discharge happens initially i.e. no lumen output from the lamp.

 At that full voltage first the glow discharge is established in the starter. This is because the electrodes gap in the neon bulb of starter is much lesser than that of inside the fluorescent lamp.

 Then gas inside the starter gets ionized due to this full voltage and heats the bimetallic strip that is caused to be bent to connect to the fixed contact. Current starts flowing through the starter. Although the ionization potential of the neon is little bit more than that of the argon but still due to small electrode gap high voltage gradient is appeared in the neon bulb and hence glow discharge is started first in starter.

 As voltage gets reduced due to the current causes a voltage drop across the inductor, the strip cools and breaks away from the fixed contact. At that moment a large L di/dt voltage surge comes across the inductor at the time of breaking.

 This high valued surge comes across the tube light electrodes and strike penning mixture (mixture argon gas and mercury vapor).

 Gas discharge process continues and current gets path to flow through the tube light gas only due to low resistance as compared to resistance of starter.

 The discharge of mercury atoms produces ultra violet radiation which in turn excites the phosphor powder coating to radiate visible light.

 Starter gets inactive during operation of tube light.