UTILISATION OF ELECTRICAL ENERGY AND TRACTION

LEACTURE NOTE

DEPARTMENT OF ELECTRICAL ENGG.

SAUBHAGINI BISWAL

MOB.-9668716723

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ILLUMINATION

Illumination is the process of glowing and radiating energy in the form of visible **light**. The word **illumination** often used in a qualitative sense rather than quantitative. **Illumination light** can be described as a luminous flux per unit area incident on a surface.

TERMS USED IN ILLUMINATION

LUMINOUS INTENSITY

It is the measure of luminous flux in lumen emitted per unit solid angle by a point source.

- It's unit is candela.

LUMEN

It is the unit of luminous flux, a measure of the total amount of visible light emitted by a source.

INTENSITY OF ILLUMINATION

It is the luminous intensity per projected or apparent area of either a surface of light or illumination surface.

LUMINOUS FLUX

it is the rate of energy radiations in the form of light waves .unit is lumen

CANDLE POWER

it is the no. of lumens e mitted in a unit solid angle in a given direction .it is denoted by symbol c.p

c.p=lumen/solid angle.

MHCP

-mean horizontal candle power

It is average of all the candle power in all direction in the horizontal plane containing the source of light.

MSCP

mean spherical candle power
It is the mean of candle powers in all direction in all planes from the source of light.
Mscp=total flux in lumen/4π
-

MHSCP

its full form is mean horizontal spherical candle power.it is the mean of candle powers below horizontal plane passing through the light source

BRIGHTNESS

it is defined as the luminous intensity per unit projected area of either a surface source of light

SOLID ANGLE

solid angle is the angle generated by the line passing through the point in space and the periphery of the area. its unit is steradians.it is denoted by ‘ ω’

ω= A / (Radious)2

LUMINOUS EFFICIENCY OR RADIANT EFFICIENCY

it is the ratio of lumens emitted per one watt of electric power.
Luminous efficiency=lumen / watt

LAWS OF ILLUMINATION

there are two laws of illumination

- Inverse square law
- Cosine law

PLANE ANGLE

:It is measured in radians or degrees. An angle made by two straight lines that lie in the same plane.

θ =arc / radius

REFLECTION FACTOR

It is ratio between reflected light and incident light is called reflection factor.

REDUCTION FACTOR

It is the ratio of mscp to source of light is called reduction factor.
R.F=MSCP/MHCP

LIGHT

It is defined as the radiant energy from a hot body which produces the visual sensation upon the human eye.

DEPRECIATION FACTOR

It is the ratio of initial illumination to the maintained illumination the working plane .DF>1always

There are two laws of illumination

- Inverse law
- Lamberts law or cosine law

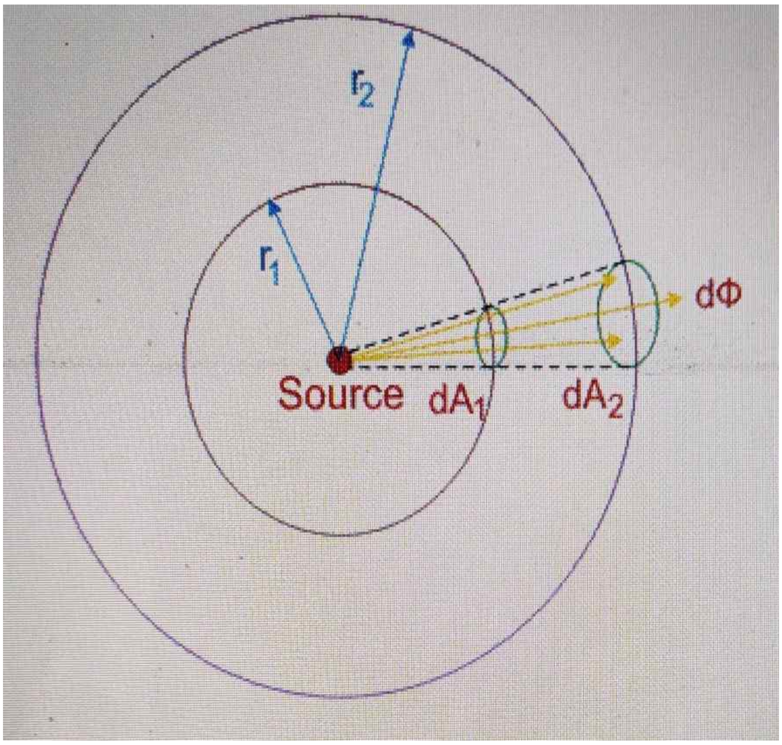
Inverse square law

This law states that the Illuminance (E) at any point on a plane perpendicular to the line joining the point and source is inversely proportional to the square of the distance between the source and plane.

Where, I is the luminous intensity in a given direction.

$E=I/d^2$

Suppose a source is present with luminous intensity I in any direction. From this source two distances are taken as the radius making this source as centre.



As per the above figure, the two radiuses are r_1 and r_2. At distance r_1 dA_1 is the elementary surface area taken. In this direction of dA_1, dA_2 is considered at r_2 distance.

dA_1 and dA_2 are within same solid angle Ω with same distributed luminous flux Φ.

Area dA_1 at r_1 receives the same amount of luminous flux as area dA_2 at r_2 as the solid are the same.

$$Intensity\ I = \frac{d\phi}{d\Omega}\ is\ for\ dA_1\ and\ Intensity\ I = \frac{d\phi}{d\Omega}\ is\ for\ dA_2$$

Again solid angle for both elementary surfaces

$$d\Omega = \frac{dA_1}{r_1^2} = \frac{dA_2}{r_2^2} \dots\dots\dots equation(i)$$

The Illuminance at distance

$$r_1 = E_1 = d\phi/dA_1 = Id\Omega/dA_1 \dots\dots\dots equation(ii)$$

The Illuminance at distance

$$r_2 = E_2 = d\phi/dA_2 = Id\Omega/dA_2 \dots\dots\dots equation(iii)$$

Now, from equation (i) we get,

This indicates the well known inverse square law relationship for point source.

It is seen that Illuminance varies inversely as the square of the illuminated point from the source.

If the light source is not a point source, then we can assume this large source as the summation of many point sources.

This relationship can be applied to all light sources.

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Laws of illumination :-

There are 2 types of laws
* Inverse square law
* Cosine law

Inverse square law :-

The illumination of a surface is inversely proportional to square of distance betn the source & surface.

Consider a point source S having an intensity I lumens / steradian. Let two surfaces having areas A_1 & A_2 be placed at distances r & 2r meters

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away respectively from the source. The two surfaces are enclosed in the same solid angle 'ω'.

Since the source gives I lumens per steradian, any surface enclosed by solid angle 'ω' will receive a total flux = I × ω lumens

Flux on Area A_1 = I × ω lumens — (1)

$$\text{Solid angle } (\omega) = \frac{\text{Area } (A)}{(\text{Distance})^2}$$

$$= \frac{A_1}{r^2} \text{ steradian}$$

Total flux on surface area

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$$\phi = \frac{I \cdot A_1}{r^2} \quad \text{——— (2)}$$

Putting (ii) in (i)

Illumination E_1 on surface A_1

$$= \frac{\phi}{A_1} = \frac{I \cdot A_1}{r^2} \times \frac{1}{A_1}$$

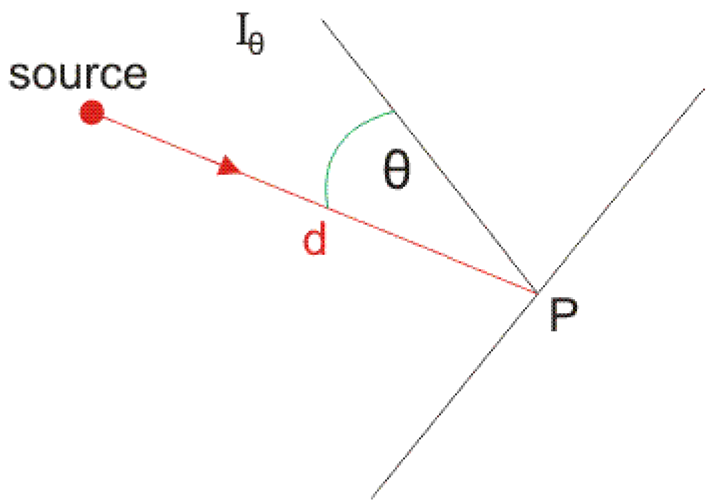
$$E_1 = \frac{I}{r^2} \text{ Lumens/m}^2$$

COSINE LAW

The law states that Illuminance at a point on a plane is proportional to the cosine of the angle of light incident (the angle between the direction of the incident light and the normal to the plane)

$$E = \frac{I_\theta}{d^2} \cos\theta$$

It is the point source Illuminance equation.
Where, I_θ is the luminous intensity of the source in the direction of the illuminated point, Θ is the angle between the normal to the plane containing the illuminated point and the line joining the source to the illuminated point, and d is the distance to the illuminated point.

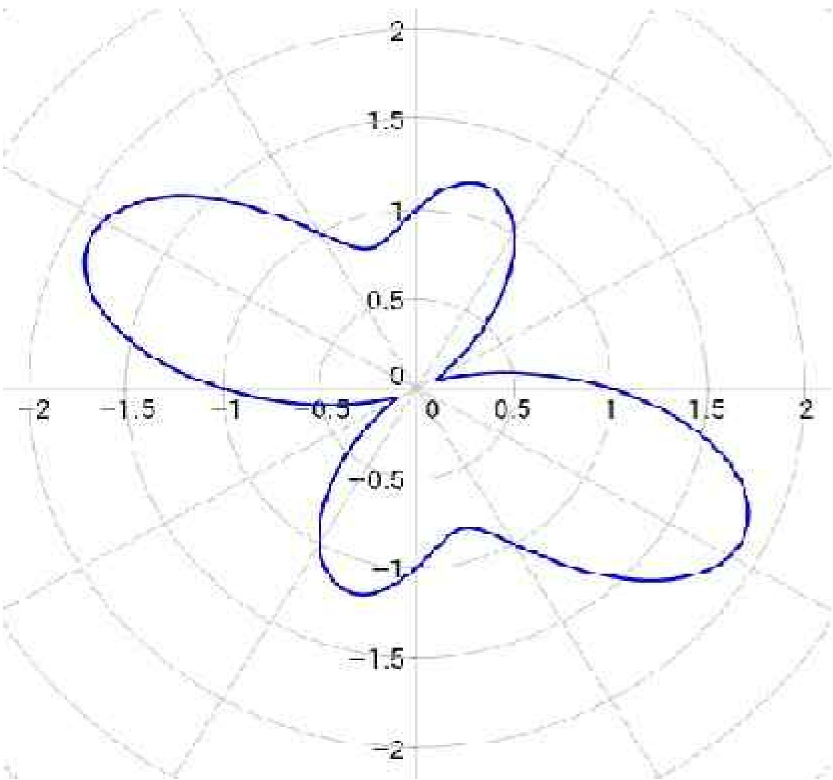


But for non point source, the cosine law of Illuminance can be analyzed in term of luminous flux instead of luminous intensity.
The Illuminance or the surface density of the light flux received by an elementary area varies with the distance from the light source and the angle of the elementary area with respect to the direction of the light flux.
The maximum Illuminance occurs when the element of area receives the light flux normal to its surface.
When the element of area is tilted with respect to the direction of the light flux, the Illuminance or flux density on the elementary surface is reduced.
This can be thought of in two ways.

1. The tilted elementary area (δA) cannot intercept all the light flux it previously received and so the Illuminance falls.
2. If the elementary area (δA) increases, the Illuminance falls

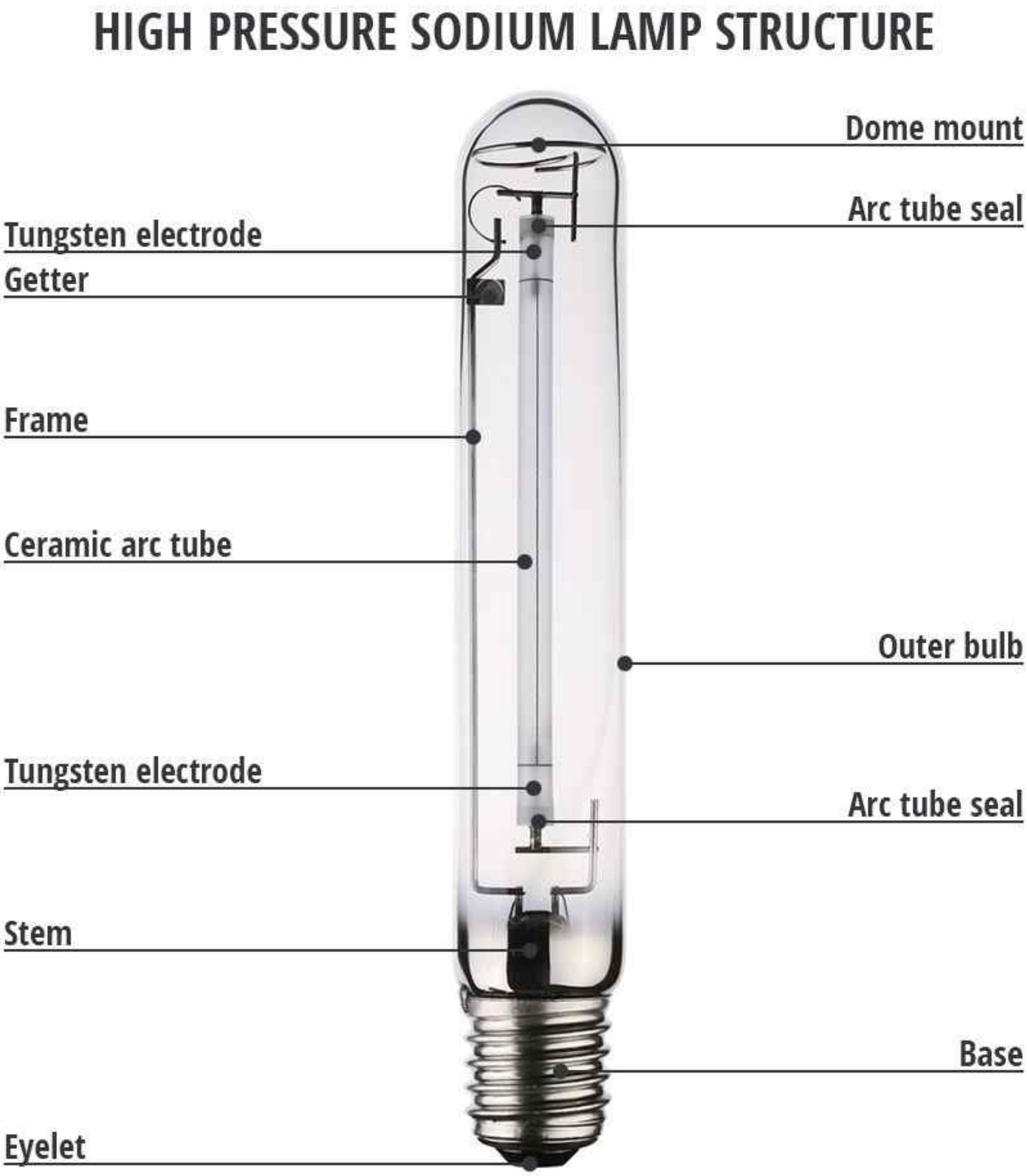
POLAR CURVES

A **polar curve** is a shape constructed using the polar coordinate system. Polar curves are defined by points that are a variable distance from the origin (the pole) depending on the angle measured off the positive xx-axis. Polar curves can describe familiar Cartesian shapes such as ellipses as well as some unfamiliar shapes such as cardioids and lemniscates.



$r=1-\cos\theta\sin3\theta$

Whereas Cartesian curves are useful to describe paths in terms of horizontal and vertical distances, polar curves are more useful to describe paths which are an absolute distance from a certain point. One practical use of polar curves is to describe directional microphone pickup patterns. A directional microphone will pick up different qualities of sound depending on what location the sound comes from outside of the microphone. For example, a cardioids microphone has a pickup-pattern in the shape of a cardioids.



The arc tube consists of frame and is highly pressured with sodium for better efficiency. The arc tube is made of aluminum oxide ceramic which is resistant to the corrosive effects of alkalis like sodium.

The start of lighting up process begins through pulse start. High voltage energy is sent through ignitor through the arc tube. Firstly, the pulse starts an arc through the xenon gas which makes the lamp turns sky blue due to xenon lighting up.

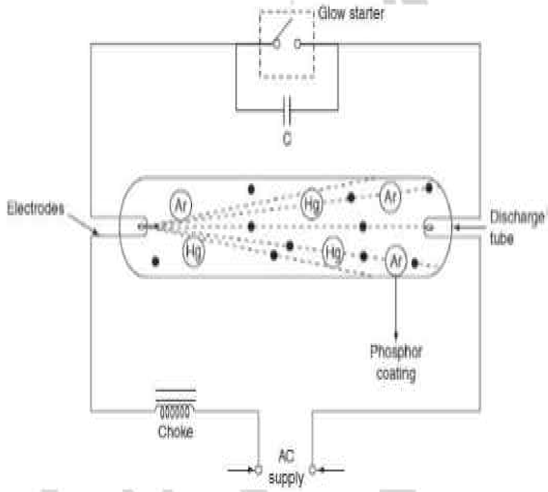
After that the arc then heats up the mercury and the mercury vapor then lights, giving the lamp a bluish color.

Sodium is the last material to vaporize as sodium vapor strikes an arc over 240 C. The sodium is mixed with other impurities to create a more “white” light. The mercury helps add a blue spectrum light to the pure yellow of the sodium.

For maintaining a vacuum, oxygen and other gasses can seep in over time. The **getter** keeps a stable vacuum by sucking out remaining oxygen and unwanted gas elements. The sodium is stored often stored in the amalgam reservoirs on the ends of the arc tube when it is cool unlike the LPS lamp where the sodium is stored in the bumps on the side of the tube

FLUORESCENT LAMPS:

It is a low pressure mercury vapor lamp. It consists of a glass tube 25 mm in diameter and 0.6 m, 1.2 m and 1.5 m in length. The tube contains argon gas at low pressure about 2.5 mm of mercury. At the two ends, two electrodes coated with some electron emissive material are placed.



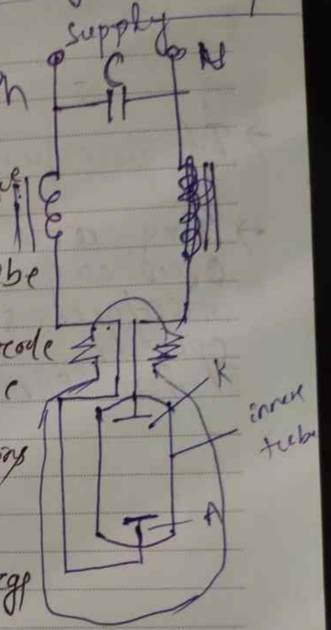
Fluorescent lighting has a great advantage over other light sources in many applications. The tubes can be obtained in a variety of length, with illumination in a variety of colours. It is possible to achieve quite high lighting intensities without excessive temperature rise and owing to the nature of light sources, the danger of glare is minimized. The efficiency of the fluorescent tube is about 40 lumens per watt, about three times the efficiency of an equivalent tungsten filament lamp. The fluorescent tube consists of a glass tube 25m.m in diameter and 0.38m-1.52m in length. The inside surface of the tube is coated with the thin layer of fluorescent material in the form of a powder

A starting switch is provided in the circuit, which puts the electrodes directly across the supply mains at the time of starting, so that electrodes may get heated and emit sufficient electrons. A stabilizing choke is connected in series with it, which acts ballast in running condition and provides a voltage impulse for starting. A capacitor is connected across the circuit to improve the power factor at the supply side. The filament is connected to a starter switch which is small with bimetal strip connecting the two electrodes.

Working:

When the starter is cold the electrodes are open.When supply is given the current traces the

High pressure mercury Vapour lamp.



Action Plan for Previous Month

→ H.P.M.V lamps are similar to sodium vapour lamp.

→ It has an outer tube & discharge tube, contains the electrode i.e cathode & anode

Review

→ The electrodes contains tungsten

→ It is a gas discharge lamp that uses an electric arc through vaporised mercury to produce light.

→ The outer tube coated with phosphor.

→ It has 35 to 65 lumens/watt

Self Analysis

→ The electric discharge takes place through argon & they vaporises the mercury drops inside the discharge tube.

Mercury vapour lamp

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→ The mercury vapour lamp is similar in construction to the sodium vapour lamp.

→ It consists of hard glass tube enclosed in outer bulb of ordinary glass.

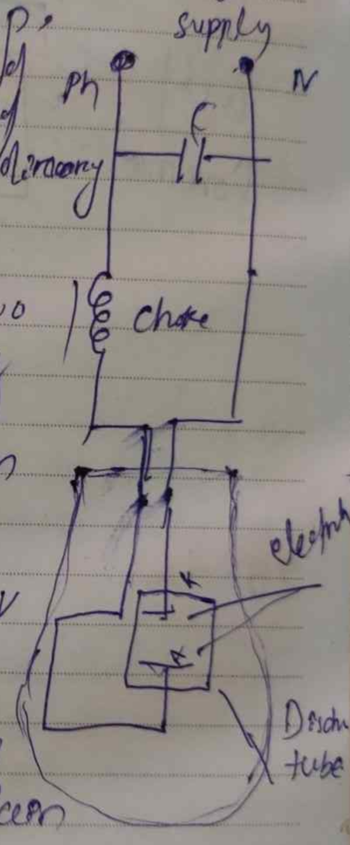
→ The space betn two bulbs are completely evacuated to prevent heat loss by convection from inner bulb.

28 Sunday

→ The outer bulb absorbs harmful UV rays.

→ The inner bulb contains argon gas with certain quantity of Mercury.

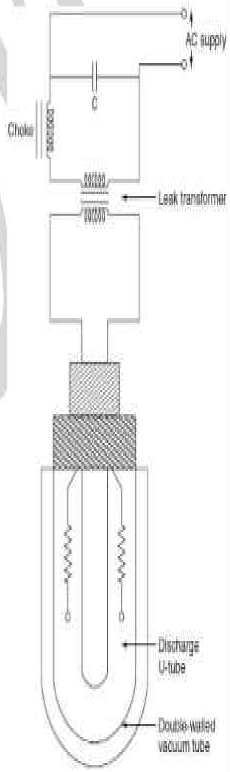
→ In addition with two electrode an starting electrode having high resistance in series also provided.



SODIUM VAPOUR LAMP:

This type of the lamp has low luminosity, so length of lamp is large. To get required length it is made in form of U tube. Two oxide coated electrodes are sealed with the ends. The tube contains Neon and Sodium gas. The U tube is enclosed in a double walled vacuum flask to keep the temperature within the working range. It employs high leakage reactance transformer to provide sufficient voltages to increase the temperature of the oxide coated electrodes that emits the electrons to liberate light. Due to this transformer the regulation will be poor and the power factor will be low about 0.3. Capacitor at the input terminals is provided to improve power factor to 0.8.

Working:



Before stating the Sodium in the solid form is deposited on the walls of the tube. When the supply is fed by closing the switch, the bulb operates as low pressure Neon lamp with pink color. The lamp gets warm and the Sodium is vaporized and radiates yellow light. After 10-15 minutes it illuminates full light.

For a 40 W lamp, 380 V is required to start the discharge. For 100W lamp 450V is required. These voltage levels are obtained from the high reluctance transformer or auto transformer.

The no-load voltage is high, which decreases gradually when the lamp starts glowing on account of production of electron current between the electrodes, which results in poor regulation of transformer.

Specifications:

- Efficiency of lamp is about 40-50%.
- Available in 45W, 60W, 85W, 140W ratings.
- Average life is 3000 hrs.
- It is not affected by voltage variations.
- At the end of life output is reduced by 15% due to aging.

Causes for failure of lamp:

- Burn out or breaking of filament.

CHAPTER-2

ELECTRICAL HEATING

1. Explain advantages of electrical heating?

   Ans-

- Advantages of Electric Heating

- Electric heating has several advantages when compared to gas or oil furnaces and boilers. These include –

- The temperature can be controlled easily room by room or zone by zone.
- Electric heating systems are generally less expensive to purchase and install than others.
- If several space heaters are used, the house will not be thrown into a no-heat condition by the failure of one unit.
- Electric heat is quick to respond.
- Electric heat is clean (at least from the homeowner’s perspective).
- Electric heat can be added on a localized basis to heat specific cool areas.
- Electric heat can take up less space in the house than other conventional systems (assuming space heaters are used).
- There is no chimney, so there is no off-cycle loss when the system is at rest.
- The system is safe because there is no combustion process. There is no chance of flames starting a fire or having combustion products contaminate the air.
- Electric heat can be very quiet.
- In most electric heating systems, there are few moving parts.

1. **Explain mode of heat transfer and Stephen's law?**

Modes of Heat Transfer

Heat flows from higher temperature to lower temperature. Though it looks simple, heat transfer is a quite complex phenomenon. There are three basic modes of heat transfer.

Conduction

Conduction takes place at a microscopic level. Atoms or molecules at higher temperature have high levels of energy. Through vibration, this energy is passed on to neighboring atoms and molecules. In other words, in conductive mode of heat transfer, vibrating atoms and molecules a part of their energy.

This kind of heat transfer can take place between two or more substances or through the substance. Conduction can also take place when electrons move from one atom to another. Transient conduction takes place when temperature within an object changes a the function of time.

Convection

Convection is a mode of heat transfer which takes place through the movement of collective masses of heated atoms and molecules. Convection requires actual flow of material particles whereas in conduction, the heat is transferred through vibration without the atoms or molecules leaving their original position. In convection, heat transfer takes place through both diffusion and advection.

As convection requires the actual movement of the heated atoms/ molecules, it requires presence of a fluid for heat transfer.

Radiation

Radiation is a mode of heat transfer which takes place through vacuum and hence, does not need a physical medium. Radiation takes place either through vacuum or through a transparent medium. In radiative mode, heat transfer takes place through photons present in the electromagnetic waves. The random movement of atoms and molecules in heated substances results in emission of electromagnetic waves which carry the heat to be transferred.

The radiative heat transfer is governed by Stephen- Boltzman law. A body radiates heat at all temperatures above the absolute zero, irrespective of the ambient temperature

Stefan-Boltzmann law, statement that the total radiant heat power emitted from a surface is proportional to the fourth power of its absolute temperature. Formulated in 1879 by Austrian physicist Josef Stefan as a result of his experimental studies, the same law was derived in 1884 by Austrian physicist Ludwig Boltzmann from thermodynamic considerations: if *E* is the radiant heat energy emitted from a unit area in one second (that is, the power from a unit area) and *T* is the absolute temperature (in kelvins), then $E = \sigma T^4$, the Greek letter sigma (σ) representing the constant of proportionality, called the Stefan-Boltzmann constant. This constant has the value $5.670374419 \times 10^{-8}$ watt per metre^2 per K^4. The law applies only to blackbodies, theoretical surfaces that absorb all incident heat radiation.

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2. Explain principle of microwave heating and its application?

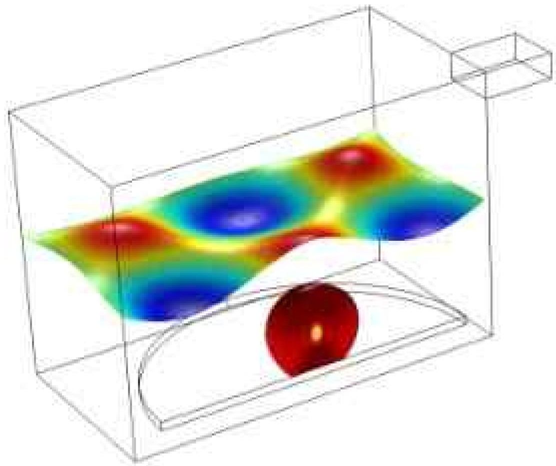
The Microwave Heating Principle

Microwave heating is a multiphysics phenomenon that involves electromagnetic waves and heat transfer; any material that is exposed to electromagnetic radiation will be heated up. The rapidly varying electric and magnetic fields lead to four sources of heating. Any electric field applied to a conductive material will cause current to flow. In addition, a time-varying electric field will cause dipolar molecules, such as water, to oscillate back and forth. A time-varying magnetic field applied to a conductive material will also induce current flow. There can also be hysteresis losses in certain types of magnetic materials.

Applications of Microwave Heating

Heating Food

One obvious example of microwave heating is in a microwave oven. When you place food in a microwave oven and press the “start” button, electromagnetic waves oscillate within the oven at a frequency of 2.45 GHz. These fields interact with the food, leading to heat generation and a rise in temperature.



Potato in a microwave: Electric field and temperature plot. The rectangular block on the right represents a waveguide feed.

Treating Cancer

Another application that leverages the effects of microwave heating is cancer treatment, in particular hyperthermic oncology. This type of cancer therapy involves subjecting tumor tissue to localized heating, without damaging the healthy tissue around it.

Doctors performing microwave coagulation therapy insert a thin microwave antenna directly into the tumor and heat it up. The microwave heating generates a coagulated region, killing the cancerous cells. This treatment method requires controlling the spatial distribution and heating power. The temperature sensors must be both well designed and strategically placed in order to avoid harming healthy tissue.

Dielectric Heating

The definition of dielectric heating can be stated as – 'the process of heating up material by causing dielectric motion in its molecules using alternating electric fields". All materials are made up of molecules that are composed of atoms

Working principle of Dielectric Heating and its application

As described below, the circuit diagram of the dielectric heating system consists of two metals plates to which the electric field is applied. The material to be heated is placed in between these two metals. There are two types of ways in which material are heating using the heating process.

Heating using low-frequency waves, as a near – field effect and heating with high-frequency waves using electromagnetic waves. The type of materials heated using these different types of waves is also different

Low-frequency waves have higher wavelengths. Thus they can penetrate through non-conductive materials more deeply than electromagnetic waves. The systems using low-frequency fields should have the distance between the radiator and absorber to be less than $1/2\pi$ of the wavelength. So, the process of heating using a low-frequency electric field is near – contact process. Higher frequency systems have lower wavelengths. Electromagnetic waves and microwaves are used for these systems. In these systems, the distance between metal plates is larger than the wavelength of the applied field. In these systems, conventional far-field electromagnetic waves are formed between the metal plates.

Applications of Dielectric Heating

Dielectric heating principle using high-frequency electric fields was proposed in the 1930s at Bell Telephone Laboratories. By varying the frequency of electric fields the Dielectric systems are designed for many types of applications.

When Microwaves are Used

In this dielectric heating, the 2.45GHz of the microwave of frequency is used. Microwave ovens used in homes are an example of this type of applications. These systems provide less penetrative and highly efficient heating system. Microwave volumetric heating provides a larger penetration depth. Thus this heating is used for heating liquids, suspensions, and solids on an industrial scale.

When Radio Frequencies are Used

- RF dielectric often finds applications in the crop production area.
- This type of heating is used to kill some pests in food after harvest of the crop.
- This type of heating can heat materials uniformly.
- This type of heating can process food quickly.
- Diathermy, the process of RF heating of muscle for muscle therapy uses this type of heating.

- The process called Hyperthermia therapy, in which higher temperatures are used to
- kill cancer and tumor tissues, heating with RF frequencies is applied

Food Processing

In post-baking of biscuits in the production line, RF dielectric heating will reduce the baking time. Right size, shape and color biscuits can be produced with oven but RF heating can remove the remaining moisture from already dried parts of the biscuits.

- RF heating can increase the capacity of the oven, used in food production factories, up to 50%.
- Cereal-based baby products and breakfast cereals use the post-baking by RF dielectric heating.
- In the drying of food, dielectric baking is used along with conventional baking.
- When an electromagnetic dielectric is used for the baking better quality of food is achieved.
- Nutritional and sensory properties of food can be preserved during food processing when electromagnetic dielectric heating is used, as higher processing temperatures can be achieved in a shorter amount of time.

Right from the period of its invention, dielectric heating is being used in various forms. From an amazing food processor to a precise Electro surgery method, dielectric had found its application in almost every field of science.

Dielectric heating mechanism setup can be viewed as similar to the structure of the capacitor. In capacitor dielectric is placed in between two conducting plates and electricity is produced in a dielectric. Whereas in a dielectric heating system, the material to be heated is placed in between two conducting plates, to which electric field is applied and heat is generated inside the material.

Now a day's dielectric heating has found many applications in the agriculture industry, for implementation of many pest control methods. The electric field applied for a microwave oven is Lower frequency or higher frequency field

ILLUMINATION QUESTION BANK SHORT AND LONG

1. What is luminous intensity?
   Ans: It is the measure of luminous flux in lumen emitted per unit solid angle by a point source.
   - It's unit is candela.
2. What is lumen?

Ans :It is the unit of luminous flux, a measure of the total amount of visible light emitted by a source.

3. What is intensity of illumination?

Ans:It is the luminous intensity per projected or apparent area of either a surface of light or illumination surface.

4. What is luminous flux?
   Ans-it is the rate of energy radiations in the form of light waves .unit is lumen
5. What is candle power?
   Ans-it is the no. of lumens e mitted in a unit solid angle in a given direction .it is denoted by symbol c.p
   c.p=lumen/solid angle.
6. What is MHCP?
   ANS-mean horizontal candle power
   It is average of all the candle power in all direction in the horizontal plane containing the source of light.
7. What is MSCP?
   Ans-mean spherical candle power
   It is the mean of candle powers in all direction in all planes from the source of light.
   Mscp=total flux in lumen/4π
8. What is MHSCP?
   Ans-its full form is mean horizontal spherical candle power.it is the mean of candle powers below horizontal plane passing through the light source
9. Define brightness?
   Ans-it is defined as the luminous intensity per unit projected area of either a surface source of light

10. Define solid angle?

    Ans-solid angle is the angle generated by the line passing through the point in space and the periphery of the area. its unit is steradians.it is denoted by ‘ ω’

    ω= A / (Radious)2

11. What is Luminous efficiency or radiant efficiency?

    Ans – it is the ratio of lumens emitted per one watt of electric power. Luminous efficiency=lumen / watt

12. What are the laws of illumination?

    Ans – there are two laws of illumination

    - Inverse square law
    - Cosine law

13. What is plane angle?

    Ans:It is measured in radians or degrees. An angle made by two straight lines that lie in the same plane.

    θ =arc / radius

14. Define reflection factor?

    Ans:It is ratio between reflected light and incident light is called reflection factor.

15. What is reduction factor?

    Ans:It is the ratio of mscp to source of light is called reduction factor.

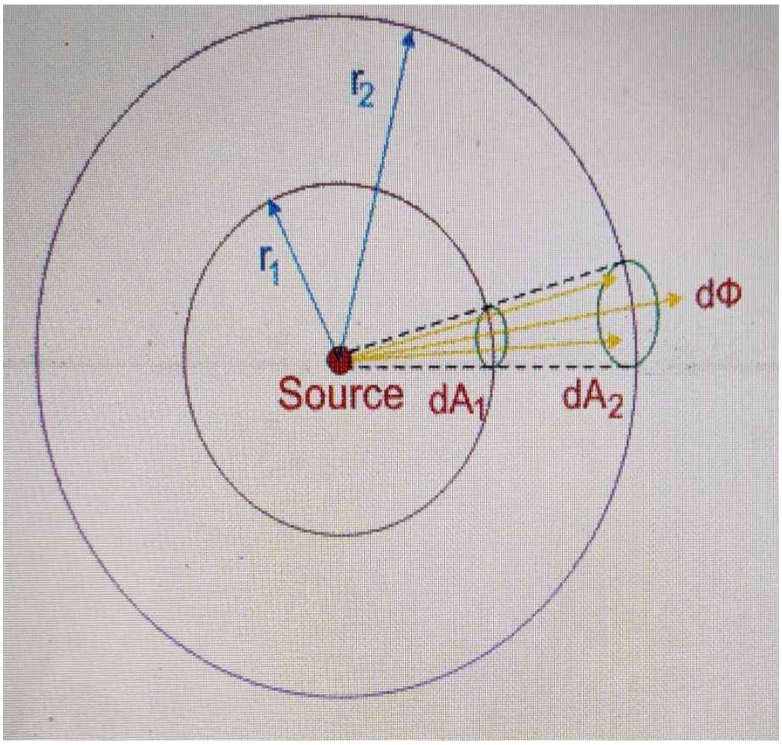
3. Explain the Inverse Square Law of Illumination?

This law states that the Illuminance (E) at any point on a plane perpendicular to the line joining the point and source is inversely proportional to the square of the distance between the source and plane.

Where, I is the luminous intensity in a given direction.

$E=I/d^2$

Suppose a source is present with luminous intensity I in any direction. From this source two distances are taken as the radius making this source as centre.



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dA_1 and dA_2 are within same solid angle Ω with same distributed luminous flux Φ.

Area dA_1 at r_1 receives the same amount of luminous flux as area dA_2 at r_2 as the solid are the same

$$Intensity\ I = \frac{d\phi}{d\Omega}\ is\ for\ dA_1\ and\ Intensity\ I = \frac{d\phi}{d\Omega}\ is\ for\ dA_2$$

Again solid angle for both elementary surfaces

$$d\Omega = \frac{dA_1}{r_1^2} = \frac{dA_2}{r_2^2} \ldots\ldots\ldots\ldots equation(i)$$

The Illuminance at distance

$$r_1 = E_1 = d\phi/dA_1 = Id\Omega/dA_1 \ldots\ldots\ldots\ldots equation(ii)$$

The Illuminance at distance

$$r_2 = E_2 = d\phi/dA_2 = Id\Omega/dA_2 \ldots\ldots\ldots\ldots equation(iii)$$

Now, from equation (i) we get,