LESSON - 19

Emission of Radiation:

As discussed earlier Lesson 18, energy emitted in form of electromagnetic radiation by bodies by virtue of their temperature is called thermal radiation. Thermal radiation emitted by a body is a function of temperature, condition of surface and material of emitting body. Therefore, two bodies maintained at same temperature emit different amounts of thermal radiation.

The ability of a body to emit radiation is called emission and magnitude of energy emitted per unit area per unit time by the body is called emissive power.

Black Body:

A perfect black body is one that absorbs all the thermal radiation, irrespective of wavelength, received by it. It does not reflect or transmit incident thermal radiation; therefore, absorptivity of such a body is 100%. At a given temperature and wavelength, a black body emits more energy as compared to any other body.

A perfect black body is a hypothetical body which behaves like a perfect absorber and emitter of thermal radiation and in practice no substance or body possesses properties of a perfect black body. However, bodies showing close approximation to a perfectly black body can be constructed.

Consider a hollow sphere with inside surface blackened and having a small hole at its surface. Thermal radiations entering the sphere through the hole are reflected repeatedly by the inner walls till they are completely absorbed. To avoid a direct reflection from inner surface, a pointed projection is made inside the sphere facing the hole as shown in Figure 1. Therefore, the small hole acts as a black body absorber.

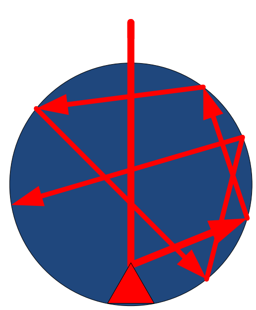

Figure 5

In order to compare radiative properties of real surfaces, a hypothetical body called blackbody is defined. A blackbody is an hypothetical body and has following properties.

- A black body absorbs all incident radiation irrespective of their wavelength and direction.
- At a given temperature and wavelength, energy emitted by a black body is the highest as compared to any other body.
- The radiation emitted by a black body depends upon wavelength and temperature, but it is independent of direction.

Monochromatic emissive power ($E_{b\lambda}$) and Planck's Law:

Monochromatic emissive power is defined as the energy emitted by a black body at a given wavelength in all directions per unit area per unit time and it is expressed in the units as W/(m^2- μm). Using his quantum theory, Max Planck derived the expression for monochromatic emissive power ($E_{b\lambda}$) which is expressed as

$$E_{b\lambda} = \frac{2\pi c^2 h \lambda^{-5}}{\left(\exp\frac{ch}{\lambda kT}\right) - 1} \qquad (1)$$

Where

c – Velocity of light

= 2.98 X 10^8 m/sec

h – Planck's constant

= 6.625 X 10^{-34} Joule-Sec

k – Boltzmann constant

= 1.3805 X 10^{-23} Joule/K

λ – Wavelength of monochromatic radiation emitted, m

T – Absolute temperature, K

Equation (1) can also be expressed as

$$E_{b\lambda} = \frac{C_1 \lambda^{-5}}{\left(\exp\frac{C_2}{\lambda T}\right) - 1} \qquad (2)$$

Where

$C_1 = 2\pi c^2 h = 37.404 \times 10^{-17}$ J-m²/K

$C_2 = ch/k = 1.4387 \times 10^{-2}$ m – K

Equation (2) is known as Planck's law or Planck's distribution.

Monochromatic emissive power of a black body is a function of wave length and its variation with wavelength at selected temperatures has been plotted as shown in Figure 2. Following observations have made from this plot:

- At a specified temperature, monochromatic emissive power increases with increase in wavelength and attains a maximum value corresponding to a particular wavelength. However, further increase in wavelength results in decrease in emissive power.
- With increase in temperature, emissive power increases for all wavelengths.
- An increase in temperature results in decreases in value of wavelength for which emissive power is maximum.
- Area under each curve represents energy emitted by the black body at a particular temperature for the range of wavelength considered. With increase in temperature area under the curve increases as energy emitted increases.

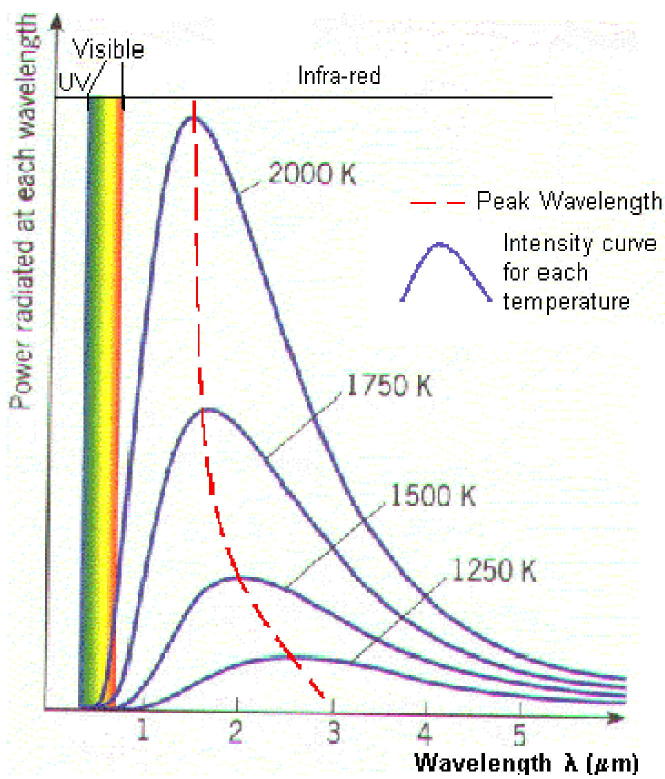

Figure 2

REVIEW QUESTIONS:

Q.1 Thermal radiation emitted by a surface is function of its

a) Temperature
b) Material
c) Condition
d) All the above

Q.2 Absorptivity of a black body is

a) Greater than 50% but less than 100%
b) Less than 100%
c) 100%
d) Less than 50%

Q.3 For a given temperature, monochromatic emissive power of a body

a) Increases with increase in wavelength, attains a maximum value and then decreases
b) Increases with increase in wavelength
c) Increase in wavelength does not affect emissive power
d) None of the above

Q.4 With increase in temperature, monochromatic emissive power for all wavelengths

a) decreases
b) remains constant
c) increases
d) None of the above

Q.5 In specular reflection, angle of incidence is

a) Less than angle of reflection
b) Greater then angle of reflection
c) Equal to angle of reflection
d) None of the above