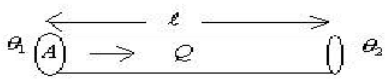
TRANSMISSION OF HEAT

1. Coefficient of Thermal conductivity :

a. In steady state the quantity of heat Q flowing through a metal rod of length ℓ and cross-section A in a time t when its ends are at temperature θ_1 and $\theta_2\left(\theta_1>\theta_2\right)$ is given by



$$Q = \frac{KA\left(\theta_1 - \theta_2\right)}{l}t$$

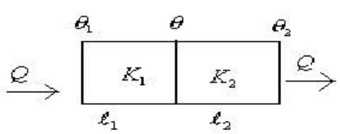
where K is coefficient of thermal conductivity

b. K depends on the nature of the metal.

c. It is defined as the rate of flow of heat per unit area and per unit temperature gradient in steady state.

2. a. If one end of a metal rod is kept in a steam jacket and other end is kept in an ice block, then the amount of ice that melts is $m=\dfrac{KA(\theta_1-\theta_2)t}{d.L_{ice}}$

b. Junction temperature : In steady state when conduction takes place through two layers of composite wall with different thermal conductivities, then



$$\theta=\frac{K_1\theta_1+K_2\theta_2}{K_1+K_2}$$

3. Thermal Resistance : R

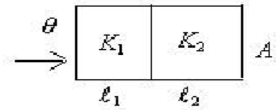
Thermal resistance R of a conductor of length ℓ, cross-section A and conductivity K is given by

$$R=\frac{l}{KA}$$

4. Effective conductivity :

a. Series combination :

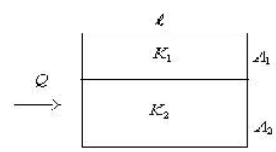
If two rods of same cross-sectional area having lengths l_1 *and* l_2 and conductivities K_1 *and* K_2 are connected in series, then in steady state conductivity of the combination K is given by



$$K=\frac{2K_1K_2}{K_1+K_2}$$

b. Parallel combination :

If two rods of same length having cross-sectional area A_1, A_2 and conductivities K_1, K_2 are arranged in parallel, then in steady state, the conductivity of the combination is



$$K=\frac{K_1+K_2}{2}$$

5. EMISSIVE POWER (e_λ) :

a. The amount of energy emitted per second per unit surface area of a body at a given temperature for a given wavelength range $(\lambda \textit{ and } \lambda+d\lambda)$ is called emissive power.

b. At a given temperature if the radiations emitted have a wave length difference $d\lambda$, then the emissive power is equal to $e_\lambda d\lambda$.

c. S.I unit of emissive power is Wm^{-2} and its dimensional formula is MT^{-3}.

6. **EMISSIVITY (e):** The ratio of radiant energy emitted by a surface to radiant energy emitted by a black body under same conditions is called emissivity.

a. For a perfect black body emissivity e = 1.

7. **ABSORPTIVE POWER (a_λ) :**

a. At a given temperature, for a given wavelength range, the ratio of energy absorbed to the energy incident on the body is absorptive power.

$$\therefore a_\lambda = \frac{Amount\ of\ radiant\ energy\ absorbed}{Amount\ of\ radiant\ energy\ incident}$$

b. For a perfect black body, the absorptive power, $a_\lambda = 1$.

8. **REFLECTING POWER (r):**

$$r = \frac{\text{Amount of radiant energy reflected}}{\text{Amount of radiant energy incident}}$$

9. **TRANSMITTING POWER (t)**:

a.

$$t = \frac{\text{Amount of radiant energy transmitted}}{\text{Amount of radiant energy incident}}$$

b. $a_\lambda + r + t = 1$

Here 'a_λ' is absorptive power, 'r' is reflecting power and 't' is the transmitting power.

10. **KIRCHOFF'S LAW:**

a. At a given temperature, for a given wave length range, the ratio of emissive power to absorptive power of a substance is constant.

b. This constant is equal to the emissive power of a perfect black body at the given temperature and wavelength.

i.e ., $\frac{e_\lambda}{a_\lambda} = const = E_\lambda$

Where 'E_λ' is the emissive power of perfect black body. 'e_λ' and 'a_λ' are emissive and absorptive powers of a given substance respectively.

c. Good absorbers are good emitters.

d. Poor absorbers are poor emitters.

11. **STEFAN'S LAW:**

a. The amount of heat radiated by a black body per second per unit area is directly proportional to the fourth power of its absolute temperature.

$E \propto T^4 \Rightarrow E = \sigma T^4$.

Where

σ = Stefan's constant

$= 5.67 \times 10^{-8} Wm^{-2}K^{-4}$

12. **STEFAN - BOLTZMANN'S LAW:**

a. If a black body at absolute temperature T is surrounded by an enclosure at absolute temperature T_o, then the rate of loss of heat energy by radiation per unit area is given by.

$E = \sigma(T^4 - T_0^4)$

b. For any hot body, $E = \sigma Ae(T^4 - T_0^4)$

Where 'e' is the emissive power and 'A' is the area of cross-section of the hot body.

13. **NEWTON'S LAW OF COOLING:**

The rate of cooling of a hot body is directly proportional to the mean excess of temperature of the body above that of the surroundings, provided the difference in temperature of the body and that of surroundings is small.

$\frac{d\theta}{dt} = K\left(\frac{\theta_1 + \theta_2}{2} - \theta_s\right)$.

here $\frac{d\theta}{dt}$ = Rate of cooling.

θ_1, θ_2 are the initial and final temperatures of the body respectively. θ_s is temperature of surroundings and K is the cooling constant.