UNIT – 3 (THERMAL PHYSICS)

CONTENTS

3.4.Thermal conductivity of bad conductors – Lee's disc method

3.4.1 Principle

In the steady state, the quantity of heat flowing across the bad conductor in one second is equal to the quantity of heat radiated in one second from the lower face area and edge area of the metal disc in the Lee's disc apparatus.

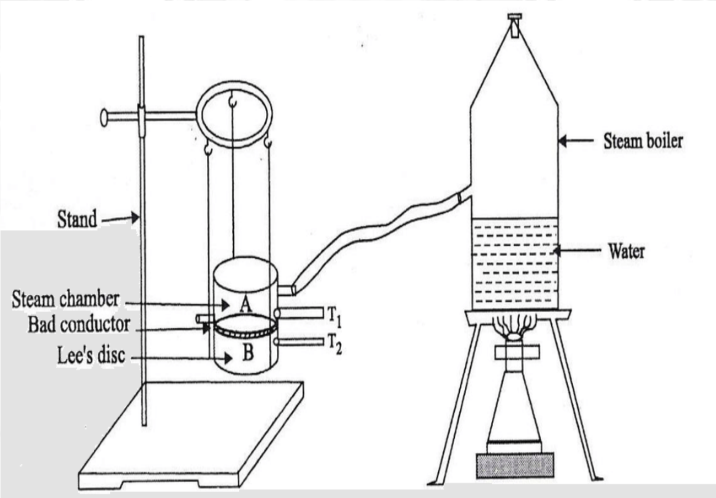

Fig 3.4.1 Lee's disc apparatus-

3.4.2.Apparatus

A flat cylindrical steam chamber 'S' and a disc D of equal diameters are arranged to sandwich the given bad conductor B taken in the form of a thin sheet of uniform thickness and having same diameter. There are holes in S and D into which thermometers T_1 and T_2 can be introduced. The bad conductor B is placed above the disc D and the steam chamber is placed above B. The whole set up is suspended by means of strings and a stand (figure3.4.1)

3.4.3.Experiment

Steam is passed through the steam chamber. The heat flows across the bad conductor from its upper surface to the lower surface. The upper surface of B is raised to the temperature of steam. Due to poor thermal conductivity of bad conductor, the lower surface will be at lesser temperature.

When the steady state is reached, the heat flowing across B is taken up by D and radiated away at the same rate from its lower face and its edges. When the thermometers show steady temperatures, theirreadings θ_1 and θ_2 are noted.

The heat flowing across the bad conductor 'B' in one second,

$$Q = \frac{(\theta_1 - \theta_2)}{x}$$

The heat radiated by metal disc 'D' in one second

$$Q' = (\pi r^2 + 2\pi r h)$$

In the steady state, $Q = Q'$

$$\frac{(\theta_1 - \theta_2)}{x} = (\pi r^2 + 2\pi r h)E$$

Since the area A of the bad conductor is πr^2, the same as that of D

$$\frac{K\pi r^2(\theta_1 - \theta_2)}{x} = (\pi r^2 + 2\pi r h)E$$

$$K = \frac{(r + 2h)}{(\theta_1 - \theta_2)} \quad \ldots\ldots\ldots\ldots(1)$$

Now the steam chamber is lifted up and the bad conductor B is removed and the steam chamber is placed directly on the metal disc D. When the temperature of the disc D is 10^0C above its steady state temperature, the steam chamber is removed and the disc D is allowed to cool. The time is noted for every 1^0C fall of temperature from about 5^0C above and below its steady state temperature T_2.

The emissivity is,

$$E = \frac{Rate\ of\ loss\ of\ heat}{Area\ of\ surfaces}$$

$$E = \frac{MS\frac{d\theta}{dt}}{2\pi r^2 + 2\pi r h}$$

Substituting the value of E in equation (1), we get

$$K = \frac{MS \frac{d\theta}{dt} (r + 2h)}{\pi r^2 (\theta_1 - \theta_2) 2(r + h)}$$

Where

K – Thermal conductivity of bad conductor BM – Mass of the disc D

S – Specific heat capacity of disc D

$\frac{d\theta}{dt}$ – Rate of fall of temperature

x – Thickness of bad conductor B

r – Radius of the metallic disc D

h – Thickness of the metallic disc D

θ_1 – Steady temperature of steam chamber

θ_2 – Steady temperature of metallic disc D

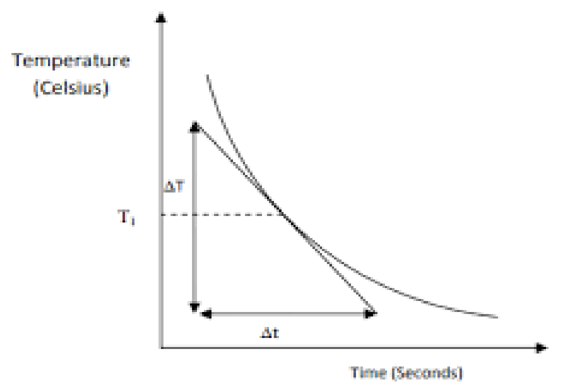

Fig 3.4.2 variation of temperature with time

A graph of temperature against time is drawn (figure) and the slope of graph at the temperature θ_2 is measured. Let it be $\frac{d\theta}{dt}$. Thus, substitute the above values in equation (2) we can find out the thermal conductivity of bad conductor.