Experiment 9.2. To find the co-efficient of thermal conductivity of a bad conductor by Lee's method.

Apparatus. Lee's disc apparatus, two 1/10°*C* thermometers, circular disc of the specimen of a bad conductor, (ebonite or card board), a stop watch, a screw gauge, vernier callipers etc.

Theory. On passing steam through the cylindrical vessel a steady state is reached soon. In this condition the rate at which heat is conducted across the specimen disc is equal to the rate at which heat is emitted through the exposed surface of the lower disc. If K is the co-efficient of thermal conductivity of the material of bad conductor, d its thickness and r its radius; θ_1 and θ_2 the constant readings of the thermometers T_1 and T_2 in the steady state, then rate at which heat is conducted across the disc of the material

$$Q = K\frac{\pi r^2(\theta_1 - \theta_2)}{d}$$

If M is the mass of the metal disc, s the specific heat of its material, then rate of cooling at θ_2 is equal to

$$= Ms\frac{d\theta}{dt}$$

where $\frac{d\theta}{dt}$ is the rate of fall of temperature at θ_2.

$$\therefore \quad \frac{K\pi r^2(\theta_1 - \theta_2)}{d} = Ms\frac{d\theta}{dt}$$

or

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

The rate of cooling is found by heating the metal disc to a temperature about 10°C above the steady temperature θ_2, it is then allowed to cool and temperature is noted after every 30 seconds till the temperature falls to about 10°C below θ_2. A graph is then plotted between the temperature and time. A tangent is drawn at a point P corresponding to θ_2. The slope of the tangent gives the value of $\frac{d\theta}{dt}$ corresponding to temperature θ_2.

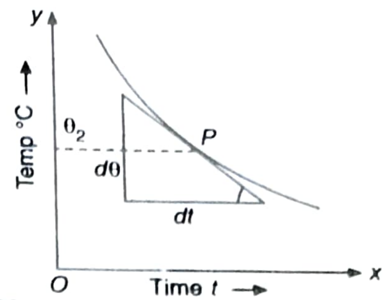

Fig. 9.5

Procedure. 1. Set the apparatus as shown in Fig. 9.4 so that the flat surface of the disc is horizontal. Insert the disc of the material in between this disc and the cylindrical vessel. Place the thermometers T_1 and T_2 in position.

2. Pass steam from the inlet of the cylindrical vessel and wait till the steady state is reached. This will take 30-40 minutes. When the temperatures indicated by the thermometers T_1 and T_2 are steady note down the temperatures. Interchange the thermometers T_1 and T_2 and again note down the temperatures.

3. Remove the cylindrical vessel as also the disc of the material and heat the disc A till its temperature is about 10°C above the steady temperature indicated by T_2. Allow it to cool and note the temperature at intervals of about 30 seconds, till its temperature falls to about 10°C below θ_2. Plot a graph between temperature and time.

4. Measure the diameter of the disc with a vernier callipers along two diameters mutually perpendicular to each other and measure its thickness with a screw gauge at different points. Also find the mass of the disc when cooled.

Observations.

Mass of the metallic disc M = gm = kg

Specific heat of metal s = kilo-cal/kg

Diameter of the disc = 1. 2.

Mean diameter D = cm = m

∴ Radius of the disc r = cm = m

Thickness of the disc d = 1..., 2..., 3..., 4...

Mean thickness = cm = m

Steady temperature of the thermometers

T_1 = (*i*) (*ii*)

T_2 = (*i*) (*ii*)

Mean temperature θ_1 = °C

Mean temperature θ_2 = °C

Readings for cooling curve.

No. of Obs.	1	2	3	4	5	6	7	8	9
Time in seconds	30	60	90	120	150	180	210	...	...
Temp. of disc									

To find the rate of cooling $\frac{d\theta}{dt}$. Draw a graph taking time t along the X-axis and temperature θ along the Y-axis. Draw a tangent to the graph at a point P corresponding to the steady temperature θ_2 as shown in Fig. 9.6 cutting the X-axis at A. Draw PM perpendicular to OA.

The rate of fall of temperature $\frac{d\theta}{dt}$ at the temperature θ_2 ...

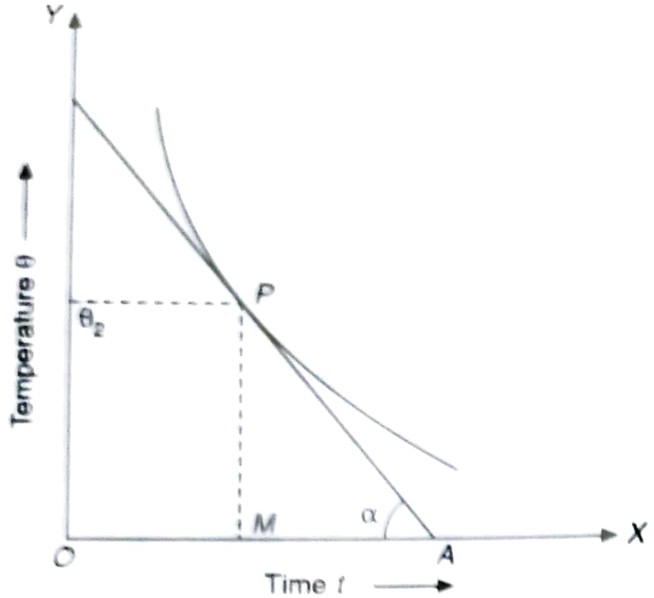

Fig. 9.6

$$\frac{d\theta}{dt} = \tan\alpha = \frac{PM}{MA}$$

$\therefore$ Rate of cooling $\frac{d\theta}{dt}$ from the graph corresponding to steady temperature θ_2 = °C/sec.

Calculations. $K = \frac{Msd}{\pi r^2(\theta_1 - \theta_2)} \times \frac{d\theta}{dt} =$

Precautions. 1. Thickness d of the disc of the material should be measured at a number of places on its surface.

2. The diameter of the disc should be equal to that of the cylindrical vessel and the metallic disc and should be measured in two perpendicular directions.

3. The thermometers should be placed close to the face of the disc of the specimen.

4. There should be a good thermal contact between the disc of material and the lower surface of the cylindrical surface and the upper surface of the circular metallic disc. If necessary glycerine may be applied between the surfaces.

5. The steady state temperatures should be recorded only when the readings of T_1 and T_2 remain constant after an interval of about five minutes.

Oral Questions

1. **Conductivity.** (*i*) Define co-efficient of thermal conductivity. (*ii*) What are the units in which it is expressed? (*iii*) What are the dimensions of thermal conductivity? (*iv*) What do you mean by temperature gradient? (*v*) On what factors does the rise of temperature of any portion of the rod depends (*a*) in the variable state and (*b*) in the steady state. (*vi*) Distinguish between steady and variable states. (*vii*) Why is it necessary to obtain the steady state before taking observations? (*viii*) Which material is the best conductor of heat? (*ix*) Can Searle's apparatus be used for finding the conductivity of a bad conductor? If not why? (*x*) In Lee's method why should the experimental disc be thin? (*xi*) Why the two thermometers are placed close to the disc?