Thermal conductivity of a bad conductor

1 Aim

To determine the coefficient of thermal conductivity of a bad conductor using Lee's disc method.

2 Introduction

Thermal conductivity is an intrinsic property of a material that indicates the ability of a material to transfer heat. The Lee's disc method uses the concept of thermal equilibrium to measure heat transfer across a bad conductor. The Lee's disc apparatus consist of a hollow cylinder (steam chamber) resting on a thin metallic disc of identical diameter. The steam chamber has inlet and outlet tubes for steam and slots on the side to insert thermometers. When steam is passed through the cylindrical vessel a steady state is reached. In the steady state, heat conducted through the bad conductor is equal to heat radiated from the Lower disc.

If k is the coefficient of thermal conductivity of the material, d is its thickness and r is the radius, then the rate of heat transfer across two faces having temperatures T_1 and T_2 is given by,

$$\frac{dQ}{dt} = k\frac{\pi r^2 (T_1 - T_2)}{d}. \tag{1}$$

If M is the mass of the disc and s is the specific heat of the disc, then the rate of cooling at T_2 is given by,

$$\frac{dQ}{dt} = Ms\frac{dT}{dt}. \tag{2}$$

By the definition of equilibrium, the rate of transfer of heat must be equal to the rate of cooling. This leads to,

$$K = \frac{Msd}{\pi r^2 (T_1 - T_2)}\frac{dT}{dt}. \tag{3}$$

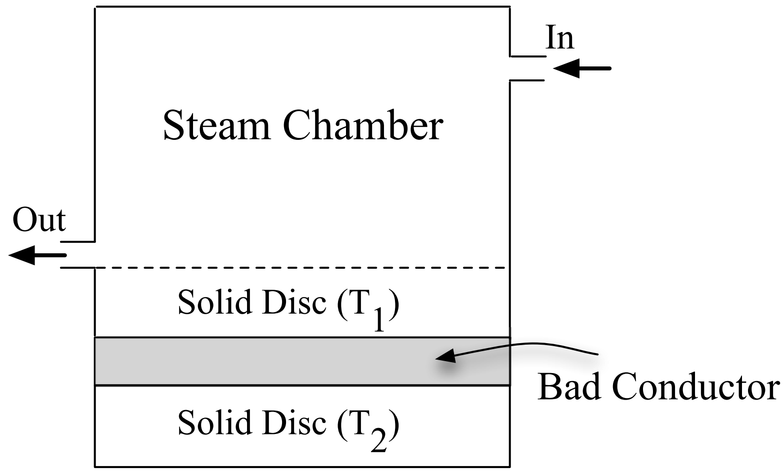

Figure 1: Schematic view of the Lee's disc apparatus.

3 Apparatus in the lab and Procedure

1. Set the apparatus as shown in the figure, so that the flat surface of the disc is horizontal. Place the disc of the bad conductor specimen between the lower disc and the hollow cylindrical vessel (steam chamber). Place the thermometers T_1 and T_2 in their positions.

2. Pass steam into the inlet of the cylindrical vessel and wait till the steady state is reached. This could take 30-40 minutes. When the temperatures indicated by the thermometers are steady, note the readings.

3. Remove the disc of the specimen, and heat the lower disc till its temperature is about $10°C$ higher than the steady state 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 $10°C$ lower than the steady state value. Plot a graph between temperature and time.

4. Measure the diameter of the lower disc with vernier callipers, and its thickness using screw gauge. Also find the mass of the disc after it has cooled.

3.1 Other specifications

- Specific heat of the Lee's disc material: $s = 420$ J/(kgK)

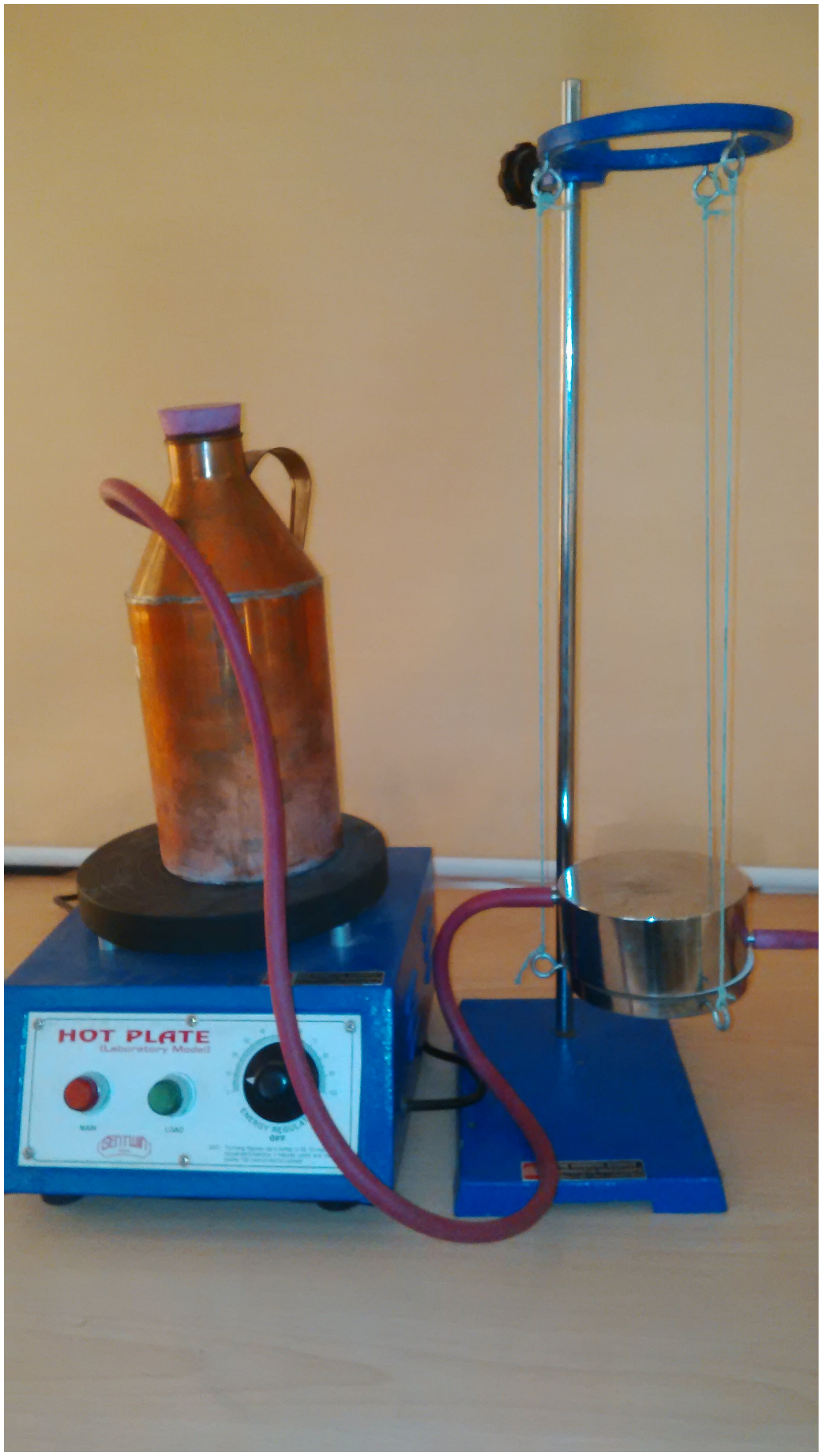

Figure 2: Schematic view of the Lee's disc apparatus.

4 Calculations

1. Find the rate of cooling dT/dt from the cooling curve.
2. Measure the dimensions of the Lee's disc and measure its weight.
3. Calculate the coefficient of thermal conductivity using the formula discussed above.