Thermal conductivity of a good conductor

1 Aim

To find the coefficient of thermal conductivity of a good conductor using Searle's apparatus.

2 Introduction

The rate of heat flowing through a block of a material with uniform cross-sectional area A and length l with opposite ends maitained at temperatures T_1 and T_2 ($T_1 > T_2$) is given by,

$$\frac{dQ}{dt} = k\frac{A(T_1 - T_2)}{l}. \tag{1}$$

The value of the constant k depends on the nature of the material and is called the coefficient of thermal conductivity.
The state in which the temperature of each part of the bar is rising is called the variable state. After a sufficiently long time, the temperatures reach a steady state. If the bar is well insulated, so that the heat losses due to convection and radiation are minimum, then the rate of flow of heat is equal to the rate at which the heat is leaving from the cold end. In order to calculate the later, water is run through a copper coil wrapped around the colder end. The temperatures of the incoming and outgoing water are recorded as T_3 and T_4. If m is the mass of water flowing per second, then the rate at which the heat is absorbed by the water is given by,

$$\frac{dQ}{dt} = ms(T_4 - T_3), \tag{2}$$

where s is the specific heat of water. In SI units, $s = 4185.5$ J/(kgK), at 288K. Using equations (1) and (2) one can find the coefficient of thermal conductivity k.

3 Apparatus in the lab and Procedure

1. Fill the steam generator about half with water and start heating it.

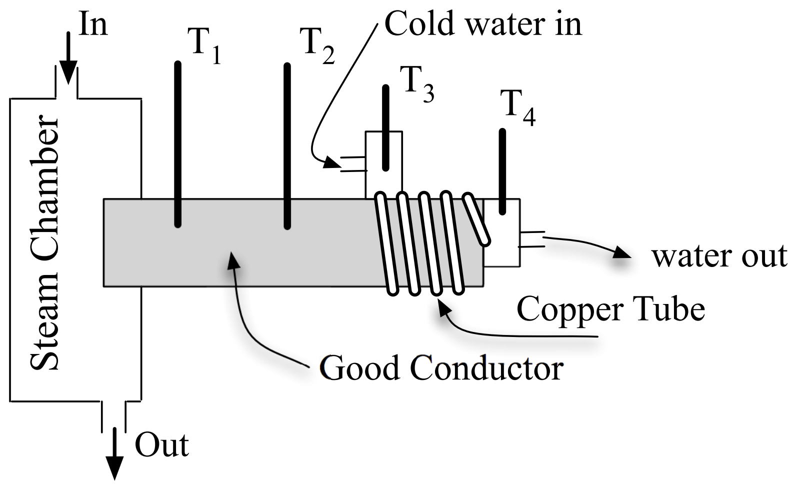

Figure 1: Schematic view of the Searle's Apparatus.

Figure 2: Searle's Apparatus in the lab.

2. Place the two $\frac{1}{2}^{\circ}$ thermometers T_1 and T_2 in position along the copper bar. Insert the other two thermometers ($\frac{1}{10}^{\circ}$ or $\frac{1}{5}^{\circ}$) T_3 and T_4 at the entrance and exit point of water in the coil.
3. Connect the steam generator by a rubber tube to the inlet of the steam chamber.
4. Connect the water entrance end of the coil to the constant level water tank. Adjust the flow of water through the coil so that water comes out in a trickle.
5. Wait till the steady state is reached. If the thermometers show the same temperature reading for about 10 minutes, the steady state has reached. This will take about half an hour.
6. Take a clean and dry beaker and weigh it. Collect about 100 cc of water in it and note the time taken to collet the water. Repeat the observation a few times.
7. Change the rate of water flow and repeat the experiment. Note that after changing the water flow, you should again wait until a staeady state has been reached.
8. Measure the diameter of the bar to calculate the cross-sectional area A of the copper bar. Also measure the distance l between the holes in the bar where thermometers T_1 and T_2 are placed.

4 Precautions

1. Water should be allowed to flow at a uniform rate and a mere trickle of water should be let out of the outlet so that the rise of temperature is constant and sufficient.
2. Temperatures should be recorded only after the steady state has been achieved.
3. The rod should be thermally insulated to prevent heat loss due to radiation.