1.THERMAL CONDUCTIVITY OF A METAL ROD

AIM OF THE EXPERIMENT:

a) To measure the temperature gradient along the length of the metal (copper) rod.

b) To determine the co-efficient of thermal conductivity of the metal (copper).

INTRODUCTION:

Conduction is a process of heat transfer through solids. When a temperature gradient exists in a body, experience has shown that there is a transfer of heat from the high temperature region to the low temperature region. The heat transfer rate per unit area is proportional to the temperature gradient given by:

$$\frac{q}{A} \propto \frac{\Delta T}{\Delta X} \qquad \text{--- Eq (1)}$$

Where, 'q' is the heat transfer rate (watts), A is the area of heat transfer (m^2), $\Delta T / \Delta X$ is the temperature gradient in the direction of heat flow (°C/m). When the proportionality constant is inserted, we get,

$$\frac{q}{A} = \frac{-K\,\Delta T}{\Delta X} \qquad \text{---Eq (2)}$$

The positive constant 'k' is called the co-efficient of thermal Conductivity of the material. The negative sign indicates that heat transfer takes place in the direction of decreasing temperature. Co- efficient of thermal conductivity has the units of watts/m°C. Note that heat flow rate is involved and the numerical value of the co- efficient of thermal conductivity indicates how fast heat will flow in a given material.

Thermal conductivity co- efficient is a physical property of the material. Although it is fairly constant in a narrow temperature range, it varies over a wide temperature range. Metals which are good conductors of heat have high values of co-efficient of thermal conductivity; for example, 385 watts/m°C for copper. Insulating materials have low values of co-efficient of thermal conductivity – for example 0.048 watt/m°C for fiber insulating board.

In any conduction heat transfer problem, it is essential to have the knowledge of co-efficient of thermal conductivity of the material involved in the heat transfer process. This set-up has been designed to measure the temperature gradient along the length of the rod and to determine its co- efficient of the thermal conductivity.

<u>APPARATUS</u>:

It consists of a copper rod one end of which is heated by an electric heater and the other end projects inside the cooling water jacket. The middle portion of the rod is thermally insulated from the surroundings using asbestos rope. The temperature of the rod is measured at four different locations along its length. Following are the important features of the experimental setup.

a) Copper rod, Length : 450mm

Diameter : 20mm.

No. of thermocouples mounted : 4 (at the interval of 58 mm) a long the length

b) Band heater used to heat up one end.

c) Thermal insulation covering the copper rod to reduce heat losses to the surroundings.

d) Cooling water jacket at the other end with water supply connections and thermocouples at both inlet T_5 and outlet T_6.

e) Heat controller or regulator to vary input power to the heater.

f) Measuring jar to measure water flow rate in the cooling water jacket.

g) Thermocouples to measure temperatures at 1, 2, 3 & 4 along the length of the copper rod and 5 & 6 to measure temperatures at inlet & outlet of water jacket.

h) Digital temperature indicator and channel selector.

PROCEDURE:

a) Switch ON the mains.

b) Open the valve at the inlet of the cooling water jacket and maintain constant water flow rate.

c) Switch ON the heater.

d) Set the heat control or regulator and adjust the power input to the heater.

e) Wait for reasonable time till the temperatures T_1 toT_4 are fairly constant with time that is steady state is reached.

f) Read the temperatures T_1 to T_4 on the metal rod using channel selector and digital temperature indicator.

g) Read inlet and outlet water temperatures (T_5 & T_6) of the cooling water jacket.

h) Measure the cooling water flow rate using measuring jar and stop watch.

i) Using the measured temperatures and water flow rate, the temperature gradient along the length of the brass rod and co- efficient of thermal conductivity of copper are calculated using the procedure given below.

Formulae:

The heat balance equation is given by,

$q_i = q_o + q_1$ ---Eq (2)

Where,

q_i = Input heat rate from the heater to the copper rod (Watts).

q_o = Output heat flow rate from the rod.

= Heat flow rate absorbed by water in the cooling water jacket (Watts).

q_1 = Heat loss from the rod to the surrounding s through thermal insulation, watts (Watts), Assumed to be zero.

We can assume that $q_1 = 0$, because of good thermal insulation. Therefore, we get heat flow rate through the rod given by:

$$q_i = q_o = m\,C_p.\ \Delta T_w \qquad \text{--- Eq (3)}$$

Where,

m = Water flow rate in Kg/ sec. in the cooling water jacket.

C_p = Specific heat of water, 4.18 KJ / Kg°C

= 4180 J / Kg°C.

ΔT_w = Rise in temperature of the cooling water in the cooling water jacket.

= T_6-T_5 (°C).

T_6 = Water temperature at the outlet (°C).

T_5 = Water Temperature at the inlet (°C).

Determination of temperature gradient (dT/dX) along the length of the Copper rod:

From the measured temperatures T_1, T_2, T_3, T_4 surface temperature distribution along the length of the rod can be determined by plotting a graph of distance along the rod (X) on the X-axis and temperature (°C) on the Y-axis as shown.

Thus, the temperature gradient (dT/dX) at the centre of the brass rod in °C /m can be determined from the slope of the curve (by drawing a tangent).

Determination of Co-efficient of Thermal Conductivity**:**

The heat conduction equation is given by

$$q = kA\left(\frac{dT}{dX}\right) \qquad \text{---Eq (4)}$$

Where,

Q = Heat flow rate through the Copper rod, watts

k = Co-efficient of thermal conductivity of copper, Watts/m^2 °C.

A = Area of heat transfer, m^2

$= (\pi d^2) / 4.$

$= (\pi \times 0.02^2) / 4$

$= 3.14 \times 10^{-4}\ m^2.$

d = Diameter of the Copper rod (m). = 0.02 m

From EQ (3) & (4), we get,

$$k A \left(\frac{dT}{dX}\right) = m \cdot C_p \cdot \Delta T_w \qquad \text{---- Eq (5)}$$

$$k = \frac{m \times C_p \times \Delta T_w}{A\left(\frac{dT}{dX}\right)} \quad \text{in} \quad w/m^0 c$$

The co-efficient of thermal conductivity (k) can be obtained by substituting the measured values of m, ΔT_w, (dT /dX), A and C_p.

The above analysis assumes that the heat loss from the brass rod is negligible due to thermal insulation.

OBSERVATION TABLE:

Power meter reading, in Watts	T_1	T_2	T_3	T_4	T_4	T_5	T_6	Time duration for steady state

T_1 – FIRST POINT TEMPERATURE
T_2 – SECOND POINT TEMPERATURE
T_3 – THIRD POINT TEMPERATURE
T_4 – FOURTH POINT TEMPERATURE
T_5 –WATER INLET TEMPERATURE
T_6 –WATER OUTLET TEMPERATURE

GRAPHS: Temp Vs Distance

RESULTS:

2.THERMAL CONDUCTIVITY OF COMPOSITE WALLS

INTRODUCTION:

Conduction is a process of heat transfer through solids For a given temperature difference between the surfaces, the rate of heat transfer (q watts) depends upon the co-efficient of thermal conductivity of the substance (k, watts/ m^{o}C), area of heat transfer (A, m^{2}) and temperature differences (ΔT, ^{o}C) between the surfaces and thickness of the material (ΔX, m) according to the equation,

$$Q = k A (\Delta T / \Delta X) \qquad \text{----Eq (1)}$$

Substances such as metals conduct more heat and have high values of co-efficient of thermal conductivity , as high as about 200 watts / m^{o} C. Insulating materials conduct less heat and have low values of co-efficient of thermal conductivity, say about 0.1 to 1 watts / m^{o} C. In circumstances where heat loss from the system has to be minimized, such as in power plant transmission lines, furnaces, etc. It is essential to cover heat carrying systems with proper materials. This set-up has been designed to study heat transfer through composite materials.

AIM OF THE EXPERIMENT:

To determine rate of heat transfer co efficient through composite material consisting of Copper, Asbestos and Mild Steel, Alluminium.

SPECIFICATION AND DESCRIPTION:

The set-up consists of the following items:

a) Composite Walls:

It consists of a Heater at one end with Mild Steel, Asbestos, Alluminium and Copper plates composited to form heat flow path. The test pieces are covered with MS Sheet Guard to prevent heat loss.

b) Flat Heater:

Provided to heat the composite walls at one end.

* Capacity : 250 watts
* Diameter of copper,
  Asbestos & Mild Steel plates : 150 mm.
* Thickness of test plates : 6 mm