OBJECTIVES

1. Determine the thermal conductivity (k) of a metal specimen by using linear heat conduction.

INTRODUCTION

Thermal conduction is the transfer of heat energy in a material due to the temperature gradient within it. It always takes place from a region of higher temperature to a region of lower temperature. A solid is chosen for the experiment of pure conduction because both liquids and gasses exhibit excessive convective heat transfer. For practical situation, heat conduction occurs in three dimensions, a complexity which often requires extensive computation to analyze. For experiment, a single dimensional approach is required to demonstrate the basic law that relates rate of heat flow to temperature gradient and area.

THEORY

According to Fourier's law of heat conduction: If a plane wall of thickness (ΔL) and area (A) with temperature difference (ΔT) then the heat transfer rate per unit time (Q) by conduction through the wall can be determined as follows :

$$Q = \alpha \, A \, \frac{\Delta T}{\Delta L} \text{ where } \Delta T = (\, T_b - T_a \,)$$

If the material of the wall is homogeneous and has a thermal conductivity k (the constant of proportionality) then :

$$Q = -\text{k} \, A \, \frac{\Delta T}{\Delta L} \text{ where } \Delta T = (\, T_a - T_b \,)$$

It should be noted that heat flow is positive in the direction of temperature fall hence the negative sign in the equation. For convenience the equation can ve rearranged to avoid the negative sign as follows:

$$Q = \text{k} \, A \, \frac{\Delta T}{\Delta L} \text{ where } \Delta T = (\, T_b - T_a \,)$$

PROCEDURE

1. Linear heat conduction experiment setup and the schematic diagram of the construction of the apparatus as shown in **Figure 1** and **Figure 2**, respectively.
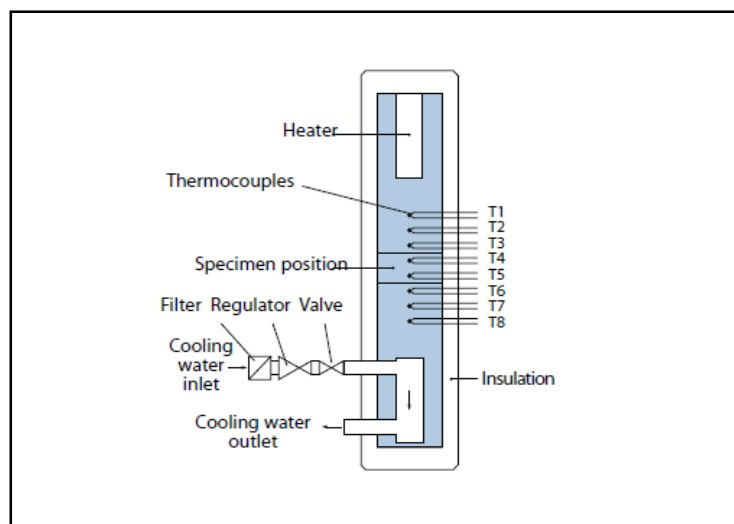

Figure 1 : HT11 Linear Heat Conduction Unit

Figure 2 : Schematic diagram showing construction of HT11

2. Clamp the specimen section in place.
3. Switch on the front mains switch A.
4. Turn on the cooling water and adjust the water discharge approximately 1.5 litres per minute. The actual flow can be checked using a stopwatch and measuring cylinder.
5. Set the Heater Voltage to 17 Volts. Adjust the voltage control potentiometer to 17 volts on the top panel meter with the selector switch set to position V.
6. When the temperatures are stable record the current temperatures T1, T2, T3, T6, T7, and T8 using the selector switch to select each required value in turn.
7. Set the Heater Voltage to 21 Volts using the same method as before. Allow the HT11 to stabilise then repeat the above readings.
8. Repeat the procedure with different specimen

Results and Discussion

Let V = Heater Voltage (volts), I = Heater Current (amperes), Heat Flow, Q (watts)

T1 = Heater section high temperature (℃)
T2 = Heater section mid temperature (℃)
T3 = Heater section low temperature (℃)
T6 = Cooled section high temperature (℃)
T7 = Cooled section mid temperature (℃)
T8 = Cooled section low temperature (℃)

Length of specimen   = 0.030 (m)
Diameter of bar   = 0.025 (m)

The necessary data for calculations will be recorded to the table given below

MATERIALS	VOLTS	AMP	Q	T1	T2	T3	T4	T5	T6	T7	T8
	V	I	W	℃	℃	℃	℃	℃	℃	℃	℃
	Thermocouple position			1	2	3	-	-	6	7	8

For each set of readings plot a graph of temperature against thermocouple position. Observe that each temperature profile is a curve and that the gradient at any point on the curve decreases with increasing distance from the heater.

Calculations: Using the equation given below, calculate the thermal conductivity.
Thermal conductivity is defined as:

$$k = \frac{Q\Delta L}{A\Delta T}$$

Conclusion :

1. Search the value of thermal conductivity, k for each specimen from appropriate references.
2. Calculate the percentage difference between the theory and experimental value of thermal conductivity, k.
3. Explain why there is a difference value between theory and experimental ?