INSTRUCTION MANUAL
FOR
THERMAL SCIENCE LABORATORY EXPERIMENTS

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GENERAL INSTRUCTIONS

1. The instructions in this manual provide only the outline. Come prepared with the back-up material i.e. go through the theory related to the experiments, know in advance the readings to be taken, the calculations to be performed and the results to be presented

2. The data sheets are to be countersigned by the instructor. The calculations are to be completed and checked by the instructor on the same day. The complete report should be submitted on the day of next lab class.

3. Each student has to submit his/her individual report and his/her individual comments and remarks.

4 The report should include
   - The aim of the experiment
   - A sketch/block diagram of the apparatus
   - A listing of the instruments used with details (type, range, accuracy etc.)
   - Transient/steady state readings in tabular form
   - Results in graphical form where required
   - Comments and natures of the results with standard/reference values.
   - Source of errors and error analysis.

5. The report need not include
   - A description of the Apparatus
   - A description of the experimental procedure

6 The following points should be attended before starting the experiment.
   - Take note of any precaution with regard to the experimental set-up
   - Check electrical connections before starting the experiment.
   - Clarify any doubt with regard to the experiment
   - Do not put on the computer attached to the set-up

DO NOT PUT ON THE SYSTEM UNTIL THE CONNECTION ARE CHECKED BY THE INSTRUCTOR

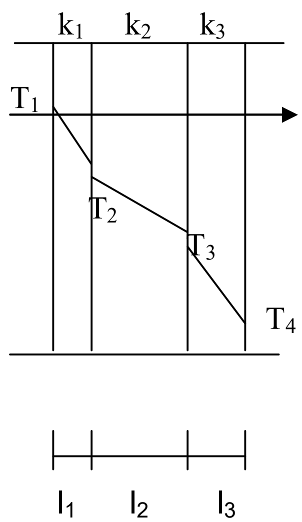
HEAT CONDUCTION

AIM: To determine the linear and the radial temperature distribution in a plane wall and a composite wall. Also, to find the thermal conductivity of the material for which the temperature distribution is measured.

PRINCIPILE: Thermal conduction is the transport of the energy in a medium due to a temperature gradient and the physical mechanism is that of random atomic or molecular activity. The quantity of heat flow through the cross-section of a solid body over time t in a study state is governed by the Fourier's law of heat conduction. Fourier's law is applicable for all matter regardless of its state: solid, liquid and gas.

LINEAR CONDUCTION

Heat conduction through a wall is given by $Q = -k\, A\, \frac{dT}{dx}$. The conduction through a wall made up of several layers is given by



First Layer: $Q=k_1\, A\, (T_1-T_2)/l_1$

Second Layer: $Q=k_2\, A\, (T_2-T_3)/l_2$

Third Layer: $Q=k_3 A(T_3-T_4)/l_3$

$$Q = \frac{A(T_1-T_4)}{l_1/k_1+l_2/k_2+l_3/k_3}$$

RADIAL CONDUCTION

It corresponds to the conduction of the heat through a hollow cylinder and is given by

$$\mathbf{Q} = \frac{2\Pi\, L\, k\, (T_1-T_2)}{\ln(r_2/r_1)}$$

DESCRIPTION*:* The linear conduction unit comprises of three elements namely the heater, various inserts and a movable part with a cooler. By opening the toggle fastener and sliding back the cooler, the insert can be installed. By this means the heat is transferred linearly from the heater through an insert to the cooler. The heater consists of external insulation, lid, brass rod and the electrical heater element. There are three measuring points under the insulation in the brass rob. Together, with the insert, there are nine measuring points. Three different types of insert rods can be inserted in order to measure the linear conduction. Insert 1 has three temperature measuring points in a brass rod. This brass rod has the same diameter as the heater and the cooler. Insert 2 also has the same diameter as the heater and the cooler, but is made from corrosion resistant steel and does not have temperature-measuring points. Insert 3 is made of brass but of lesser diameter 15mm and it also does not have measuring points. The cooler consists of external insulation and a brass rod as for the heater. However, this brass rod has bores through which the cooling water can flow. The distance between adjacent measuring points is 10 mm. The diameter of the heater, cooler, insert 1and insert 2 is 25 mm. If insert 1 is not used in the experiments, the temperature displayed measuring 4,5, and 6 should be ignored.

The radial conduction unit consists of an insulating housing with lid and disc with heater and cooler. The heater is fixed from below in the center of the brass disc. There is copper pipe around the disc through cooling water can flow. From above, six temperature-measuring points are fitted in a line that stretches radially from the center to the circumference. In radial conduction, the measuring points are numbered from the center to outwards. The distance between adjacent measuring points is 10 mm. The diameter of the disc is 110 mm; it is 4 mm thick. The heater is in the center of the disk on the underside and has a diameter of 12 mm. The temperatures for measuring points 7, 8 and 9 should be ignored during the experiments.

The control and display unit has a digital temperature (deg C) and power (Watts) display. The measuring point for the temperature display is selected by a rotary knob. The heater power is switched with on\off switch and adjusted using potentiometer. The measuring points in linear and radial conduction are shown in Fig1 and Fig2.

PROCEDURE:

1. Install the insert 1 adjust the cooling water flow rate (only a very low cooling water flow rate of approximately 1 liter/hour is required to dissipate a heater power of 90 W at a temperature difference of 90^0 C).
2. Switch on the unit and adjust the power to 40 W using the potentiometer of the control and display unit.
3. When the thermal conduction process has reached a steady state condition, i.e., the temperatures at the individual measuring points are stable and no longer changing, note the temperatures at various locations and the power supplied to the heater.
4. The same procedure holds good for all the inserts and for both the linear and radial conduction.

WARNING:

1. Do not operate the conduction unit above 120^0 C. The plastic part disintegrates after this temperature.
2. Never operate the conduction unit without cooling water. The unit gets overheated.
3. Do not connect the heater directly to mains.
4. Always switch off the control and display unit prior to changing the power supply. Otherwise, the temperature sensors may get damaged.

RESULTS:
Plot a graph with temperature vs. location of the thermocouple. At each location of the thermocouple, calculate the thermal conductivity**.**

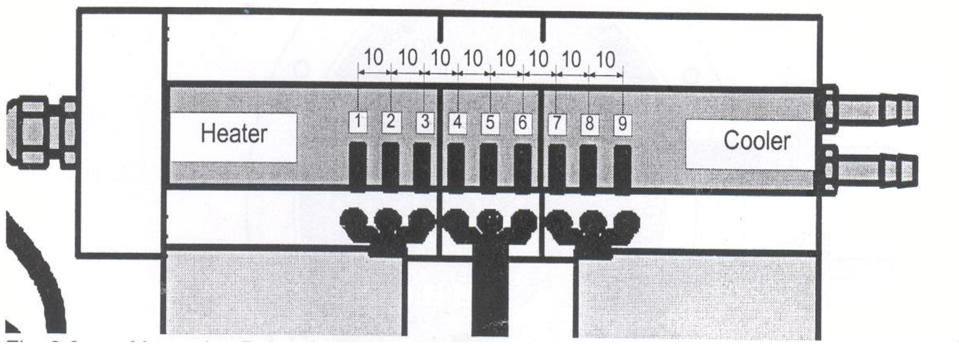


Figure 1: Measuring points for linear Conduction

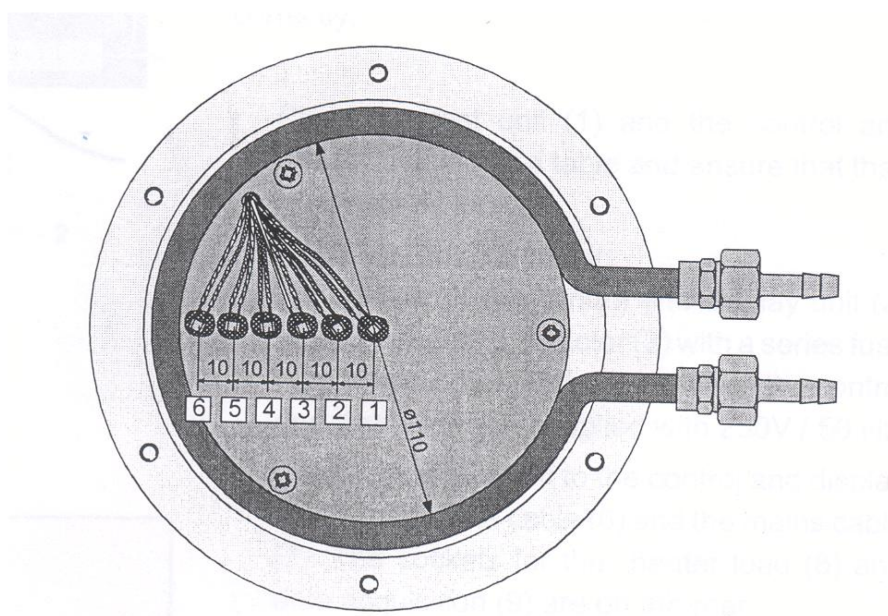


Figure 2: Measuring points for radial Conduction

Data Sheet for linear conduction:

Insert-1. Material:_Brass______Length:_20 mm______ Diameter:______25 mm____.

Sl. No	Heat Input Q (W)	T_1	T_3	T_4	T_6	T_7	T_8
1	8	54.8	51.3	44.7	41.6	35.1	33.1
2	11	63.1	57.9	48.0	44.1	36.4	33.6

Insert-2, Material:__Brass_________Length:____20 mm___ Diameter:__15 mm.

Sl. No	Heat Input Q (W)	T_1	T_3	T_7	T_8
1	8	56.6	53.4	34.6	33.1
2	11	62.3	58.2	35.6	339.

Insert-3, Material:__SS___Length:____20 mm____ Diameter:_25 mm

Sl. No	Heat Input Q (W)	T_1	T_3	T_7	T_8
1	8	67.3	64.6	36.2	29.8
2	11	80.6	76.9	31.1	30.6

Data Sheet for Radial conduction:

Material:_____Brass_________Thickness:___4mm____ Diameter:__110 mm_______.

Sl no	Heat Input	T_1	T_2	T_3	T_4	T_5	T_6
01	8	**35.5**	**34.0**	**32.2**	**31.4**	**30.5**	**30.1**
02	11	**43.5**	**40.3**	**36.6**	**34.4**	**32.7**	**31.8**

Conclusion :