THERMAL CONDUCTIVITY OF LIQUIDS (HT-107)

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1. OBJECTIVE:

To study the heat transfer through liquids.

2. AIM:

To calculate the thermal conductivity of a liquid.

3. INTRODUCTION:

When a temperature gradient exists in a body, there is an energy transfer from the high temperature region to the low temperature region. Energy is transferred by conduction and heat transfer rate per unit area is proportional to the normal temperature gradient.

$$\frac{q}{A} \alpha \frac{\Delta T}{\Delta X}$$

When the proportionality constant is inserted,

$$q = -kA\frac{\Delta T}{\Delta X}$$

Where q is the amount of heat transfer and $\Delta T/\Delta X$ is the temperature gradient in the direction of heat flow. The constant k is called thermal conductivity of the material.

4. THEORY:

For thermal conductivity of liquids using fourier's law, the heat flow through the liquid from hot fluid to cold fluid is the heat transfer through conductive fluid medium.

Fourier's equation:

$$q = \frac{-kA}{\Delta X}(T_2 - T_1)$$

Fourier's law for the case of liquid

At steady state, the average face temperatures are recorded (T_h and T_c) along with the amount of heat transfer (Q) knowing, the heat transfer area (A_h) and the thickness of the sample (ΔX) across which the heat transfer takes place, the thermal conductivity of the sample can be calculated using fourier's law of heat conduction.

$$Q = kA\,\frac{(T_h - T_C)}{\Delta X}$$

$$k = \frac{Q \times \Delta X}{A \times (T_h - T_C)}$$

5. DESCRIPTION:

The apparatus consists of a heater, it heats a thin layer of liquid. Funnel is provided with valve for fill the liquid. Drain valve is given for maintain the liquid level. Plate is for circulation of water. Flow control vale is provided for control the flow of water. Six temperature sensors are provided to measure the temperature across the liquid layer.

6. UTILITIES REQUIRED:

6.1 Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15 Amp combined socket with earth connection.

6.2 Water Supply: Continuous @ 2 LPM at 1 Bar.

6.3 Floor drain required.

6.4 Bench area required: 1 m x 1 m.

7. EXPERIMENTAL PROCEDURE:

7.1 STARTING PROCEDURE:

7.1.1 Close all the valves V_1-V_3.

7.1.2 Connect continuous water supply to the inlet of water chamber.

7.1.3 Connect outlet of chamber to drain.

7.1.4 Open the valve V_2.

7.1.5 Fill the liquid (whose thermal conductivity have to be measure) through funnel till the liquid retain in funnel.

7.1.6 Adjust the valve V_3 to keep the liquid at axis level.

7.1.7 Ensure that mains ON/OFF switch given on the panel is at OFF position & dimmer stat is at zero position.

7.1.8 Connect electric supply to the set up.

7.1.9 Switch ON the mains ON / OFF switch.

7.1.10 Start the water supply and adjust the flow of water by valve V_1.

7.1.11 Set the heater input by the dimmer stat, voltmeter in the range 40 to 100 V.

7.1.12 After 1.5 hrs. note down the reading of voltmeter, ampere meter and temperature sensors in the observation table after every 10 minutes interval till observing change in consecutive readings of temperatures (± 0.2 °C).

7.1.13 Repeat the experiment for different liquids.

7.2 Closing Procedure:

7.2.1 When experiment is over set the dimmer stat to zero position.

7.2.2 Switch OFF the mains ON/OFF switch.

7.2.3 Switch OFF electric supply to the set up.

7.2.4 Stop flow of water by closing the valve V_1.

7.2.5 Drain the water by open the valve V_3.

8. Observation & Calculation:

8.1 Data:

Thickness of liquid ΔX	= 0.018 m
Diameter of plate D	= 0.165 m

8.2 Observation Table:

Sr. No	V (volts)	I (amp)	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_4 (°C)	T_5 (°C)	T_6 (°C)

8.3 CALCULATIONS:

$$Q = V \times I \ (W)$$

$$A = \frac{\pi}{4} D^2 \ (m^2)$$

$$T_h = \frac{T_1 + T_2 + T_3}{3} \ (^\circ C)$$

$$T_c = \frac{T_4 + T_5 + T_6}{3} \ (^\circ C)$$

$$k = Q \frac{\Delta X}{A (T_h - T_c)} \ (W/m\ ^\circ C)$$

CALCULATION TABLE:	
Sr. No	**k (W/m °C)**

9. NOMENCLATURE:

Nom	Column Heading	Units	Type
A	Heat transfer area	m^2	Calculated
D	Diameter of plate	m	Given
I	Ammeter reading	Amp	Measured
k	Thermal conductivity of liquid	W/m °C	Calculated
Q	Heat supplied by heater	W	Calculated
T_1-T_3	Temperature of the temperature sensors on the hot side	°C	Measured
T_4-T_6	Temperature of the temperature sensors on the cold side	°C	Measured
T_c	Cold face average temperature	°C	Calculated
T_h	Hot face average temperature	°C	Calculated
V	Volt meter reading	volts	Measured
ΔX	Thickness of liquid	m	Given

10. Precaution & Maintenance Instructions:

10.1 Never run the apparatus if power supply is less than 200 volts and more than 230 volts.

10.2 Never switch ON mains power supply before ensuring that all the ON/OFF switches given on the panel are at OFF position.

10.3 Operate selector switch of temperature indicator gently.

10.4 Always keep the apparatus free from dust.

11. Troubleshooting:

11.1 If electric panel is not showing input on the mains light, check the main supply.

11.2 If voltmeter showing the voltage given to heater but ampere meter does not, check the connection of heater in control panel.

12. References:

12.1 Cengel, Y.A (2007). *Heat and Mass Transfer.* 3rd Ed. ND: Tata McGraw Hill. pp 17-19.

12.2 Kern, D.Q (2007). *Process Heat Transfer.* 16th Ed. ND: McGraw Hill. pp 6-9

13. Block Diagram: