Engineering Growth Connection

THERMAL CONDUCTIVITY OF INSULATING POWDER (HT-104)

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1. OBJECTIVE:

To study the heat transfer through conduction in insulating powder.

2. AIM:

To calculate the thermal conductivity of insulating powder.

3. INTRODUCTION:

In many heat transfer equipments, heat loss to surroundings is to be minimized to achieve maximum economy. In such cases they are lagged by materials of lower thermal conductivity, which are referred as insulators. Because of demand of such insulating materials, many industries have come up to produce such material. Preference is given to produce materials having lower thermal conductivities. Also these materials are available in different shapes, sizes and forms of powders. Powders have the advantage that they can take any complicated shape between any two confirming surfaces. In addition its conductivity will be much lower than that of the Basic solid from which the powder has been made. This is because of a very large number of air spaces in between particles, which have much lower thermal conductivity values. Thermal conductivity of such materials is a complicated function of the geometry of the particles, the nature of heat transfer, conduction, convection and radiation in air spaces, which is determined by the air space size and temperature level etc. Thus it is very difficult quantity to estimate and almost in all practical cases it is measured experimentally.

4. THEORY:

Consider the transfer of heat by conduction through the wall of hollow sphere formed by the insulating powdered layer packed between two thin copper spheres.

Let:

r_i = radius of inner sphere in m

r_o = radius of outer sphere in m

T_i = average temperature of the inner surface in °C

T_o = average temperature of the outer surface in °C

From the Experimental values of q, T_i and T_o, the unknown thermal conductivity k can be determined by following formulae:

$$k = \frac{Q(r_o - r_i)}{4\pi r_o r_i (T_i - T_o)}$$

5. DESCRIPTION:

The apparatus consists of two thin walled concentric spheres of copper of different size. The small inner copper sphere is provided with the heater. The insulating powder (Asbestos) is packed between the two spheres. Ten temperature sensors at proper positions are fitted to measure surface temperature of spheres. Voltmeter and ammeter is provided with dimmer stat and variac to measure the heat input.

6. UTILITIES REQUIRED:

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

6.2 Bench Area Required: 1m x 1m.

7. EXPERIMENTAL PROCEDURE:

7.1 STARTING PROCEDURE:

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

7.1.2 Connect electric supply to the set up.

7.1.3 Switch ON the mains ON / OFF switch.

7.1.4 Set the heater input by the dimmer stat, voltmeter in the range 40 to 100 volt.

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

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 the power supply to the set up.

8. Observation & Calculation:

8.1 Data:

Inner radius r_i = 0.05 m

Outer radius r_o = 0.1 m

8.2 Observation Table:

Sr. No.	V (volt)	I (Amp)	T_1 (°C)	T_2 (°C)	T_3 (°C)	T_4 (°C)	T_5 (°C)	T_6 (°C)	T_7 (°C)	T_8 (°C)	T_9 (°C)	T_{10} (°C)

8.3 Calculations:

$$Q = V \times I \text{ (W)}$$

$$T_i = \frac{T_1 + T_2 + T_3 + T_4}{4} \text{ (°C)}$$

$$T_o = \frac{T_5 + T_6 + T_7 + T_8 + T_9 + T_{10}}{6} \text{ (°C)}$$

$$k = \frac{Q(r_o - r_i)}{4\pi r_o r_i (T_i - T_o)} \text{ (W/m °C)}$$

Calculation Table:

S.No	k (W/m °C)

9. NOMENCLATURE:

Nom	Column Heading	Units	Type
I	Ammeter reading	Amp	Measured
k	Thermal conductivity of insulating powder	W/m °C	Calculated
Q	Amount of heat transfer	W	Calculated
r_i	Inner radius	m	Given
r_o	Outer radius	m	Given
T_1 - T_4	Temperature of temperature sensors embedded on the inner sphere	°C	Measured
T_5 - T_{10}	Temperatures of temperature sensors embedded on the outer sphere	°C	Measured
T_i	Inside surface temperature	°C	Calculated
T_o	Outside surface temperature	°C	Calculated
V	Voltmeter reading	volts	Measured

10. PRECAUTION & MAINTENANCE INSTRUCTIONS:

10.1 Never run the apparatus if power supply is less than 200 volts and above 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 the input on the mains light, check the main supply.

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

13. Block Diagram: