Experiment Details

Department Name	Mechanical Engineering
Class	TY BTech.
Semester	1st
Subject Name	Heat Transfer
Experiment No.	1
Experiment Name	THERMAL CONDUCTIVITY OF INSULATING POWDER

Version History

Sr. No.	Version Number	Created By	Approved By	Date
1	v1.0	Vedant Mandrupkar	Mr. Rohit Ghulanavar	10/10/2020

AIM:

To determine thermal conductivity of insulating powder.

THEORY:

Thermal insulation is of great importance because it involves considerable cost in industries in minimizing the heat losses. Different materials are used as insulating materials. These materials used may be of solid (sheet or powder or yarn etc), liquid and gases. Solid insulating materials are popular as they can be easily used in many situations. One of the desirable properties of insulating materials is low thermal conductivity or high thermal resistance.

Thermal conductivity is defined as the ' rate of heat transfer by conduction per unit area per unit temperature gradient' and its S.I unit is W/mK or W/m℃. While calculating the thermal conductivity experimentally Fourier's law of heat conduction is used. It can be stated as:

'Rate of heat transfer by conduction in steady state is directly proportional to the normal area and temperature gradient'.

Mathematically,

$Q \propto A(dx/dT)$; Where Q = heat transfer rate in W

T = Temperature in 0C or K

A = Area normal to heat transfer in m2

Removing proportionality the law can be written as

$Q = -kA(dx/dT)$;

where k = constant of proportionality called as 'Thermal conductivity'. Negative sign here indicates that the there is decrease in temperature in the direction of heat transfer.

Insulating materials need to have high thermal resistance. Thermal resistance can be calculated using electrical analogy as given below.

Heat transfer rate = (Thermal Potential Difference/Thermal Resistance) ; $Q = \Delta T/Rth$

Where Q is analogous to Current I , ΔT analogous to Voltage V and Rth analogous to Electrical Resistance R. S.I unit of thermal resistance is ℃/w or K/W. Expression for thermal resistance depends on the geometry for heat conduction. Rth expression for slab, hollow cylinder and hollow sphere is given below.

Slab:

$Rth = L/kA$; where L =thickness of slab, k = thermal conductivity and A = normal area.

Hollow Cylinder:

Rth = (ln(r2/r1))/2πkL ; where r2 = outer radius , r1= inner radius, k= thermal conductivity and L=length of cylinder.

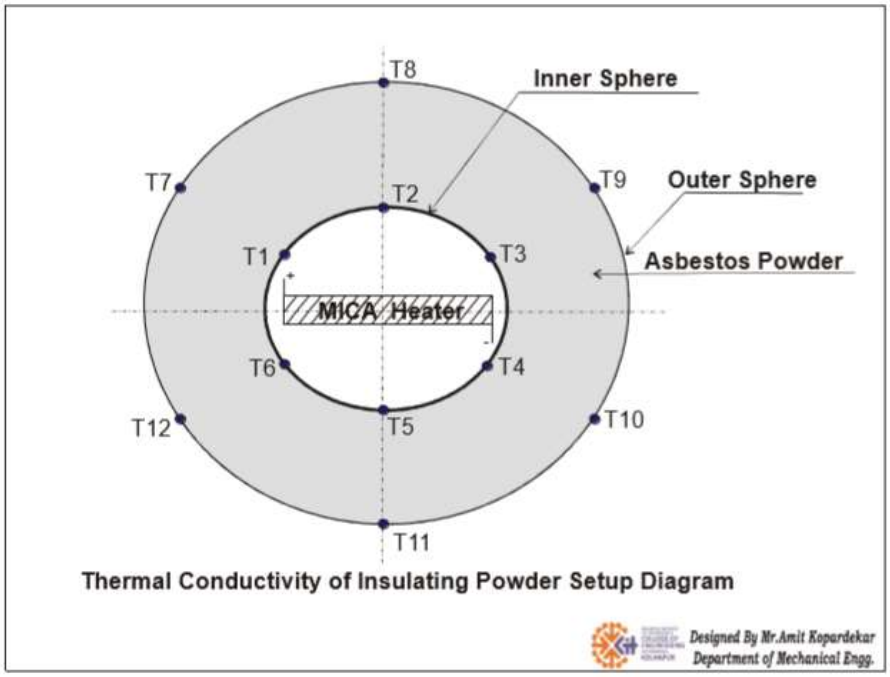
Hollow Sphere:

Rth = (r2-r1)/4πkr1r2 ; where r2 = outer radius , r1= inner radius, k= thermal conductivity

DISCRIPTION OF APPARATUS:

The experimental setup consists of two concentric spheres as shown in figure. The gap between the spheres is filled with asbestos powder whose thermal conductivity is to be found out. Six thermocouples of k-type are attached on inners sphere and six on outer sphere for measuring the temperature. Mica heater is kept inside the inner sphere. With the help of dimmerstat heat input can be controlled. Voltmeter, Ammeter and Selector switch with temperature indicator are provided on the console.

DIAGRAM:



PRE TEST:

Write minimum five MCQ's along with the answer. (Based on pre requisites of experiment)

PROCEDURE:

1. Set the values of Voltage and Current.
2. Note down the temperature readings of all twelve thermocouples.
3. Calculate Thermal Conductivity (k) of insulating powder using given formulae.
4. Repeat the above procedure 3 more times with different Voltage and Current inputs.
5. Calculate average Thermal Conductivity.

SPECIFICATIONS:

1. Radius of inner sphere = ri =50mm
2. Radius of outer sphere = ro =100mm
3. Mica heater: 1000 W
4. Dimmerstat: 2 - 5 kW
5. Voltmeter: 0 - 300 Volts
6. Ammeter: 0 - 5 Amperes
7. Multi channel digital temperature indicator: 0 - 400°C
8. Thermocouples: k-type (12 Nos.)

CALCULATIONS:

1. Heat Input = Q = V x I (W)
2. Average surface temperatures: $T_i = (T1+T2+T3+T4+T5+T6)/6$;

   $T_o = (T7+T8+T9+T10+T11+T12)/6$;
3. Thermal Conductivity of Insulating Powder: $Q = \Delta T/R_{th} = (T_i - T_o) / [(r_o - r_i) / (4\pi k r_i r_o)]$;

   Therefore, $k = [Q (r_o - r_i)] / [4\pi k r_i r_o (T_i - T_o)]$;

POST TEST:

Write minimum five MCQ's along with answer. (Based on given experiment)

REFERENCES:

Write names of text books and reference books for experiment.