



**Heat Transfer lab.**  
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**Subject: Heat Transfer Lab.**

**Third Class**

**Experiment 2**

## **THERMAL CONDUCTIVITY OF COMPOSITE WALLS :**

### **2.1:objective:**

1. To determine total thermal resistance and thermal conductivity of a composite wall.
2. To plot temperature gradient along composite wall structure.

### **2.2: Theoretical part:**

Many engineering applications of practical utility involve heat transfer through a medium composed of two or more materials of different thermal conductivities arranged in series or parallel. Consider for example the walls of a refrigerator, hot cases, cold storage plants, hot water tanks etc., which always have some kind of insulating materials between the inner and the outer wall. A hot fluid flow inside the tube covered with a layer of thermal insulation is an example of composite system because in this case the thermal conductivities of tube metal insulation are different. The problem of heat transfer through the composite system can be solved by the application of thermal resistance concept.

When heat conduction takes place through two or more solid materials of different thermal conductivities, the temperature drop across each material depends on the resistance offered to heat conduction and the thermal conductivity of each material.

The total resistance through composite wall is given by:

$$\sum R_{th} = R_1 + R_2 + R_3 + \dots = \frac{\Delta X_1}{K_1 A_1} + \frac{\Delta X_2}{K_2 A_2} + \frac{\Delta X_3}{K_3 A_3} + \dots$$

Which gives a total heat flow (q) of

$$q = \frac{\Delta T_{overall}}{\sum R_{th}}$$

The apparatus consists of three slabs of different materials namely Press Wood Plate, Bakelite Plate and Cast iron Plate. The heater is provided to supply heat input across these composite walls. Total heater assembly comprises of a heater bound between two aluminum plates, on both sides of these heater identical structures of composite walls are placed. Thermocouples are provided at proper position in the composite walls to record desired inside temperature of composite wall. Multi-channel temperature indicator is used to measure this temperature. Small hand press provided to press the wall on each other and ensure that no air gap remaining between two plates. Heat input to heater is given through a dimmer stat variac and measured by voltmeter and ammeter. By varying heat input and combination of the composite structures, wide range of experiment can be performed.

### **2.3:Apparatuious:**

The apparatus shown in figure (2-1), uses known insulating material of large thickness to enable unidirectional heat flow. The apparatus is used mainly to study the resistance offered by different slab materials and to establish the heat flow similar to that of current flow in an electrical circuit.



Figure 2.1: The experimental apparatus

Composite slabs:

1. Wall thickness:
  - a) cast iron plat = 1cm,
  - b) bakelite plate =1.3cm,
  - c) press wood plate=0.6cm.
2. Slab diameter = 300mm
3. Temperature Indicator : 0 - 300°C
4. Ammeter : 0 – 5A
5. Voltmeter : 0 – 300V

#### **2.4:Procedure:**

1. Arrange the plates in proper fashion (symmetrical) on both sides of the heater plates.
2. Operate of the hand press properly to ensure perfect contact between the plates.
3. Close the box by cover sheet to achieve steady environmental conditions.
4. Switch on the supply heater.



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5. Give known steady input to the heater with the help of dimmer stat.
6. Keep initially 100V for 20 minutes almost and then reduce to 80V till steady state is reached so that steady state can be reached within less time.
7. Check the input to the heater with selector switch, voltmeter and ammeter.
8. Note down the temperature every 5 minutes till steady conditions is reached.
9. Calculate the thermal resistance of the material based on the steady state condition readings.

**2.5: Calculation:**

Test no.	V (volt)	I (ampere)	Q= V*I	T1 Ċ	T2 Ċ	T3 Ċ	T4 Ċ	T5 Ċ	T6 Ċ	T7 Ċ	T8 Ċ
1											
2											
3											

(1) Rate of heat supply  $Q = V \times I$  W (For calculating the thermal conductivity of composite walls, it is assumed that due to large diameter of the plates, heat flowing through the central portion is unidirectional i.e. axial flow. Thus for calculating central half diameter area where unidirectional flow is considered. Accordingly thermocouples are fixed at closed to center of the plates.)

$$A = (\pi/4) * d^2$$

$$q = \text{heat flux} = (Q/A), (\text{W/m}^2)$$

**Mean reading:**

$$T_A = \frac{T_4 + T_5}{2}$$

$$T_B = \frac{T_3 + T_6}{2}$$

$$T_C = \frac{T_2 + T_7}{2}$$

$$T_D = \frac{T_1 + T_8}{2}$$

(2) Total thermal resistance of composite slab:

$$R_{\text{tot}} = \frac{T_A - T_D}{q}$$

(3) Thermal conductivity of composite slab:

$$K_{\text{composite}} = \frac{q * b}{T_A - T_D}$$

**b = total thickness of the slab in m**

(4) Thermal conductivity of individual materials:

$$K_{C.I} = \frac{q * b}{T_A - T_B}$$

$$K_{\text{bakelite}} = \frac{q * b}{T_B - T_C}$$

$$K_{\text{wood}} = \frac{q * b}{T_C - T_D}$$



press wood
backlite
cast iron
heater
cast iron
backlite
press wood

**2.6:Question for discussion:**

1. How will you verify the temperature distribution in case of composite wall?
2. Discuss the difference between the resistance of each slabs.