Ministry of Higher Education and Scientific Research
Al-Mustaqbal University College
Air Conditioning and Refrigeration Technologies

Heat Transfer Laboratory

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Experiment No. (2)

Heat transfer through composite wall

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Experiment (2)

أسم التجربة: انتقال الحرارة خلال جدار ذو طبقات متعددة.

Experimental Title: Heat transfer through composite wall

Objective:

1. To determine total thermal resistance and thermal conductivity of a composite wall.

2. To plot temperature gradient along composite wall structure.

Theoretical Part:

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 the composite wall is given by:-

$$\Sigma R_{th} = R_1 + R_2 + R_3 + \cdots = \frac{\Delta x_1}{k_1 A_1} + \frac{\Delta x_2}{k_2 A_2} + \frac{\Delta x_3}{k_3 A_3} + \cdots \qquad (2.1)$$

which gives a total heat flow (***q***) of

$$\boldsymbol{q} = \frac{\Delta T_{overall}}{\Sigma R_{th}} \qquad (2.2)$$

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 side of these heater identical structures of composite walls are placed. Thermocouples are provided at proper positions 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 & combination of the composite structure, wide range of experiment can be performed.

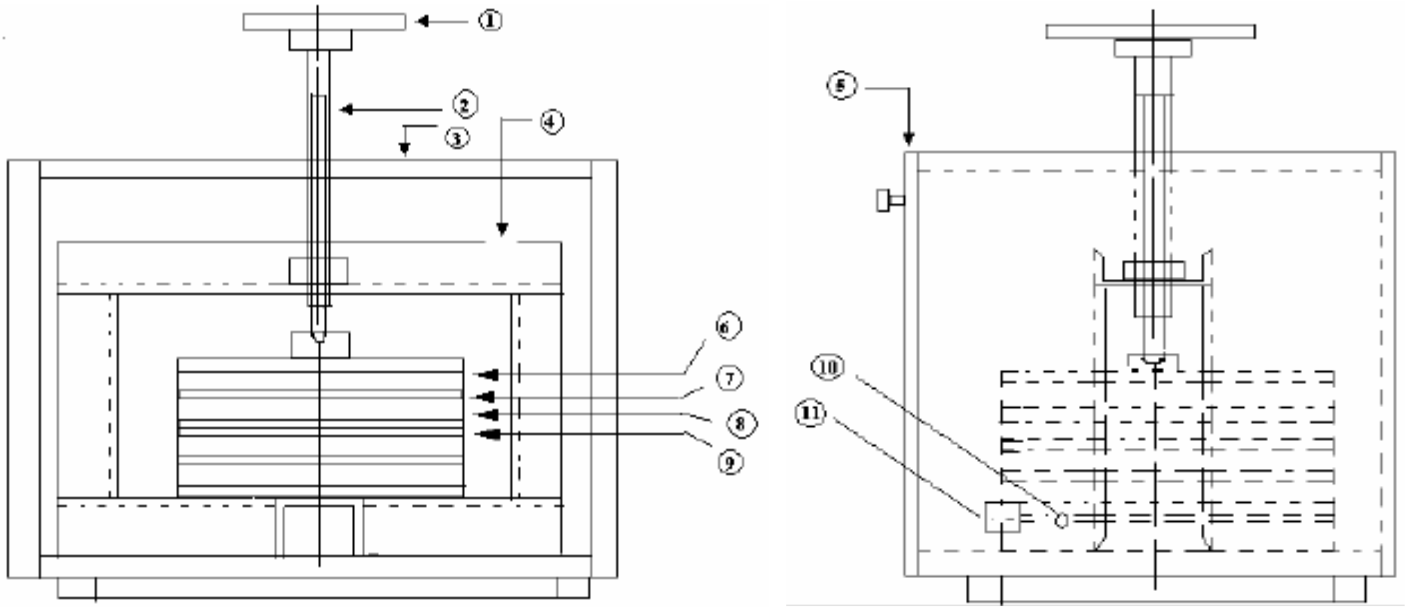
The apparatus shown in Figure (2.1) and Figure (2.2) uses known insulating material of large thickness to enable unidirectional heat flow. The apparatus is used mainly

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.

Experimental procedure

Apparatus:

Figure (2.1) the experimental Apparatus



(1) Hand Wheel (2) Screw (3) Cabinet (4) Fabricated Frame
(5) Acrylic Sheet (6) Press Wood Plate (7) Bakelite Plate (8) cast iron Plate
(9) Heater (10) Heater Cable (11) Thermocouple Socket 12 Way T1 To T6 Thermocouple Positions

Figure (2.2) Schematic of the experimental set-up.

Procedure:

1- Arrange the plates in proper fashion (symmetrical) on both sides of the heater plates.

2- See that plates are symmetrically arranged on both sides of the heater plates.

3- Operate the hand press properly to ensure perfect contact between the plates.

4- Close the box by cover sheet to achieve steady environmental conditions.

5- Switch on the supply of heater.

6- Give known steady input to the heater with the help of dimmer-stat.

7- Keep initially 100 V for 20 minutes almost and then reduce to 80 V till steady state is reached so that steady state can be reached within less time.

8- Check the input to the heater with selector switch, voltmeter & ammeter.

9- Note down the temperature every 10 minutes till a steady condition is reached.

10- Calculate the thermal resistance of the material based on the steady state condition readings.

Composite Slabs:

Detailed information of the experimental set up is as follows:

1. Wall thickness:

a. Thickness of cast iron Plate = (1 cm)

b. Thickness of Bakelite Plate = (1.3 cm)

c. Thickness of Press wood Plate = (0.6 cm)

2. Slab diameter = (300 mm)

3. Thickness of slab (b) = 2.9 cm

Observation Table:

Voltmeter reading (V)			
Ammeter reading (I)			
Thermocouple Readings (°C)	SET (1)	SET (2)	SET (3)
T_1			
T_2			
T_3			
T_4			
T_5			
T_6			
T_7			
T_8			

Mean Readings:

$$T_A = \frac{T_4 + T_5}{2} \qquad T_B = \frac{T_3 + T_6}{2}$$

$$T_C = \frac{T_2 + T_7}{2} \qquad T_D = \frac{T_1 + T_8}{2}$$

Calculations:

1. Rate of heat supply Q = V x I (Watt)

(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).

$$q = Heat\ flux = \frac{Q}{A} \quad ,[W/m^2] \qquad (2.3)$$

Where

$$A = \frac{\pi}{4} d^2 = \quad (2.4)$$

2. Total thermal resistance of composite slab:

$$R_{tot} = \frac{T_A - T_D}{q} \quad (2.5)$$

3. Thermal conductivity of composite slab:

$$K_{composite} = \frac{q * b}{T_A - T_D} \quad (2.6)$$

b = total thickness of the slab in (m)

4. Thermal conductivity of individual materials

$$K_{C.I} = \frac{q * b_{C.I}}{T_A - T_B} \quad K_{bakelite} = \frac{q * b_{bakelite}}{T_B - T_C} \quad K_{wood} = \frac{q * b_{wood}}{T_C - T_D}$$

Discussion:

1. Discuss the differences between the resistances of each slab.

2. Plot and discuss the thickness of the slab material vs temperature gradient.