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Development of Thermal Conductivity of Composite Wall

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***Abstract*: It's being very difficult to calculate & analyze the thermal behavior of the wall of different material attached to each other. Study of composite material is used to find the heat transfer rate. These composite materials are used in many applications with different properties such as, Air Craft, Trains, and Marine etc. In this, we are going to study thermal behavior of three composite materials. Experimental text is carried out for finding Thermal conductivity of composite materials. And CFD analysis is done to compare the values between theoretical and experimental. Now a day, a significant number of thermal engineering researchers are seeking for new enhancing heat transfer methods between surfaces and the surrounding fluid. This technique refers to different methods used to increase rate of heat transfer without affecting much the overall performance of the system. The subject of enhanced heat transfer has developed to the stage that it was of serious interest for heat exchanger design.**

***Keywords*: Thermal Conductivity, Composite.**

1. Introduction

Heat transfer Occurs at a lower rate across materials of lower thermal conductivity than across materials of high thermal conductivity. Correspondingly, materials of high thermal conductivity are widely used in heat sink applications and materials of lower thermal conductivity are used as thermal insulation. To quantify the ease with which a particular medium conducts, engineers employ the thermal conductivity, also known as the conduction coefficient; k. Thermal conductivity is a material property that is primarily dependent on the material's phase, temperature, density, and molecular bonding.

Heat is energy in transition from a region of higher to one of lower temperature in such a way that the regions reach thermal equilibrium. This temperature difference is the driving force for the transfer of the thermal energy, also known as heat transfer. This much the Second Law of Thermodynamics tells us. There are three modes of heat transfer: Conduction, convection and radiation.

2. Related work

A. Heat transfer

Heat is a form of energy in transit due to temperature difference. Heat transfer is transmission of energy from one region to another region as a result of temperature difference between them. Whenever there is temperature difference in mediums or within a media, heat transfer must occur. The amount of heat transferred per unit time is called heat transfer rate and is denoted by Q. The rate of heat transfer per unit area normal to the direction of heat flow is called heat flux. As Figure 1, there is a metal stick. Using a candle to heat the left side of the stick for a while, then the right side of the stick will be found to be hot as well. It is because the energy has been transferred from the left side of the stick to the right side. And this kind of heat transfer is conduction.

B. Conduction

Steady state conduction is a form of conduction that happens when the temperature difference driving the conduction is constant, so that after an equilibration time, the spatial distribution of temperatures in the conducting object does not change any further in steady state conduction, the amount of heat entering a section is equal to amount of heat coming out.

C. Convection

When temperature different exists between a surface and a fluid flowing over it, heat transfer between them will occur by convection. This heat transfer largely due to the air motion close to the surface of the wall. The air motion is driven by natural or free convection which arises from density differences due to temperature differences of air. This is always the case of the interior surfaces. In forced convection the air motion is produced by an external agency like a wind in a case of exterior wall surface. Both mechanisms may operate together.

D. Radiation

The transfer of energy across a system boundary by means of electromagnetic mechanism which is caused solely by a temperature difference whereas the heat trans by conduction and convection take place only in the presence of medium, radiation heat transfer does not require any medium.

E. Steady state heat transfer

For analysis of heat transfer problems, two types of heat transfer are considered-steady state and unsteady state. In steady state heat transfer, the temperature at any location on the system does not vary with time. The temperature is function of space coordinates only, but it is independent of time. During steady state conditions, the heat transfer rate is constant and there is no change of internal energy of the system. For example, the heat transfer in coolers, heat exchangers, heat transfer from large furnaces etc.

3. Problem statement

In this innovative word there are so many are so many materials are available researching are not focused on all of them. So in our work we took mild steel as Conductive material and Bakelite and wood for determining and checking the feasibility, where these are insulating materials.

4. Objective

The temperature distribution across the composite wall can be studied for given arrangement of disc. To determine the overall heat, transfer co-efficient for the composite wall and to compare the same with that calculated from the equation.

5. Methodology

Step 1:

- Selection of material for composite wall. (Mild steel, Bakelite, Press wood)
- Selection of Heater.
- Selection of Temperature Sensor. (Thermocouple)

Step 2:

- Design of control panel including temperature indicator, Digital Voltmeter, Digital Ammeter.

Step 3:

- Assembly of setup.

Step 4:

- Performing Experiment on setup and data analysis.

A. Conducting material

In this material, they bump into their neighbors and transfer the energy to them, a process which continues as long as heat is still being added. The physical properties of the materials involved. Basically, when it comes to conducting heat, not all substances are created equal. Metals and stone are considered good conductors since they can speedily transfer heat, whereas materials like wood, paper, air, and cloth are poor conductors of heat. In our project we have used wood, Bakelite and mild steel of dimensions: Diameter 215mm and Thickness 12mm.

6. Experiment

A. Working

- The apparatus consists of a central heater between two wall and three types of slabs which are provided on both sides of heater that forms a composite structure.
- A small nut is used to tight to ensure the perfect contact between the slabs. A dimmerstat is provided for varying the input to the heater and measurement of input is carried out by a voltmeter and ammeter.

Fig. 1. Setup of Thermal Composite of Composite Wall

- Thermocouples are embedded between interfaces of the slabs, to read the temperature at the surface.
- The experiments can be conducted at various values of input and calculation can be made accordingly.
- The Composite Wall Apparatus is designed for study of Heat transfer through composite wall made up of different materials. Since each material has different thermal conductivity, heat transferred through each of them is different.
- Using different Heat transfer correlations we can determine the thermal conductivity of entire slab as a single wall.
- The equipment consists of slab made up of different materials with heater at its centre. The slab materials are Cast iron, Bakelite and press wood. The walls are circular in cross section Heating element is also circular in shape.
- In order to ensure equal rate of heat flow from both sides of heating element, the heating element is sandwiched between two identical sets of composite slabs. In order to remove the air gaps between the plates, the composite wall is kept pressed with the help of a screw arrangement.

B. 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 dimmerstat.
7. Keep initially 140 V for 20 minutes almost and then reduce to 130 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 15 minutes till a steady condition is reached.
10. Calculate the thermal resistance of the material based on the steady state condition readings.

Table 1
Observation Table

Input Voltage (V) = 130V							
Input Current (I) = 0.53A							
Temperature							
T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
118	115	97	93	72	68	44	42

7. Calculation

1. Rate of heat supply: Q = V×I ......Watt
= 130×0.53
Q = 68.9 Watt

2. Heat Flux : $q = \frac{Q/2}{A} \ldots \frac{W}{m^2}$

Where,Area $(A) = \frac{\pi}{4} d^2 \ldots\ldots m^2$ ......(d=215mm= 0.215m)

$= \frac{\pi}{4} 0.215^2$

A = 0.03630 m^2

Q in any one direction = $\frac{Q}{2}$

$= \frac{68.9}{2}$ = 34.45 Watt

$q = \frac{34.45}{0.03630}$

$q = 949.035 \frac{W}{m^2}$

1) Mean Reading:

$$T_A = \frac{T_1 + T_2}{2} = \frac{118 + 115}{2}$$
$$T_A = 116.5\ ºC$$
$$T_B = \frac{T_3 + T_4}{2} = \frac{97 + 93}{2}$$
$$T_B = 95\ ºC$$
$$T_C = \frac{T_5 + T_6}{2} = \frac{72 + 68}{2}$$
$$T_C = 70\ ºC$$
$$T_D = \frac{T_7 + T_8}{2} = \frac{44 + 42}{2}$$
$$T_D = 43\ ºC$$

2) Total thermal resistance of composite wall:

$$R_{Total} = \frac{T_A - T_D}{Q/_2} = \frac{116.5 - 43}{34.45}$$
$$R_{Total} = 2.1335\ ºC/Watt$$

2) Thermal conductivity of composite wall:

$$K_{Composite} = \frac{q \times b}{T_A - T_D} = \frac{949.035 \times 0.012}{116.5 - 43}$$
$$K_{Composite} = 0.1549 Watt - m/\ ºC$$

Where, b = total thickness of the wall in m = 0.012m

4) Thermal conductivity of individual materials

$$K_{M.S.} = \frac{q \times b_{M.S.}}{T_A - T_B} = \frac{949.035 \times 0.012}{116.5 - 95}$$
$$K_{M.S.} = 0.52969\ Watt - m/\ ºC$$

$$K_{\ Bakelite} = \frac{q \times b_{bakelite}}{T_B - T_C} = \frac{949.035 \times 0.012}{95 - 70}$$

$$K_{\ Bakelite} = 0.455\ Watt - m/\ ºC$$

$$K_{wood} = \frac{q \times b_{wood}}{T_C - T_D} = \frac{949.035 \times 0.012}{70 - 43}$$

$$K_{wood} = 0.4217 Watt - m/\ ºC$$

8. Comparing result

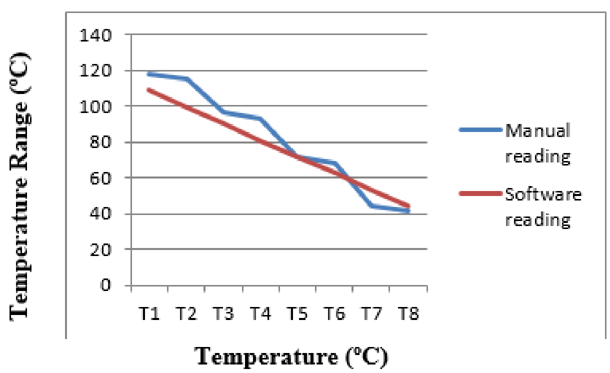

Fig. 2. Comparison of Temperature

Table 2
Temperature, manual and software reading

Temperature	Manual reading	Software reading
T1	118	108.77
T2	115	99.531
T3	97	90.296
T4	93	81.062
T5	72	71.827
T6	68	62.593
T7	44	53.358
T8	42	44.124

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9. Experimental and ANSYS result

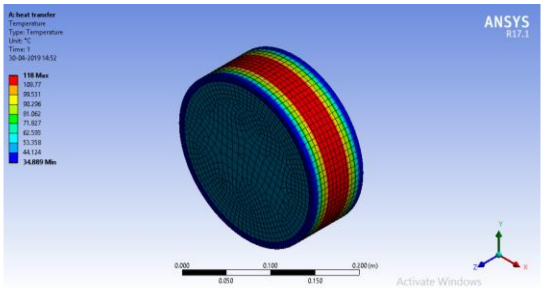

Fig. 3. Temperature distribution

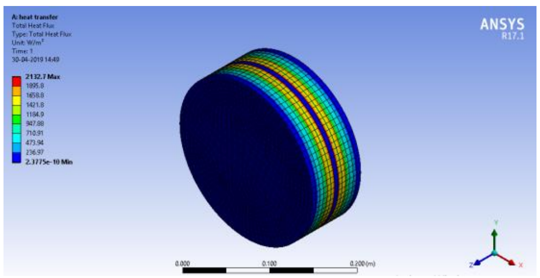

Fig. 4. Heat flux

10. Conclusion

From the above experiment we concluded that this apparatus is useful to find out thermal conductivity of composite slab, consisting of different materials. From the result it is seen that for different material of composite slab the value of thermal conductivity varies according to material to material which is useful to select the specific material for given application. Hence experimental investigation is proved by our apparatus.

"The future is in composites" is the acknowledgment of numerous many years of high innovation advance towards diverse materials and parts gathered and consolidated as solid units that would give a mix of adaptability, quality and different properties past the potential outcomes of traditional materials like metal, wood, or cement. In this paper the thermal analysis of composite wall are analyzed for a steady state condition. By comparing the results of above temperature distribution values it is concluded that results from the Experimental method is varying with the ANSYS solution. And the thermal conductivity of wood has come less than Mild Steel and Bakelite materials.

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