International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2494-9150 Vol-02, Issue 08, Nov 2016

Design and Fabrication of Test Rig for Measurement of Thermal Conductivity of Composite Slab

[1]Belage Yogesh, [2]Gawade Nikhil, [3]Ningnure Vikrant

[1,2,3]Department Of Mechanical Engineering, [1]MIT College of Engineering, Pune, [2]JSPM Narhe Technical Campus, Narhe Pune, [3]Vishveshwarya Technical Campus, Patgaon Miraj, Maharashtra, India.

[1]*yogeshb2510@gmail.com*, [2]*nikhilgawade33@gmail.com* , [3]*vikrant.ningnure336@gmail.com*

Abstract **The paper consists of design and fabrication of a test rig for measurement of conductivity of composite slab which consists of a heater sandwiched between two sets of slabs. Three types of slabs are provided on either sides of heater, which forms a composite structure. Main aim of paper is to calculate conductivity of composite slab. Thermal conductivity is a bulk property that describes the ability of material to transfer heat. Thermal conductivity plays an important role where cooling is required.**

Keywords: Thermal conductivity, Thermal resistance, Temperature, Thermocouple.

I. 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.

On a microscopic scale, heat conduction occurs as hot, rapidly moving or vibrating atoms and molecules interact with neighboring atoms and molecules, transferring some of their energy (heat) to these neighboring particles. In other words, heat is transferred by conduction when adjacent atoms vibrate against one another, or as electrons move from one atom to another. Conduction is the most significant means of heat transfer within a solid or between solid objects in thermal contact. Fluids especially gases are less conductive. Thermal contact conductance is the study of heat conduction between solid bodies in contact. 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. Transient conduction occurs when the temperature within an object changes as a function of time. Analysis of transient systems is more complex and often calls for the application of approximation theories or numerical analysis by computer.

For general scientific use, thermal conductance is the quantity of heat that passes in unit time through a plate of particular area and thickness when its opposite faces differ in temperature by one kelvin. For a plate of thermal conductivity k, area A and thickness L, the conductance calculated is kA/L, measured in W·K−1 (equivalent to: W/°C). The thermal conductance of that particular construction is the inverse of the thermal resistance. Thermal conductivity and conductance are analogous to electrical conductivity (A·m−1·V−1) and electrical conductance (A·V−1).

II. LITRATURE SURVEY

The paper consists of design and fabrication of a test rig for measurement of conductivity of composite slab which consists of a heater sandwiched between two sets of slabs. Three types of slabs are provided on either sides of heater, which forms a composite structure. Main aim of paper is to calculate conductivity of composite slab. Thermal conductivity is a bulk property that describes the ability of material to transfer heat. Thermal conductivity plays an important role where cooling is required.

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.

III. CONSTRUCTION & WORKING

A. Operations used for test rig

1. Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. In test rig casting process is used to manufacture cast iron slab. Also turning operation is used to get required diameter.
2. For Bakelite and press wood slab turning operation is used to get required diameter and for required thickness facing operation is used on lathe machine.
3. Welding is a fabrication or sculptural process that joins materials, usually metals or thermoplastics, by causing fusion. In test rig it is used to join base plate with various parts.
4. Cutting operation is used in cutting various parts of test rig.
5. Finishing operation is used to increase contact between two slabs. Due to finishing operation roughness of surface is decreased.
6. Coloring is done to all parts of test rig to protect from corrosion problem.

B. Experimental Setup

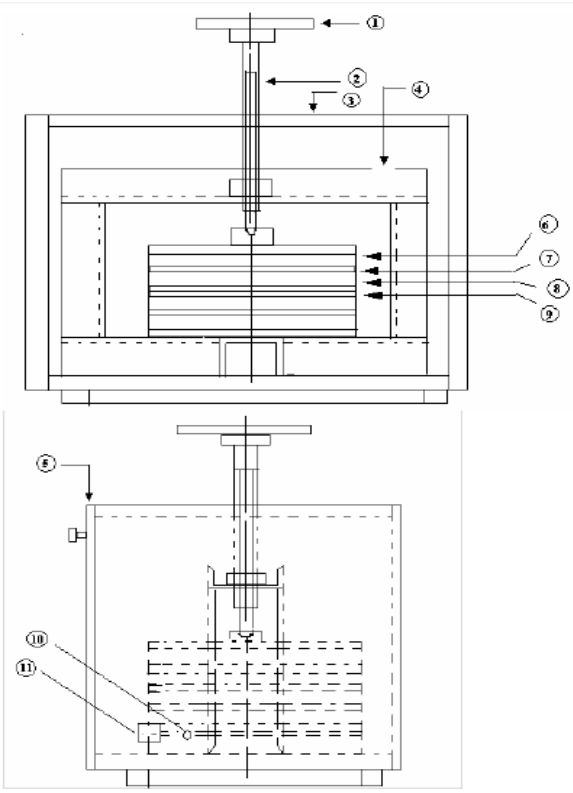

Fig 1 Schematic of Experimental Setup of Thermal Conductivity of Composite Slab

(1) Hand Wheel
(2) Screw
(3) Cabinet
(4) Fabricated Frame
(5) Acrylic Sheet
(6) Press Wood Plate
(7) Bakelite Plate
(8) C.I. Plate
(9) Heater
(10) Heater cable
(11) Thermocouple Socket

C. Working

1. The apparatus consists of a central heater sandwiched between two sheets and three types of slabs which are provided on both sides of heater that forms a composite structure.
2. A small hand press frame is provided 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, ammeter.
3. Thermocouples are embedded between interfaces of the slabs, to read the temperature at the surface.
4. The experiments can be conducted at various values of input and calculation can be made accordingly.
5. The Composite Wall Apparatus is designed for study of Heat transfer through composite slab made up of different materials. Since each material has different thermal conductivity, heat transferred through each of them is different.
6. Using different Heat transfer correlations we can determine the thermal conductivity of entire slab as a single wall.
7. The equipment consists of slab made up of different materials with heater sandwiched at its center. The slab materials are Cast iron, Bakelite and press wood. The slabs 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.
8. In order to remove the air gaps between the plates, the composite slab is kept pressed in between two pressure plates (M.S. plates) with the help of a screw arrangement.
9. Instruments provided include sensors for measuring temperatures at different points, indicators to measure power supplied to the heater.

D. Procedure

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

1. See that plates are symmetrically arranged on both sides of the heater plates.
2. Operate the hand press properly to ensure perfect contact between the plates.
3. Close the box by cover sheet to achieve steady environmental conditions.
4. Start the supply of heater by varying the dimmerstat; adjust the input at the desired value.
5. Take readings of all the thermocouples at an interval of 10 minutes until fairly steady temperatures are achieved and rate of rise is negligible.
6. Note down the reading in observation table.

IV. RESULT ANALYSIS

Test Rig is used to measure thermal Conductivity of Composite Slab consist of cast iron, wood And Bakelite.
It is also used to calculate thermal conductivity of individual materials.

Fig.2 Test Rig

A small hand press frame is provided 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, ammeter.

Fig. 3 Composite slab structure

The equipment consists of slab made up of different materials with heater sandwiched at its center. The slab materials are Cast iron, Bakelite and press wood. The slabs are circular in cross section.

V. CALCULATIONS

A. Observation Table

1. Voltage(V)=75 volts
2. Current(I)=0.28 Amp
3. Temperatures- (in degree Celsius)

Sr. No.	Volt 'V'	Current 'I'	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
1	75	0.28	44	43.7	42.9	42.4	40.9	40.2	39.4	38.3

Fig. 4 Observation Table

1. Heater input

$$Q = V \times I$$
$$= 75 \times 0.28 = 21 \text{ Watts.}$$

2. Mean readings

a. $T_a = \frac{T_1 + T_2}{2} = \frac{44 + 43.7}{2} = 43.85$

b. $T_b = \frac{T_3 + T_4}{2} = \frac{42.9 + 42.4}{2} = 42.65$

c. $T_c = \frac{T_5 + T_6}{2} = \frac{40.9 + 40.2}{2} = 40.55$

d. $T_d = \frac{T_7 + T_8}{2} = \frac{39.4 + 38.3}{2} = 38.85$

3. Thermal conductivity of the slab.

$$K = \frac{Q \times L}{2 \times A \times (Ta - T_d)} \text{ W / m. k}$$
$$= \frac{21 \times 0.045}{2 \times 0.049 \ (43.85-38.85)} = 1.9285 \text{ W / m. k}$$
$$K=1.9285 \text{ W / m. k}$$

Where, L = Length of the slab = 0.045 m
& A = Area of the heater = 0.049 m^2)

4. Thermal resistance of the slab –

$$R = \frac{2 \times A \times (T_a - T_{d)}}{Q} \ m^2 \text{ k /W}$$
$$= \frac{2 \times 0.049 \times (43.85 - 38.85)}{21} = 0.023 \ m^2 \text{ k /W}$$

$$R=0.023 \ m^2 \text{ k /W}$$

VI. CONCLUSION

The thermal conductivity of composite wall is K=1.9285 W/m.k. The thermal resistance of composite wall is R=0.023 m^2 k /W. Similarly we calculate thermal conductivities of cast iron, wood, Bakelite. From heater to wood the value of temperature goes on decreasing. Thermal conductivity of cast iron is greater than bakelite and press wood.

REFERENCES

[1] *Heat Transfer: A Practical Approach* 2nd Edition Yunus A. Cengel

[2] *Transient heat conduction in one-dimensional composite slab. A 'natural' analytic approach* by F. de Monte. Dipartimento di Energetica, University of L'Aquila, Localitá Monteluco, 67040 Roio Poggio, L'Aquila, Italy

[3] J. Raymond, E. Bilgen, "*On the thermal and ventilation performance of composite walls*", Energy and Buildings 39 1041-1046 (2007).

[4] Wei Chen, "*A Study of Heat Transfer in a Composite Wall Collector System with Porous*", Renewable Energy Resources and a Greener Future Vol. VIII-3-1.

[5] Abdulaziz Almujahid Zakariya Kaneesamkandi, "*Construction of a test room for Evaluation Thermal Performance of Building Wall System under Real Conditions*," International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 6, June 2013.

[6] Hu Xiaojun, Zhu Wei, "*Analysis of Application of External Wall Thermal insulating Technology in Affordable Housing in Tonglu County*", Energy Procediab14 488 - 492 (2012).

[7] H. Baig and M. A. Antar," *Conduction / Natural convection analysis of heat transfer across multi-layer building blocks*", 5th European ThermalSciences Conference, the Netherlands, 2008.

[8] Jibao Shen, Stephane Lassue, Laurent Zalewski, Dezhong Huang, "*Numerical study on thermal behavior of classical or composite Trombe solar walls*", Energy and Buildings 39 962- 974 (2007).

