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Fabrication of Heat Transfer Through Composite Wall

Mr. Vaibhav V. Mate [*1], Mr. Harshal R. Sonune[*2], Mr. Nisarg N. Meshram[*3], Mr. Vipul J. Wankhade[*4], Ms. Vedika S. Bhoyar[*5]

Prof. A.D. Bhandarkar[*6], Department of Mechanical Engineering, SIPNA College of Engineering and Technology, Amravati, Maharashtra, India

Abstract : Heat transfer due to temperature difference and mass concentration difference as heat and mass transfer. So many research has been made in past on heat transfer through composite wall of different materials. Which I have extended this work by taking a new material like a Mild Steel, Backlite and Wood as a composite material. In which I conduct a experiment on a composite material wall apparatus and Stainless Steel Round Heater plate centrally in the combination on the composite wall and varying the voltage at 60, 80, 100 and current is different so I found the thermal conductivity of the material as followed Mild Steel– 28.5 W/m-k , Plywood 10.7 W/m-k , Backlite- 6.5 W/m-k.

***IndexTerms* - Heat transfer, Composite Slab, Thermal Conductivity**

INTRODUCTION

Heat Transfer through composite wall is a fundamental concept in thermal engineering and plays a crucial role in various engineering applications, including building insulation, aerospace engineering, and manufacturing process. A composite wall typically consists of multiple layer of different material with distant thermal properties stacked together to achieve specific thermal performance requirement. Understanding heat transfer to composite wall is essential for designing efficient thermal insulation, system optimization energy use and ensuring the comfort and safety of structure and equipment.

Conduction:- Conduction is one of the primary mechanisms through which heat transfers through a composite wall. It occurs when heat energy is transferred from one molecule to another within a material or between different materials in direct contact. In the context of a composite wall, conduction plays a crucial role in transferring heat through the solid layers comprising the wall.

Convection:- Convection is another important mechanism in heat transfer through composite walls, particularly when there is fluid flow (such as air or water) adjacent to the surface of the wall. Convection involves the transfer of heat between the solid surface of the composite wall and the fluid medium in motion. The convection process can be categorized into natural (or free) convection and forced convection, depending on whether the fluid flow is induced by density differences or external forces, respectively.

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.

MODELING AND ANALYSIS.

In heat transfer analysis through a composite wall, engineers typically employ a systematic process to understand and predict the thermal behavior of the structure. This process involves considering various heat transfer mechanisms, material properties, and boundary conditions to accurately model and analyze heat flow through the composite wall. Here's an overview of the composite wall analysis process

Identification of Constituent Layers The first step in analyzing heat transfer through a composite wall is to identify and characterize the individual layers comprising the wall. Each layer may consist of a different material with distinct thermal properties such as thermal conductivity, thickness, and emissivity Heat Transfer Mechanisms, Identify the predominant heat transfer mechanisms involved in the system, which typically include conduction, convection, and radiation. Determine the relative significance of each mechanism based on the specific application and operating conditions.

Heat Transfer Equations, Apply appropriate heat transfer equations governing conduction, convection, and radiation to each layer of the composite wall. These equations describe how heat flux and temperature distributions vary within the wall under given boundary conditions.

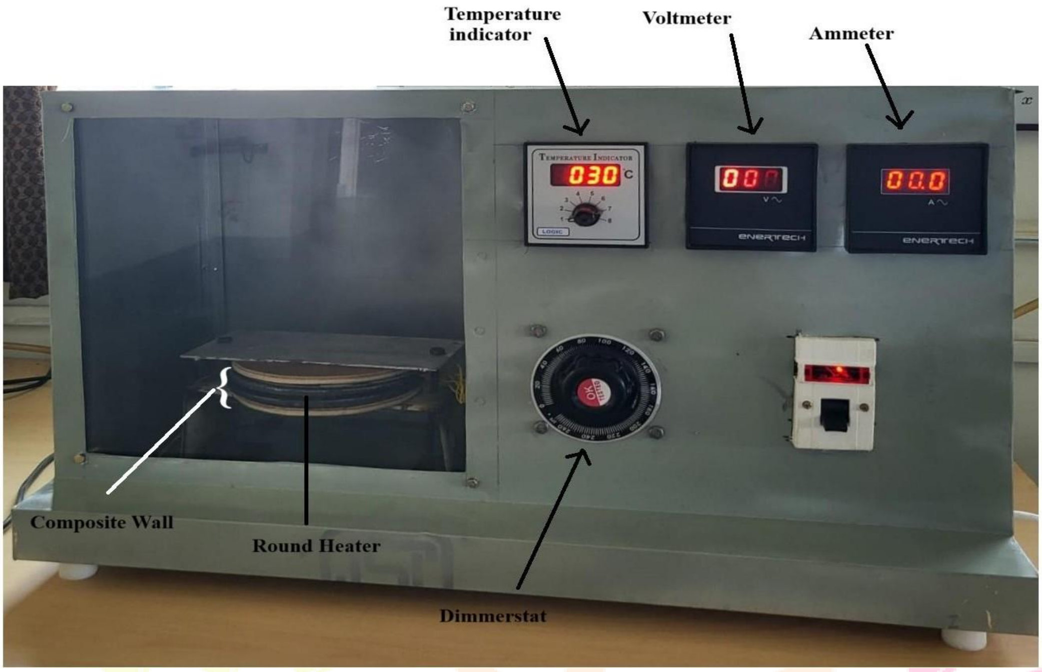

figure 1: fabrication of heat transfer through composite wall

OBSERBVATION AND CALCULATION

Observation table

Sr. No.	Initial temp.	Ammeter (I) in Ampere	Voltmeter (V) in Volt	T1	T2	T3	T4	T5	T6
1	113	1.1	60	95	88	67	80	47	57
2	164	1.5	80	138	123	87	112	56	75

Calculation

Let,

Ti = Initial Temperatures °C

T_1= initial temperature of mild steel °C

T_2=Final temperature of mild steel °C

T_3= initial temperature of Backlite °C

T_4= Final temperature of Backlite °C

T_5= initial temperature of plywood °C

T_6= Final temperature of plywood °C

T_A = Temperatures of Mild Steel °C

T_B = Temperatures of Backlite °C

T_C = Temperatures of plywood °C

Q = Heat Supplied W

q = Heat Flux W/m^2

K = Thermal Conductivity W/mK

V = Supplied Voltmeter reading (V)

I = Supplied Ammeter reading (A)

R_{th1} = Thermal Resistance for Mild Steel W

R_{th2} = Thermal Resistance for Backlite W

R_{th3} = Thermal Resistance for Wood W

A = Area of plate m^2

1. **Thermal conductivity of material**

a. Thermal Conductivity of Mild Steel

According to one-dimensional Steady State het conduction

Q = V x I

= 80 x 1.5

= 120 Watt

Now,

$$q = \frac{Q}{A} = \frac{120}{\frac{\pi}{4}(d^2)}$$

q = 4718.09

Where,

$$\frac{Q}{A} = \frac{\Delta T}{\frac{L_1}{Ak}} = \frac{(164 - 130.5)}{\frac{0.005}{\frac{\pi}{4}(0.18^2)\text{x K}}}$$

$$K_{MildSteel} = 27.6\, Watt$$

b. Thermal conductivity for Backlite

$$\frac{Q}{A} = \frac{\Delta T}{\frac{L_1}{Ak}} = \frac{(143 - 99.5)}{\frac{0.002}{\frac{\pi}{4}(0.18^2)\text{x K}}}$$

$$K_{Backlite} = 14.3\, Watt$$

c. Thermal conductivity for Plywood

$$\frac{Q}{A} = \frac{\Delta T}{\frac{L_1}{Ak}} = \frac{(143 - 65.5)}{\frac{0.005}{\frac{\pi}{4}(0.18^2)\text{x K}}}$$

$$K_{Plywood} = 9.4\, Watt$$

2. Thermal Resistance of Material

$$R_{th1} = \frac{L_1}{Ak} = 0.007\, Watt$$

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$$R_{th1} = \frac{L_1}{Ak} = 0.007\, Watt$$

3. Total Thermal Resistance

$$R_{th} = \frac{T_i - T_d}{\frac{Q}{2}}$$

$$Q = \frac{164 - 75}{\frac{120}{2}}$$

$$R_{th} = 1.48\ ℃/w$$

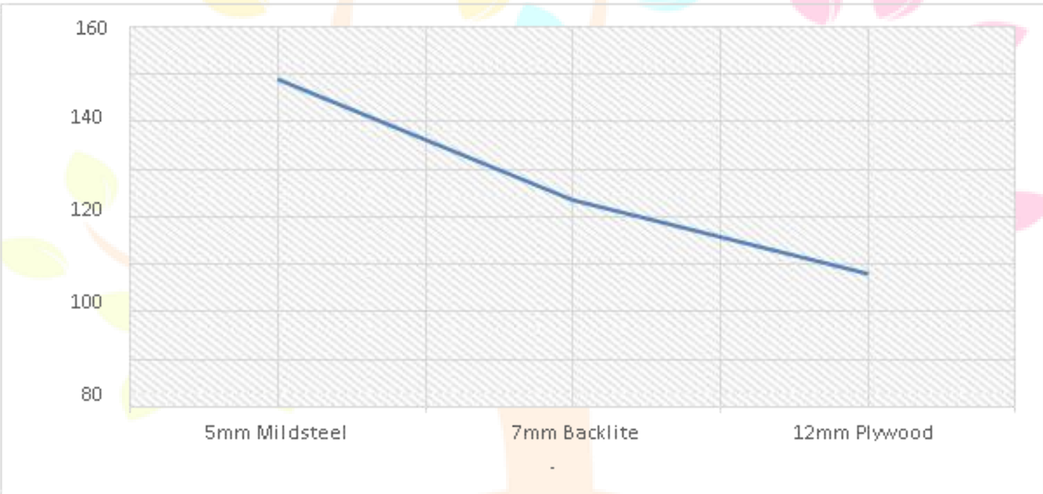
4. Total thermal conductivity

$$\frac{Q}{A} = \frac{\Delta T}{\frac{L_{Total}}{Ak}}$$

$$47.18 = \frac{98.5}{\frac{0.012}{\frac{\pi}{4}(0.18^2)\text{x K}}}$$

$$K = 22.5\ W/mK$$

GRAPHS



graph 1: temperature vs distance

graph 2: thermal conductivity vs material

CONCLUSION

In this experiment, we investigated the thermal conductivity and conductive resistance of various homogeneous and composite materials. We utilized mild steel, backlite, and plywood as composite materials. Our findings are as follows:

1. At different temperatures, the thermal conductivity of mild steel, backlite, and plywood are 27.6, 14.3, and 9.4 W/mK, respectively.
2. The composite material exhibits a thermal conductivity of 22.5 W/mK and a conductive resistance of 1.48 K/watt.
3. The thermal conductive resistance of mild steel, backlite, and plywood are 0.007, 0.005, and 0.002 K/w, respectively.

From these results, we conclude that mild steel demonstrates greater conductivity than backlite and plywood.

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