ANALYSIS OF STEADY STATE HEAT CONDUCTION IN DIFFERENT COMPOSITE WALL

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Abstract : As we all know that composite material are widely used in industries because of their incredibly high strength-to-weight and stiffness-to-weight ratios it is very difficult to calculate and analyze with precision the thermal behavior of the walls of different materials attached to each other. The study of composite materials thermal behavior is useful for the determination of heat transfer rate and heat flux. These composite materials which can be implemented to many applications such as thermal ventilations, Insulators, metallic multiwall thermal protection systems, etc. In this study we are going to analyze the thermal behavior of two composites. For finding heat flux and heat flow rate the finite element program ANSYS is used. The experimental test is carried out for heat flux and heat flow rate of composite materials. Experimental Results are compared with the finite element ANSYS results and the validation is done.

Key Words: **Thermal Conductivity, Composite Materials, Heat Flux, Conduction, Heat Flow Rate**

I. INTRODUCTION:-

A composite (or composite material) is defined as a material that consists of at least two constituents (distinct phases or combinations of phases) which are bonded together along the interface in the composite, each of which originates from a separate ingredient material which pre-exists the composite. 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 heat transfer rate has unit J/s which is equivalent to Watt. When the rate of heat transfer Q is available, then total amount of heat energy transferred ΔU during a time interval Δt can be obtained from.

$$\Delta U = \int_0^{\Delta t} Q dt = Q\Delta t \text{(Joule)}$$

The rate of heat transfer per unit area normal to the direction of heat flow is called heat flux and is expressed as, $q = Q/A$.

II. RELATED WORK:-

A lot of research is going on to study the heat transfer through composite. The research papers dealing with the thermal analysis of composite have been studied. Some of the research papers reviews are given below

J. Raymond, and et al, studied thermal and ventilation performance in composite walls of traditional wood frame single houses. For a standard composite wall, the channel width and its surface emissivity are varied and their effect on the overall performance is evaluated. There is no optimum width to minimize the heat transfer or to maximize the humidity transport.

Wei Chen explained heat transfer and flow in a composite solar wall with porous absorber. The excess heat is stored in the porous absorber and wall by the incident solar radiation and there is a temperature gradient in the porous layer. Therefore, the porous absorber works as thermal insulator in a degree when no solar shining is available.

Abdulaziz Almujahid1, et al, studied the heat transfer across building wall systems is now a globally important research topic that bears wide consequences on energy consumption as well as conservation in buildings

.III. METHODOLOGY:-

In engineering applications, we deal with many problems. Heat Transfer through composite walls is one of them. It is the transport of energy between two or more bodies of different thermal conductivity arranged in series or parallel. For example, a fastener joining two mediums also acts as one of the layers between these mediums. Hence, the thermal conductivity of the fastener is also very much necessary in determining the overall heat transfer through the medium. A composite slab consists of slab of three different materials which are MS, Fiber Glass, & Brick for one composite and MS, Hylum, Wood for another composite. Slabs & heating element are circular in cross section. The experimental set up consists of three disks of equal diameters but variable thickness arranged to form a slab of same diameter and the heater ware placed at one side of composite wall. Three types of slabs are provided on heater which forms a composite structure. A small hand press frame ware provided to ensure the perfect contact between the slabs. A dimmer stat used for varying the input to the heater and the volt meter and ammeter readings were recorded. Thermocouples are placed between interfaces of the slabs, to read the temperature at the surface.

Composition of materials:
1. MS-Hylum-wood
2. MS-Concrete-Fiber
3. MS-Fiber Glass-Brick
4. MS-Wood-Fiber Glass

Specifications:

Plate Dimensions:

Materials	Diameter (mm)	Thickness (mm)
MS	300	25
Fiber glass	300	20
Hylum	300	20
Wood	300	15
Brick	300	15
Concrete	300	15

Table 3.1:- Plate Dimensions

IV.EXPERIMENTATION:-

A composite slab consists of slab of three different materials which are MS, Hylum, & wood for one composite. There are such four composites of different materials. Slabs & heating element are circular in cross section. The instrument consists of three disks of equal diameters but variable thickness arranged to form a slab. The set up consists of a heater placed at one side of composite wall and experimentation is done.

Experimental Result Table for Temperature Distribution:-

Sr. No.	Temperature	Q (W)	q(W/m^2)	K(W/m^{0}c)
1	100	5	70.82	0.0544
2	150	7.5	106.23	0.0497
3	200	9.0	127.47	0.0429

Table 4.1:-MS-Hylum-Wood

Sr. No.	Temperature	Q (W)	q (W/m^2)	K(W/m^{0}c)
1	100	8	113.31	0.0871
2	150	14	198.30	0.0929
3	200	18.6	263.45	0.0888

Table 4.2:- MS-Concrete-Fiber Glass

Sr. No.	Temperature	Q (W)	q (W/m^2)	K (W/m^{0}c)
1	100	7.3	103.39	0.0795
2	150	12.6	178.47	0.0836
3	200	16.8	237.96	0.0802

Table 4.3:- MS-Fiber Glass-Brick

Sr. No.	Temperature	Q(w)	q (W/m^2)	K (W/m^{0}c)
1	100	7.5	106.23	0.0817
2	150	9.5	134.56	0.0630
3	200	14	198.30	0.0668

Table 4.4:- MS-Wood-Fiber Glass

Experimental Result Table for Directional Heat Flux:-

Temperature (^{0}C)	MS-F-GB	MS-H-W	MS-C-FG	MS-W-FG
100	103.39	70.8	113.31	106.23
150	178.47	106.23	198.3	134.56
200	237.96	127.47	263.45	198.3

Table 4.5 Directional Heat Flux

Experimental Result Table for Heat Flow Rate:-

Temperature (^{0}C)	MS-F-GB	MS-H-W	MS-C-FG	MS-W-FG
100	7.3	5	8	7.5
150	12.6	7.5	14	9.5
200	16.8	9	18.6	14

Table 4.6 Heat Flow Rate

Experimental Result Table for Thermal Conductivity:-

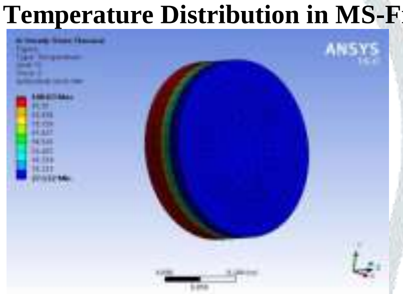
Temperature (^{0}C)	MS-F-GB	MS-H-W	MS-C-FG	MS-W-FG
100	0.0795	0.0544	0.0871	0.0817
150	0.0836	0.0497	0.0929	0.063
200	0.0802	0.0429	0.0888	0.0668

Table4.7 Thermal Conductivity

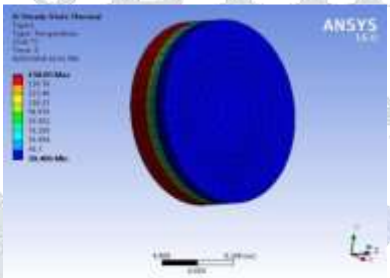
V.FINITE ELEMENT ANALYSIS:-

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in engineering schools and in industries. In more and more engineering situations today, we find that it is necessary to obtain approximate numerical solutions to problems rather than exact closed form solution.

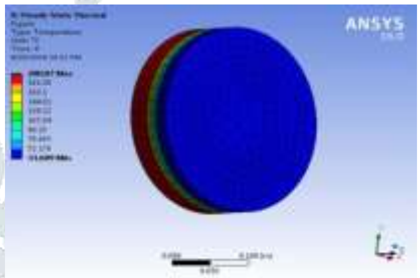
Temperature Distribution in MS-Fiber Glass-Brick:-



(At100 ^{0}C)

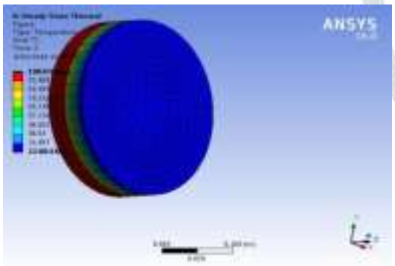


(At150 ^{0}C)

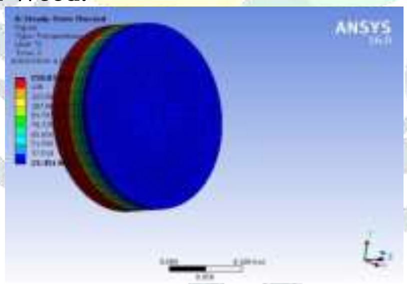


(At200 ^{0}C)

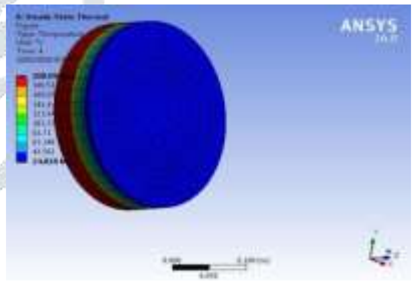
Temperature Distribution in MS-Hylum-Wood:-



(At100 ^{0}C)

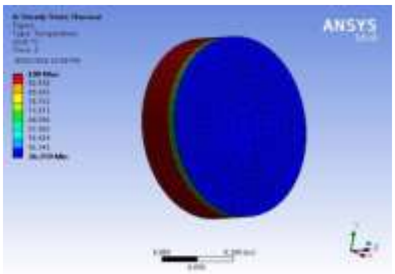


(At150 ^{0}C)

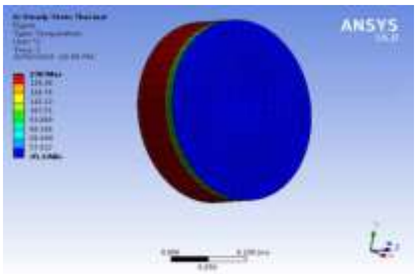


(At200 ^{0}C)

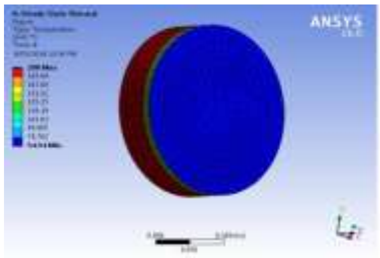
Temperature Distribution in MS-Concrete-Fiber Glass:-



(At100 ^{0}C)

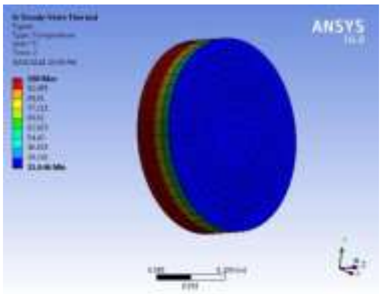


(At150 ^{0}C)

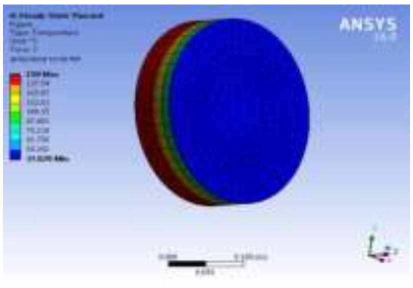


(At200 ^{0}C)

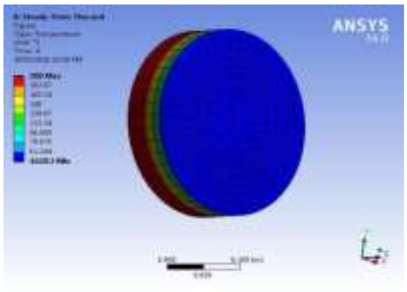
Temperature Distribution in MS-Wood-Fiber Glass:-



At100 ^{0}C)



(At150 ^{0}C)



(At200 ^{0}C)

ANSYS Result table for Temperature Distribution:-

Materials	T1	T2	T3	T4
MS-F-GB	100	99.95	28.49	27.12
MS-H-W	100	99.97	38.05	22.88
MS-C-FG	100	99.95	96.86	36.25
MS-W-FG	100	99.96	71.63	31.6

Table 5.1 Temperature Distribution at 100^{0}c

Materials	T1	T2	T3	T4
MS-F-GB	150	149.93	32.66	30.39
MS-H-W	150	149.96	48.34	23.45
MS-C-FG	150	149.92	144.85	45.42
MS-W-FG	150	149.95	103.46	37.82

Table 5.2 Temperature Distribution at 150^{0}c

Materials	T1	T2	T3	T4
MS-F-GB	200	199.9	36.82	33.67
MS-H-W	200	199.95	58.64	24.01
MS-C-FG	200	199.89	192.84	54.54
MS-W-FG	200	199.93	135.28	44.01

Table 5.3 Temperature Distribution at 200^{0}c

ANSYS Result table for Directional Heat Flux:-

Temperature (^{0}C)	MS-F-GB	MS-H-W	MS-C-FG	MS-W-FG
100	98.25	52.63	111.08	73.65
150	161.24	86.36	182.28	120.86
200	224.225	120.106	253.49	168.08

Table 5.4 Directional Heat Flux

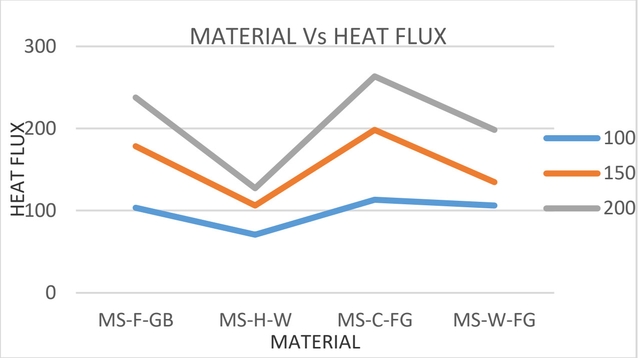
ANSYS Result table for Heat Flow Rate:-

Temperature (^{0}C)	MS-F-GB	MS-H-W	MS-C-FG	MS-W-FG
100	6.945	3.7602	7.8519	5.3114
150	11.397	6.1706	12.885	8.7162
200	15.85	8.5802	17.919	12.121

Table 5.5 Heat Flow Rate

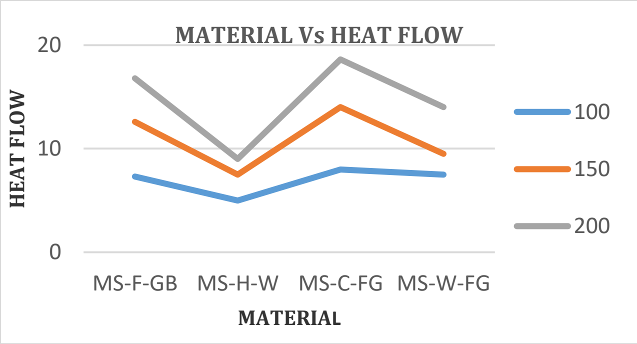
VI.GRAPHICAL RESULTS:-

Graphical Experimental Results of Materials Vs Heat Flux for all Composite Materials:-



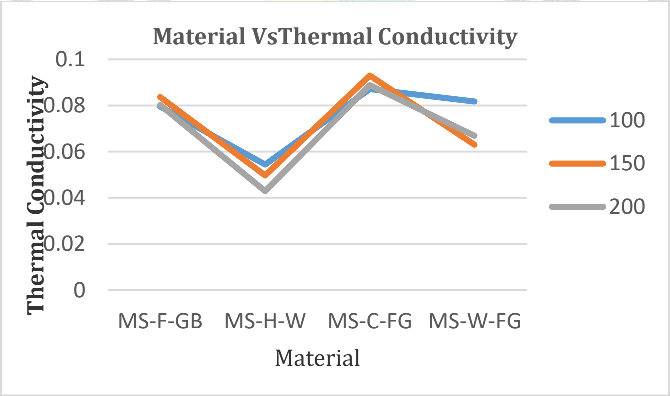
Graph 6.1 Materials Vs Heat Flux

Graphical Experimental Results of Materials Vs Heat Flow Rate for all Composite Materials:-



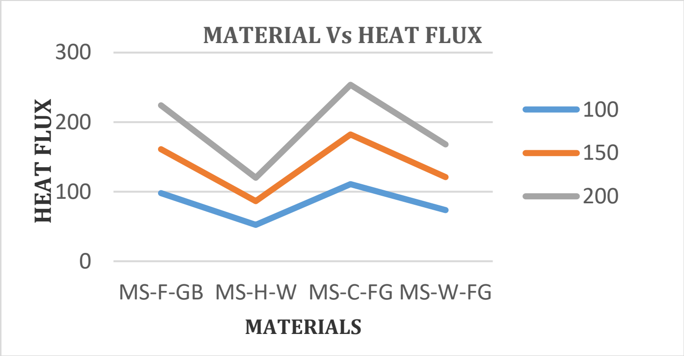
Graph 6.2 Materials Vs Heat Flow Rate

Graphical Experimental Result of Materials Vs Thermal Conductivity for all Composite Materials:-



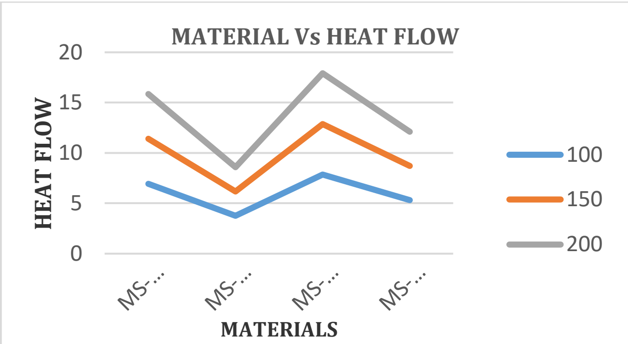
Graph 6.3 Materials Vs Thermal conductivity

Graphical ANSYS Results of Materials Vs Heat Flux for all Composite Materials:-



Graph 6.4 Materials Vs Heat Flux

Graphical ANSYS Results of Materials Vs Heat Flow rate for all Composite Materials:-



Graph 6.5 Materials Vs Heat Flow Rate

VII. CONCLUSIONS:-

Based on the analytical, finite element and experimental investigation on the thermal behavior of different composites, it can be concluded that:

1) The results obtained from the proposed analytical method are in close approximation with the values obtained by FEM simulation using ANSYS.
2) The values obtained from the proposed analytical method are in close approximation with the values obtained from experimental values.
3) The study shows that the thermal conductivity of the composite material MS-Concrete-Fiber Glass is 0.0871MS-Fiber Glass-Brick is 0.0795 MS-Wood-Fiber Glass is 0.0817 &MS-Hylum-Wood is 0.0544
4) The study shows that the heat flow rate MS-Hylum-Wood is 5 MS-Concrete-Fiber Glass is 8MS-Fiber Glass-Brick is 7.3&MS-Wood-Fiber Glass is 7.5
5) The study shows that Heat flux of composite material MS-Hylum-Wood is 70.08 MS-Concrete-Fiber Glass is 113.31 MS-Fiber Glass-Brick is 103.39&MS-Wood-Fiber Glass is 106.23
6) The temperature distribution of MS-Hylum-Wood is 23.05 MS-Concrete-Fiber Glass is 370.2MS-Fiber Glass-Brick is 29.49&MS-Wood-Fiber Glass is 32.05
7) It is seen that the Finite element method (FEM) can be gainfully employed for determination of thermal behavior like heat flux, heat flow rate and temperature distribution of all composite walls.
8) Then it can be concluded that the composite MS-Hylum-Wood shows lower heat flux, temperature distribution, heat flow rate and thermal conductivity values than that of the other composites like MS-Concrete-Fiber Glass,MS-Fiber Glass-Brick &MS-Wood-Fiber Glass respectively.

VIII. ACKNOWLEDGEMENT:-

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