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EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER BY ELECTRICALLY HEATED RECTANGULAR SURFACE

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Abstract - *An experimental investigation was conducted to determine the heat transfer from a electrically heated rectangular surface. The surrounding medium is air & the transfer of heat takes place by means of natural or free convection. The free convection occurs as a result of temperature difference, which causes a density difference & this density difference introduces a buoyant force which results in fluid flow near the surface. Experiment was performed for a plate temperature of 347 K to 365 k. The experiment was carried out in an air – conditioned room so that the surrounding air temperature is kept constant within the limit 294 K to 298 K. The rectangular flat plate with its heated surface facing upwards moved through various angular positions. The experimental values of the temperature were recorded at various distances. In vertical position, the data obtained agrees well with earlier experimental work. The experiment shows that the temperature distribution is not affected with the increase in distance from the leading edge of the plate for horizontal position. Effect of angular position of plate on heat transfer is discussed.*

Key words: Free convection , Laminar flow , heat transfer coefficient

1.INTRODUCTION

Various researchers showed a considerable interest in recent years in the problem of heat transfer by natural convection through plates. "Convection" is the transfer of heat by the circulation or movement of the heated parts of a liquid or gas. Convection is possible only in a fluid medium & is directly linked with the transport of medium itself. Convection constitutes the macro-form of the heat transfer since macroscopic particles of a fluid moving in space cause the heat exchange. The effectiveness of heat transfer by convection depends largely upon the mixing motion of the fluid [1]. When a surface is maintained in still fluid at a temperature higher or lower than that of the fluid, a layer of liquid adjacent to the surface gets heated or cooled. A density difference is created between this layer & the still fluid surrounding it. The density difference introduces a buoyant force causing flow of fluid near the surface. Heat transfer under such conditions is known as free or natural convection. Thus "Free or natural convection is the process of heat transfer which occurs du e to movement of the fluid particles by density changes associated with temperature differential in a fluid." This method of heat transfer occurs very commonly.

Several investigators performed their studies on convection heat transfer from plates both experimentally & theoretically, but most of the published papers deal only with two particular position - horizontal & vertical. However, there is limited data available for inclined surface. The main purpose of the present work is to determine an understanding of effect of angular position of plate on the heat transfer. The information obtained in the present study will be very useful for the study of the heat transfer from inclined plate by natural convection.

2.EXPERIMENTAL APPARATUS & PROCEDURE

2.1 EXPERIMENTAL APPARATUS

To study the problem of the heat transfer by means of free or natural convection, an aluminum flat plate apparatus was designed. The aluminum flat plate is rectangular in shape & can be inclined in any position from vertical to horizontal, with either the hot surface facing upwards or downwards. The rectangular flat plate is 26.6 inch in length & 6.9 inch in breadth. The thickness of the plate is approximately 0.3 inch. The plate was super finished to a flat tolerance of about ± 0.002 inches with its hot surface exposed to air. In order to measure the temperature of the plate, total eight holes were drilled, four on each side of the plate to permit for insertion of the thermocouples.
Heat is equipped at the bottom of the plate in a good distribution through the utilization of electrical

resistance heating components. The plate is massive & of comfortable thickness to permit for a good distribution of the warmth generated by resistance components. The temperature distribution over the whole surface of the plate becomes uniform when the steady state is reached. The schematic diagram of the apparatus is shown in Figure.1.

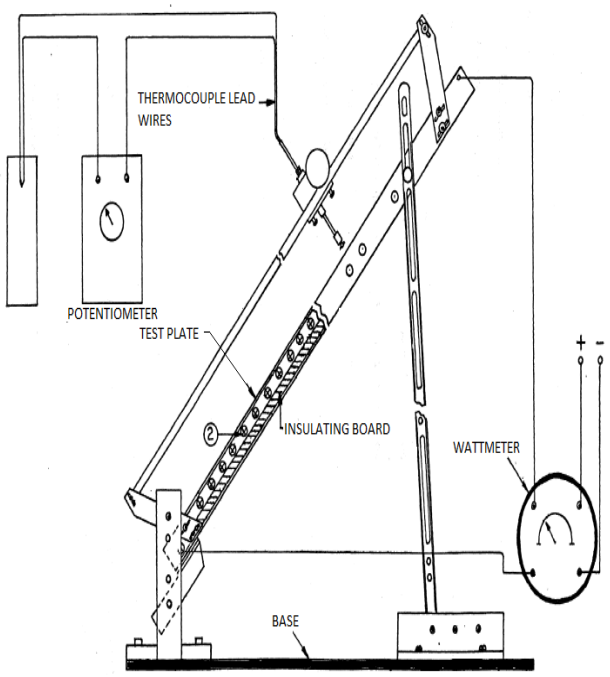

Fig-1: schematic diagram of experimental apparatus

2.2 PROCEDURE

First of all, the aluminum test plate is set to the desired angle. The angle of inclination is measured from the vertical. After this, the test plate is heated by means of supply of electricity by adjusting the variable autotransformer. A steady state equilibrium temperature is obtained at each value of wattmeter, shown by temperature reading from plate thermocouple. The temperature of the room measured with the help of mercury glass thermometer.

To measure the temperature distribution within the boundary layer, a copper constantan thermocouple was used & was placed at the desired locations of the test plate. The thermocouple emf was measured with the help of the potentiometer[3]. The angle of inclination of the aluminum test plate was varied & the above procedure was repeated.

3. DATA COLLECTION

The experimental data was collected within a span of month. In order to achieve high reliability, the temperature of the air was recorded at every location from the plate surface for every two turns of dial of micro motion box[4]. The data was collected for horizontal, vertical as well as various inclined positions of plate[2].

4. RESULTS & DISUSSION

The main objective of this experimental work is to study the mechanism of free or natural convection from a heated aluminum flat plate in horizontal, vertical & in angular position.

The table of results for $\lambda = 0^0$ & 60^0 are shown below. Here λ is the angle of inclination of plate from the vertical.

Table-1: For $\lambda = 0^0$

X in	Room temp (t_∞) (in K)	Surface temp (t_s) (in K)	Nusselt number	Heat Transfer Coefficient (W/m^2K)	Rayleigh Number x 10^{-6}
1	295.1	350.11	6.011	6.468	0.0614
3	295	352.21	14.29	5.175	1.71
8	295.5	353.7	32.612	4.412	33.012
10	294.9	354.26	39.554	4.297	64.658

Table-2: For $\lambda = 60^0$

X in	Room temp (t_∞) (in K)	Surface temp (t_s) (in K)	Nusselt number	Heat Transfer Coefficient (W/m^2K)	Rayleigh Number x 10^{-6}
1	294.9	346.86	4.190	4.548	0.05845
3	295.1	347.86	14.98	5.440	1.5923
5	295	347.92	20.01	4.289	7.6542
8	295.2	348.25	32.94	40465	31.0125

Fig-2 & 3 shows the variation of dimensionless temperature distribution against dimensionless length coordinate which is a function og grashoff number &

comparison of nusselt number for various angle of inclination of the test plate from the vertical position respectively.

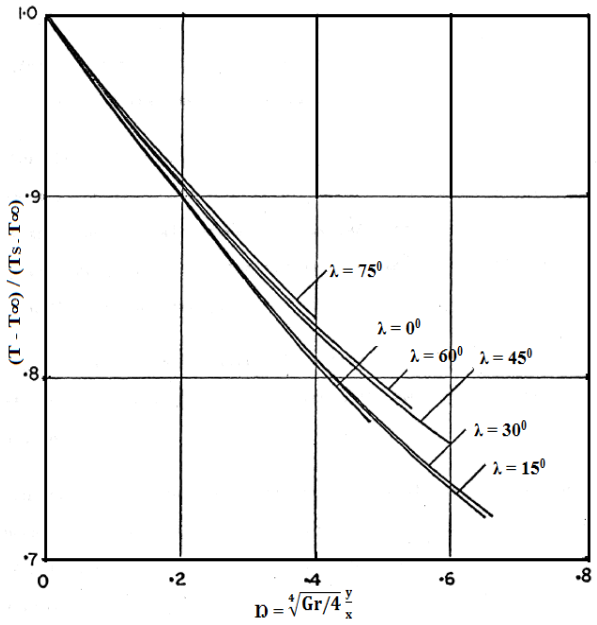

Fig-2: Temperature distribution for various angle of inclination of plate

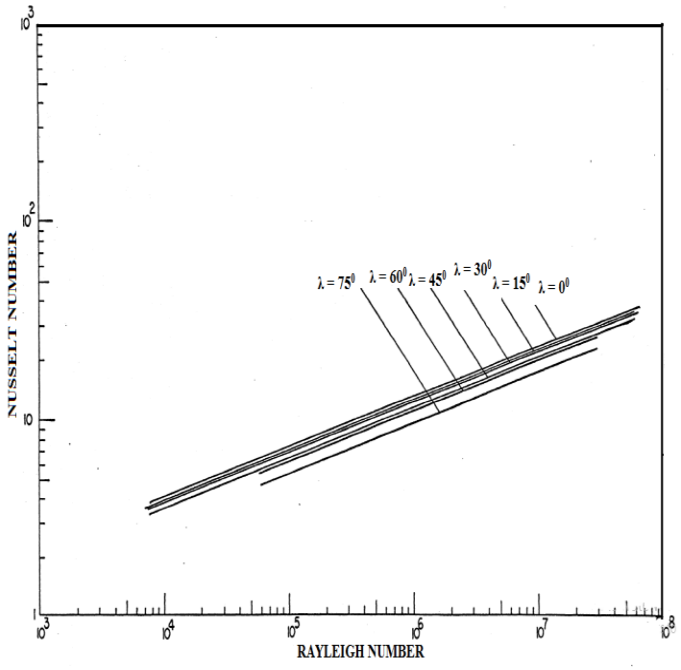

Fig-3: Nusselt number comparison for various angle of inclination

5. CONCLUSION

The presented paper of "EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER BY ELECTRICALLY HEATED RECTANGULAR SURFACE" provides analysis of heat transfer by means of free convection from inclined flat plate. For horizontal position, the temperature distribution is independent of the distance x from the leading edge of the plate. For inclined plate, the slope of the curve decreases with the increase in angle of inclination of the plate.

6. REFERENCES

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