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EXPERIMENTAL ANALYSIS OF HEAT TRANSFER FROM RECTANGULAR FIN ARRAY AT DIFFERENT INCLINATIONS BY NATURAL CONVECTION

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ABSTRACT

Heat transfer enhancement is the major research area in which many researchers are working to fulfill the need heat exchangers having high heat transfer abilities. This work consists of the study of heat transfer enhancement rectangular fin array at different inclinations. In this work angle of inclination of the fin array has been maintained at 0^0, 30^0, 45^0, 60^0 and 90^0. This work is conducted for the experimental analysis of heat transfer from Rectangular fin array at different inclinations by natural convection. In this work fin arrays with different angles of inclinations are tested and their results are studied to find out their effect on the heat transfer from fin array. The results of this study shows that with change in angle of inclinations the heat transfer coefficient and the Nusselt number also changes. At 0^0 inclinations both the heat transfer coefficient and the Nusselt number has lowest magnitudes in entire study. At 45^0 inclinations both the heat transfer coefficient and the Nusselt number has highest values.

KEYWORDS: Fins, Heat Transfer Enhancement, Angular Inclination, Extended surfaces.

INTRODUCTION

Fins are used to enhance convective heat transfer in a wide range of engineering applications, and offer a practical means for achieving a large total heat transfer surface area without the use of an excessive amount of primary surface area. Natural convection heat transfer can be enhanced by using fins of various shapes and sizes but rectangular fins are usually used because of their easy installations and manufacturing. **[1]** To increase further heat transfer rate from the fin, research on different techniques is carried out by different researchers. There are many passive techniques of heat transfer enhancements like inserts, extensions etc which can effectively enhance the heat transfer rates [2][3]. Also heat transfer enhancement by pin elements and porous fin will also leads to higher heat transfer rates with low weights of fins [4][5][6]. This work consists of the study of heat transfer enhancement rectangular fin array at different inclinations. In this study heat transfer from rectangular fin array will be studied for different angles of inclinations of fin array. First heat transfer from a fin array at horizontal position is studied then the angular position of the fin array will be changed and it is made inclined then effect of this inclination on heat transfer from fin will be studied. In this way effect of inclination of fin array will be studied in this work.

FIN ARRAY

In this work a fin array is used as a heat transfer surface from heater to the air. The heater is placed in the middle of the fin array as shown in the fig. 1 heat from this heater will travel through the fin array and it will be finally removed by the air. This fin array has five fins on each side of the heater. The material of this fin array is aluminium alloy. The height of each fin is 20 mm and thickness is 2 mm. The base area of the fin array is 75*110 mm^2. The total surface area of the fin array is 0.06218 m^2.

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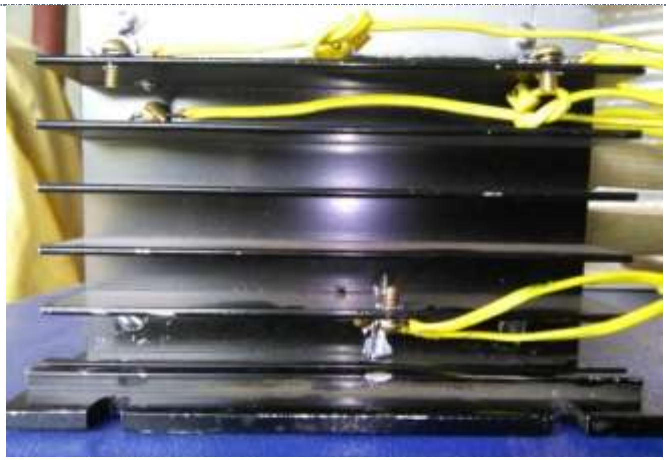

Fig. 1 Thermocouple Connection on Fin

Total 13 thermocouples of Chromium-Aluminium alloy (k type) having 18 gauge sizes are used in this experimental setup, out of these 13 thermocouples 12 thermocouples are connected to the fin array. As fins are placed on the both sides of the heater, 6 thermocouples are connected at the each side of the fin array. To increase the accuracy of temperature recording, these thermocouples are connected at base as well as at the tip of the fin. Fig. 1 shows the positions of the thermocouples on the fin array. All the thermocouples are connected to the temperature indicator where recording of these temperatures can be done.

EXPERIMENTAL INVESTIGATION

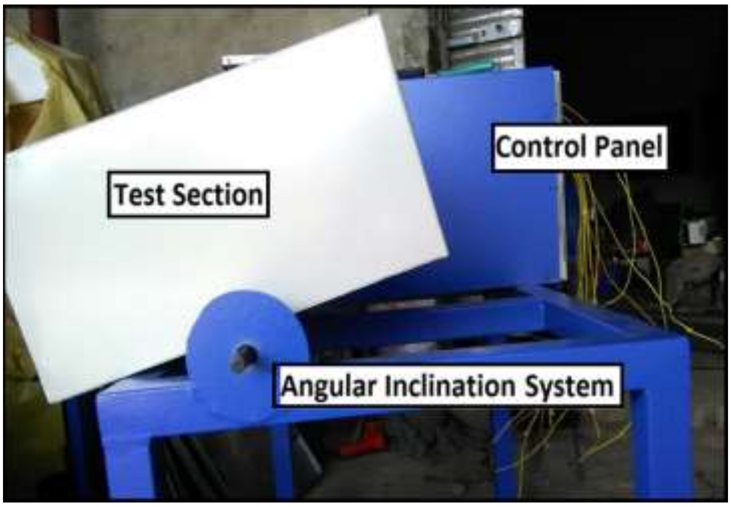

Fig 2 Experimental Setup

From fig 2 different components of experimental setup used for experimental analysis of heat transfer from rectangular fin array at different inclinations by natural convection can be observed. This experimental setup is used to study the heat transfer from fin array with change in angular position of the fin array.

This fig. shows the control panel, angular inclination mechanism and test section of the experimental setup. In this experimental setup fin array with different diameters will be placed and different angular positions and the observations are recorded. To change the angle of the fin array angular inclination mechanism is used.

SAMPLE CALCULATIONS

1) Heater Input (Q):

Heater Input (Q) = V × I = 6 Watts

Where,

V= Voltage supplied to heater

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I = Current supplied to heater

2) Heat Lost by Radiation (Q_{rad}):

$$\mathbf{Q_{rad} = \sigma \times \varepsilon \times A \times [\ T_s^4 - T_{amb}^4\ ]} = 0.398 \text{ Watts}$$

Where,
σ = Stefan Boltzmann Constant = 5.67×10^{-6}
ε = Emissivity = 0.1
A = Area available for radiation = 0.06218 m^2
T_s= Average surface temperature in K
T_{amb}= Ambient temperature in K = T_{13}

3) Heat removed by Convection =

$$\mathbf{Q_{Conv} = Q - Q_{rad}} = 5.6 \text{ Watts}$$

Where,
Q = Heater Input
Q_{rad}= Heat lost by radiation

4) Convective Heat Transfer Coefficient (h):

$$\mathbf{h = \frac{Q_{Conv}}{A \times \Delta T}} = 9.65\ W/m^2\ {}^0C$$

Where,
A = Area available for Convection
$\Delta T = T_S - T_{amb} = 24.36$

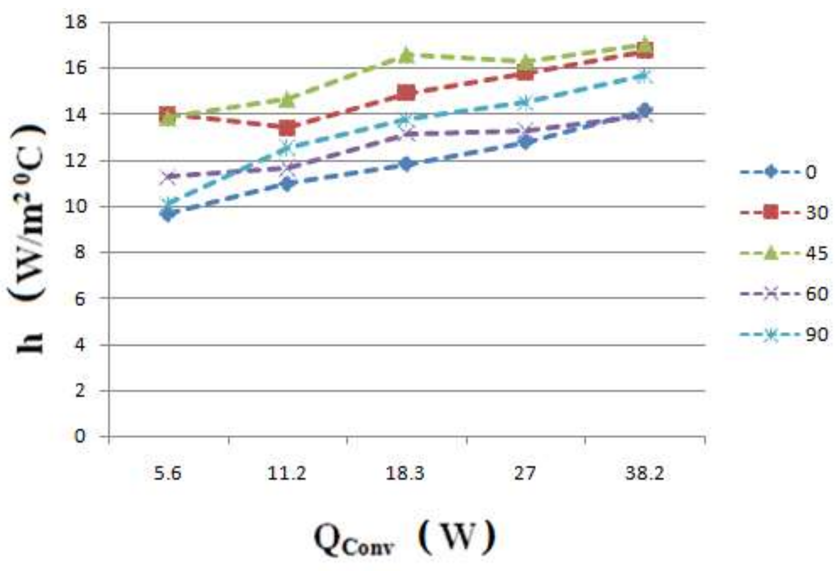
5) Nusselt Number (Nu):

$$\mathbf{Nu = \frac{h \times L}{k}} = 38.68$$

Where,
L = Characteristic length = 0.11 m
K = Thermal conductivity of air at average mean film temperature

RESULTS AND DISCUSSION

Effect of Variation in Convection Heat Transfer and angle of inclination on Heat transfer Coefficient:



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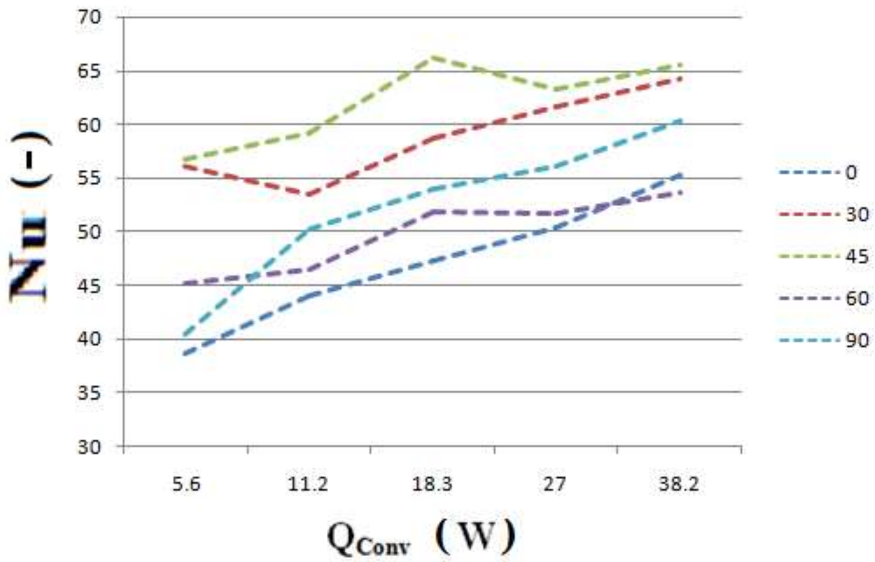
Graph 1 Convection Heat Transfer Vs Heat Transfer Coefficent

Fig. 1 shows the effect of change in the heat available for convection and angle of inclination of fin array on the heat transfer coefficient of the process. It can be observed from the graph that as heat input increases the heat transfer coefficient of the heat transfer process increases with it. This phenomenon occurs due to the fact that with more heat available to transfer any system will actually transfer the heat in that proportion. Hence as more heat available more heat will get transferred and more will be the heat transfer coefficient. All the other set of observations shows same type of behaviour in the graph.

This graph also shows the effect of change in angle of inclination of the fin array on the heat transfer coefficient. This graph shows that at 0^0 inclination the heat transfer coefficient has lowest values compare to the all other angle of inclinations of the fin array. It is observed that at 45^0 angle of inclination the heat transfer coefficient of the heat transfer process is highest compare to the all other angle of inclinations of the fin array, it is averagely 31.8% higher than the heat transfer coefficient at 0^0 angle of inclination as the average value of heat transfer coefficient at the 0^0 inclination is 11.88 $W/m^{2\,0}C$ and average value of heat transfer coefficient at the 45^0 inclination is 15.67 $W/m^{2\,0}C$. In this graph it can be also observed that heat transfer coefficient increases for change in angle in order of 0^0 inclination, 60^0 inclination, 90^0 inclination, 30^0 inclination and finally it reaches to highest value at 45^0 inclination.

This phenomenon occurs due to the fact that due to increase in temperature of air density of air decreases and natural convection current starts. Air starts moving in the direction opposite to that of gravity due to buoyancy effect. At 0^0 inclination there will not be any resistance to air flow air will simply get heat ted and leave the surface of fin. At 45^0 inclinations the air will be in contact with more surface area while leaving the surface after getting heated. Hence heat transfer will be more in 45^0 inclination of fin array.

. ***Effect of Variation in Convection Heat Transfer and angle of inclination on Nusselt Number:***



Graph 2 Convection Heat Transfer Vs Nusselt Number

This Graph 2 shows the effect of variation in convection heat transfer and angle of inclination on Nusselt number. Nusselt number is nothing but the ration of amount of heat transfer by convection to the amount of heat transfer by conduction. As conductive heat transfer from fin array to air is not dominant it generally gives idea about amount of heat transfer by the convection. It can be observed from this graph that as the convection heat transfer increase the Nusselt number increases with it.

This graph also shows that with change in angel of fin array Nusselt number changes, it is highest for the 45^0 inclinations and lowest for the 0^0 inclinations. The results shows that at 0^0 inclinations the average value of

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Nusselt number is 47.12 which increase for 60^0 inclinations to 49.7, for 90^0 inclinations it is 52.13 and for 30^0 inclinations it becomes 58.81. Finally it reaches to 62.17 for 45^0 inclinations.

CONCLUSION

In this experimental research study, heat transfer from Rectangular fin array at different inclinations by natural convection is studied. In this study, the heat transfer characteristics of rectangular fin array are studied at different inclinations of fin array. The findings of this works are presented below;

i. It is observed in this study that as the heat input to the fin array increases the heat transfer coefficient and Nusselt number also get increased. This happen due to as the amount of heat supplied is higher the average fin array temperature also increases and atmospheric temperature remains constant which changes temperature gradient between air and surface due to this more heat transfer from surface to the air and hence the heat transfer coefficient and the Nusselt number increases.

ii. The results of this study shows that with change in angle of inclinations the heat transfer coefficient and the Nusselt number also changes. At 0^0 inclinations both the heat transfer coefficient and the Nusselt number has lowest magnitudes in entire study. At 45^0 inclinations both the heat transfer coefficient and the Nusselt number has highest values.

REFERENCES

[1] K. E. Starner ,H. N. McManus,1962, An Experimental Investigation of Free-Convection Heat Transfer From Rectangular-Fin Arrays, J. Heat Transfer 85(3), 273-277.

[2] Jeff T. Collins, Craig M. Coley and John N. Attig, Enhanced Heat Transfer using Wire-Coil inserts for High Heat-Load Applications, 2nd International Workshop on Mechanical Engineering Design of Synchrotron Radiation Equipment and Instrumentation (MEDSI02), September 5-6, 2002, Argonne, Illinois U.S.A.

[3] A Dewan, P Mahanta, K Sumithra Raju and P Suresh Kumar, 2004, Review of passive heat transfer augmentation techniques Proc. Instn. Mech. Enggs Vol. 218 Part A : J. Power and Energy ,IMechE.

[4] N. Sahiti, F. Durst, A. Dewan, Heat transfer enhancement by pin elements International Journal of Heat and Mass Transfer 48 (2005) 4738–4747.

[5] Abdullah H. Al Essa and Mohammed Q. Al-Odat, 2009, “Enhancement Of Natural Convection Heat Transfer From A Fin By Triangular Perforations Of Bases Parallel And Toward Its Base” The Arabian Journal for Science and Engineering, Volume 34, Number 2B, pp 531-544.

[6] Rama Subba Reddy Gorla , A.Y. Bakier, “Thermal analysis of natural convection and radiation in porous fins”, International Communications in Heat and Mass Transfer 38 (2011) 638–645.

[7] Umesh V. Awasarmol, Ashok T. Pise, “An experimental investigation of natural convection heat transfer enhancement from perforated rectangular fins array at different inclinations” Experimental Thermal and Fluid Science 68 (2015) pp. 145–154.

[8] V. Zoman, D. D. Palande, “Experimental analysis of natural convective heat transfer performance from rectangular fin array with perforations”, International Engineering Research Journal (IERJ) , June 2016, ISSN 2395-1621, pp 504-511.