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Air Convection Heat Transfer from Horizontal Rectangular Fin Array with Change in Geometry

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Abstract –Natural convection Heat transfer because ofair from notched, full rectangular fin array have been investigated experimentally. For study purpose short fin array has been selected which show single chimney flow pattern. Middle portion of fin array becomes ineffective due to low temperature difference between entering air & fin surface. So in nearby study, mid portion is removed by cutting circular notch and added where more fresh air come in contact with fin surface area. Results have been obtained over range of spacing from 12mm to 25mm and heat input from 25W to 100W. Length & height of rectangular fin array was kept constant. Comparison has been made between full, Compensatory & notched rectangular fin array. It is found that notched array performed better as expected.

Keywords: Fin arrays, Grash of number, Rayleigh number, Heat transfer, Free convection, Spacing.

I INTRODUCTION

Starner and McManus, Harahan and McManus, Jones and Smith, Mannan have studied the general problem of free convection heat transfer from rectangular fin arrays on a horizontal surface experimentally and theoretically by Sane and Sukhatme. During their investigations, flow visualization studies have also been conducted and it has been found out that the single chimney flow pattern was preferred from the heat transfer stand point and was present in most of the lengthwise short arrays used in practice.

The present paper is consists of an experimental study on horizontal rectangular short fin arrays with notch, without notch at the center & compensatory area on fin surface dissipating heat by free convection. In case of a single chimney flow pattern, the chimney formation is due to cold air entering from the two ends of the channel flowing in the horizontal direction and developing a vertical velocity flow of air as it reaches the middle portion of fin channel resulting in the heated plume of air going in the upward direction Notched fin arrays are investigated with different spacing & heat inputs. Optimum spacing for

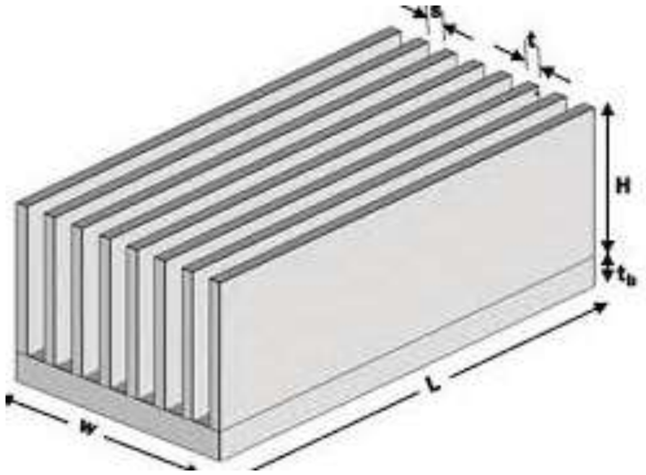

Fig.1 Rectangular fin array

Notched fin arrays are decided according to Rayleigh number. This study also leads to proposal of optimum notch profile for the given range of base heat flux.

Conducting glue used results in reduced contact resistance. Insulating C4X blocks are used to protect from leakage of heat from bottom and sides of the fin array. C4X blocks placed at bottom and sides of assembled array make provision for six numbers of thermocouples to account for conduction loss through bottom and sides of the array. Resistance wattmeter is used to supply variable voltage input from 0 Watt to 200 Watt. Two Cartridge type heaters with maximum capacity 200 watt per heater are used for heating base plate.

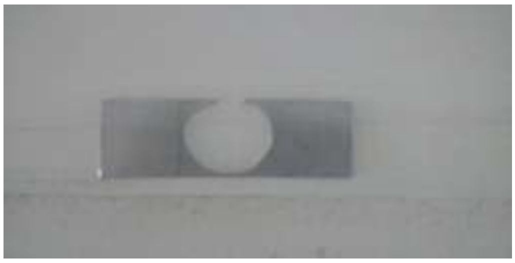

Fig.2 Circular Notch Fin

Fig.4 Rectangular Fin

III EXPERIMENTATION

The following procedure is used for the experimentation:

1. The fin arrays are assembled by gluing the required number of fin plates by using epoxy resign and positioning the thermocouples at the appropriate locations.
2. Cartridge heaters (02 numbers) are placed in their position, connected in parallel with power circuit.
3. Assembled array as above is placed in the slotted C4X insulating block.
4. Thermocouples are placed in the C4X block for measuring conduction loss. The assembled array with insulation is placed at center of an enclosure.
5. The decided heater input is given and kept constant by connecting to stabilizer, which is provided with dimmerstat voltage.
6. The temperatures of base plate at different positions, C4X brick temperature and ambient temperature are recorded at the time intervals of 15 min. up to steady condition. (Generally it takes 2 to 3 hours to attain steady state condition).

Table.1 Parameters of Experimentation

Spacing in mm	Heater input in watt	Length of fin array in mm	Height of fin array in mm
12	25	120	40
14	50		
18	75		
25	100		

Readings were recorded on reading table when the steady state was reached. Readings were taken at least four times for four different configuration and heater input to ensure the validity and repeatability of readings. It is decided that variables for experimental work are spacing, heater input, and geometry. Spacing are 12mm, 14mm, 18mm and 25mm. Heater inputs are 25watt, 50watt, 75watt & 100 watt. The results were obtained from the observation.

Experimental Calculations

1. Conduction Loss $=KA\frac{dT}{dx}$

2. Radiation Loss = $\in\sigma A\ [Ts4- T\infty4]$

3. Heat Transfer Coefficients $=\frac{Q}{A\Delta T}$

4. Nusselt Number = $\frac{hL}{K}$

5. Grashof number= $\frac{g\beta(Ts-T\infty)Lc^3}{U^2}$

IV RESULT & DISSCUSSION

Results have been obtained in terms of average heat transfer coefficient, base heat transfer coefficient, Average Nusselt number, Base Nusselt number, Rayleigh number.

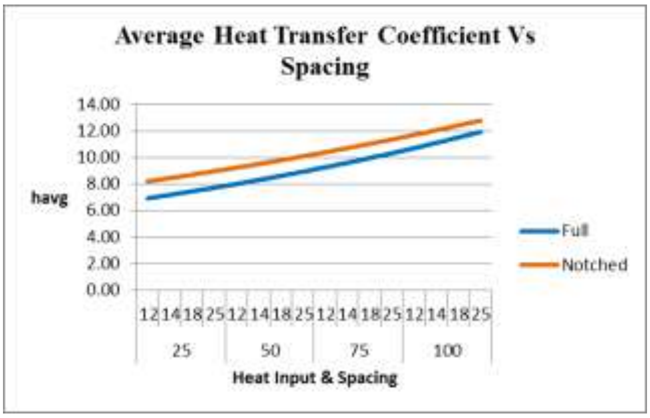

Fig.6 Graph of Average heat transfer coefficients Vs spacing

Fig. 4 show the effect of fin spacing on h_a with heater input as the parameter. As the fin spacing increases h_a increases for full fin array, as expected. The highest value of ha is 13.24 W/m2 K at the spacing of 25 mm. The increasing trend is steep up from spacing about 18 mm. Before which there is a gradual rise. The trend of increase in ha and hence in the Nusselt number with fin spacing is observed in case of the notched array also with increase in ha values at every point. The notched configurations yield higher values, thus indicating superiority over full fin arrays.

Also fig.4 shows the relative performance of fin array with notch and that of without notch. It is evident from the graph that ha increases with the heater input, maintaining the superiority of notched array. It is clear that for the given heater input ha of notched array is 10 to 25% higher than corresponding full fin array. Average heat transfer coefficient of Notched fin array is 22% higher than full fin array for 12mm spacing. Also it is clear that for the given heater input ha of notched fin array is 20 to 25% higher than corresponding compensatory fin array. Average heat transfer coefficient of Notched fin array is 14% higher than full fin array for 14mm spacing. By doing data analysis, Percentage increase in average heat transfer coefficient of notched fin array in comparison with full fin array is decreased as the spacing increases. It is shown that 12mm spacing is more effective when comparison have been made between Notched & Full fin array.

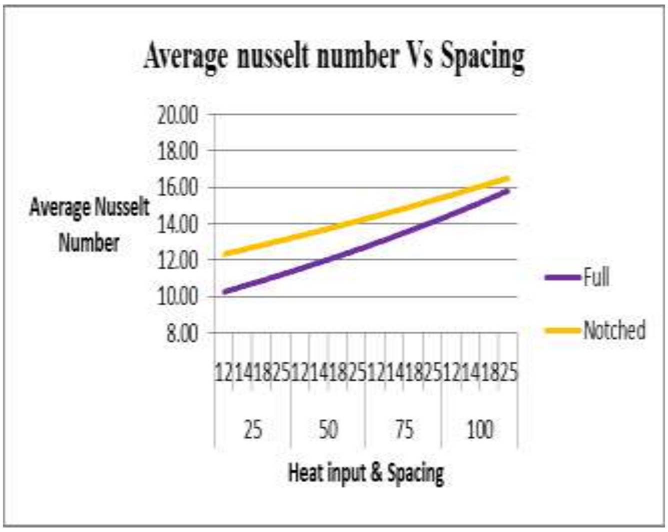

Fig.8 Graph of Average Nusselt numberVs Spacing

Fig.7 shows that Grashof number is high for notched fin array than that of compensatory & full fin array. Grash of number is increasing continuously up to 18mm fin spacing & then suddenly decreasing after that spacing for notched fin array. Best fin spacing for notched fin array is 18 mm. Grash of number is very low for 14mm spacing of full fin array. Compensatory fin array has increasing trend of Grash of number.

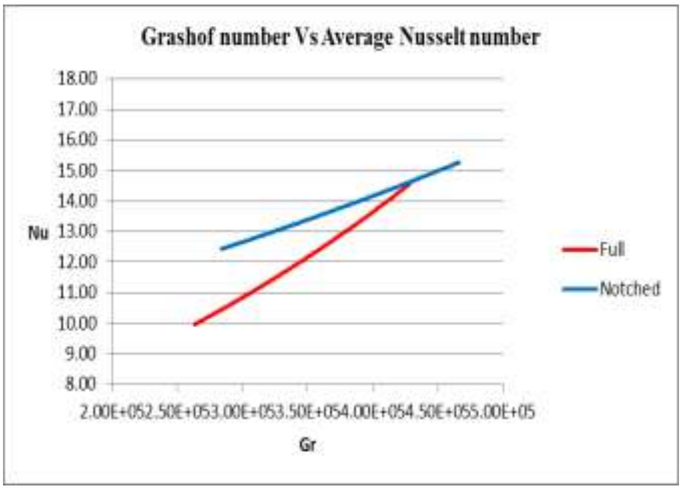

Fig.9 Graph of number Vs Average nusselt number

Graph shows the relationship between Grash of number and Nusselt Number. Grash of number is necessary for the determination of flow. Grash of number is the ratio of buyoncy force to the viscous force. If flow is less than 109 then flow is laminar and if flow is more than 109 then flow is turbulent. Nusselt number increases with increase in the grash of number. The highest value of nusselt number is 75W having spacing 25mm. at that time grash off number is also high.

V CONCLUSION

The problem of free convection heat transfer from horizontal rectangular fin array has been the subject of experimental as well as theoretical studies.

The important findings of the experimentation are as follows:

- Single chimney flow pattern reported to be preferred by earlier investigators is retained in the notched fin arrays as well by performing simple smoke test.
- Study shows that notched horizontal rectangular fin array is more effective than that full fin array.
- Rise in h_a for Notched fin arrays exhibit 10-25% higher than corresponding full fin array configuration.
- Average Nusselt number for notched fin arrays is 10-25% higher than corresponding full fin array.
- h_b& Base Nusselt number is continuously decreasing with increase in spacing for notched & compensatory fin array.
- Grash of number & Rayleigh number for notched fin array is 8-15% higher than corresponding full fin array.
- Results show that Grashof number is less than 10^9. Therefore, free convection heat transfer with laminar flow of air is confirmed.

Nomenclature

ACross Sectional Area of C4X bricks

$\frac{dt}{dx}$Temperature Gradient along bricks

$\in$Emissivity of Brick

σ Stefan Boltzmann's constant

g Acceleration due to gravity

β Coefficient of volume expansion

T_s Average Temperature of fin surface

T_∞Temperature of Air

U Kinematic viscosity of air

K Thermal Conductivity of C4X bricks

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