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Study of Air Convection Heat Transfer from Horizontal Rectangular Fin Array with Circular Notch

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***Abstract* - Natural convection Heat transfer because of air from notched, compensatory, 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 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.

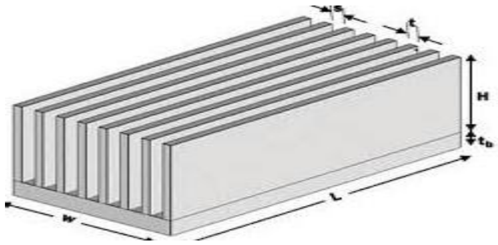

Fig.1 Rectangular fin array.

II. EXPERIMENTAL SET UP

Experimental setup is developed on the basis of simplicity and practicability. Fin arrays are assembled & manufactured using 2 mm thick commercially available aluminum sheet. Size of sheet is 120X40. It is observed meticulously that all the fin flats are cut to the same size simultaneously. All fins are glued to base plate with help of adhesive backing which sustain for high temperature. Holes were drilled for placing cartage heater in base plate.

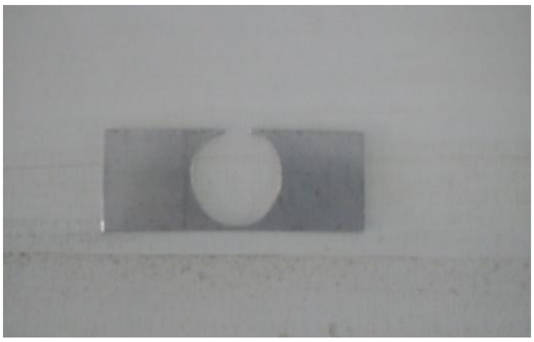

Fig.2 Circular Notch Fin

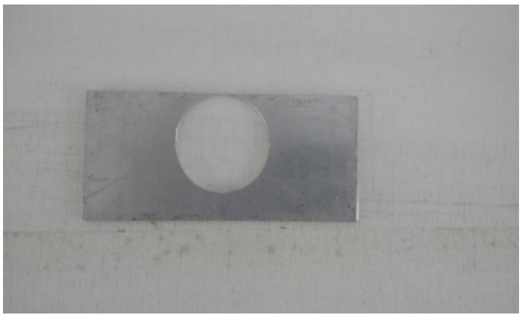

Fig.3Compensatory Circular Notch Fin.

Fig.4 Rectangular Fin.

In the assembly it is ensured to maintain required parallelism between fin flats. It is ensured to keep minimum air gap between base plate & numbers of fins. L=120 mm, W=100 mm, H=40 mm are the dimensions of rectangular fin array used for experimentation. These dimensions are decided by taking into account the conveniences of measurement of base plate temperatures, input power as well as position of thermocouples so as to observe flow patterns by using simple smoke technique. Fin arrays are formed by sticking fin flats to base plates and tied together by tie bolts.

Fin flats separated to form fin channels. To obtain accurate results rectangular fin array is covered with enclosure as heat is transferred due to free convection. An enclosure is fabricated with plywood material in the form of cube with a volume of approximately 1 m^3. Three walls of enclosure are covered with plywood sheets and the front wall with acrylic sheet.

To maintain proper undistributed flow of free convection, top portion of enclosure is kept open. Two cartridge type heaters are used to heat up the base plate. For realistic temperature measurement of the fin surface and ambient temperature, seven calibrated Cu-Constantan 30 gauge thermocouples, mounted at appropriate locations, are used. Use of 32 gauge enabled visualization of flow pattern with minimum resistance. Holes of 0.79 mm diameter are drilled in fins for housing the thermocouples and allowing direct metal to metal contact between thermocouples and fin surface. This together with the

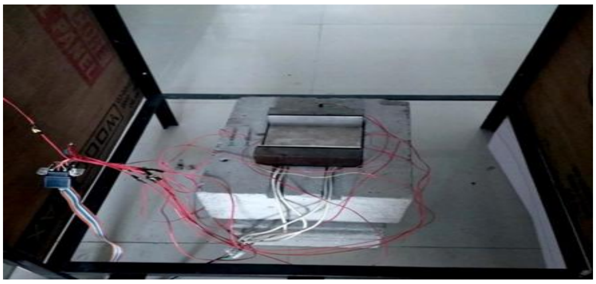

Fig.5 Experimental Set Up.

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.

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 = $\in \sigma A\, [Ts4 - T\infty 4]$
3. Heat Transfer Coefficients $= \frac{Q}{A \Delta T}$
4. Nusselt Number $= \frac{hL}{K}$
5. Grash of number $= \frac{g\beta (Ts - T\infty) Lc^3}{\upsilon^2}$

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.

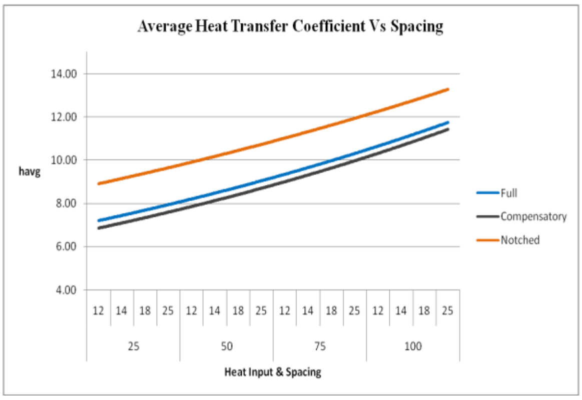

Fig.6 Graph of Average heat transfer coefficients Vs spacing.

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 13.95 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 30% higher than corresponding full fin array. Average heat transfer coefficient of Notched fin array is 32% 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.

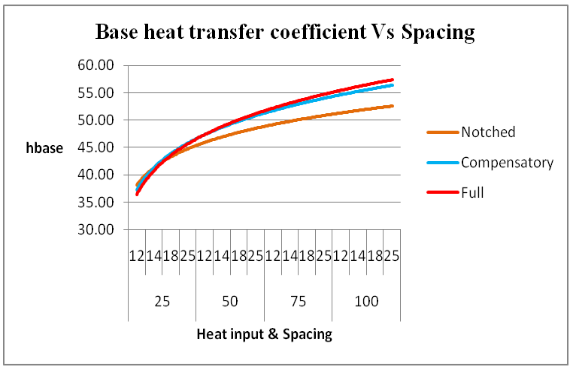

Fig.7 Graph of Base heat transfer coefficients Vs Spacing.

Fig. 5 show the effect of fin spacing on h_b with heater input as the parameter. From the figure it is clear that the values of h_b decreases as fin spacing increases. It starts to its minimum value at fin spacing about 12 mm and again decreases gradually. This trend can be attributed to restriction of entry of air in the channel at smaller fin spacing. The trend of increase in base heat transfer coefficient with the maxima at a fin spacing of 14 mm is observed in case of the full fin array.

It is therefore concluded that performance of full fin array is bettering terms of base heat transfer coefficient. At the spacing of 18mm, h_b is nearly 61 W/m^2 K for the full fin array and is of the order of 55 W/m^2 K for the notched fin array. This is due to decrease in heat transfer area. It is clear from the fig.6 that as spacing increases the average Nusselt number Nu_a increases for the notched fin array. The increasing trend is gradual up to a spacing of 14 to 18 mm. After that the rise is sudden. The notched configurations yield higher values, thus indicating superiority of notched fin array over Compensatory & full fin array. The highest Nua is about 18 W/m^2 K for the notched fin array at heater input of 100 W.

In general it is observed that the Nua increases with increase in fin spacing, this is due to reason that with increase in spacing, the fluid can flow more freely through the fin channel. This may be attributed to the phenomenon of lateral boundary layer interference at lower fin spacing. Nua dimensionless number increases from 11 to 18 with increase in heat input from 25 to 100

W for notched fin array which is higher than that of compensatory & full fin array. Best fin spacing is above 18 to 25 mm.

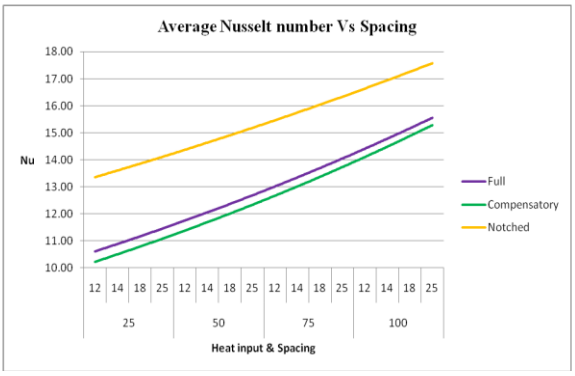

Fig.8 Graph of Average Nusselt number Vs Spacing.

Fig.7 shows that Grash of 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.

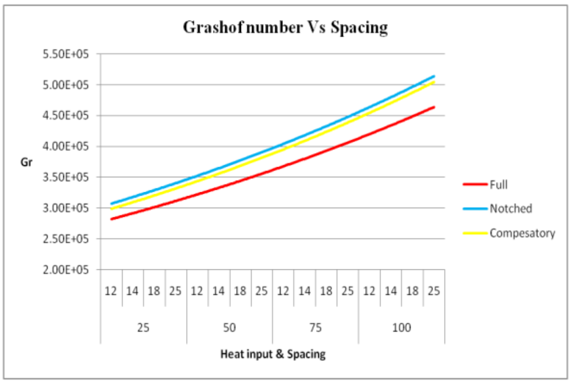

Fig.9 Graph of Grash of number Vs Spacing

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 ha for Notched fin arrays exhibit 10-30% higher than corresponding full fin array configuration. Average Nusselt number for notched fin arrays is 10-30% higher than corresponding full fin array. hb & 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 Grash of number is less than 109. Therefore, free convection heat transfer with laminar flow of air is confirmed.

Nomenclature

A Cross Sectional Area of C4X bricks
dt/dx Temperature Gradient along bricks
∊ Emissivity of Brick
σ Stefan Boltzmann's constant
g Acceleration due to gravity
β Coefficient of volume expansion
Ts Average Temperature of fin surface
T∞ Temperature of Air
Ʋ Kinematic viscosity of air
K Thermal Conductivity of C4X bricks

REFERENCES

[1]. N.G.Narve1, N.K.Sane2, R.T.Jadhav3, 'Free convection Heat Transfer from symmetrical triangular fin arrays on vertical surface'. International Journal of scientific & Engineering Research, Volume 4, Issue 5, May 2013.
[2]. Starner K. E. and McManus H. N.: 'An experimental investigation of free convection heat transfer from rectangular fin arrays', Journal of Heat Transfer, Trans ASME, series C,85, 273(1963).
[3]. Harahan, F and. McManus H. N: 'Free convection heat transfer from horizontal rectangular fin arrays', Journal of Heat Transfer, Trans ASME, series C,89, 32(1967).
[4]. Jones C. D. and Smith L. F.: 'Optimum arrangement of rectangular fins on horizontal surfaces for free convention heat transfer', Journal of Heat Transfer, Trans ASME, series C, 92, 6(1970).
[5]. Sane N.K. and Sukhatme S.P., Free convection heat transfer from horizontal rectangular fin arrays, in: Proc. Of 5th International Heat Transfer Conference, Tokyo, Japan, Vol. 3, NC3.7, pp. 114–118, 1974.
[6]. Sane N. K., Kittur M. B. and Magdum J.D.: 'Free convection heat transfer from horizontal rectangular fin arrays with a rectangular notch at the centre', proceedings of first ASME ISHMAT Conference
[7]. Krishnan A.S., Premachandran B., Balaji C. and Venkateshan S.P.: 'Combined experimental and numerical approaches to multi-mode heat transfer between vertical parallel plates', Experimental Thermal and Fluid Science 29, 75–86,(2004).
[8]. RammohanRao V. and Venkateshan S.P., Experimental study of free convection and radiation in horizontal fin arrays, Int. J. Heat Mass Tran. 39, 779–789,(1996).
[9]. Dayan A., Kushnir R., Mittelman G. and Ullmann A.: 'Laminar free convection underneath a downward facing hot fin array', International

Journal of Heat and Mass Transfer 47, 2849–2860, (2004) and 12th National heat and mass transfer conference, R.E.C. Suratkal, paper No. HMT-94-046 343-348. (January 1994).

[10]. Shalaby M.A.I., Gaitonde U. N. and Sukhatme S. P.: 'Free convection heat transfer from rectangular fin arrays', Indian Journal of Technology, 22,321. (1984).