International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 3, May-Jun-2019, ISSN (Online): 2395-566X

Natural Convection Heat Transfer from Rectangular Fin Array with Compensated Rectangular Semi Circular Notch

PG Student A.A.Pawar
Dept. of Mechanical Engg.
YTC, College of Engineering
Satara, MH, India

Principal N.G.Narve
Dept. of Mechanical Engg.
YTC, College of Engineering
Satara, MH, India

Emeritus Prof. N.K.Sane
Dept. of Mechnical Engg.
Walchand College of Engineering, Sangli
Sangli, MH, India

***Abstract* - Heat transfer due to natural convection of air from 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 present study, middle portion is removed by cutting rectangular 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 rectangular fin array. It is found that compensated array gives better result as expected.**

***Keywords*- Fin arrays, Grash of number, Rayleigh number, Heat transfer, Natural convection, Spacing.**

I. INTRODUCTION

Starner and McManus, Harahan and McManus, Jones and Smith, Mannan have studied the general problem of natural 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 natural 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 is 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.

Fig.2 Rectangular Fin with compensated area

II. 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

International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 3, May-Jun-2019, ISSN (Online): 2395-566X

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	No. of fins	Length of fin array in mm	Height of fin array in mm
12	8	120	40
14	7		
18	6		
25	5		

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 observations.

Experimental Calculations

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

III. RESULT & DISSCUSSIONS

Results have been obtained in terms of average heat transfer coefficient, base heat transfer coefficient, Average Nusselt number, Base Nusselt number, Rayleigh number. Fig. 4 show the effect of fin spacing on h_a with heater input as the parameter. As the fin spacing increases ha increases for full fin array, as expected. The highest value of ha is 12.51 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 compensatory array also with increase in ha values at every point. The compensatory configurations yield lower values, Also fig.4 shows the relative performance of full fin array and compensatory fin array.

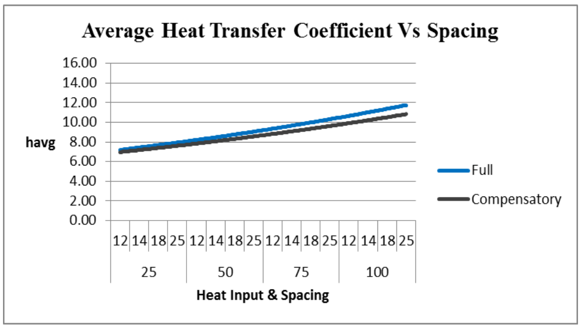

Fig.4 Graph of Average heat transfer coefficients Vs spacing.

It is evident from the graph that ha increases with the heater input, maintaining the superiority of full fin array. It is clear that for the given heater input ha of full fin array is 10 to 15% higher than corresponding compensatory fin array. Average heat transfer coefficient of compensatory fin array is 10 to 12% lower than full fin array for 12mm spacing. It is shown that 25mm spacing is more effective when comparison have been made between compensatory &Full fin array.

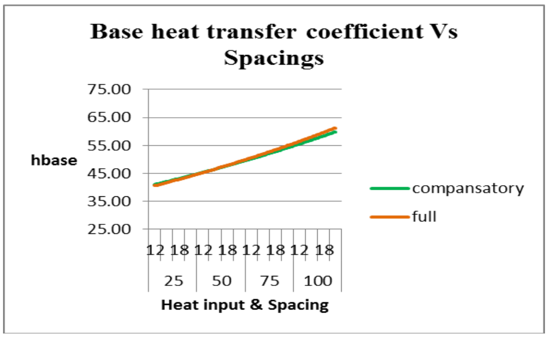

Fig.5 Graph of Base heat transfer coefficients Vs Spacing.

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 51 W/m^2 K for the compensatory fin array. This is due to decrease in heat transfer area. Temperature difference between ambient & Base plate is directly proportional to heat input & spacing. According to Newton's law of Cooling, ΔT having large value then Convection heat transfer is large.

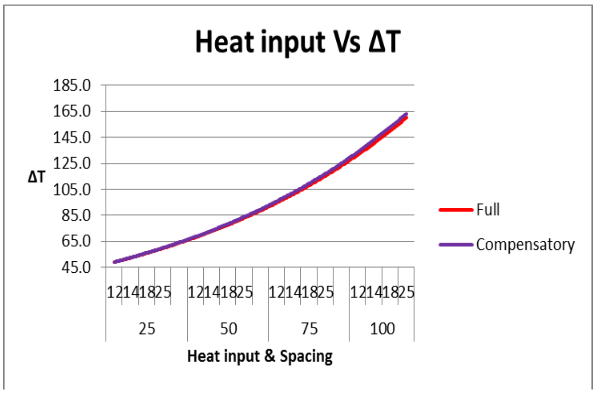

Fig.6 Graph of Heat Input VsTempreture difference.

From fig.6, it is shown that compensatory fin array has large temperature difference compare to full fin array as spacing is increased. But for 12mm spacing compensatory fin array has less temperature difference as compare to full & compensatory fin array. This shows that less spacing develop obstruction to flow of air over fin & ineffective section due to same temperature of fin & ambient. Best fin spacing should be 18to 20 mm for which temperature difference is large. So heat is transferred to surrounding is large.

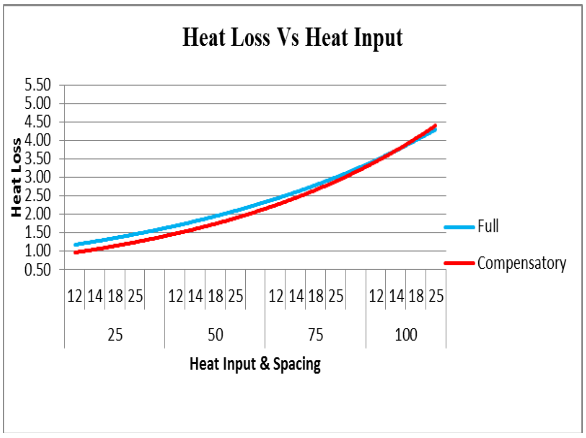

Fig.7 Graph of Heat Loss Vs Heat input.

As Fig 7 shows Heat input & spacing verses Heat loss. There are two losses 1) Conduction loss 2) Radiation Loss. Heat loss is directly proportional to heat input & Spacing. It shows that full fin array has more heat loss as compare to compensated fin array . But for spacing of 25mm compensated fin array has more heat loss as compare to full fin array.Heat loss between compensatory fin array &full fin array. It is concluded that full fin array dissipated more heat by conduction & radiation to surrounding as compare to compensatory fin array

IV. CONCLUSION

The problem of natural 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 full horizontal rectangular fin array is more effective than that compensated fin array. Fall in h_a for compensated fin arrays exhibit 10-15% lower than corresponding full fin array configuration. Average Nusselt number for notched fin arrays is 10-17% higher than corresponding full fin array. h_b& Base Nusselt number is continuously decreasing with increase in spacing for full& compensatory fin array.

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, 'Natural 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: 'Natural 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., Natural 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.: ‘ Natural convection heat transfer from horizontal rectangular fin arrays with a rectangular notch at the centre’, proceedings of first ASME ISHMAT Conference and 12th National heat and mass transfer conference, R.E.C. Suratkal, paper No. HMT-94-046 343-348. (January 1994).

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