Comparison of Free Convection Heat Transfer Performance by using Horizontal Rectangular Fin Array with Compensatory Area & Inverted Triangular Notch

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Abstract – Heat transfer in case of free convection of air from compensatory, full rectangular fin array have been analyzed experimentally. For further investigation purpose short fin array has been confirmed which gives single chimney flow pattern. Central portion of fin array becomes inefficient due to low thermal differences between coming air & fin surface. Therefore in present analysis, central portion is detached by cutting inverted triangular notch and added where maximum fresh air comes in association with fin surface. Outcomes have been obtained over range of spacing from 12mm to 25mm and heat input from 25W to 100W. Length & height of quadrilateral fin array was kept unchanged. Comparison has been made between full, Compensatory inverted triangular notched fin arrays. It is concluded that full rectangular fin array executes better as expected.

Keywords: Fin arrays, Average Heat transfer coefficient, Free convection, Spacing.

I INTRODUCTION

Starner and McManus, Harahan and McManus, 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 creating a vertical velocity flow of air as it reaches the middle portion of fin channel resulting in the warm flow of air going in the vertically upward direction Full & compensatory fin arrays are investigated with different spacing & heat inputs.

Fig.1 Rectangular fin array

II EXPERIMENTATION

Jones and Smith, Mannan have studied the general problem of natural convection heat transfer from quadrilateral fin arrays on a horizontal surface experimentally and theoretically by Sane and Sukhatme. During their analysis, flow visualization studies have also been done and it has been concluded 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 research comprises of an experimental study on horizontal rectangular short fin arrays with notch, without notch at the center & compensatory area on fin surface dissipates heat by free convection. In case of a

The accompanying strategy is utilized for the experimentation:

1. The balance exhibits are amassed by sticking the required number of blade plates by utilizing epoxy glue and situating the thermocouples at the fitting areas.

2. Cartridge heaters (02 numbers) are set in their position, associated in parallel with power circuit.

3. Assembled cluster as above is set in the opened C4X protecting square.

4. Thermocouples are put in the C4X hinder for estimating conduction misfortune. The collected cluster with protection is put at focal point of a fenced in area.

5. The chose warmer information is given and kept consistent by associating with stabilizer, which is given dimmer stat voltage.

6. The temperatures of base plate at various positions, C4X block temperature and surrounding temperature are recorded at the time interims of 15 min. up to consistent condition. (For the most part it takes 2 to 3 hours to accomplish unfaltering state condition).

Fig.2 Rectangular Fin Assembly 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		

Observations were recorded on reading table when the steady state was reached. Observations were taken minimum four times for four dissimilar configuration and heater input to confirm the reliability and repeatability of readings. It is confirmed that changing parameters 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 drawn from the observations.

Experimental Calculations

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

III RESULT & DISSCUSSION

Results have been obtained regarding average heat transfer coefficient, base heat transfer coefficient, Heat loss, heat input etc.

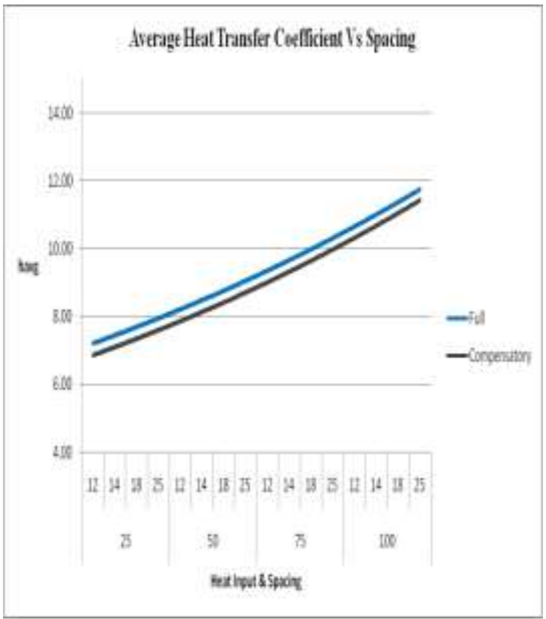

Fig.4 Graph of Average heat transfer coefficients Vs spacing

Fig. 4 show the impact of distances between fins on h_a with heater input as the parameter. As the distance between fins increases, h_a increases for full fin array, as anticipated. The maximum value of h_a is 13.95 W/m2 K at the fin distances of 25 mm. The increasing trend is steep up from spacing about 18 mm. Before which there is a gradual hike. The trend of hike in h_a and hence in the Nusselt number with distance of fin is recorded in case of the compensatory array also with rise in h_a values at every single point. The full grouping yield higher values, thus providing supremacy over compensatory fin arrays.

Also fig.4 shows the corresponding execution of fin array with unnotched and that of notched with compensatory area. It is oblivious from the graph that h_a rises with the heater input, keeping the superiority of full array. It is distinct that for the provided heater input h_a of unnotched array is 8 to 10% higher than corresponding notched compensatory area fin array. Average heat transfer coefficient of notched compensatory area fin array is 10% higher than full fin array for 12mm fin distance.. By observing data analysis, Percentage rise in average heat transfer coefficient of unnotched fin array in comparison with notched compensatory area fin array is increased as the distance between fins increases. It is concluding that 14 mm spacing is more effective when comparison have been made between notched compensatory area fin & unnotched full fin array.

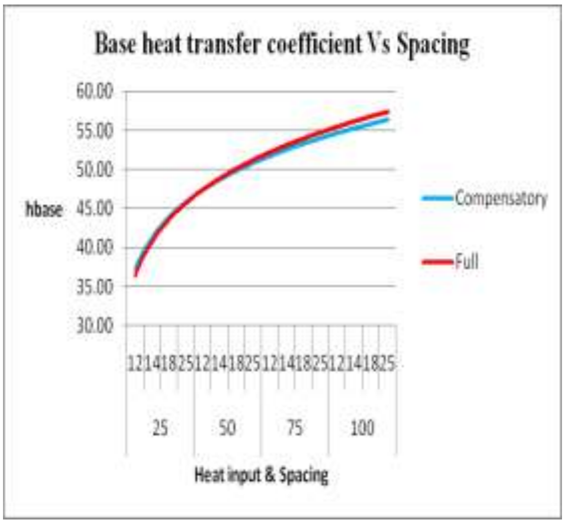

Fig.5 Graph of Base heat tran.sfer coefficients Vs Spacing

Fig. 5 reveals the impact of distance between fins on h_b with heater input as the parameter. From the graph it is clear that the values of h_b reduce as fin spacing rises. It starts to its lowest value at distance between fin about 12 mm and again reduces moderately. This trend can be accredits to restriction of approach of air in the channel at smaller fin distance. The trend of rise in base heat transfer coefficient with the maxima at a distance between fins of 14 mm is observed in case of the full fin array. It is thereafter confirmed that execution of unnotched full fin array is better in terms of base heat transfer coefficient. At the fin distance of 18mm, h_b is nearly 61 W/m^2 K for the unnotched full fin array and is of the order of 54 W/m^2 K for the notched compensatory area fin array.

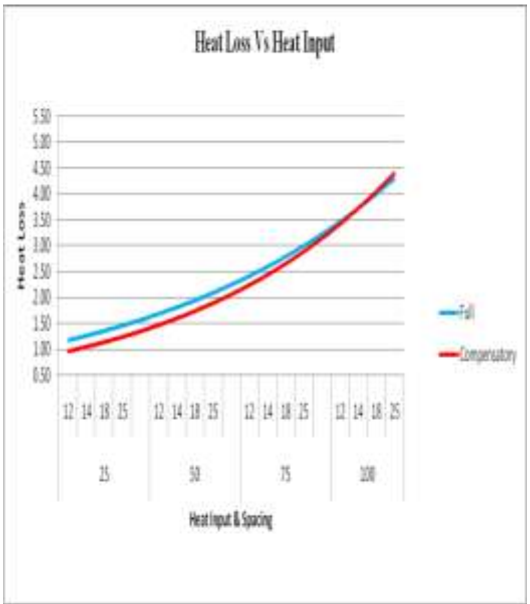

Fig.6 Graph of Heat loss Vs Heat input

As Fig. 6 provides graph between Heat input & spacing verses Heat loss. There are two losses 1) Conduction loss 2) Radiation Loss. Heat loss is directly proportional to heat input & distance of fins. As comparison has been done between losses, radiation losses are insignificant. It shows that notched compensatory area fin array has 16% more heat loss as compare to unnotched full fin array for spacing 12 mm. But for remaining fin distances unnotched full fin array has 2-3% more heat loss as compare to notched compensatory area fin array. It is judged that unnotched full fin array dissipated more heat by conduction & radiation to surrounding as compare to notched compensatory area fin array.

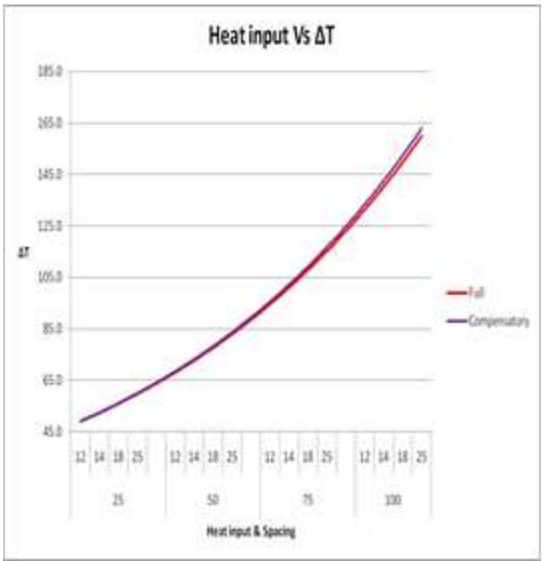

Fig.7 Graph of ΔT Vs Heat input

Temperature contrast between ambient & Base plate is directly proportional to heat input & fin distances. According to Newton's law of Cooling, ΔT having maximum value then convection heat transfer is maximum. From fig. 6, it is clear that notched compensatory area fin array has large temperature difference compare to unnotched full fin array as distance between fins is increased. But for 12mm fin distance notched compensatory area fin array has less temperature difference as compare to unnotched full fin array. This shows that small fin spacing develop obstruction to flow of air over fin & inefficient section due to same temperature of fin & ambient. Premier fin spacing should be 14 to 20 mm for which temperature difference is large. So heat is transferred to atmosphere is large.

IV CONCLUSIONS

The issue of free convection heat transfer from horizontal quadrilateral fin array has been the subject of trial just as hypothetical investigations..

The important findings of the experimentation are as follows:

- Single chimney flow pattern outlined to be preferred by earlier investigators is obtained as it in the notched fin arrays as well by performing simple smoke test.
- Study clears that unnotched full horizontal rectangular fin array is more effective than that notched compensatory area fin array.
- Hike in h_a for unnotched full fin arrays reveals 8- 10% higher than corresponding notched compensatory fin array configuration.
- Average Nusselt number for unnotched full fin arrays is 8-10% higher than notched corresponding compensatory fin array.
- h_b & Base Nusselt number is continuously reducing with rise in fin spacing for notched compensatory fin array.
- h_b & Base Nusselt number is high at spacing 14mm & then decreasing with increase in fin spacing for unnotched full fin array.

Nomenclature

A Cross Sectional Area of C4X bricks $\frac{dt}{dx}$ Temperature Gradient along bricks

? Emissivity of Brick

? 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

V 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 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.: 'Free convection heat transfer from rectangular fin arrays', Indian Journal of Technology, 22,321. (1984).

8. Cohen-Bar and Rohsenow W.M.: 'Thermally best spacing of vertical, natural convection cooled, parallel plates', ASME Journal of Heat Transfer 106 116–123,(1984).

9. 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.

10. Shalaby M.A.I., Natural convection heat transfer from rectangular fin arrays, Ph.D. Thesis, I.I.T. Mumbai, India, (1983).

11. 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).

12. Karagiozis A.N.: 'An examination of laminar free convection heat transfer from isothermal finned surface', PhD thesis, University of Waterloo. (1991).

13. Patil J. D., Tikekar A. N. and Sane N. K.: 'Three dimensional analysis of horizontal rectangular fin arrays under natural convection', 8th ISME Conference on Mechanical Engineering, IIT, Delhi. (March 1993).