

# Experimental Investigation of Free Convection Heat Transfer from Horizontal Rectangular Fin Array with Compensatory Area & Rectangular Notch

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**Abstract** - Heat transfer due to free 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 arrays. It is found that full rectangular fin array performed better as expected.

**Keywords**- Fin arrays, Average Heat transfer coefficient, 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 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. Full & compensatory fin arrays are investigated with different spacing & heat inputs.

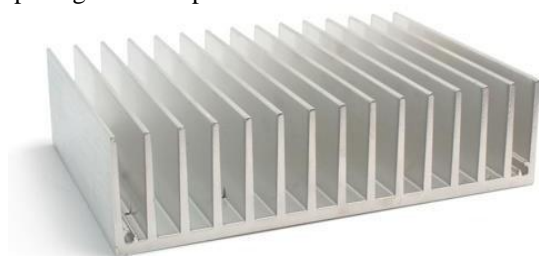


Fig.1 Rectangular fin array.

## 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 resin 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).



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		

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 =  $\epsilon \sigma A [T_s^4 - T_\infty^4]$
3. Heat Transfer Coefficients =  $\frac{Q}{A \Delta T}$
4. Nusselt Number =  $\frac{hL}{K}$
5. Grash of number =  $\frac{g\beta(T_s - T_\infty)L_c^3}{\nu^2}$

### III. RESULT & DISSCUSSION

Results have been obtained in terms of average heat transfer coefficient, base heat transfer coefficient, Heat loss, heat input etc.

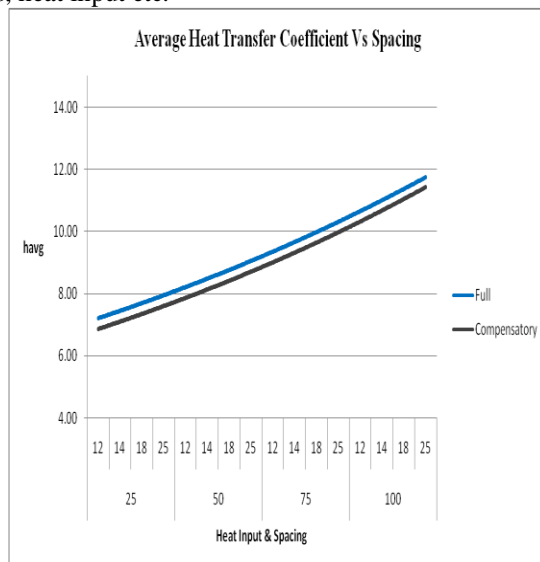


Fig.4 Graph of Average heat transfer coefficients Vs spacing.

Fig. 4 show the 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  $h_a$  is 13.95 W/m<sup>2</sup> 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  $h_a$  and hence in the Nusselt number with fin spacing is observed in case of the compensatory array also with increase in  $h_a$  values at every point. The full configurations yield higher values, thus indicating superiority over compensatory fin arrays.

Also fig.4 shows the relative performance of fin array with full and that of compensatory. It is evident from the graph that  $h_a$  increases with the heater input, maintaining the superiority of full array. It is clear that for the given heater input  $h_a$  of full array is 8 to 10% higher than corresponding compensatory fin array. Average heat transfer coefficient of compensatory fin array is 10% higher than full fin array for 12mm spacing.. By doing data analysis, Percentage increase in average heat transfer coefficient of full fin array in comparison with compensatory fin array is increased as the spacing increases. It is concluding that 14 mm spacing is more effective when comparison have been made between compensatory & full fin array.

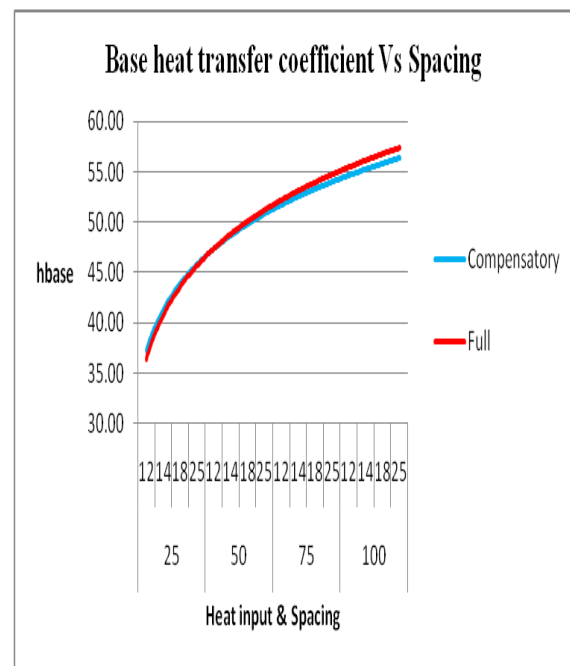


Fig.5 Graph of Base heat transfer coefficients Vs Spacing.

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  $61 \text{ W/m}^2 \text{ K}$  for the full fin array and is of the order of  $54 \text{ W/m}^2 \text{ K}$  for the compensatory fin array.

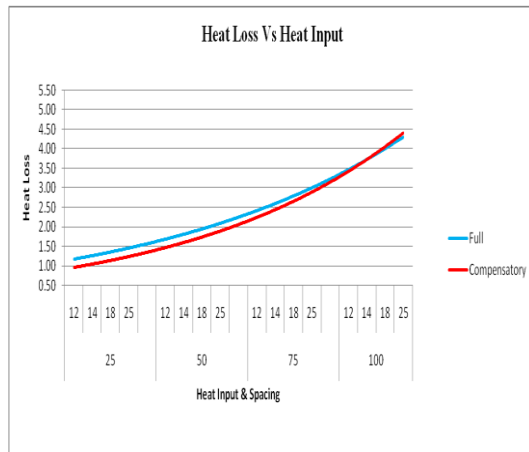


Fig.6 Graph of Heat loss Vs Heat input.

As Fig. 6 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. As comparison has been done between losses, radiation losses are negligible. It shows that compensatory fin array has 16% more heat loss as compare to full fin array for spacing 12 mm. But for remaining spacing full fin array has 2-3% more heat loss as compare to compensatory fin array. It is concluded that full fin array dissipated more heat by conduction & radiation to surrounding as compare to compensatory fin array.

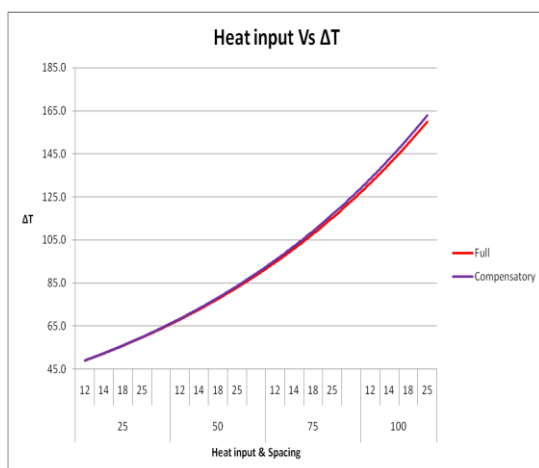


Fig.6 Graph of  $\Delta T$  Vs Heat input.

Temperature difference between ambient & Base plate is directly proportional to heat input & spacing. According to Newton's law of Cooling,  $\Delta T$  having large value then Convection heat transfer is large. 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 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 14 to 20 mm for which temperature difference is large. So heat is transferred to surrounding is large.

#### IV. 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 full horizontal rectangular fin array is more effective than that compensatory fin array.
- Rise in  $h_a$  for full fin arrays exhibit 8-10% higher than corresponding compensatory fin array configuration.
- Average Nusselt number for full fin arrays is 8-10% higher than corresponding compensatory fin array.
- $h_b$  & Base Nusselt number is continuously decreasing with increase in spacing for compensatory fin array.
- $h_b$  & Base Nusselt number is high at spacing 14mm & then decreasing with increase in spacing for full fin array.

#### Nomenclature

- A Cross Sectional Area of C4X bricks
- $\frac{dt}{dx}$  Temperature Gradient along bricks
- $\epsilon$  Emissivity of Brick
- $\sigma$  Stefan Boltzmann's constant
- $g$  Acceleration due to gravity
- $\beta$  Coefficient of volume expansion
- $T_s$  Average Temperature of fin surface
- $T_\infty$  Temperature of Air
- $U$  Kinematic viscosity of air
- $K$  Thermal Conductivity of C4X bricks

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