NATURAL CONVECTION HEAT TRANSFER FROM HORIZONTAL RECTANGULAR FIN ARRAY WITH STEPPED RECTANGULAR NOTCH

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Abstract - Heat transfer due to natural convection of air from notched, compensatory, full rectangular fin array have been investigated experimentally. Rectangular fins are fabricated of aluminum material because it has low cost & high thermal conductivity. Orientation of rectangular fin array is horizontal because it is more effective than other orientations such as vertical or inclined. For study purpose short fin array has been selected which show single chimney flow pattern. Length of rectangular fin array is 120mm. Fin thickness is kept constant, fixed at 2mm. 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. Experimental set has been developed with control panel, dimmerstat, thermocouples with temperature indicator. Eleven thermocouples are used for recording of temperatures. Forty eight different fin configurations were tested. Parameters like average heat transfer coefficient, base heat transfer coefficients, Nusselt number, Grashof number & Rayleigh number are calculated for notched, compensatory, full rectangular fin array from observations. The separate roles of fin spacing and base to ambient temperature difference were investigated. The results of experiments have shown that the convective heat transfer rate from fin arrays depends on geometric parameters and base to ambient temperature difference. Comparison has been made between full, Compensatory & notched rectangular fin array.

Key Words **Fin arrays, Average Heat transfer coefficient, Free convection, Spacing.**

1. 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 full fin, stepped rectangular notch fin, stepped rectangular compensated area at the center & 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 & Notched fin arrays are investigated with different spacing & heat inputs.

Fig.1 Exploded view of fin array

2. EXPERIMENTAL SETUP

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.

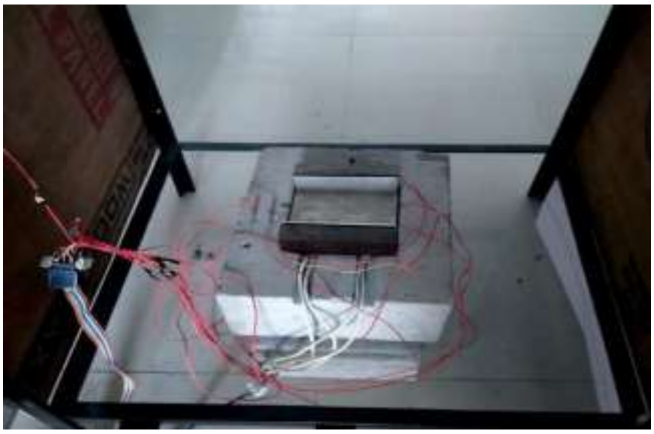

Fig.2 Experimental setup

3. 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).

Fig.3 Assembly of Rectangular fin array

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 = $\in \sigma A\,[Ts4 - T\infty 4]$

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

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

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

4. RESULT & DISSCUSSION

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

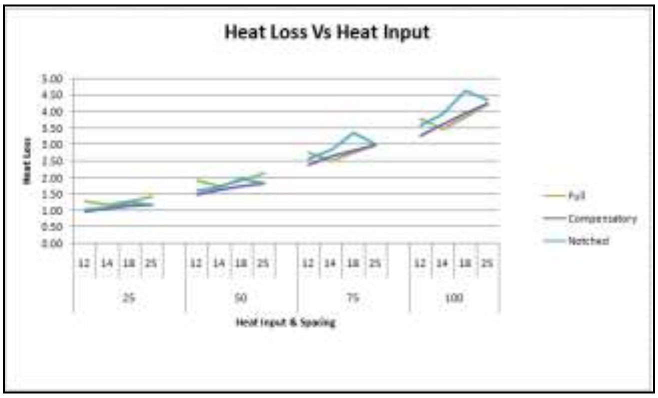

Fig.4 Graph of Heat Loss Vs Heat input

As Fig 4 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 Notched fin array has 2% more heat loss as compare to full fin array for spacing 25mm. But for spacing of 12mm notched fin array has 5% less heat loss as compare to full fin array. Heat loss for compensatory fin array is in between notched & full fin array. It is concluded that notched fin array dissipated more heat by conduction & radiation to surrounding as compare to full fin array.

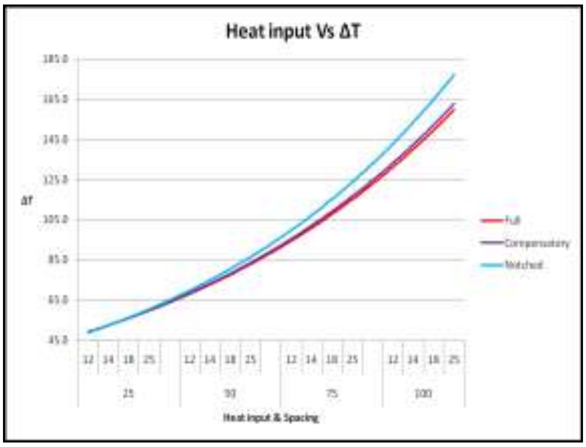

Fig.5 Graph of Heat input verses Temperature difference

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. From fig.5, it is shown that notched fin array has large temperature difference compare to full & compensatory fin array as spacing is increased. But for 12mm spacing notched 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.

Fig.6 Graph of Average heat Transfer Coefficient Vs Spacing

Fig.6 show the effect of fin spacing on ha 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 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.

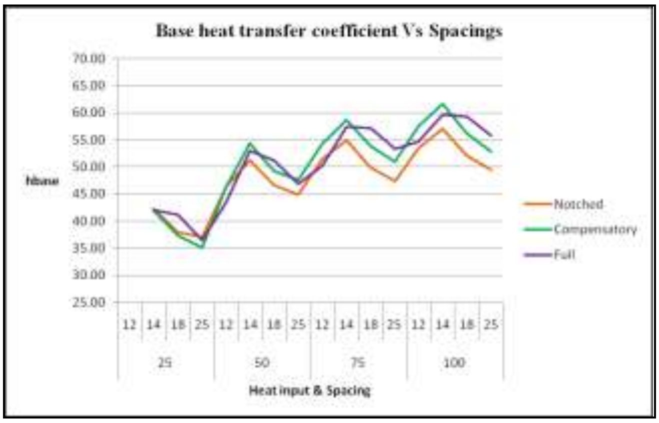

Fig.7 Graph of Base Heat Transfer Coefficient Vs Fin Spacing

Fig.7 show the effect of fin spacing on hb with heater input as the parameter. From the figure it is clear that the values of hb 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, hb is nearly 61 W/m2 K for the full fin array and is of the order of 55 W/m2 K for the notched fin array. This is due to decrease in heat transfer area.

5. CONCLUSIONS

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.
- Grashof number & Rayleigh number for notched fin array is 8-15% higher than corresponding full fin array.
- Results show that Grashof number is less than 109. Therefore, Natural convection heat transfer with laminar flow of air is confirmed.

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