Analysis of Free Convention Heat Transfer from Rectangular Fin Array with Modification in Geometry

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Abstract – Heat sink is known as thermal device, which is convective & conductive in nature. Its geometry has been designed to remove heat from an electronic component such as Desktop, smart phones, Audio video players and fridges. It removes heat from electrical component or circuit, dissipate heat to surrounding medium. But continuously heating of intermediate portion becomes ineffective because of heat flow in single chimney flow pattern in short fin array. 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. Effect on fin obtained by changing the parameters of fin like Height and Spacing. Contrast has been made between full, notched rectangular fin array. After the comparison of different parameters of result like average heat transfer coefficients and average nussult number etc. It is found that notched fin array carry out better than full fin array.

Keywords: Fin arrays, Grashof number, Rayleigh number, Heat transfer, Natural convection, Spacing, Nussult number.

1. INTRODUCTION

Levy & Sane and Sukhatme investigated the problem of horizontal fin array for the single chimney flow pattern; and down and up flow pattern. Shalaby and Shalaby investigated laminar natural convection from vertical fin arrays. They solved the problem without neglecting the velocity components perpendicular to the fin flats. Karagiozis investigated laminar, free convection heat transfer from isothermal finned surfaces and confirmed the findings of Shalaby Baskaya et.al. Yuncu and Anbar Alami et.al. Krishnan in their paper reported an experimental study of free convection heat transfer from rectangular fin-arrays on a horizontal base. The experiments were conducted so as to clearly identify the separate roles of fin height, fin spacing and base-to-ambient temperature difference. Sane investigated experimentally the problem of natural convection heat transfer from horizontal rectangular fin arrays with a rectangular notch at the center.

Morankar carried out experimental work on natural convection heat transfer from vertical rectangular notched fin arrays So Short fin array with length of 120mm is selected for experimentation

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

Fig.1 Rectangular fin array

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.

Fig.3 Rectangular Fin Array With Notched

2. 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.

5. The fix heater input is given and kept constant by using dimmerstat voltage.

6. The temperatures of base plate at different locations, 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).

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		

Table.1 Parameters of Experimentation

Readings were recorded on 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 = $\frac{g\beta(Ts-T\infty)Lc^3}{\upsilon^2}$

3. 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.

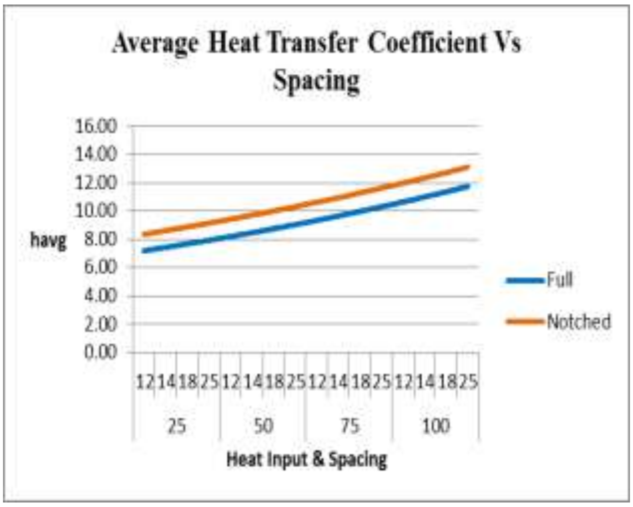

Fig.4 Graph of Average heat transfer coefficients Vs spacing

Graph shows the influence of fin spacing on ha with heater input as the parameter. As the fin spacing rises ha rises for full fin array, as expected. The highest rate of ha is 13.73 W/m2 K at the spacing of 25 mm. The growing trend is steep up from spacing about 18 mm. Before which there is a steady rise. The inclination of rise 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 alignments yield greater values, thus indicating dominance over full fin arrays.

Graph shows the relative performance of fin array with notch and that of without notch. It is patent from the graph that ha upsurges with the heater input, maintaining the superiority of notched array. It is flawless that for the given heater input ha of notched array is 23 to 28% higher than corresponding full fin array. Average heat transfer coefficient of Notched fin array is 25.25% greater than full fin array for 12mm spacing. Also it is flawless 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 25% higher than full fin array for 14mm positioning. By doing data analysis, Percentage rise in average heat transfer coefficient of notched fin array in comparison with full fin array is decreased as the spacing rises. It is shown that 14 to 18mm spacing is more effective when comparison have been made between Notched & Full fin array.

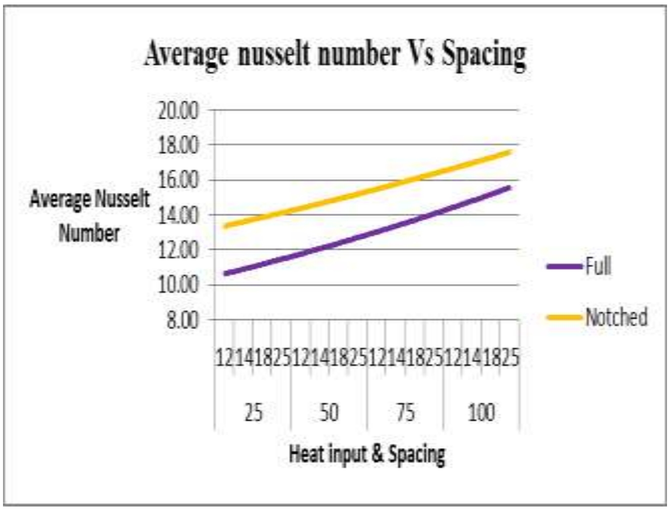

Fig.5 Graph of Average Nusselt Number Vs Spacing

It is clear from the graph that as spacing increases the average Nusselt number Nu_a increases for the notched fin array. The growing tendency is gradual up to a spacing of 14 to 18 mm. After that the rise is sudden. The notched alignments yield upper values, thus representing dominance of notched fin array above Compensatory & full fin array. The highest Nu_a is about 18.26 W/m^2 K for the notched fin array at heater input of 100 W. In overall it is detected that the Nu_a rises with rise in fin spacing, this is due to reason that with rise in design, the fluid can stream more freely through the fin channel. This may be attributed to the phenomenon of lateral boundary layer interference at lower fin spacing. Nu_a dimensionless number rises from 11 to 18 with increase in heat input from 25 to 100 W for notched fin array which is greater than that of compensatory & full fin array. Optimal fin spacing is above 18mm.

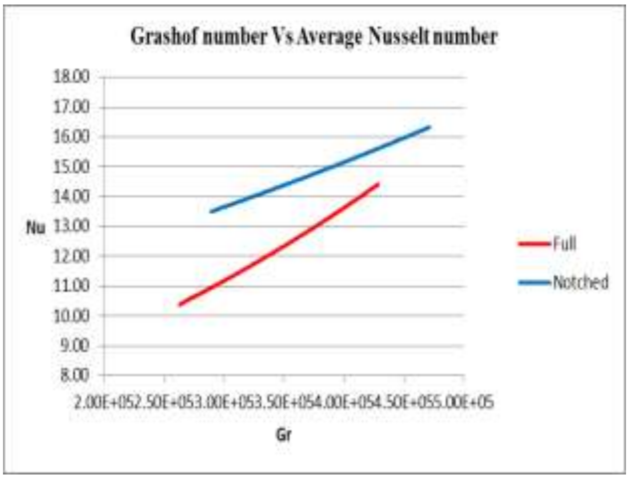

Fig.6 Graph of Grashof number Vs Nusselt number

Graph shows the relationship between Grashof number and Nusselt Number. Grashof number is necessary for the determination of flow. Grashof number is the ratio of buyoncy force to the viscous force. If flow is less than 109 then flow is laminar and if flow is more than 109 then flow is turbulent. Nusselt number increases with increase in the grashof number. The highest value of nusselt number is 75W having spacing 25mm. at that time grashoff number is also high.

4. CONCLUSIONS

The problem of natural convection heat transfer from flat quadrilateral 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 flat quadrilateral fin array is more effective than that full fin array.
- Rise in h_a for Notched fin arrays exhibit 10-30% higher than corresponding full fin array configuration.
- Average Nusselt number for notched fin arrays is 25.52% higher than corresponding full fin array.
- h_b & 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 10^9. Therefore, Natural convection heat transfer with laminar flow of air is confirmed.

Nomenclature

A Cross Sectional Area of C4X bricks

$\frac{dt}{dx}$ Temperature Gradient along bricks

$\in$ 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

U Kinematic viscosity of air

K Thermal Conductivity of C4X bricks

5. REFERENCES

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