"Comparative Study of Performance of Rectangular Fins and V Fins on a Vertical Base Plate under Free Convection Heat Transfer"

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Abstract : Natural convection heat transfer is generally enhanced by provision of various shapes of fins such as rectangular fins, pin fins, perforated fins or V shape fins etc. In this work, the experiments are performed to determine the various heat transfer parameters using rectangular fins and V fins. From experimental observations, various parameters are calculated and graphs are plotted between various parameters such as average heat transfer coefficient, base heat transfer coefficient and Nusselt number versus heat input. The results revealed that the V shape fins produced a better performance than the rectangular shape fins. The calculation of the base coefficient of heat transfer is carried out towards establishment of the ideal temperature range for the base material.

Keywords- "Heat transfer enhancement, natural convection, rectangular fins, V fins".

I. INTRODUCTION

Advanced technologies are needed to improve performance in heat transfer equipment. Methods used for enhancing the heat transfer rate are classified as active and passive methods. In the design point of view, active methods are sometimes complex and costly because they require some external power input for necessary flow adjustments and to improve the heat transfer rate and thus applications are limited. On the other hand, passive methods require some geometrical or surface adjustments to the flow passage by adding additional devices. The amount of conduction, convection, and radiation of an object shows the amount of heat it transfers. The heat transfer rate is enhanced by increasing the temperature difference between the object and the environment or by enhancing the coefficient of convective heat transfer or by maximizing the surface area of the body. In some cases, it is not appropriate or cost effective to alter the first two options.

Introducing a fin to a body, however, expands the surface area and sometimes this is a cost effective solution for heat transfer problems. Extended surfaces or fins are examples of passive methods that are generally used in different industrial applications for the enhancement of heat transfer between the primary surface and the surrounding fluid. The easiest and cheapest ways to dissipate unwanted heat is tackled by the use of fins."Rectangular fins are the most popular type of fins because of their low production costs and high effectiveness. Natural convection heat transfer is augmented usually by provision of rectangular fins on horizontal or vertical surfaces. As a result, energy saving and cost effective solution can be achieved by the use of V shape fins also. [1-2]

II. LITERATURE REVIEW

N. K.Sane and J.G.Kulkarni et.al [1]: The study investigated the free convection heat transfer of vertical tapered fin arrays. It was performed by varying the fin spacing and the base area of the arrays. The results indicated that downward-tended fins are more effective than upward-tended fins in achieving the same free convection heat transfer. Baskaya et al. [2]: Various geometrical factors such as height, width, and fin spacing were examined to study the natural convection heat transfer using horizontal fin arrays. The results indicated that the varying heights and lengths of the fin can affect the overall heat transfer from the arrays. Edlabadkar et.al. [3]: An experiment on a single V-type partition plate was performed to investigate the air flow over a base plate with varying angles in air as an ambience. The V shape fin was attached to the plate. The computational fluid dynamics simulations were performed to determine the optimal configurations for the air flow. The study revealed that the 90° V partition plate provides the smallest struggle to flow departure than the other partition plates. In the downstream zone, it also provides the most efficient high heat transmission area. V. Wankar and S. Taji et al. [4]: Under natural convection, flow patterns on rectangular fin arrays were investigated and tested experimentally. The purpose of the experiment is to investigate the effects of natural convection on a rectangular fin array. Lampblack coating is used to accomplish this. Sable et al. [5]: Multiple V-type partition plates adjacent to a vertical heated plate are used in the authors' proposed heat transfer augmentation technique. The key components that contribute to the heated plate's thermal conductivity are vertical fins that act as flow tabulators and expanded surface partition plates.

III. EXPERIMENTAL SETUP

The system is designed and manufactured for the measurement of heat transfer parameters for which the details are as follows: Aluminium is used to manufacture plain base plate and fin patterns for experimentation work. The aluminium base plate used for research work having the dimensions as 200mm X 200mm X 20mm. The total surface area of rectangular fins and the total surface area of V-fins is kept equal. Fins of two different patterns are utilized to conduct experiments which are as follows;

1] Rectangular fin pattern

2] V type fin pattern

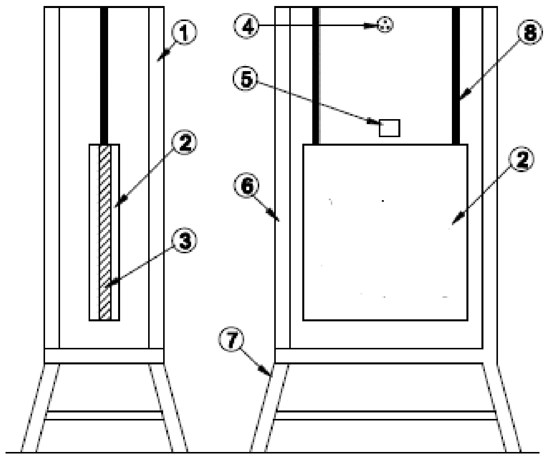


Fig.No.1: Schematic layout of Experimental System

1) Enclosure 2) Heated Plate, 3) Heater, 4) Heater Socket 5) Thermocouple Socket

6) Acrylic Sheet, 7) Stand, 8) Hanger

IV. EXPERIMENTATION

The whole system is kept under natural convection conditions and All measurements were taken in steady state circumstances.

In the present dissertation work, following different configurations are tested:

1) Plain Vertical Plate

2) Vertical Plate with Vertical fins

3) Vertical Plate with Horizontal fins

4) Vertical Plate with V-fins (Apex downwards)

5) Vertical Plate with V-fins (Apex upwards)

6) Vertical Plate with V-fins (Apex on Left Hand Side)

7) Vertical Plate with V-fins (Apex on Right Hand Side)

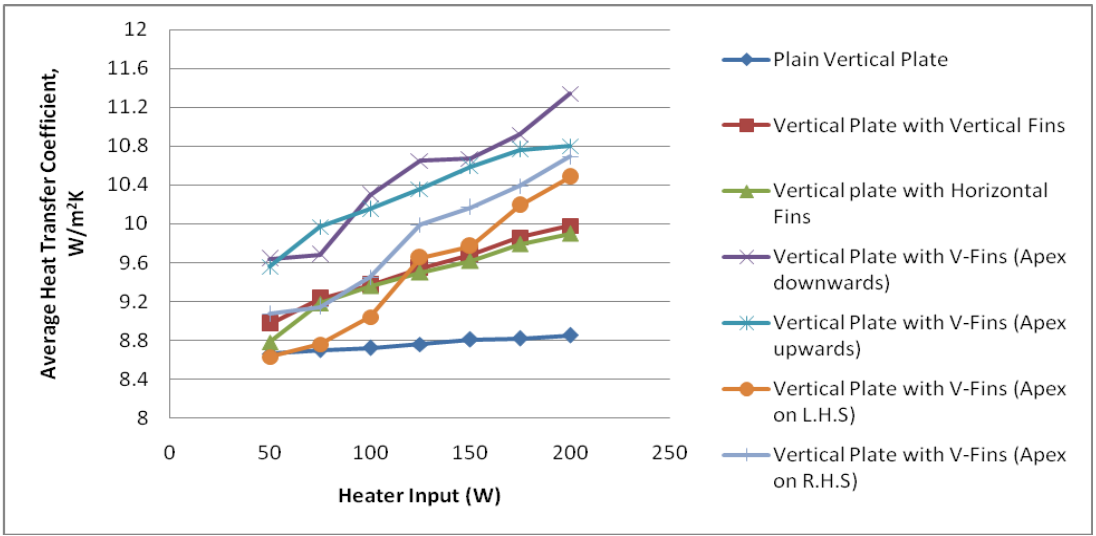
By varying heater inputs through dimmerstat at regular interval of time, wattmeter readings were recorded as Q watt. The temperatures of base plate surface, ambient temperature (T_{amb}) and fins were recorded using digital temperature indicator. The experimental results were obtained for different heater inputs as 50, 75, 100, 125, 150, 175 and 200 watts.

V. RESULTS AND DISCUSSIONS

From experimental observations, various parameters such as average coefficient of heat transfer, Base coefficient of heat transfer, Nusselt number, Grashoff number, Prandtl number, and Rayleigh number were calculated. All the fluid properties are calculated at mean film temperature and are taken from standard tables. The graphs are plotted to show the different trends.

The below mentioned are the results observed after experimentation -

Sr. No.	Heater Input (W)	Average heat transfer coefficient h – W/m² K						
		Plain Vertical Plate	Vertical plate with Vertical Fins	Vertical plate with Horizontal Fins	V-Fins with Apex Downwards	V-Fins Apex Upwards	V-Fins (Apex on L.H.S.)	V-Fins Apex on R.H.S.
1	50	8.66	8.97	8.78	9.64	9.56	8.63	9.07
2	75	8.70	9.23	9.18	9.68	9.97	8.76	9.14
3	100	8.72	9.37	9.36	10.30	10.15	9.04	9.45
4	125	8.76	9.54	9.50	10.65	10.36	9.65	9.99
5	150	8.81	9.68	9.62	10.67	10.59	9.77	10.17
6	175	8.82	9.86	9.79	10.92	10.76	10.19	10.39
7	200	8.85	9.98	9.90	11.34	10.80	10.48	10.69

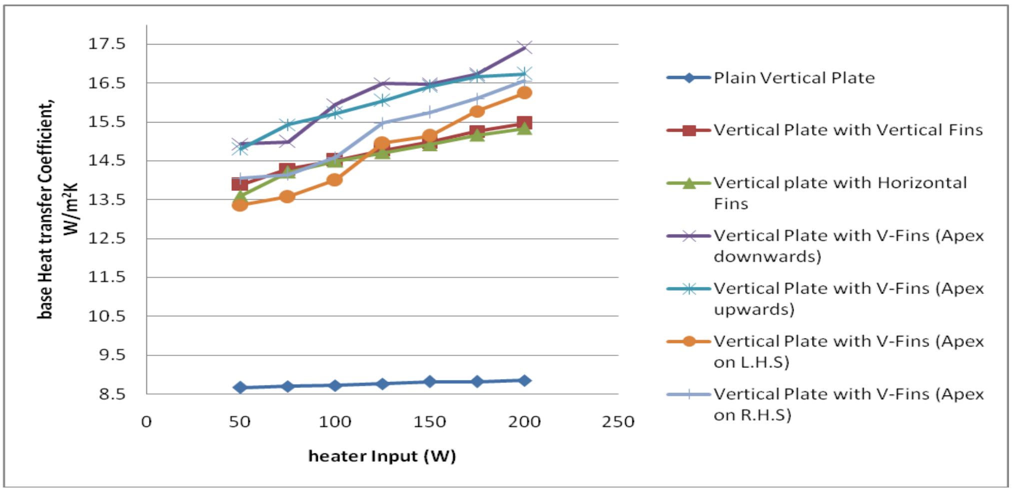


Graph 1 Variation of Heater Input vs Average Heat Transfer Coefficient

(Combined Graph for all Different Configurations)

Graph no 1. Shows the combined graph of variation of average heat transfer coefficient with heater input. The average heat transfer coefficient for V-fins with apex downward ranges from 9.64 to 11.34 W/ m² K. It is found from the data that V-fins with apex downward arrangement have the highest value of the heat transfer coefficient, and thereby has more better performance in comparison with the other configurations.

Sr. No.	Heater Input (W)	Base heat transfer coefficient h_b – W/m² K						
		Plain Vertical Plate	Vertical plate with Vertical Fins	Vertical plate with Horizontal Fins	V-Fins with Apex Downwards	V-Fins Apex Upwards	V-Fins (Apex on L.H.S.)	V-Fins Apex on R.H.S.
1	50	8.66	13.89	13.59	14.93	14.80	13.36	14.05
2	75	8.70	14.29	14.21	14.99	15.43	13.57	14.15
3	100	8.72	14.51	14.49	15.95	15.72	14.00	14.59
4	125	8.76	14.77	14.71	16.49	16.04	14.95	15.47
5	150	8.81	14.98	14.91	16.46	16.41	15.14	15.74
6	175	8.82	15.26	15.16	16.72	16.67	15.78	16.10
7	200	8.85	15.46	15.33	17.40	16.73	16.24	16.55



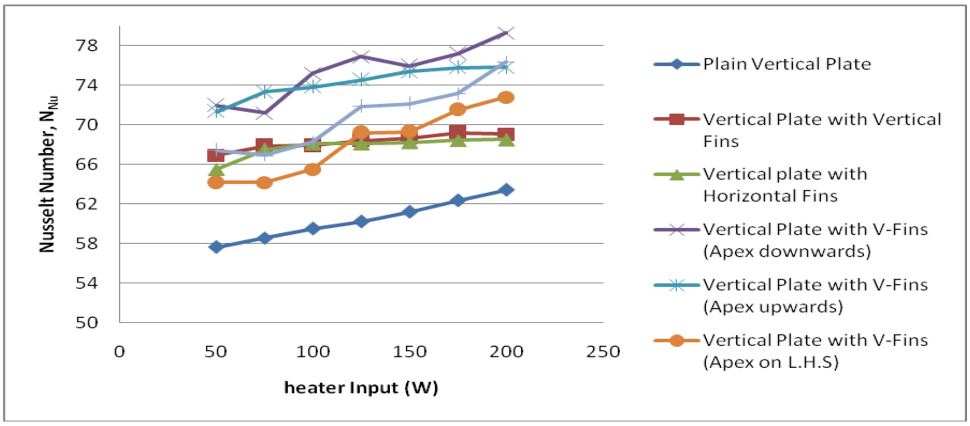
Graph 2 Variation of Heater Input vs Base Heat Transfer Coefficient

(Combined Graph for all Different Configurations)

For all setups, graph no.2 shows the combined graph of fluctuation of base heat transfer coefficient with heater input.

For "V-fins with the apex downwards", the basal heat transfer coefficient ranges from 14.93 to 17.40 W/ m2 K. According to the findings, the base coefficient of heat transfers for "V-fins with apex downwards" arrangement is higher than the other designs.

Sr. No.	Heater Input (W)	Nusselt No. N_{Nu}						
		Plain Vertical Plate	Vertical plate with Vertical Fins	Vertical plate with Horizontal Fins	V-Fins with Apex Downwards	V-Fins Apex Upwards	V-Fins (Apex on L.H.S.)	V-Fins Apex on R.H.S.
1	50	57.65	66.94	65.52	71.94	71.34	64.16	67.43
2	75	58.6	67.87	67.50	71.18	73.31	64.18	66.96
3	100	59.53	67.89	68.07	75.18	73.82	65.51	68.26
4	125	60.21	68.39	68.10	76.89	74.53	69.18	71.87
5	150	61.19	68.65	68.23	75.94	75.37	69.29	72.13
6	175	62.37	69.19	68.46	77.17	75.77	71.51	73.17
7	200	63.44	69.07	68.51	79.30	75.80	72.78	76.36



Graph 3. Variation of N_{Nu} with Heater Input

(Combined Graph for all Different Configurations)

The Nusselt number for V-fins with apex downwards ranges from 71.94 to 79.30, which is higher than the other configurations.

VI. CONCLUSION

When compared to other configurations, the average heat transfer coefficient value for V-Fins with apex downwards is larger. V-Fins showed 20% improvement in average heat transfer coefficient when compared to Plain Vertical Plate. When V-Fins were compared with vertical plate with vertical Fins, V fins showed 10.33% improvement. For V-Fins with Apex facing Downwards configuration, the base heat transfer coefficient is in the range of 14.93 – 17.40 W/m^2 K. The Nusselt number value for V-Fins with Apex facing downwards configuration is in the range 71.94 to 79.30, which is the highest as compared to other configurations.

Results from the present theoretical analysis clearly show that the V-Fins arrangement has good heat transfer performance than all other configurations because it disturbs the flow and due to this the flow of heat becomes turbulent, thereby increasing the heat transfer rate.

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