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Effect on an Aluminium Plate with V-fins under Natural convection heat transfer conditions

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Abstract: ***This paper reveals the experimentation of vertical aluminium plate on which v-fins are attached. The parameters of performance like average heat transfer coefficient and Nusselt number are calculated and compared. The rectangular fins are arranged to form a v-shape and are tested for various heater inputs like 50W, 100W, 125W and so on. As per the results it is concluded that the v-fins arrangement with apex downwards is the best arrangement as compared to rectangular arrangement.***

Keywords: Heat Transfer, Natural Convection, Rectangular Fins, V-fins

I. INTRODUCTION

Convective heat transfer takes place between bodies exposed to free air and solid body, while the fluid is in motion. Direction of heat transfer should be either from fluid to solid surface or from solid surface to fluid depending upon the direction of temperature gradient. Convective heat transfer may be forced or free convection. Convection heat transfer situations may have internal flow or external flow. The convective heat transfer is of great importance for very large number of industrial applications e.g. fluid flow in heat exchangers, boilers, furnaces, cooling of electronic chip, transfer of heat due to fluid flow in pipes, condensers, automobile radiators, cooling towers, evaporators.etc. The travel of heat in Natural Convection occurs with the transfer of fluid particles due to change in density associated with a difference in temperature in a fluid. In natural convection, the velocity of flow considered is less as compared to velocity of flow in forced convection. So the heat transfer coefficient is less. Fins are provided as an extended surface on the system in order to dissipate the heat to the surrounding.

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If the unutilized energy is not dissipated to surrounding, then the system can fail due to overheating. The rectangular fins are formed in order of a V-shape to increase the heat transfer rate.

II. LITERATURE REVIEW

Prasolov et al. (1961)[1], Heya *et al.* (1982)[2], Bhavnani *et al.(*1990)[3] studied the rough area with variation in height under natural convection conditions and concluded that the roughness elements only act as a flow depressor instead of increasing the heat transfer rate. **T. Fujii et.al [4]** studies the output of fins with rough surface and concluded that as the surface gets rough its ability to transfer heat also reduces. The work on the effect of horizontal partition plate attached to a vertical plate was reported by **Misumi and Kitamara K [5]**. This was followed by the same authors **Misumi and Kitamara K.[6]**, where they have studied the effect of partition plate and V-plate. They also compared the performance of V-plate array with conventional vertical fin array and obtain better performance. **Starnar and McManus [7]** studied the work on vertical fin arrangements and compared the results with horizontal parallel plates. They concluded that the vertical plates perform better when they are held straight vertical but the performance lowers as there is an orientation in the system. N.K.Sane and J.G.Kulkarni [8] carried out study on heat transfer from vertical tapered fin arrangements. Fins both with upward and downward taper have been investigated. Also arrays formed by changing the fin spacing have been tested at different power input values. Baskaya et al. [9] studied the work on horizontal plate with fins attached on its surface. The experiment was carried out for various parameters such as variation in distance between fins and its height. They concluded that it was not possible to obtain the results for overall heat transfer coefficient by taking into consideration only a few parameters. Wankhede et al. [10] studied the work related to notch fin arrays connected to a horizontal rectangular plate with fins. They concluded that the fins with notches at the upper side are having a higher heat transfer coefficient. Futher, they also studied the effects of various parameters such as fin spacing, length. Wani et al. [13] studied the review of fins with horizontal and vertical arrangement. The fins attached to the plate had constant area and the study concluded that there is an improvement in heat transfer rate when the fins are attached to a plate.

III. EXPERIMENTAL WORK

From the above literature survey, it is found that -

1) Several studies are carried out on heat transfer through rectangular fins by variation in Height of fins and number of fins.

2) More study has been focused on the use of Partition plate for V-Fins between the base Plates.
3) To the author's knowledge, it has been observed that very less work has been done on the above title mentioned for enhancement of heat transfer.
The convection area of the plate with fins is kept constant. The enhancement of heat transfer will take place due to the attachment of fins arranged in V-form to the vertical base plate. From the literature survey, it is observed that very few researchers have worked on V-fins.. The basic idea behind the configuration is to keep the total surface area constant in both the cases. The whole system is exposed for natural convection conditions and the readings are noted down when the system approaches a steady condition..

The experimentation is carried out by varying the power input with the help of a dimmerstat while the total surface area remaining constant in each case.

IV. ASSEMBLY OF SYSTEM

The system is assembled and manufactured and the test is conducted for calculating the performance parameters in natural convection as under :- The aluminium base plate used for research work having the dimensions as 200mm X 200mm X 25mm. The division of base plate is in such a way that there are equal areas on the plate in order to locate the position of both, rectangular and V-form fins. The vertical plate will be hanged by hooks which are provided at the top side of enclosure The base plate also has hooks at its far end on every side. The base plate will be hanged at the mid centre of the enclosure with the helps of a nylon string. The base plate has three cartridge heaters inserted throughout at equal distances. The aluminium base plate is shown in Figure No.1 below:-

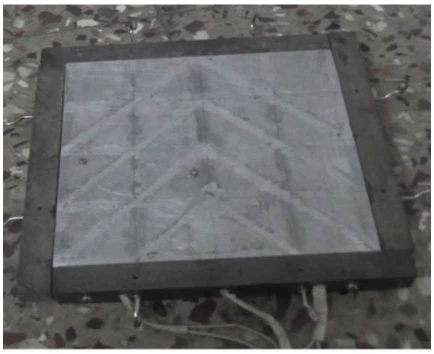


Figure 1. Plain Aluminium Plate

The figure no.2 shows the vertical Rectangular fins attached to the base plate and the plate hanged at the centre of enclosure.

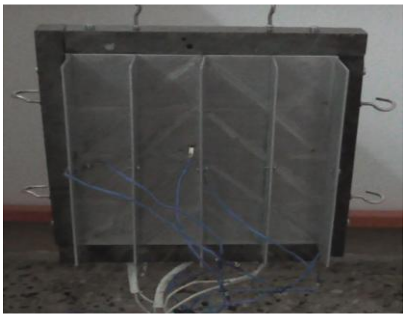


Figure 2. Plain Aluminium Plate with rectangular fins

The figure no.3 shows the vertical Rectangular fins attached in V-Form to the base plate and the plate hanged at the centre of enclosure.

Figure 3. Plain Aluminium Plate with V-fins

V. RESULTS AND DISCUSSIONS

The below mentioned are the observation tables for various arrrangements –

Table no.1 – Observations for Plain Vertical Plate

Sr. No	Heater Input (W)	Base Plate Temperatures (°C)				Enclosure Temperature(°C)
		T1	T2	T3	T4	Tamb.
1	50	59.4	62.2	59.5	61.2	26.2
2	75	76.4	75.5	78.2	79.2	26.3
3	100	92.2	93.4	94.1	95.6	26.4
4	125	108.6	110.1	109.5	111.7	26.6
5	150	124.6	126.5	124.6	126.4	26.7
6	175	140.2	142.4	140.3	141.6	26.8
7	200	154.2	156.9	156.5	157.3	27.0

Table no.2 – Observations for Vertical Plate with Rectangular Fins

Sr. No	Heater Input (W)	Base Plate Temperatures (°C)				Fin Array Temperatures (°C)					Enclosure Temperature (°C)
		T1	T2	T3	T4	T5	T6	T7	T8	T9	Tamb.
1	50	57.5	56.2	57.2	57.1	42.6	41.2	40.2	39.5	39.8	26.8
2	75	69.2	69.2	70.9	70.1	48.8	48.5	48.9	47.9	46.2	27.0
3	100	83.2	84.2	84.2	83.2	55.2	56.2	55.2	54.3	52.2	27.3
4	125	98.2	94.5	96.2	95.6	62.4	62.9	61.2	60.8	58.2	27.4
5	150	106.5	103.8	106.2	105.2	70.1	70.7	71.5	70.2	67.5	27.6
6	175	118.1	116.2	115.8	114.2	78.5	78.8	76.2	77.1	73.2	27.8
7	200	126.4	125.8	127.5	125.5	85.9	88.6	84.3	82.2	78.4	28.0

Table no.3 – Observations for Vertical Plate with V-fins

Sr. No	Heater Input (W)	Base Plate Temperatures (°C)				Fin Array Temperatures (°C)								Enclosure Temperature (°C)
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	Tamb.
1	50	49.9	51.4	50.1	51.3	44.8	46.7	45.3	45.4	42.8	44.3	43.6	43.5	26.8
2	75	61.1	64.3	61.9	63.6	53.6	55.7	54.2	54.8	50.6	52.6	52.3	51.5	26.9
3	100	70.1	74.8	71.3	72.6	57.0	63.1	60.8	60.2	59.9	59.2	61.1	57.8	27.0
4	125	80.2	85.5	80.7	82.8	63.7	70.5	67.2	65.6	66.4	65.6	68.2	65.1	27.1
5	150	90.6	97.5	92.6	93.8	71.1	78.6	75.3	74.2	74.4	73.4	76.2	72.1	27.3
6	175	100.3	108.4	102.8	103.4	78.4	85.9	82.6	81.7	81.4	80.4	82.8	78.5	27.5
7	200	110.1	117.6	112.5	113.4	85.2	90.3	87.6	86.4	85.9	84.3	86.2	83.4	27.8

The value of average heat transfer coefficient is based on the total surface are including that of the extended surfaces. It is observed that there in an increase in value of 'h' with increase in heater input thereby increasing the temperature difference for all arrangements. For a plain vertical plate, the value of h was found in the range of 8.66 to 8.85 W/ m2 K.

For Vertical Plate with Vertical fins, the value was in the range of 9.42 to 10.58 W/ m2 K. The value of h for V-fins with apex facing downwards comes out in the range of 10.09 to 11.80 W/ m2 K. From the results, it is concluded that the value of h for V-fins with apex facing downwards arrangement is higher as compared to the other configurations, thereby giving better performance

Table no.4 – Results for Plain Vertical Plate

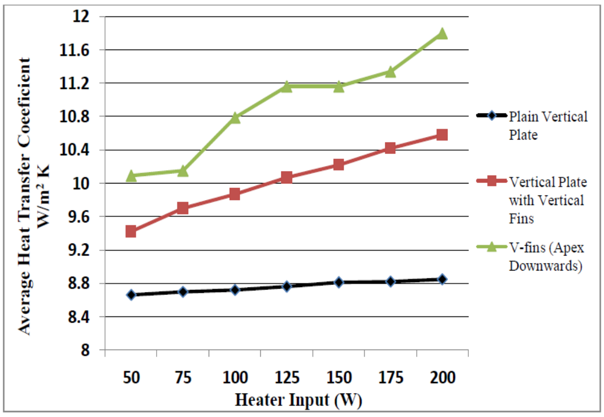
Sr. No.	Heater Input (W)	Enclosure Temperature $T_{amb.}$ (°C)	Average Surface Temp. Ts (°C)	Temp.Difference ΔT (°C)	q (radiation) W	q (convection) W	Average heat transfer coefficient h - W/m^2 K
1	50	26.2	60.58	34.38	3.84	46.16	8.66
2	75	26.3	77.33	51.03	6.18	68.82	8.70
3	100	26.4	93.83	67.43	8.85	91.15	8.72
4	125	26.6	109.98	83.38	11.83	113.17	8.76
5	150	26.7	125.53	98.83	15.08	134.92	8.81
6	175	26.8	141.13	114.33	18.75	156.25	8.82
7	200	27.0	156.23	129.23	22.71	177.29	8.85

Table no.5 – Results for Vertical Plate with Rectangular Fins

Sr. No.	Heater Input (W)	Enclosure Temperature $T_{amb.}$ (°C)	Average Surface Temp. Ts (°C)	Temp.Difference ΔT (°C)	q (radiation) W	q (convection) W	Average heat transfer coefficient h - W/m^2 K
1	50	26.8	47.92	21.12	2.22	47.78	9.42
2	75	27.0	57.74	30.74	3.40	71.60	9.70
3	100	27.3	67.54	40.24	4.67	95.33	9.87
4	125	27.4	76.67	49.27	5.98	119.02	10.07
5	150	27.6	85.74	58.14	7.38	142.62	10.22
6	175	27.8	94.23	66.43	8.79	166.21	10.42
7	200	28.0	102.73	74.73	10.30	189.70	10.58

Table no.6 – Results for Vertical Plate with V-Fins

Sr. No.	Heater Input (W)	Enclosure Temperature $T_{amb.}$ (°C)	Average Surface Temp. Ts (°C)	Temp.Difference ΔT (°C)	q (radiation) W	q (convection) W	Average heat transfer coefficient h - W/m^2 K
1	50	26.8	46.59	19.79	2.07	47.93	10.09
2	75	26.9	56.35	29.45	3.23	71.77	10.15
3	100	27.0	63.99	36.99	4.22	95.78	10.79
4	125	27.1	71.79	44.69	5.29	119.71	11.16
5	150	27.3	80.82	53.52	6.63	143.37	11.16
6	175	27.5	88.88	61.38	7.91	167.09	11.34
7	200	27.8	95.24	67.44	8.97	191.03	11.80



Graph no.1 – Comparison of Average Heat transfer coefficient

The Nusselt number for the Plain base plate is in range from 57.5 to 63.42. For Vertical Plate with Vertical fins, the value was in the range of 70.12 to 72.7. The value of Nu for V-fins in downward comes out in the range of 75.02 to 82.46.

Table no.7 – Results for Plain Vertical Plate

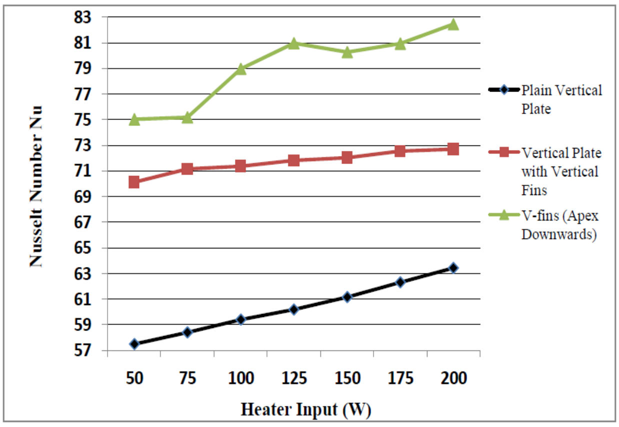
Sr.No.	Heater Input (W)	Enclosure Temperature $T_{amb.}$ (°C)	Average Surface Temp. Ts (°C)	Mean Film Temp. Tm (°C)	Nusselt No. Nu
1	50	26.2	60.58	43.39	57.50
2	75	26.3	77.33	51.81	58.41
3	100	26.4	93.83	60.11	59.41
4	125	26.6	109.98	68.29	60.18
5	150	26.7	125.53	76.11	61.15
6	175	26.8	141.13	83.96	62.30
7	200	27.0	156.23	91.61	63.42

Table no.8 – Results for Vertical Plate with Rectangular Fins

Sr.No.	Heater Input (W)	Enclosure Temperature $T_{amb.}$ (°C)	Average Surface Temp. Ts (°C)	Mean Film Temp. Tm (°C)	Nusselt No. Nu
1	50	26.8	47.92	37.36	70.12
2	75	27.0	57.74	42.37	71.17
3	100	27.3	67.54	47.42	71.36
4	125	27.4	76.67	52.03	71.81
5	150	27.6	85.74	56.67	72.03
6	175	27.8	94.23	61.02	72.54
7	200	28.0	102.73	65.37	72.70

Table no.9 – Results for Vertical Plate with V-Fins

Sr.No.	Heater Input (W)	Enclosure Temperature $T_{amb.}$ (°C)	Average Surface Temp. Ts (°C)	Mean Film Temp. Tm (°C)	Nusselt No. Nu
1	50	26.8	46.59	36.70	75.02
2	75	26.9	56.35	41.63	75.18
3	100	27.0	63.99	45.50	78.97
4	125	27.1	71.79	49.45	80.87
5	150	27.3	80.82	54.06	80.28
6	175	27.5	88.88	58.19	80.93
7	200	27.8	95.24	61.52	82.46



Graph no.2 – Comparison of Nusselt No.

VI. CONCLUSION

1) As the value for all V-fins is higher, it is concluded that V-fins arrangement is best as compared to the base plate and the conventional fin arrangement.
2) Due to this, the arrangement when applied to any automobile, will help in reducing the temperature and cool better in less time.
3) Due to the fins arranged in V-form, the heat becomes turbulent and it dissipates in the surroundings in less time, thereby effectively increasing the engine performance.

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