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Experimental Comparison of Natural Convection Heat Transfer from a Special V-Fin Array

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Abstract: *In Convective heat transfer the transfer of heat occurs from one place to another due to the movement of fluids, a process that is initiated by the transfer of heat via transfer. It is significant in many physical situations where Bulk motion of fluid enhances heat transfer, such as between a solid surface and the fluid. Thus the dominant form of heat transfer in liquids and gases is usually Convection., convection is usually used to describe the combined effects of heat conduction within the fluid (diffusion) and heat transference by bulk fluid flow streaming although sometimes discussed as a third method of heat transfer. This paper is about an investigation for a special V-Fin Array effecting the convective heat transfer.*

Keywords: *Fin Array, Heat Transfer, Natural Convection, , Vertical Plate, V-Fins*

1. Introduction

Heat transfer generally refers to the transfer of heat from body to body, surface to surface. When the streams and currents in the fluid are induced by external means—such as fans, stirrers, and pumps—creating an artificially induced convection current it is referred as Forced convection.

Natural or free convection is observed as a result of the motion of the fluid due to density changes arising from the heating and cooling process. Natural convection represents an inherently reliable cooling process. In the situation of the failure of forced convection due to fan break down, this mode of heat transfer is often designed as a backup.

For management of heat in electrical appliances such as computer power supplies or substation transformers, fins are commonly applied. Convective heat transfer in a wide range of engineering applications is enhanced using Fins, which offer a practical means for achieving a large total heat transfer surface area without the use of an excessive amount of primary surface area. Other applications include Internal Combustion engine cooling, such as fins in a car radiator. The use of finned surfaces is the practical and feasible means to improve natural convection heat transfer.

2. Literature Review

Starnar and McManus [1] determined average heat transfer coefficients for four arrays positioned with base vertical, at 45° and horizontal. It was found that vertical arrays performed 10-30 % below the similarly placed parallel plates, followed by arrays at 45° performing 5-20 % below the vertical arrays and the horizontal fin arrays performed least. Flow visualization tests were conducted using smoke technique.

Baskaya et al. [2] carried out parametric study of natural convection heat transfer from the horizontal rectangular fin arrays. A wide range of geometrical parameters like fin spacing, fin height, fin length and temperature difference between fin and surroundings, were considered for their effect on the heat transfer for horizontal fin arrays and were investigated. But unfortunately no clear conclusions were drawn due to the various parameters involved.

An experimental setup was developed by Wankhede et al. [3] to carry out the investigation on horizontal rectangular fin array with and without inverted notch under natural and forced convections to experimentally determine the heat transfer characteristics, and further to find out the enhancement in heat transfer in the case of notched fin arrays for comparison with normal fin arrays. The effect of different parameters like length, height, spacing of fins on heat transfer coefficient (h). Were analyzed.

The free convection from isothermal vertical base rectangular fin arrays was experimentally investigated by Karagiozis [4] using the fins having rectangular and triangular cross-sections. Two different orientations of fins: viz. vertical and horizontal were examined and also the arrays with blocked ends with both fin orientations were investigated. The experiments to determine the radiation contribution also carried out.

Prasolov et al [5], Heya et al. [6], Bhavnani et al [7] put forth that the roughness elements having height less than the boundary layer thickness will have only trivial influence on the heat transfer of natural convection and these elements will not work as the heat transfer promoter but only as flow retarder. The local heat transfer coefficients for surfaces with repeated ribs and steps were determined using an interferometric technique.

Wani et al. [8] discussed the efforts of earlier researchers for heat transfer enhancement in natural convection and suggested a proposal for further investigations to enhance the heat transfer of V-fins by arrangement of an array attached to the base plate with the edges faced downstream and blackened in order to increase the radiative heat transfer.

Barhatte et al [9] did the study on heat transfer rate through different types of notches in the fin. Various types of notches such as rectangular, circular, triangular and trapezoidal were used and comparison of notch fin array with without notch fins was done by supplying different heat inputs. The dimensions of fin were fixed. It is concluded that heat transfer through triangular notch fin is higher than all other types investigated.

Wani et al. [10] investigated the enhancement of the convective heat transfer from a V-Fin Array which is blackened. Blackened V-Fins array and concluded that the configuration gives the better performance.

Tsuji et.al. [11] conducted an experimental study on heat transfer enhancement for a turbulent natural convection boundary layer in air along a vertical flat plate has been performed with a long flat plate inserted in the span wise direction (simple heat transfer promoter) and aligning a short flat plates in the span wise direction (split heat transfer promoter) and providing clearances into the near-wall region of the boundary layer.

3. Summary Of Review

From the above literature review, it is seen that,

1. Very few researchers have worked on Natural Convection conditions for Vertical Plate with V-Fins
2. Less work is carried out on Vertical Plate with V-Fins.
3. No any work has been carried out on V-fins with variation in orientation of Apex

4. Experimental Setup

Enhancement of heat transfer under natural convection conditions can be achieved by connecting the fins to the base plate which will be vertically hanged inside a closed enclosure. The arrangement will be vertical and the fins will be attached to the surface of the base plate. From the literature survey, it is found that very few investigators have worked on the problems related to this type of arrangement. Hence, an experimental work to find the enhancement and performance in heat transfer by a special V-fin arrangement is to be carried out for investigating the facts. The total length of rectangular fins will be kept equal to the total length of V-fins, which in turn will maintain the equal surface area during both conditions. The characteristics of V-fins are ascertained by sticking the rectangular fins to form V-fins on the base plate. Therefore, same height of both fins will be there and the enhancement in heat transfer for both conditions can be carried out. The base plate is equally divided into four parts. The heaters are placed between the base plate at an equal length from each other for effective heat distribution to the base plate. The enclosure used is for the development of undisturbed natural convection condition

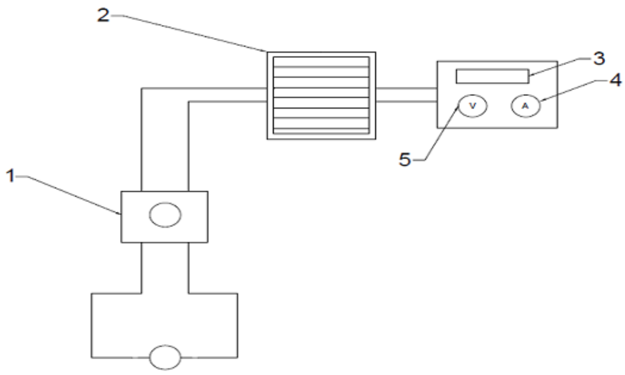


Figure1. *Experimental Setup*

1. Dimmerstat 2. Fin Array 3. Temperature Indicator 4. Ammeter 5. Voltmeter

5. Development Of System

The system is designed and developed for the measurement of heat transfer parameters for which the details are as follows:

The base plate used for investigation work is made up of aluminium and of dimension 200mm X 200mm X 25mm. To identify the positions of rectangular fins as well as V-fins several markings are done on the base plate. The vertical plate will be hanged by hooks which are provided at the top side of enclosure The strings will be attached to the hooks for positioning the base plate right at the mid center of the enclosure. The rectangular fins are arranged in such a way that they look like a V-fin.

Figure2. *Plate with V-Fins*

The cartridge type heater of dimension Ø 5mm X 200mm was used. The heaters were placed in the holes inside the base plate symmetrically. The maximum rated power output of heater was 260 Watts..The setup is hanged at the top side of the enclosure. The enclosure is covered with acrylic sheets from all the four sides out of which one side is kept transparent for observation purpose. The enclosure is 1m x 1m x 1m in dimension.

Figure3. *Plain Vertical Plate with Fins*

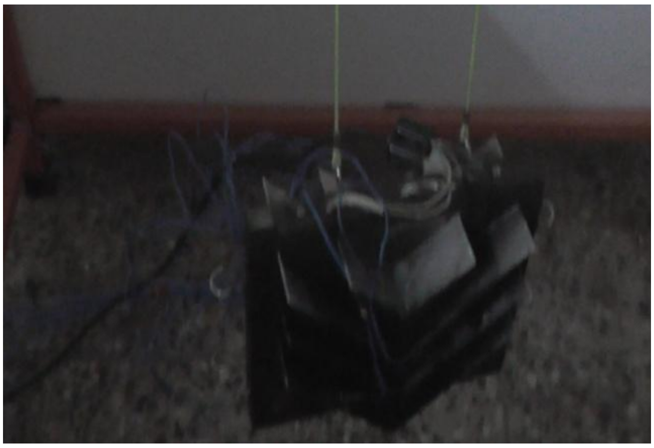


Figure4. *Plain Vertical Plate with V- Fins*

The experimental procedure carried out is as follows:

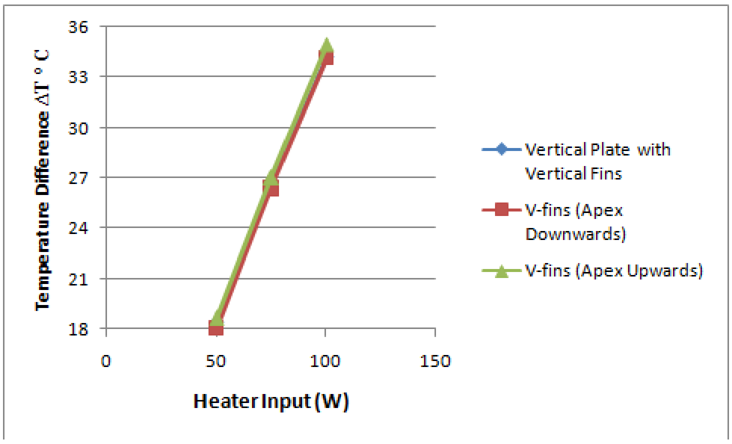
Initially, the fins are sticked to the base plate and given some time for adhesion. The enclosure is opened from two sides. This is in order to hook the test plate to the enclosure from inside end. After that, the sides of the enclosure are closed by acrylic sheets. The connections of the thermocouples were made at required positions. The remaining electrical connections are checked i.e. connections of heater, wattmeter and dimmer stat etc. The heater is heated by supplying a.c.current through dimmer stat and wattmeter. After checking all the connections, the switch of temperature indicators and dimmer stat is turned ON. The setup is now given some time to achieve a steady state. After steady state is reached, the temperatures at different points were read by the digital temperature indicator and were recorded at a time interval of 30 minutes. The heater input was kept constant by varying the dimmer stat to account for voltage fluctuations. The final reading was recorded when steady state is reached.

6. Results And Discussions

After certain series of observations and calculations, the results found are as follows:

Table1. *Results of Temperature Difference*

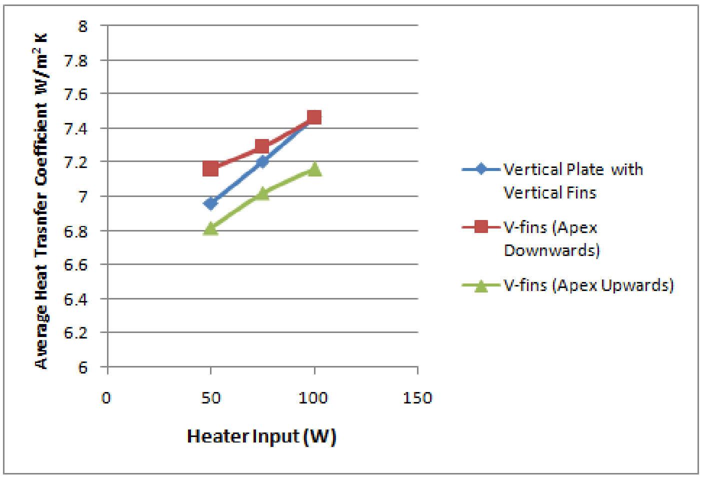
Sr.No.	Heater Input Q (W)	Temperature Difference Δ T (°C)		
		Vertical Plate with fins	Vertical Plate with V-Fins	Vertical Plate with V-Fins (Apex upwards)
1	50	18.38	18.06	18.80
2	75	26.56	26.37	27.00
3	100	34.35	34.16	34.98



As the whole surface being black, the radiation increases thereby reducing the temperature at all the nodes. Out of all the surfaces, the lowest temperature difference is found out to be for V-fins with apex facing downwards configuration.

Table2. *Results of Average heat transfer coefficient*

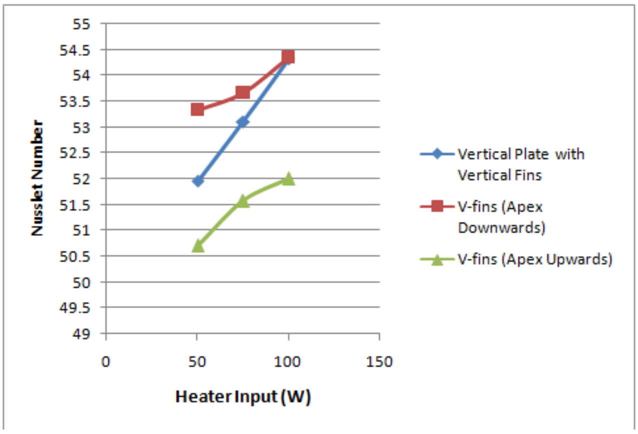
Sr. No.	Heater Input Q (W)	Average heat transfer coefficient h - W/m^2 K		
		Vertical Plate with fins	Vertical Plate with V-Fins	Vertical Plate with V-Fins (Apex upwards)
1	50	6.88	7.25	6.99
2	75	7.15	7.38	7.12
3	100	7.35	7.50	7.25



It has been observed from the graph, that the highest value of the average heat transfer coefficient is for V-fins with apex downwards configuration and thereby has more better performance in comparison with the other configurations.

Table2. *Results of Nusselt Number*

Sr.No.	Heater Input Q (W)	Nusselt Number Nu		
		Vertical Plate with fins	Vertical Plate with V-Fins	Vertical Plate with V-Fins (Apex upwards)
1	50	51.78	53.38	50.6
2	75	53.15	53.77	51.52
3	100	54.50	54.25	52.00



, it has been observed from the graph that for V-fins with Apex facing downwards the value of Nusselt Number is higher than the other configurations. This type of configuration will give better performance as compared to other fin configurations as Nusselt Number is higher,

7. Conclusion

1. The configuration of V-Fins with Apex facing Downwards, the average heat transfer coefficient is in the range of 7.25. – 7.50 W/m^2 K which is the highest value of average heat transfer coefficient for any other configuration. This concludes that V-Fins facing downwards give better performance than Vertical Plate with Vertical Fins and V-Fins with Apex upwards.

2. For the increase in heater input from 50W to 100W, the temperature difference also increases, and it is observed that for V-Fins with Apex facing downwards configuration, the temperature difference is in the range of 18.06 – 34.16ºC, which is the lowest as compared to any configuration. This means that this configuration gives the better performance.
3. Nusselt number value for V-Fins with Apex facing downwards configuration is in the range 53.38 – 54.25, which is the highest as compared to other configurations.
4. The V-Fins arrangement shows good heat transfer performance than a plain vertical plate owing to its flow disturber action to heat flow over the plate.

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