A CONVECTIVE STUDY ON HEAT TRANSFER ENHANCEMENT FROM VERTICAL PLATE

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ABSTRACT

Vertical plates are the useful geometry in many applications Many authors have investigated the natural convection heat transfer from wide vertical flat plate over the past so many years. Among the geometrical variations, rectangular plates are the most commonly encountered fin geometry because of their simple construction, cheap cost and effective cooling capability. In this paper, the experimental investigation of enhancing heat transfer from vertical rectangular and V fins under natural convection condition is performed. It was investigated that partition plates of different shapes attached on vertically heated plate would create suitable fluid motion and in turn they promote the heat transfer rate. The prime objectives of this paper is to measure heat transfer coefficient of vertical fins and V-fins under natural convection. For the same height of the partition plate, V-plates have higher average heat transfer coefficient Ha than vertical partition plate.

KEYWORDS: *Natural convection; Vertical plate; Heat transfer coefficient*

1.0 INTRODUCTION

Convection heat transfer is a major branch of study and is directly related with needs of any engineering industry anywhere. Natural convection from a vertical surface is one of the fundamental subjects among a wide variety of heat transfer studies. Natural convection heat transfer on the surface depends on the geometry of the surface as well as its orientation. Purpose and analysis of fins is explained in almost all the heat transfer books (Cengel, 2003; Holman, 2000). The convective removal of heat from a surface can be substantially improved if we put extension on that surface to increase its area. These extensions can take variety of forms. There are many different ways in which the surface of commercial heat exchange tubing can be extended with protrusions of a kind we call as fins .Vertical plate enhances heat transfer rate but when tall vertical plates are attached on base plate,

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boundary layers of these plates interfere with each other and increase the resistance to heat transfer which reduces heat transfer rate from base vertical plate surrounding. M.Fujii et al., (1996) have conducted series of experiments on natural convection heat transfer to air from an array of vertical parallel plates (Fujii & Gima, 1996). Misumi T. and Kitamura have reported an experimental work on augmentation of natural convection heat transfer from a vertical plate and 'V' shaped partition plate in the environment of water (Misumi & Kitamura, 1990). As per the experiment done by A.N. Tikekar and N.K. Sane on experimental investigation showing enhancement in the heat transfer rate due to addition of extended surfaces due to different partition plate, they found that V-shaped partition plates are advantageous over other partition plates and optimum extension from the base plate is 50 mm (Tikekar & Sane, 2004).

2.0 EXPERIMENTAL SETUP

An experimental setup is designed and fabricated to investigate the enhancement in heat transfer in natural convection using vertical rectangular fins. The attempt was made to perform the experiments under perfect natural convection. To ensure natural convection a large enclosure is required to be made symmetrical about a vertical plane. It is required to heat the plate arrangement to obtain the natural convection effects by using suitable heating arrangement. For the development of undisturbed boundary layer, it is also necessary to hang the plate in the enclosure. The experimental evaluation of the results requires temperature measurements at several locations on the plate and also temperature of the surrounding. The enclosure is open from top and bottom.

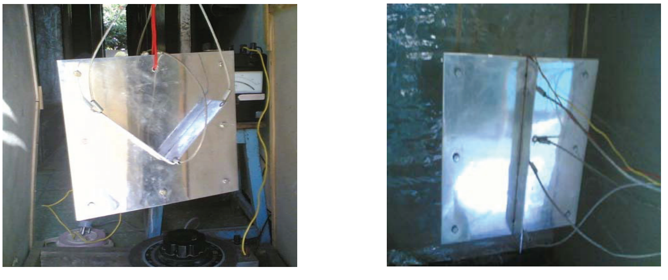


Figure 1. Experimental setup

The base plates used for experiment were made of 3 mm thick, 300 mm height, and 300 mm wide aluminum. Aluminum plates of 3 mm thickness and 300 mm length and 50 mm width were used as vertical rectangular fins as shown in figure 1 (Tikekar & Sane, 2004). All the plates were buffed with cotton wheel and polished using mixed leather wheel. A dimmer stat was used to vary the heat input in steps A calibrated wattmeter was used to measure the heat input. Deluxe Mica electrical heater was sandwiched between the symmetrical vertical base plates. The spread of the sandwiched electrical heater ensured almost uniform surface temperature of test plate. For the purpose of local temperature measurement total eight thermocouples of copper-constantan were used. A calibrated digital temperature indicator was used to measure the thermocouple output. Though all the experiments were carried out with utmost care and many of them were repeated to avoid errors, there is possibility of experimental uncertainty. Property values for air were taken from the data book at the film temperature. Experimental uncertainty in temperature measurements may occur due to variation in atmospheric conditions. Experimental uncertainty in Prandtl number is negligible (Cengel, 2003).

3.0 RESULTS AND DISSCUSIONS

On the basis of observations recorded, various governing and performance parameter of the problem are calculated. The parameter such as base heat transfer coefficient, average heat transfer coefficient, Nusselts number, Prandtl number, and Grashoffs number were calculated. Various fluid properties are evaluated at the mean film temperature are taken from the standard data table. Table 1 and 2 represent the variations of base heat transfer and average heat transfer coefficients against the heat inputs for rectangular and V fins.

Table 1. Base and average heat transfer coefficient and % increase in heat transfer of vertical fins for various heat inputs

Sr.No.	Type of fins	Q (W)	Hb	Ha	% Increase in heat transfer
1	Vertical Rectangular Fins	20	2.892148	3.246447	12.11
2		40	3.895367	4.379825	12.33
3		60	4.771894	5.412464	13.41
4		80	5.434662	6.173284	13.62
5		100	5.857969	6.717048	14.70
6		120	6.606525	7.598216	15.00

Table 2. Base and average heat transfer coefficient and % increase in heat transfer of V fins for various heat inputs

Sr.No.	Type of fins	Q (W)	Hb	Ha	% Increase in heat transfer
1	V shaped Fins	20	7.47705	8.484045	13.52
2		40	8.79056	10.04457	14.22
3		60	9.05482	10.40056	14.91
4		80	9.75613	11.21215	14.97
5		100	9.85612	11.36186	15.32
6		120	10.1652	11.75384	15.64

The base and average heat transfer coefficient for all heat inputs of V fins are higher than the rectangular vertical fins of the same surface area. Similarly, stagnation of high temperature fluid in the front of the plate will also be diminished. Thus the reduction of the heat transfer in the upstream region is minimized. The range of base heat transfer coefficient and average heat transfer coefficient for V fins is 7.47-10.16 and 8.48-11.75 respectively. The range for Hb and Ha for vertical rectangular fins is 2.89-6.60 and 3.24-7.59 respectively. Table 3 and 4 shows variation of dimensionless numbers

Table 3. Variation of dimensionless numbers with various heat inputs of rectangular fins

Sr.No.	Type of fins	Q (W)	Pr	Nu	$Grx10^6$
1	Vertical Rectangular Fins	20	0.705880	29.504814	14.808115
2		40	0.705250	34.485538	22.727997
3		60	0.704690	39.470131	28.875103
4		80	0.704340	47.545020	32.336163
5		100	0.703880	50.460247	36.480698
6		120	0.703600	56.779606	38.796616

Table 4. Variation of dimensionless numbers with various heat inputs of V fins

Sr.No.	Type of fins	Q (W)	Pr	Nu	Grx10^6
1	V shaped Fins	20	0.705918	66.289093	7.9219916
2		40	0.705530	77.887810	13.237831
3		60	0.705120	80.006645	18.371056
4		80	0.704790	85.703461	22.186676
5		100	0.704410	86.216951	26.237526
6		120	0.704080	88.63347	29.485565

The variations of base and average heat transfer coefficient for vertical plate and V plate is shown in Figure 2. It is observed that Nusselt number increases as Q increases in both the vertical as well as V fin is shown in figure 2. But in case of V fin Nusselt number is higher than the vertical fin.

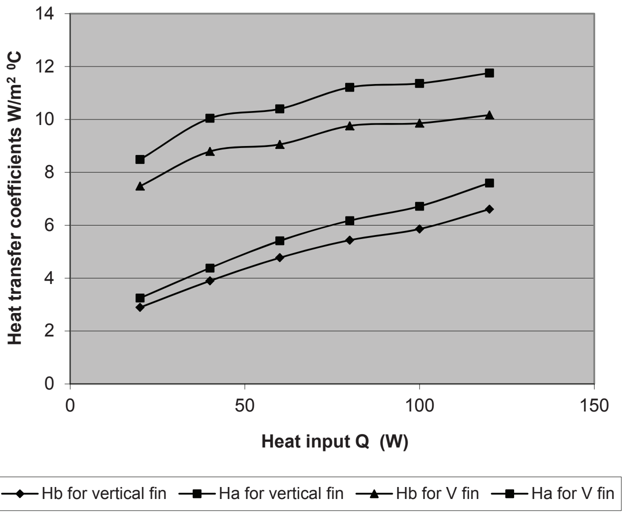
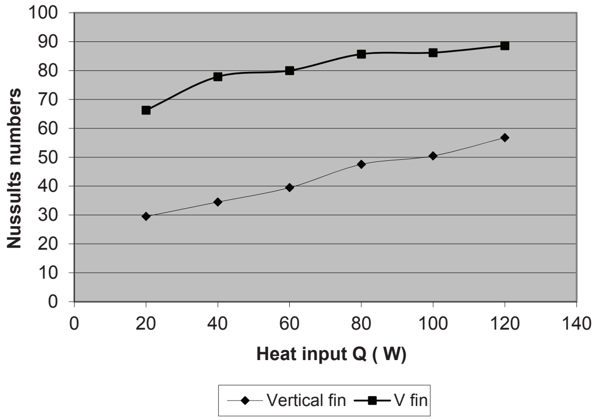


Figure 2. Effect of heat input (Q) on the heat transfer coefficient for vertical and V fins for natural convection.



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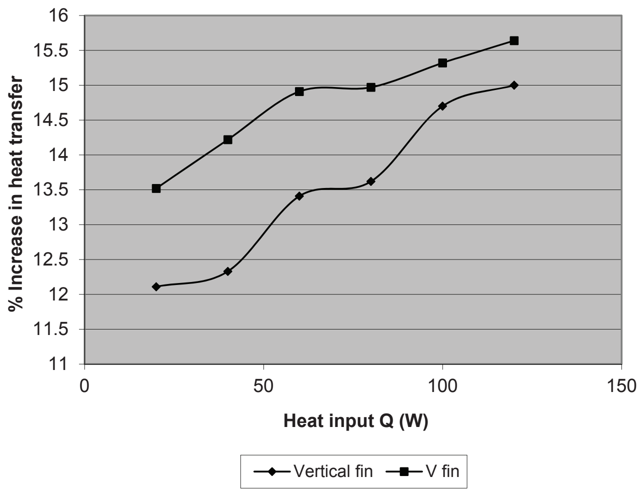

Figure 4. Effect of heat input (Q) on percentage increase in heat transfer vertical and V fins for natural convection

4.0 CONCLUSIONS

Figure 2, 3, 4 showed that the effect of heat input on the heat transfer coefficients, Nusselts number and percentage rise in heat transfer respectively. Following points observed from these figures.

a) V plate fin give higher heat transfer performance than vertical or rectangular plate. It is observed from figure 2 that as heat input increases heat transfer coefficient get increases. V fins gives better heat transfer than vertical fins or plates.

b) Nusselt Number increases with increase in heat inputs. V fins gives better results than Vertical plate fins.

c) The percentage improvement is observed from 12.11 % to 15 % for vertical fin and 13.52 % to 15.64 % for V fin.

5.0 FUTURE SCOPE OF WORK

The present work is limited to the single fin on the base plate. The study may be extended to investigate the effect with array of fins. Different other fluids may also be used as a working medium for future work. The present work is limited to experimental investigation. This problem can be solved by using numerical techniques.

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