

Analysis for Enhancement of Natural Convection Heat Transfer on Vertical Heated Plate by Multiple V Fin Array



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ABSTRACT

It is investigated that special surface geometry enhances thermal performance as well as heat transfer coefficients considerably. This heat transfer enhancing technique was investigated for natural convection adjacent to a vertical heated plate with a multiple V-type fins in ambient air surrounding. As compared to conventional vertical fins, this V-type fins works not only as extended surface but also as flow turbulator. In order to enhance the heat transfer, V-shaped partition plates (fins) with edges faced upstream were attached to the two identical vertical plates. The mica gladded nichrome flat heating element was sandwiched in between these two base plates. It is supplied with stabilized A.C. supply. The electrical heat input was controlled through dimmer stat and measured using a wattmeter. The V-type fin were tried in two different ways, first varying included angle and second varying fillet radius at base of fin and compensating the same at tip of the fin. It was observed that V-type fin array design performs better than rectangular vertical fin array. The performance was observed to improve further, with varying fillet radius. In the work herein, is investigated, experimentally and numerically. Ansys CFX software is used in order to develop a three-dimensional numerical model for investigation of V fin array. The present study show that V type fin enhances the thermal performance of fins and reduces the weight of the fin arrays, which in turn, can lead to lower manufacturing costs.

Keywords— Flow turbulator, Heat transfer enhancements, Natural convection, V-type fins

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I. INTRODUCTION

Due to the rapid development of technology, electronic devices are a part of our ordinary life. Considering multi functioning, high clock speed, shrinking package size and higher power dissipation in electronic devices, the heat flux per unit area has increased dramatically over the past few years. Besides, the working temperature of the electronic components may exceed the desired temperature level. Thus, the effective removal of heat dissipations and maintaining the die at a safe operating temperature plays an important role to ensure a reliable operation of electronic components. There are various methods to cool electronics, such as air flow cooling, heat pipe, etc. Air flow with heat sink was used in conventional electronics cooling systems which would show superiority in terms of unit price, weight and

reliability. Therefore, the most common way to enhance the air-cooling is through the utilization of air flow on a heat sink.

The active heat transfer enhancement techniques have not found commercial interest because of the capital and operating cost of the enhancement devices. The majority of passive techniques employ special surface geometry or fluid additives for enhancement i.e. no direct application of external power. Whenever it is difficult to increase the rate of heat transfer either by increasing heat transfer coefficient or by increasing the temperature difference between the surfaces and surrounding fluid, the fins are commonly used. The tall vertical fin array restricts the heat transfer enhancement from tall vertical base plate. This is because of the boundary layer thickening and subsequent interference

developed over the height. To obtain an appreciable improvement of the heat transfer in case of the horizontal fin array, the fin height may be increased.

Fins are extensively used in air cooled automobile engines, air craft engines, cooling of generators, motors, transformers, refrigerators, cooling of computer processors and other electronic devices etc. Previously, a great number of experimental and numerical works has been carried out to study the effect of fin parameters like fin height, fin spacing etc. on heat transfer rate from fin array by the investigators.

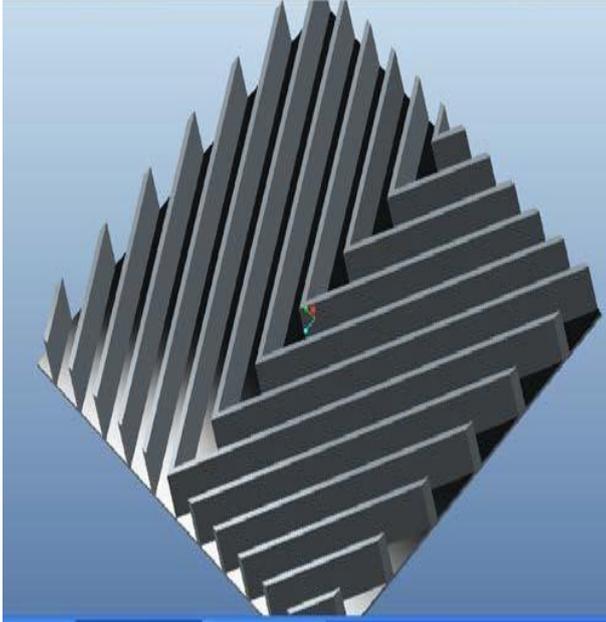


Fig.1 V-fin model creations in Pro/E

The main purpose of extended surfaces called fins to increase the heat transfer rate. Fins offer an economical and trouble free solution in many situations demanding natural convection heat transfer. Heat sinks in the form of fin arrays on horizontal and vertical surfaces used in variety of engineering applications, studies of heat transfer and fluid flow associated with such arrays are of considerable engineering significance. The main controlling variable generally available to designer is geometry of fin arrays. Fins are commonly applied for heat management in electrical appliances such as computer power supplies or substation trans-formers. Other applications include Internal Combustion engine cooling, such as fins in a car radiator. It is important to predict the temperature distribution within the fin in order to choose the configuration that offers maximum effectiveness.

II. EXPERIMENTAL SETUP & PROCEDURE

As concluded from the CFD analysis, the V-fin with included angle 60° gives the minimum ΔT and hence the maximum heat transfer coefficient amongst all the considered models. Therefore it is decided to fabricate the above said model.

Although in the CFD analysis only half the model is analyzed due to meshing and memory restrictions, the complete model is fabricated.

The experiments are to be carried out under perfect natural convection conditions. For the development of undistributed boundary layers it is required to suitably hang the configurations vertically. The experimental evaluation of results required temperature measurement at various locations of the configurations and also of the surrounding. The heater input values when measured will give total heat flow rate from the configuration under study

Requirement for experiment set up:

- Test plate with V-type fins
- Aluminum base plates
- Thermocouples
- Electrical heater
- A.C supply
- Temperature indicator



Fig-2: Front view of Experimental setu

2.1 Assumptions

This study assumes the following design considerations:

- Each fin is of uniform width, height and rectangular cross-section.
- There is no slip at the base plate and the fin surface.
- Plates are immersed in extensive, quiescent fluid (air).
- Air is an ideal gas
- The atmospheric pressure is 1.01325 bar (1 atm.) at the location and the standard properties are taken at this 1 atm.
- Radiation heat transfer is negligible.

2.2. Experimental Procedure:

The experimental procedure adopted is as follows:

- Firstly the aluminum base plates bolted on either side of the heater.
- Markings by pen and scale are made on the exposed surface of the base plate according to the geometry for V-fins with included angle 60°.
- Then the aluminum fins of the relevant marked length are glued on the surface with ‘Loctite 315’.
- Copper constantan thermocouple connections are made at the five positions on the base plate .
- Additional thermocouple connections are made on the three open sides of the enclosure to measure the ambient temperature.
- Electric heater is connected to the AC supply through dimmerstat. Similarly voltmeter and ammeter are also connected in the electric circuit.
- The main supply is switched ON and the main switch of the set-up is also switched ON.
- Then with the help of the dimmerstat the required heater input is adjusted with the help of the equation,
- The temperature at the thermocouple locations are read by digital indicator and recorded after it reaches the steady state.
- The ambient temperatures are also read by the digital temperature indicator at the three different locations.

By varying the dimmerstat position, readings are taken for different heater inputs

III.OBSERVATION

Model1: Rectangular fin.
 Model2: V fin with rectangular notch.
 Model3: filleted v fin with rectangular notch.

Table no. 1 heat transfer coefficients for various models.

Sr.no.	Q	Model1	Model2	Model3
1	58.4	3.1519	3.72	3.74
2	92	4.895	5.47	5.62
3	113.3	5.95	6.66	6.83
4	136.8	6.839	7.66	7.99

SAMPLE CALCULATIONS

Heater input (Q):
 $Q=V*I$ (watt)

Heat transfer coefficient can be calculated from the equation as below:

$$Q=h*A (ts- ta)$$

$$Q=59.2 \text{ watt}, (ts- ta)=314.5k$$

$$h=Q/ (2*A (ts- ta))$$

$$h1=3.72 \text{ w/m}^2k$$

Similarly heat transfer coefficient for varying values of Q and (ts- ta) can be found

$$h2=5.47 \text{ w/m}^2k$$

$$h3=6.66 \text{ w/m}^2k$$

$$h4=7.66 \text{ w/m}^2k$$

IV.RESULT ANALYSIS

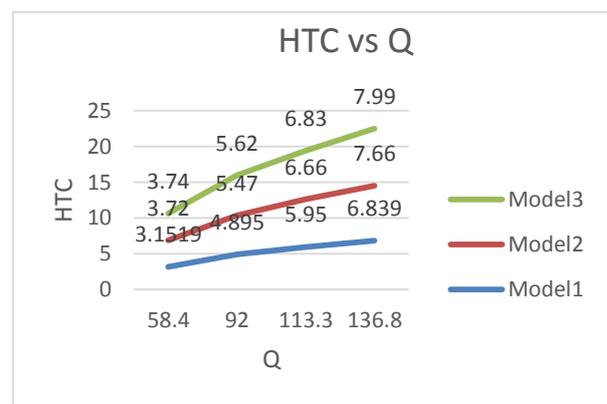


Fig. 3: HTC vs Q

V.NOMENCLATURE

- **HTC-** heat transfer coefficient. w/m^2k
- **Q-** heat input.watts
- **V-** voltage. Volts.
- **I-** current. amperes
- **A-**area of fin, m^2
- **T_s-**surface temperature. K.
- **T_a-**ambient temperature. K.
- **Tavg-** average temperature. K.

VI.CONCLUSION

From fig. 3 we conclude that, the heat transfer coefficient increases slightly by adding fillet at the base of the fins and compensating the same at the tip of the fins. Also weight reduction can be achieved by this arrangement.

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