

EFFECT ARRAY SHAPE ON THE PERFORMANCE OF FIN

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ABSTRACT

Force convection from vertical surfaces with large surface element is encountered in several technological applications of particular interest of heat dissipation in several forms. Force convection represents an inherently reliable cooling process. The purpose of this project is to find out the best of different fin patterns by calculating the heat transfer rate. The considered fin pattern types are Parallel horizontal fin pattern, Parallel split pattern and V-fin array pattern. Project consists of self-made experimental setup having Nichrome wire is used for heating. It is supplied with the stabilized A.C. supply. The electrical heat input was controlled through Dimmer stat and measured with wattmeter. Different observation like temperature, heat input etc. is taken by performing experiment and these will be used to calculate heat transfer rate for every single fin pattern mentioned above. Result of this experiment is going to be used to determine the fin pattern with highest heat transfer rate, i.e. which fin will provide greater cooling effect. As not the all pattern with different fin height and pitch distance can be practically used for the experiment, so that analysis of these fins is also included as for the future aspects, in which fin dimension can be varied and further more pattern can be designed for more results..

Keyword: - Fin, Cooling fins, heat transfer coefficient, heat transfer rate, effectiveness, thermocouples.

1. Introduction

The discipline of heat transfer, typically considered an aspect of mechanical engineering and chemical engineering, deals with specific applied methods by which heat transfer occurs. Note that although the definition of heat implicitly means the transfer of energy, the term heat transfer has acquired this traditional usage in engineering and other contexts. The understanding of heat transfer is crucial for the design and operation of numerous devices and processes. Heat transfer may occur by the mechanisms of conduction, radiation, and mass transfer. In engineering, the term convective heat transfer is used to describe the combined effects of conduction and fluid flow and is often regarded as an additional mechanism of heat transfer. How effective a fin can enhance heat transfer is characterized by the fin effectiveness which is as the ratio of fin heat transfer and the heat transfer without the fin in order to enhance heat transfer, should be greater than 1 (In case <1 , the fin would have no purpose as it would serve as an insulator instead). However, 2 is considered unjustifiable because of diminishing returns as fin length increases. To increase the fin's material should have higher thermal conductivity, k . It seems to be counterintuitive that the lower convection coefficient, h , the higher Well, if h is very high, it is not necessary to enhance heat transfer by adding heat fins. Therefore, heat fins are more effective if h is low. Increase the temperature difference between the surface and the fluid. Increase the convection coefficient h . This can be accomplished by increasing the fluid flow over the surface since h is a function of the flow velocity and the higher the velocity, the higher the .

2. LITERATURE REVIEW

Abdullah, H. Alessa et. al. [1] had studied the natural convection heat transfer enhancement from a horizontal rectangular fin embedded with equilateral triangular perforations. The heat dissipation rate from the perforated fin is compared to that of the equivalent solid one. he effect of geometrical dimensions of the perforated fin and thermal properties of the fin was studied in detail. They concluded that, For certain values of triangular dimensions, the

perforated fin can result in heat transfer enhancement. The magnitude of enhancement is proportional to the fin thickness and its thermal conductivity. The perforation of fins enhances heat dissipation rates and at the same time decreases the expenditure of the fin material.

Golnoosh Mostafavi [2] had investigated the steady-state external natural convection heat transfer from vertically mounted rectangular interrupted finned heat sinks. After regenerating and validating the existing analytical results for continuous fins, a systematic numerical, experimental, and analytical study is conducted on the effect of the fin array and single wall interruption. FLUENT and COMSOL Multiphysics software are used in order to develop a two dimensional numerical model for investigation of fin interruption effects. Results show that adding interruptions to vertical rectangular fins enhances the thermal performance of fins and reduces the weight of the fin arrays, which in turn, can lead to lower manufacturing costs.

Sable, M.J. et. al. [3] had investigated for natural convection adjacent to a vertical heated plate with a multiple v-type partition plates (fins) in ambient air surrounding. As compared to conventional vertical fins, this v-type partition plate's 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. They observed that among the three different fin array configurations on vertical heated plate, V-type fin array design performs better than rectangular vertical fin array and V-fin array with bottom spacing design. The performance was observed to improve further, with increase in the height of the Vplates (fin height).

Misumi and Kitamura [5] have reported an experimental work on enhancement of natural convection heat transfer from vertical plate having a horizontal partition plate and V-plates in the water ambience. They found that the heat transfer in the downstream region of the partition plate is markedly enhanced when the plate height 4 exceeds certain critical values because of the inflow of the low temperature fluid into the separation region. For vertical plate with V-shaped fins, Misumi and Kitamura obtained 40% higher heat transfer coefficient than the conventional vertical fins. From the results, authors observed that the ratio of the heat transfer enhancement exceeds the ratio of the surface enlargement.

Guillaum polidori and padet [6] studied natural convection on vertical ribbed wall experimentally with a wall boundary condition of uniform heat flux to get an idea about the roughness geometry influence on the heat transfer. Thus in the context of above work, it was decided to undertake experimental investigation on V-type fins, which seems to be more promising over conventional vertical fin arrays.

2.1 MANUFACTURING OF FIN PATTERNS

2.1 Material Selection As Aluminium alloys are extensively used in making heat sink for computers, most of air cooled engines have cooling fins made of it. It is widely uses in Aerospace industry, automotive industry, marine industry etc. That is why material selected for making fin patterns is Aluminium 1100 (in the form of sheet having width of 3mm) ,belongs to aluminium-1000 series (1000 series are essentially pure aluminum with Aluminum 99% aluminium content by weight and can be work hardened.).Aluminium 1100 (3mm thickness)

2.2 Properties of Aluminum 1100 1100 Aluminum alloy is an Aluminum-based alloy in the "commercially pure" wrought family (1000 or 1xxx series). With a minimum of 99.0% aluminum, it is the most heavily alloyed of the 1000 series. It is also the mechanically strongest alloy in the series, and is the only 1000-series alloy commonly used in rivets. At the same time, it keeps the benefits of being relatively lightly alloyed (compared to other series of Aluminium).

The alloy composition of aluminium 1100 is: 1.Aluminium: 99.0-99.95% 2.Copper: 0.05-0.20% 3.Iron: 0.95% max 4.Manganese: 0.05% max 5.Silicon: 0.95% max 6.Zinc: 0.1% max Residuals: 0.15% max

2.3 Fin patterns There are three different patterns of fin which are used to perform experiment and calculating the effectiveness. From which conclusion will be made for the best fin pattern as per the value of effectiveness. Three different patterns of fin which are used, mentioned below: [1]Parallel horizontal fin pattern [2]V fin pattern [3]Split fin pattern

All three fins are made of Aluminium 1100's sheet of width 3mm. Base plate dimension of cooling fin pattern are same is all pattern (i.e. 200mm×200mm). 'Parallel horizontal fin pattern' has 5 horizontal fins of dimension 200mm×40 welded by GTAW (Gas Tungsten Arc Welding) and arranged on the base plate with equal pitch distance. 'V-fin pattern' are made by bending the 200mm×40mm Al-plate from center at an angle of 120° number of fins in this case is same as in parallel horizontal fin pater i.e. 5-fins on the base plate with equal pitch distance. For making 3rd patter 'Split fin pattern' fin of dimension 50mm×40mm is used and welded on the base plate actual pics of pattern are shown below:



Fig-1. Parallel Horizontal Fin Pattern



Fig-2. V-Fin Pattern



Fig-3. Split Fin Pattern

3. EXPERIMENTAL SETUP'S MANUFACTURING

Experimental setup is a heating arrangement, whose heat input is controlled by dimmerstat, and thermocouples are used to take reading, experimental setup is made in such a way that fin patterns are easily changeable with the help of nut-bolts, nichrome heating element is use for heating purpose. Basic connection of experimental setup is shown below.

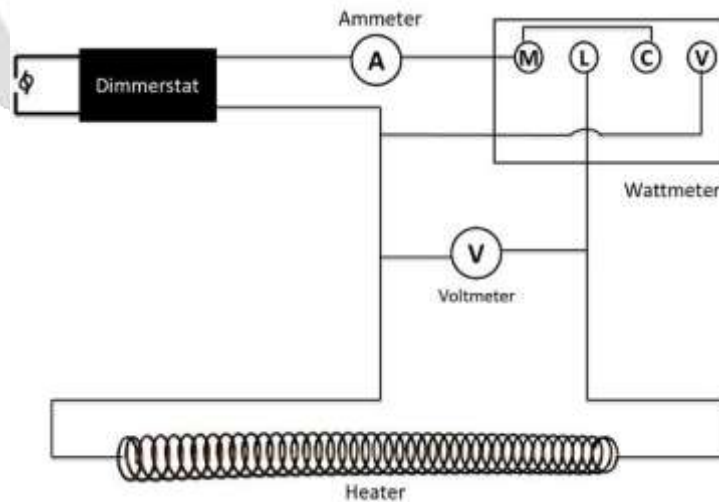


Fig-4. Basic connection of Experimental Setup

3.1 Requirements in making of experimental setup

It include apparatus as well as tools required to make the setup

1. Wooden base:
2. Dimmer stat
3. Voltmeter
4. Ammeter
5. Connecting wire
6. Thermocouples
7. Nichrome Heating element
8. Tiles
9. Bolts & Nuts
10. Tile cutter
11. Temperature scanner

Other tools are also use which is mentioned above as in the making of fins.

3.1.1 Wooden base

Wood of dimension 30cm X 38cm X 4cm is used for making the base on which whole setup is arranged. Wooden cutter is used to cut the wood in dimension mentioned above strip wooden strip are used to make fin holding arrangements. Whole arrangement is a portable table arrangement so that it can be carried everywhere. Hammer, iron nails, hacksaw are also use in this process. Fin holding arrangement has the total height of 40 cm including the height of Nichrome heater equipped with nut-bots arrangement to assemble and disassemble the fin pattern as per the requirement. Wooden arrangement consist of two table one is equipped with electrical equipment and other with the fin holding arrangement which are connection to each other by means electrical wire to give electrical supply to the heater controlled by dimmerstat.

3.1.2 Heating arrangement Heating arrangement uses a household wall tile to make a heater of Nichrome element. It uses a tile of having dimension similar to the base plate of Aluminium (i.e. 20cmX20cm). Strip of tile has been cut by tile cutter having height of 1cm to attach vertically on the tile base to make the groove. This groove made of tile act as the path for the heating element (Coil of Nichrome wire). High temperature sustainable epoxy is used to attach them as experiment is about heating of fin pattern. Nichrome coil is connected to the electrical supply coming from dimmerstat by means of electrical wire. This heating arrangement is attached to the fin holding base by wooden strips using bolts & nuts whole arrangement is made in such a way that assembly can be done or disassembled according to the need.

3.2. Study of Electrical Equipment

3.2.1 Dimmerstat Another name of dimmerstat is Autotransformer, it is the most useful and effective device for stepless, brakeless and continuous control of a.c. voltage and therefore for control of various other parameter depending on a.c. voltage. The widely known as highly acclaimed product, introduced more than 35 year ago, it is an ideal controlling device for numerous application in laboratories and in industrial & commercial fields. The basic dimmerstat is meant for operation off a nominal voltage of 240V A.C. and can give output voltage anywhere between 0 to 240V, or output 270, by a simple transformer action.

3.2.2 Voltmeter A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit; digital voltmeters give a numerical display of voltage by use of an analog to digital converter.

3.2.3 Ammeter An ammeter is a measuring instrument used to measure the electric current in a circuit. Electric currents are measured in amperes (A), hence the name. Instruments used to measure smaller currents, in the milli-ampere or microampere range, are designated as milli-ammeters or micro-ammeters.

3.2.4 Wattmeter The wattmeter is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit. Electromagnetic wattmeters are used for measurement of utility frequency and

audio frequency power; other types are required for radio frequency measurements. the range of Dimmerstat is of range 1600W.

3.2.5 Thermocouple A thermocouple is a temperature-measuring device consisting of two dissimilar conductors that contact each other at one or more spots, where a temperature differential is experienced by the different conductors (or semiconductors). Seven thermocouples are used here to show the different value of temperature, thermocouples are marked as T1, T2, T3, T4, T4, T5, T6 and T7.

- Where, T1-T5 shows the temperature of the thermocouple attached to the fins.
- T6 shows the temperature of the base plate of the fin.
- T7 shows the ambient temperature.

3.2.6 Temperature scanner A Temperature Scanner is a device that measures more than one temperature points or multi-channel. It is actually a multi-channel indicator that measures and displays signals of each channel one-by-one up to last channel and then returns to first channel and continues the process cyclically.

3.2.7 Connecting wire A wire is a single, usually cylindrical, flexible strand or rod of metal. Wires are used to bear mechanical loads or electricity and telecommunications signals. Wire is commonly formed by drawing the metal through a hole in a die or draw plate. Wire gauges come in various standard sizes, as expressed in terms of a gauge number. Here copper wire is used to connect the electrical equipment as it best electrical conductivity in its category and is easily available in the market.

3.2.8 Nichrome wire Nichrome is a non-magnetic alloy of nickel, chromium, and often iron, usually used as a resistance wire. A common alloy is 80% nickel and 20% chromium, by mass, but there are many others to accommodate various applications. It is silvery-grey in colour, is corrosion-resistant, and has a high melting point of about 1,400 °C (2,550 °F). Due to its resistance to oxidation and stability at high temperatures, it is widely used in electric heating elements, such as in appliances and tools. Typically, nichrome is wound in coils to a certain electrical resistance, and current is passed through it to produce heat.



Fig-5. Experimental setup

5. EXPERIMENT PROCEDURE

1. Ensure that main ON/OFF switch given on the panel is at OFF position & dimmerstat is at zero position.
2. Assemble the fin pattern (on which experiment has to experiment has to perform) to the heater assembly through bolts & nuts.³⁷
3. Connect electrical supply to the setup.
4. Switch ON the main ON/OFF switch.
5. Set the heater input by the dimmerstat, voltmeter reading for 1st case is 80 volts, for 2nd case is 100V.
6. After 1hr note down the reading of the voltmeter, ammeter & thermocouples (temperature scanners), in the observation table, and note down the temperature variation throughout the fin pattern.
7. After experiment is over set the dimmerstat at zero position
8. Switch OFF the main ON/OFF switch.
9. For the next fin patter disassemble the fin pattern from the heater assembly and assemble the new one.
10. Repeat step for the next fin from Step1-Step9.

Table -1: Name of the Table

Voltage	Ammeter	T ₁	T ₂	T ₃	T ₄	T ₅	T _o
V	A	°C	°C	°C	°C	°C	°C
Parallel horizontal fin pattern							
95	1.11	42.2	41.3	40.2	42.3	44.4	33.3
101	1.19	43.3	43.2	41.3	42.8	43.1	33.8
V-fin pattern							
96	1.13	45.1	48.9	51.6	54.2	56	34.9
101	1.17	41.8	40.5	40.4	45.5	48	31.2
Split fin pattern							
93	1.1	38.6	41.8	41.8	41.9	44.5	37.2
102	1.2	39	42.2	44.9	40.7	42.8	36.4

Calculation

Parallel horizontal fin pattern

$$A_t = N \cdot A_f + A_b$$

$$\text{Cross section area of fin, } A_{cs} = 20 \times 0.3 = 6 \text{ cm}^2 = 0.0006 \text{ m}^2$$

$$A_f = 5 \times [20 \times 4 \times 2 + 4 \times 0.2] = 804 \text{ cm}^2$$

$$A_b = 20 \times 20 - 6 \times 5 = 370 \text{ cm}^2$$

$$A_t = 804 + 370 = 0.1174 \text{ m}^2$$

V-fin pattern

$$A_t = N \cdot A_f + A_b$$

Cross section area of fin,

$$A_{cs} = 2 \times [10 \times 0.2] = 6 \text{ cm}^2 = 0.0004 \text{ m}^2$$

$$A_f = 5 \times [2(10 \times 4 \times 2) + 4 \times 0.2] = 812 \text{ cm}^2$$

$$A_b = 20 \times 20 - 6 \times 5 = 370 \text{ cm}^2$$

$$A_t = 804 + 370 = 1182 \text{ cm}^2 = 0.1182 \text{ m}^2$$

Split fin pattern

$$A_t = N \cdot A_f + A_b$$

Cross section area of fin,

$$A_{cs} = 5 \times 0.3 = 1.5 \text{ cm}^2 = 0.00015 \text{ m}^2$$

$$A_f = 15 \times 2 \times [5 \times 4 + 4 \times 0.2] = 624 \text{ cm}^2$$

$$A_b = 20 \times 20 - 1.5 \times 15 = 377.5 \text{ cm}^2$$

$$A_t = 624 + 377.5 = 10975 \text{ cm}^2 = 0.10015 \text{ m}^2$$

Result Table

T_{avg} $^{\circ}\text{C}$	Q W	Area m^2	h $\text{W}/\text{m}^2\text{-}^{\circ}\text{C}$
Parallel horizontal fin pattern			
42.08	105.45	0.1174	102.30
42.74	120.19	0.1174	114.52
V-fin pattern			
51.16	108.48	0.1182	56.44
43.24	118.17	0.1182	83.04
Split fin pattern			

41.72	102.3	0.10015	225.99
41.92	122.4	0.10015	221.41

4. CONCLUSION

1. According to the result obtained Split fin pattern out three pattern used where others are Parallel horizontal fin pattern and V fin pattern has best effectiveness value which show that heat enhanced by Split fin patter greater than other two patterns. 2. Surface area from which heat transfer take place plays an important role, As the area of Parallel horizontal fin pattern & V fin pattern same area which result in approximate similar values of effectiveness for both fin, whereas effectiveness of V fin pattern is slightly greater than parallel horizontal but in values of decimal. 3. In each case of fin tried in this project has effectiveness value greater than 1 which indicates that the fins are enhancing the heat transfer from the surface, where as if effectiveness has value equal to 1 than the fins to the surface do not affect heat transfer at all. 4. Another important point that is observed in this project is that, design of fin pattern is also important for enhancing the heat transfer because the value of surface area from which heat transfer take place is minimum in case of Split fin pattern but it gives maximum value of effectiveness which means greater heat transfer.

5. REFERENCES

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