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Thermal Investigation of V-fin Pattern Array Shape on Performance of Fin

Vipul Chaudhari
Mechanical Engineering Department
BVM College of Engineering
Vallabh Vidyanagar, Anand, GJ, India

Abstract:- The main method for accelerating heat transfer is fin cooling. With the combined impact of conductive and convective heat transmission, fins are used as enclosing heat transfer devices. Improvements in heat transmission for fins includes its cross section, pitch, material, thickness, velocity of air, impingement angle of air, etc. In this experiment, we used K-type thermocouples and variable speed fans to examine the thermal performance evaluation of V-fin pattern arrays and perforated fins under forced convection.

Keywords:- *V-fin Pattern Array, Fins, Heat transfer, Air velocity and K-type thermocouples.*

I. INTRODUCTION

Heat transfer is a phenomenon that takes place through various methods, namely heat conduction, mass transfer and radiation. Within the field of engineering, the concept of convective heat transfer is employed to elucidate the synergistic impact of both heat conduction and fluid movement, hence sometimes regarded as a supplementary mechanism for heat transmission. Fins, which are expansion surfaces, are frequently employed in situations where enhanced heat dissipation from the outer boundary is required. The principle known as Newton's rule of cooling asserts that the heat transfer rate is directly proportional with the area of surface involved in convective heat transfer. Consequently, this strategy is considered the most pragmatic approach. Consequently, the augmentation in surface area leads to a corresponding escalation in the heat dissipation from its surface. The utilization of expansive surfaces is evident in all instances where convective heat transfer mechanisms are present. Air conditioner condensers exhibit a wide range of variations in terms of their physical characteristics, including diverse shapes and sizes. However, at their core, these condensers adhere to a fundamental principle: the use of aluminum fins to augment the overall area of surface for heat transmission. As the size of systems decreases, the limited space available imposes greater significance and intricacy on the process of heat dissipation. However, the thermal energy is distributed across a broad expanse, diffusing via specialised narrow conduits. Enhancing the forced displacement heat transfer system of the medium resulting in an increase in the convection heat transfer coefficient. This elevated coefficient value facilitates a more effective heat dissipation process, owing to larger surface area available for the heat transfer. In these configurations, the emphasis on design and structure is very minimal, provided that the pathways for vehicles are effectively separated from the critical mass.

Tzer-ming Jeng and colleagues [1] conducted a study in which they examined the performance of squared pin-fins in comparison to round pin-fins. The researchers aimed to identify the ideal pitches for both the in lined and staggered arrangements. In their study, Deshmukh et al. [2] conducted an investigation on the impact of design parameters on the air side thermal performance of an elliptical pin fin heat sink. The researchers had determined the optimal aspects ratio and void percentage for the fin, and subsequently comparing the obtained results with those of a circular fin. In their research, T.J. John et al. [3] conducted a comprehensive investigation on the overall performance of a micro pin fin heat sink. The study focused on the effects of liquid flow single phase and various pin fin geometries, specifically square and circular fins. These experiments were conducted under identical operating conditions. The aspect ratio, transverse pitch, axial pitch and hydraulic diameter were systematically varied and subsequently compared in order to evaluate the resulting outcomes. In a study conducted by Jaideep Pandit et al. [4], several pin fin arrays with hexagonal, circular, diamond and triangular forms were examined. The fin length was kept constant while the channel height was adjusted. The findings revealed that the heat transfer performance was superior in the case of diamond-shaped fins, particularly when the ratio of pin height to channel height was 0.5. In a study conducted by Naser Sahiti [5], an examination was carried out on the analytical, experimental, and numerical evaluation of different factors affecting single phased convective heat transfer enhancement. The study also involved a comparison of the rate of heat transfer with the necessary pumping power of surfaces heat transfer that were being compared. In a study conducted by Golnoosh Mostafavi [6], the author examined the heat transfer characteristics of vertically mounted rectangular interrupted finned heat sinks under steady-state external natural convection conditions. In their research, Sable, M.J. et al. (7) investigate the phenomenon of natural convection in the vicinity of a vertical heating plate that is accompanied by several V-dividers (fins) in the surrounding ambient air. The experimental study conducted by Misumi et al. [9] investigated the augmentation of heat transmission through natural convection from a vertical plate in an aquatic environment. This was achieved by using a horizontal divider and V-shaped plates. In their research, Polidori et al. [10] conducted an experimental investigation on the phenomenon of natural convection along vertical ribbed walls under uniform heat flow boundary conditions. The primary objective of their study was to examine the influence of roughness geometry on heat transfer. In this study, Oswal et al. (11) examined the various elements that influence the thermal performance of fins by utilising the ANSYS ICEPAK software. The impact of fins on the efficiency of a stationary solar system was investigated by Sadhana et al. [12]. In a numerical study conducted by Fulle and Al. (13), an analysis was performed to investigate the heat transfer characteristics of perforated and solid fins within a cylindrical channel. The study conducted by Abdullah, H. Alessaet et al. [14] examined the augmentation of heat transmission through natural convection from a horizontal rectangular fin that contained equilateral triangular perforations. In their study, Churchill and Chu (15) established an empirical correlation that enables the prediction of the Nusselt number in the context of natural convection, assuming a condition of steady equilibrium. Vermeulen et al. (16) also derived empirical relationships for inclined and vertical flat plates based on their experimental investigations. In this study, Ra and s.[17] conduct a numerical analysis to investigate the collective impacts of natural convection and radiation on a vertical fin plate. The experimental calculation of the influence of fin shape on natural laminar convection has been accomplished by the efforts of Abid [18]. The study conducted by Sand et al. (19) aimed to improve the phenomenon of natural convection on a heated vertical plate through the implementation of several V-shaped fin arrays. In their paper, Naidu et al. (20) conducted an empirical and numerical investigation on the phenomenon of spontaneous convection in fin plates featuring varying inclination angles. Fahiminia et al. (21) conducted a numerical analysis employing the finite volume approach to assess the natural convection heat transfer from extended vertical surfaces. In a study conducted by More et al. (22), a synthesis was undertaken to investigate the phenomenon of free convection from a heating plate, examining various configurations and inclinations of the fin arrays. Hireholi et al. (23) conducted an investigation on the inherent thermal convection of the integrated circuit (IC) heatsink. The study conducted by Tiwari et al. (24) examined the phenomenon of natural convection in layers on a sheathed flat plate. The objective was to explore the impact of several parameters, including flow rate, ambient temperature, surface tilt and surface roughness, on the convective heat transfer coefficient at different heat input streams. In their study, Shivdas Kharche et al. (25) highlighted the potential for interventions to be implemented inside the transverse domain of the asterisk. In their study, P. Raghupati et al. (26) provided an explanation of the optimal thickness to length ratio for the construction of a compressor body, with the aim of maximising heat transfer rate. In their study, Mohamad Mashud et al. (27) provided additional insights into the retention of the cylindrical fin as the foundational fin. Modifications to the cylindrical design will be crucial in enhancing heat transfer over the compressor body. In their study, Wang et al. (28) conducted an experimental investigation aimed at achieving optimal heat transfer properties in a rectangular fin. The impact of perforation on rectangular fin bodies was elucidated by Mehendi Ehteshum et al. (29). The study conducted by Wange et al. (30) centred on the utilisation of grooving as a means to enhance heat transfer. In their study, He FaJiang et al. (31) provided a detailed description of the physical configuration and analytical procedures employed for various fin architectures. The performance of annular fins with various shapes under the influence of regionally variable heat transfer coefficients was examined by Esmail M.A. Mokheimer [32]. In a study conducted by Barhatte and Chopade (33), it was empirically shown that there is a direct correlation between the increase in heat transfer area and the subsequent rise in heat transfer rate. In their study, Sikindar Baba MD et al. (34) elucidated many approaches aimed at enhancing the rate of heat transfer by the augmentation of surface area. [35, 36, 37, 38] Patel Anand et al. includes studies of heat transfer enhancement in a vapor spreader, cooling tower and helical & twisted tube heat exchanger. The research including study of examination of the steady state three-dimensional natural convective flow and heat transfer for a set of vertical fin arrays with/without dimples [39-50]. The studies from [51-66] Patel Anand et al. performs thermal performance for heat transfer enhancement various solar heater a kind of heat transfer by varying the geometries of device components. [67-75] references involve study for heat transfer characteristics of embossed heat sink having repeated impressions on the fin surface subjected to natural convection.

II. EXPERIMENTAL SET UP

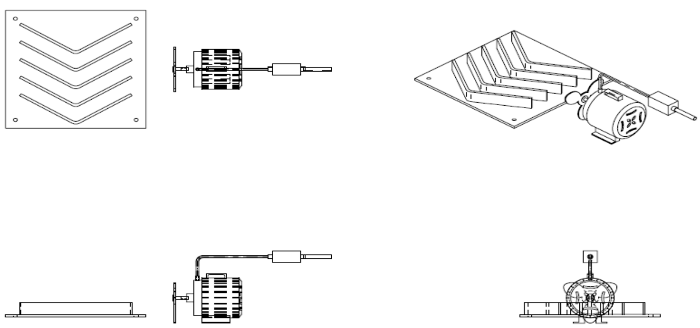

Fig. 1 CAD Model of Array Type Fins

Fig. 2 Thermocouple

Fig. 3 Heater

Fig. 4 Dimmer

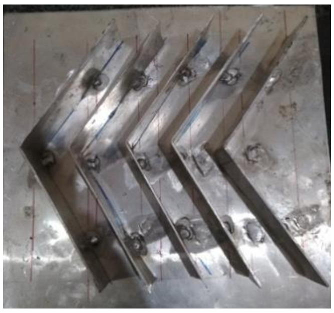

Fig. 5 V-Shape Fin

The fins are fabricated from a 3mm wide sheet of aluminium alloy 1100. All cooling fin patterns have the same base plate dimensions (i.e. 200 mm 200 mm).The 200mm40mm Al-plate is bent from the centre at an angle of 120^0, and the resulting V-fin pattern's five fins are evenly spaced. The whole assembly is placed on heater of 200 W heater and dimmer is used for change in voltage and so corresponding value of current also vary and which can be measured by digital ammeter; 6” fan is to supply air on experimental set up.

III. RESULT AND DISCUSSION

V-fin pattern Area Calculation
At = N.Af + Ab

Cross section area of fin,
Acs = 2×[10 × 0.2] = 6 cm^2 = 0.0004 m^2

Fin Area
Af = 5×[2(10×4×2) + 4×0.2] = 812 cm^2

Base Area
Ab = 20×20 - 6×5 = 370 cm^2

Total Area
At = 804+370 = 1182 cm2 = 0.1182 m^2

Table 1 Observation Table

Voltage V	Ammeter A	T_1 ^0C	T_2 ^0C	T_3 ^0C	T_4 ^0C	T_5 ^0C	T_o ^0C
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

Table 2 Result Table

T_{avg} ^0C	Q W	Area m^2	h W/ m^2-^0C
51.16	108.48	0.1182	56.44
43.24	118.17	0.1182	83.04

Here Table 1 and Table 2 show observation and result values of fin for 108 W and 118 W respectively. Here the interesting observation is that as heating power value increase the surface temperature values decrease may be due to more thermal resistance but the value of coefficient of heat transfer increases and in both the cases the air velocity of fan is constant.

IV. CONCLUSION

The major outcome is that with proposed fin better heat transfer can be obtained in case of forced convection.

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