Inclined Aluminum Vertical Plate Experimental Investigation of Natural Convection Heat Transfer with V-Shaped Fins Attached

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Abstract: most often, convection is thought of as the heat transfer in both liquids and gases. Convection is a word that always refers to the results of both internal heat conduction of a fluid and heat transmission to the streaming of bulk fluid flow, even if it is occasionally a third type of heat transfer. This study focuses on the convective heat transfer from inclined V-Fin Arrays, which have surfaces that have been blackened before fins have adhered to them to create fin arrays that are both inclined and horizontal. First, this study was completed in the phase of the plane plate, inclined plate and with straight fins and V-fins, to analyze the different states of natural convection heat transfer for aluminium plate. After that, the best result was collected in the inclined plate with V-Fins attached to it. Fins are used in a range of engineering applications to enhance convective heat transfer, and they offer a useful approach to getting large without needing a lot of primary surface area and a large total heat transmission surface area. To control heat, fins are frequently employed in electrical equipment like computer power supplies and substation transformers. Other uses include cooling for internal combustion engines and vehicle fin radiators. Finned surfaces can be used to increase natural convection heat transfer in a viable and useful way.

Index Terms— Aluminum plate, Heat transfer, Inclined V-fins, Natural convection, Vertical plate

I. INTRODUCTION

Heat transfer is the process of shifting the heat to interchange between physical and thermal energy that is dependent on temperature as well pressure. Radiation, Conduction, and convection are the three basic ways of heat transport. The transfer of kinetic energy of matter over the boundary layer between 2 systems that are at different temperatures or are in distinct environments. Heat can also be transferred from a hot area to a cooler area [1]. The internal energy of both systems is always changed through heat transfer, which violates Thermodynamics' First Law.

Mechanisms of Heat Transfer

Advection

Advection is the movement and momentum-based conveyance of a fluid substance or preserved attribute from one site to another.

Conduction or Diffusion

Energy transfer between things that are physically touching one another. A substance's ability to transfer heat is known as its thermal conductivity, which may be quantified using Fourier's Law [2].

Convection

Energy flows between the item and its surroundings as a result of fluid movement. The standard temperature is used as a yardstick to evaluate the efficiency of convective heat transfer. When the heat energy goes to expand the fluid, then external processes can push it or buoyant force can affect it (for example, in gravitational fields). Natural convection is the process used to show the latter process. All convective processes also employ diffusion to transmit heat in that part. Another form of convection is forced convection.

Convective heat transmission, sometimes referred to as convection, is a technique for moving heat through the air. Many physical situations, such as those between a solid surface and a fluid, can be characterised as being improved by the fluid's bulk motion. Another name for it is the third type of heat transmission. Although pure advection is more frequently associated with mass fluid movement, such as the advection of stones in a river, it is also the word for the process of transfer by fluid streaming [3].

When buoyancy forces are driving bulk fluid motions, this is known as free or natural convection. This is developed by density differences and temperature changes in the fluid, this is called as natural convection. External

devices such as pumps, fans, and stirrers produce current and also streams in the fluid, resulting in convection current of an artificial inducement

LITERATURE REVIEW

Baskaya et al. [4] for their parametric study, used metal as a material. They looked examined how the fin spacing, height, and length affect the overall heat transfer rate, as well as how temperature differences affect it. They investigated the impact of a range of geometrical features such as fin length, fin spacing, and temperature differential between the fin, fin height, and the surrounding environment. Horizontal fin arrays contribute to heat transfer. However, due to the different criteria involved, no unambiguous conclusions could be formed. Finally, they concluded that optimizing overall heat transfer performance can't be achieved by focusing on only one or two criteria. Baskaya et al study concerning the dissertation work are for fin spacing and fin height variation.

Çengel et al. [5] in their fin study; assumed a constant thermal conductivity of the material and assumed a continuous No heat is generated in the fin during operation. The heat transmission coefficient is thought to be constant over the whole fin surface. Fins are frequently used to improve the rate of heat transfer from the surface. The value of "h" is significantly smaller at the fluid's base than at its tip since it is surrounded by a solid surface there. A surface with too many fins will thus have a poorer overall heat transfer coefficient when h is lost more than the surface area is gained. Cengel's and others' work the rise of heat transfer rate from the surface considered to be constant is related to the dissertation work. The staggering of fins is done in the dissertation work, and it is thus utilised to analyse the work.

Swapnil Kallappa Hingangave et al [6] In liquids and gases, convection often dominates other heat transport methods. Convection is often used to explain the combined effects of heat conduction within the fluid (diffusion) and heat transference by bulk fluid flow streaming, even though it is occasionally mentioned as a third form of heat transfer. In many physical conditions, such as between a solid surface and the fluid, bulk fluid motion improves heat transmission. This study examines the convective heat transfer from an inclined V-Fin array, which has a blackened surface on which fins have adhered to create a horizontal fin array and an inclined V-Fin array.

Heya N et.al [7] The main goal of the study, which was conducted in 2004, was to examine the impact of rounding staggered heat sinks. It analysed if aerodynamic form cooling fins in staggered heat sinks are an effective method for decreasing significant flow resistance to the arrangement. The aerodynamic form may significantly increase the aerodynamic efficiency of cooling fins.

Barhatte et al. [8] worked on rectangular, circular, triangular, and trapezoidal fin arrays, among other shapes. They compared the fin arrays with and without notches by applying varying heat I/P. The dimensions of the fin were established in stone. They concluded that the triangle-notch fin transmits heat more effectively. The method of Barhatte et al has been used with a variety of fin arrays and fin shapes. This piece contains many fin stumbling arrangements.

Sable et al. [9] improve the natural convection of vertical plates by using numerous V-Fin arrays. V-fins must be stacked in a variety of plate configurations, both vertically and horizontally. Fin arrays for the same surface area in heat transfer.

Turner et al. [10] The typical heat-transfer coefficient for arrays with four fins vertically arranged at a 45° angle. The horizontal while spreading the heat to room air was explored for heat transfer free-convection from rectangular-fin arrays. The fins were investigated as constant-temperature surfaces since the lowest fin efficiency ever found was greater than 98%.

The coefficients for vertical arrays were discovered to be between 10% and 30% lower than those for similarly spaced parallel plates. Results from the 450 arrays were 5 to 20% less than what vertical plates generated. Two flow patterns were investigated for the horizontal arrays, and it was found that preventing a three-dimensional flow significantly reduced the coefficients.

CONCLUDING REMARKS

Many prior studies looked into heat transfer from broad surfaces via natural convection.

- Only a few researchers have studied V-fins.
- The expanded surfaces' much lower heat transfer rate than base surfaces is the driving force behind these studies.
- Verticality fins are ineffective for improving heat transfer through a tall large vertical plate.
- Unlike traditional vertical fins, V-type plates serve as both an expanded surface and flow turbulators.
- A vertical plate with V-shaped fins has a 40% better heat transfer coefficient than a plate with regular fins. Additionally, the surface changing ratio is greater than the heat transfer enhancement ratio, and the changes for horizontal plates and vertical fins were less significant than those for V-plates. For the actual work, the required setup for the work is shown in Fig. 1.

EXPERIMENTAL SETUP SPECIFICATIONS

The total temperature reading for the given setup and various temperature parameters is given in Table 1, 2, 3, 4, and 5.

Table 1: Experimental setup.

Sr. No	Component	Specifications
1	Dimmer stat	0-260W
2	Fin Array	Fin Length: 200mm each; Fin Height: 40mm; Thickness: 2mm
3	Temperature Indicator	Digital Type
4	Wattmeter	Digital Type
5	Base plate	Aluminium material 200mm X 200mm X 25mm.
6	Heater	Dimensional heaters in the form of cartridges of 5mm X 200mm and a power output of 260 Watts.
7	Enclosure	acrylic sheets.1m x 1m x 1m dimension

Figure 1: Assembled setup for the vertical plate with V-fin (facing Towards Upward).

Table 2: Temperature reading.

Sr. No,	Heater I/P (W)	Base Temperatures (°C)				Fin Array Temperatures (°C)				
		T1	T2	T3	T4	T5	T6	T7	T8	T9
1.	50	48.6	48.3	49.2	50.2	46.2	47.2	48.1	47.1	48.3
2	75	64.2	63.8	59.1	64.3	57.3	58.6	59.4	53.2	51.8
3	100	73.6	76.2	77.8	77.4	64.2	63.5	66.7	60.2	64.8
4	125	89.2	90.1	92.1	93.1	72.4	73.6	72.1	68.5	66.3
5	150	96.8	98.3	100.2	99.6	85.1	81.3	82.5	81.2	79.6

Table 3: Various temperature parameter calculations.

Sr. No,	Enclosure Temperature Tamb. (°C)	Avg. Surface Temp. Ts (°C)	Temperature Difference Δ T (°C)	q (radiation) W	q convection of heat (W)	Avg. heat transfer co-eff H average W/m^2 K)	Mean Film Temp. Tm (°C)
1	25.8	48.13	22.33	2.34	47.66	9.08	36.97
2	25.9	59.08	33.18	3.67	71.33	9.15	42.49
3	26.1	69.38	43.28	5.04	94.96	9.34	47.74
4	26.2	79.71	53.51	6.56	118.44	9.42	52.96
5	26.3	89.40	63.10	8.11	141.89	9.57	57.85

Table 4: Properties at mean film temperature.

Sr. No,	Mean Film Temp. Tm (K)	Density ρ (kg/m^3)	Specific Heat Cp (KJ/kg K)	(Kinematic) Viscosity (m^2/s)	Thermal Conductivity (W/m K)
1	309.97	1.1386	1.0068	0.000016693	0.026854
2	315.49	1.1186	1.0070	0.000017220	0.027257
3	320.74	1.1003	1.0073	0.000017727	0.027638
4	325.96	1.0826	1.0076	0.000018236	0.028014
5	330.85	1.0666	1.0079	0.000018718	0.028364

Table 5: Properties at mean film temperature.

Sr. No,	Dynamic Viscosity NS/m2	Nusselt No.	Prandtl No.	β	Grashoff's No.	Rayleigh's No.
1	0.000019007	67.63	0.713	0.0032	20292183	14460275
2	0.000019263	67.13	0.712	0.0032	27832738	19807573

3	0.000019504	67.56	0.711	0.0031	33697822	23953984
4	0.000019743	67.24	0.710	0.0031	38742301	27511330
5	0.000019964	67.47	0.709	0.0030	42720697	30306505

CONCLUSION

- The assembly is held upwards, and a vertical plate with attached V-fins has the highest coefficient of heat transfer. We conclude that this is the best possible V-fin configuration for enhancing heat transfer.
- Fins are attached to the plain plate to improve heat transfer and boost performance.
- Because of the turbulence caused by the V-fins, heat tends to travel upward due to lower density, allowing the system to cool more quickly.
- The values of Grashoff's number and Rayleigh's number are both relatively high, ensuring good heat transfer.
- V-Fins are a modified form of rectangular fins which can be used for various automobiles and stationary engines which require a faster cooling rate in less time
- From the graphs, for some arrangements, for increasing heater I/P, the values of the average heat transfer coefficient is increasing up to a certain extent but then decrease. This is due to the type of arrangement and the decrease in turbulence in that particular arrangement.
- The scope of this system is that changing the height of the fins can improve performance even further.
- Concentration can be increased to increase heat turbulence in the system.
- The findings of the experiment can be compared using computational fluid dynamics.

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