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# Investigating Heat Transfer from Plate Fin Arrangement in Mixed Convection Mode Experimentally

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## ABSTRACT

***An experimental investigation of heat transfer from plate fins in mixed convection mode enhancement is described in the work summarized in this publication. Following a brief overview of the fundamental techniques for improving heat transfer by increasing both the heat transfer surface area and the heat transfer coefficient at the same time, a straightforward experimental procedure for evaluating the improvement in heat transfer is provided. Although plate fins are used to illustrate the technique for improving heat transmission, other fin shapes may theoretically use it as well. That involves changing a number of factors (height, spacing). The experimentally determined order of magnitude of the heat transfer increase. The reason for this is that dimensionless variables are added to scale pressure drop and heat transfer data from the lab to the big scale, but not for performance comparison. As a result, a review of previous performance comparison techniques was also conducted. Mixed convection heat transfer from plate fin heat sinks will be the subject of experiments, with the geometry and heat flow being taken into consideration. Nine plate fins in all were adhered to the base plate's upper surface. The base plate is 150 mm by 150 mm. Aluminum was used to make the fins and base plate. However, the heat transfer performance of heat sinks with plate fins was superior to that of all evaluated plate fin heat sinks.***

***Keywords:** plate fin, mixed convection, thermal.*

## 1. INTRODUCTION

The design, construction, testing, and operation of many different types of heat exchange equipment required in our scientific and industrial technology are all areas of great interest to engineering students and practicing engineers. Electrical engineers use their knowledge of heat transfer to design cooling systems for motors, generators, and transformers, while chemical engineers are interested in the evaporation, condensation, heating, and cooling of fluids. A thorough heat transfer analysis is required to determine the equipment's size, cost, and feasibility in order to transfer a given amount of heat in a given amount of time.Boilers, heaters, refrigerators, and heat exchangers' size are determined by the pace at which heat is to be transported under specific conditions as well as the quantity of heat to be conveyed. The ability to continuously and quickly remove heat from the surface of some metal components is necessary for the proper functioning of devices like gas turbine blades and combustion chamber walls. These diverse examples demonstrate how heat transfer issues arise in nearly every area of engineering and require a study grounded in the science of heat transfer rather than being resolved just by thermodynamic reasoning.

### 1.1Problem Statement

We must investigate mixed convection heat transfer from plate fin arrays on a horizontal surface in this work. An experimental investigation of mixed convection heat transfer in plate fins is suggested in the proposed work. The study's goal is to identify several parameters. Comparisons and observations of each of these parameters.

### 1.2 The study's goal

We conducted experimental work on plate fin arrays for this project. This study aims to demonstrate that mixed convection mode facilitates moderate heat transmission. What is the intermediate stage between forced and free convection

### 1.3 Heat transmission modes

Three different forms of heat transmission are typically recognized in the literature on heat transfer. The energy that moves as a result of temperature differences is called heat transfer. Heat moves from high-temperature areas to low-temperature areas whenever there is an exit temperature differential in the body. Three distinct processes known as "modes of heat transfer" are responsible for this heat transfer. There are

- Conduction
- Convection
- Radiation

## 2. EXPERIMENTAL SETUP

The goal of this project, "combined convection heat transfer through plate (by changing different parameter) fin array," was to find the Gr/Re2 = 1 for assisting mode and opposing mode at various velocities and power output. It also looked at how different velocities affected the combined convective heat transfer coefficients. As a result, it was decided to construct fin arrays with a hot surface on a vertical base. The fin array was made up of three geometrical parameters: fin length, fin height, and fin spacing. A cartridge type heater was used, which was inserted at the base of the fin array, resulting in the use of fins and spacer pieces made of "Mild Steel having small thickness, which gives high thermal conductivity.

*2.1 Duct*

- Plate Fin Array
- Input power measurement
- Temperature measurement
- Blower's
- Anemometer

Plate fin array[H=3cm,L=150mm,S=6mm]

- SPECIMEN CALCULATION

This is the sample specimen computation for a single reading.

For "Assisting mode," at v=0.15 m/s and power=25 watts, according to the observation table.

- *Plate Fin Array Set:(01)*

S = spacing = 6 mm, H = 3 cm

1. for natural convection-induced heat flow (qn)

$$T = \frac{T1 + T2 + T3 + T4}{4}$$

$$= \frac{49.7 + 40.8 + 43.8 + 41.3}{4}$$

$$T = 44^0C$$

2. Bulk mean temperature

$$= \frac{T + Tatm}{2}$$

$$= \frac{44 + 27}{2}$$

$$T_B = 35.5°c$$

3. Properties at $35.5^0c$

$Pr = 0.7$ $L = 0.15m$

$K = 23.7 \times 10^{-3}\ w/m^2 \text{-}k$ $A = 0.2121m^2$

$V = 16.96 \times 10^{-6}\ m^2/sec$

4. Bulk means Temperature

$$\beta = \frac{1}{\text{Bulk mean temperature} + 273}$$

$$= \frac{1}{35.35 + 273}$$

$$= 3.24 \times 10^{-3}\ K^{-1}$$

5. $Gr = \frac{9.81 \times \beta \times (T - Tamb) \times L3}{V2}$

$$Gr = \frac{9.81 \times 3.21 \times 10^{-3} \times (44-27) \times (0.15)^3}{(16.48 \times 10^{-6})^2}$$

$$Gr = 1.8 \times 10^6$$

6. $Gr.Pr = 1.25 \times 10^6$

7. Since the fin array has a major portion of vertical plates then let up, use the correlation for the vertical plates, $10^4 < Gr.Pr < 10^9$

$$Nu_n = 0.59(Gr.Pr)^{0.25}$$

$$= 0.59(1.25 \times 10^6)^{0.25}$$

$$Nu_n = 19.74$$

(08) $$h_n = \frac{Nu_n \times K}{L}$$

$$= \frac{19.74 \times 23.3 \times 10^{-3}}{0.15}$$

$$h_n = 15.33 W/m^2\text{-}k$$

(09) $$q_{nat} = h_n.A.\Delta T$$

$$= 15.33 \times 0.2121 \times (44-21)$$

$$Q_{nat} = 11.04 W$$

**Heat flow due to forced convection**

(10) $$Re = \frac{V \times D}{\nu}$$

$$= \frac{0.15 \times 0.15}{16.48 \times 10^{-6}}$$

$$Re = 1334.51$$

(11) But $Re < 5 \times 10^5$ hence flow is laminar. Correction for flat plate is used as

$$Nu = 0.664 (Re)^{0.5} (Pr)^{0.33}$$

$$= 0.664 (1334.51)^{0.5} \times (0.7)^{0.33}$$

$$Nu = 9.75$$

(12) Convective heat transfer coefficient ,

$$h_f = \frac{Nu_f \times k}{L}$$

$$= \frac{9.75 \times 23.3 \times 10^{-3}}{0.15}$$

$$= 7.57 W/m^2\text{-}k$$

(13) $$Q_f = hfA\Delta T$$

$$= 7.57 \times 0.2121 \times (44-27)$$

$$= 8.89W$$

III Heat flow due to radiation

(14) $$Q_{rad} = \sigma A_s \epsilon (T^4 - T_{amb}^4)$$

$$= 5.67 \times 10^{-8} \times 0.0405(317^4 - 300^4)$$

$$Q_{rad} = 4.58W$$

(15) $$Q_{total} = Q_{nat} + Q_{forced} + Q_{radiation}$$

$$= 11.04 + 8.89 + 4.58$$

$$= 24.73W$$

(16) $$Qsupplied = V \times I$$

$$= 53.1 \times 0.452$$

$$= 24.00 W$$

The computed value of Gr/Re2 = 1.010, which indicates the presence of the combined convection region in the experiment, falls within the designated zone, i.e., 1 to 10.

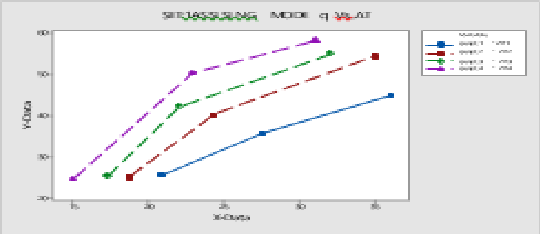
- **Observation Table (Assisting Mode)**

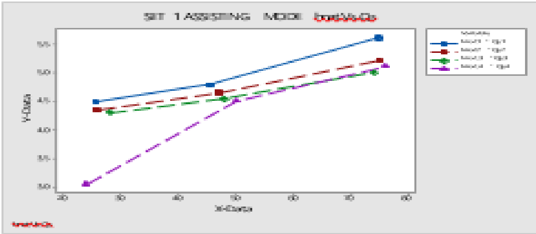
Set (01) H=3cm,S=6mm n= 15

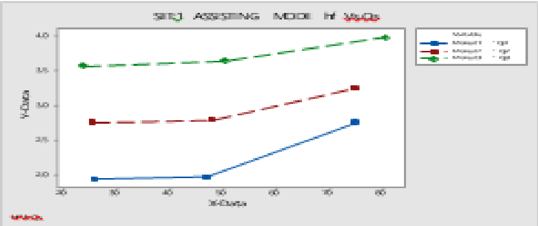
| Sr no | Velocity (m/s) v | Voltage (v)volts | Current (I)amp | Power (watts) | T1 (0c) | T2 (0c) | T3 (0c) | T4 (0c) | T=T1+T2+ T3+T4/4 (0c) | Ta (0c) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 51.9 | 0.44 | 22.836 | 51.6 | 46 | 48.4 | 45.5 | 47.95 | 27 |
| | 0.05 | 51.9 | 0.440 | 22.836 | 50.5 | 43.2 | 46 | 43.1 | 45.7 | 27 |
| | 0.10 | 52 | 0.441 | 22.932 | 49.9 | 41.8 | 44.5 | 42 | 44.55 | 27 |
| | 0.15 | 53.1 | 0.452 | 24.00 | 49.7 | 40.8 | 43.8 | 41.3 | 43.9 | 27 |
| 2 | 0 | 71.0 | 0.642 | 45.58 | 60 | 52 | 55 | 51 | 54.5 | 27 |
| | 0.05 | 72.1 | 0.652 | 47.00 | 59.2 | 47 | 51 | 48 | 51.3 | 27 |
| | 0.10 | 73.0 | 0.666 | 48.16 | 58.3 | 45.7 | 50.3 | 46 | 50.075 | 27 |
| | 0.15 | 74.30 | 0.677 | 49.55 | 59.0 | 45.3 | 49.1 | 45.9 | 49.825 | 27 |
| 3 | 0 | 90.4 | 0.851 | 76.93 | 70.4 | 60 | 62.6 | 61 | 63.5 | 27 |
| | 0.05 | 93.0 | 0.85 | 76.7 | 69.3 | 58.3 | 61.3 | 59.2 | 62.025 | 27 |
| | 0.10 | 91.6 | 0.864 | 79.14 | 68.7 | 57.6 | 60.2 | 58.1 | 61.125 | 27 |
| | 0.15 | 92.5 | 0.872 | 80.66 | 66.8 | 54.8 | 60.0 | 57.3 | 59.65 | 27 |

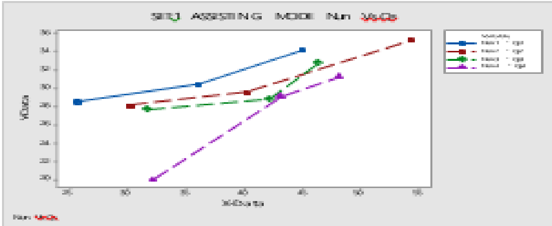
## 3. Result and Graphs

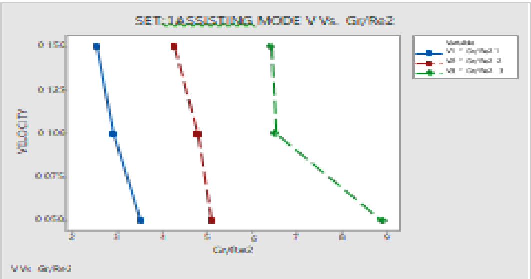
PlateFinArraySET.1[L=150mm,S=mm & H=3cm]Assisting Mode Graph Result

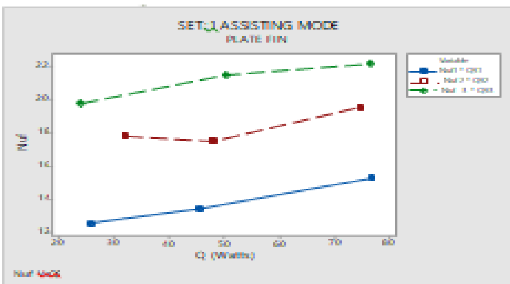



## 4. CONCLUSION

The heat transfer rate from fin arrays lost by coupled convection can be predicted thanks to the observations, findings, and comments presented in earlier articles. For the combined convection in this experiment, we employ air velocities ranging from 0 to 0.15 m/s.

- **Overall conclusions**

The following conclusion may be summed up from the experimental examination of the setup.

1. The coefficients of heat transmission for forced and natural conditions are similar. Proving that the experiments included the combined convection region.
2. As anticipated, the finned system's temperature drops as air velocity rises.
3. In contrast to the assisting mode, the specimen temperature is rising in the opposing mode.
4. The observed value of Gr/Re2, or the combined convection effect, within the designated zone, which is 1 to 10.
5. It is evident from the graph that, for a given heat input, the value of the heat transfer coefficient increases as air velocity increases.
6. It has been observed that the Reynolds Number rises as air velocity increases.

## Future Scope

1. Radiation-induced heat transfer is also taken into account. The fin arrays' polished and dull surfaces can be used to study this by applying a black coating, among other things.
2. The combined convective heat transfer from circular, square, and rhombic fin arrays was the focus of the study. Work on vertical fin arrays under both forced and natural convection conditions is worthwhile.
3. Switching the specimen material from aluminum to copper would also be feasible. A cast iron alloy, for example, since different materials have variable thermal conductivities and rates of heat transfer.
4. Similar experiments could be conducted in the future for different cross-sectional specimens, like triangular trapezoids, etc., utilizing different specimen materials and different working fluids.

## Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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