EXPERIMENTAL STUDY OF HEAT TRANSFER FROM PLATE FIN ARRAY IN MIXED CONVECTION MODE

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ABSTRACT

The work summarized in this paper presents an experimental study of heat transfer from plate fin in mixed convection mode enhancement by the use of plate fins is presented. After a brief review of the basic methods used to enhance the heat transfer by simultaneous increase of heat transfer surface area as well as the heat transfer coefficient, a simple experimental method to assess the heat transfer enhancement is presented. The method is demonstrated on plate fins as elements for the heat transfer enhancement, but it can in principle be applied also to other fin forms. That is varying various parameters (height, spacing). The order of the magnitude of heat transfer enhancement obtained experimentally, it was found that by a direct comparison of Nu and Re no conclusion regarding the relative performances could be made. This is because the dimensionless variables are introduced for the scaling of heat transfer and pressure drop results from laboratory to large scale but not for the performance comparison. Therefore a literature survey of the performance comparison methods used in the past was also performed. Experiments will carried out on mixed convection heat transfer from plate fin heat sinks subject to the influence of its geometry and heat flux. A total of 9 plate fins were pasted into the upper surface of the base plate. The area of the base plate is 150mm by 150mm. The base plate and the fins were made of aluminum. For all tested plate fin heat sinks, however, the heat transfer performance for heat sinks with plate fins was better than that of solid pins.

KEYWORDS: plate fin, mixed convection, thermal.

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INTRODUCTION

Heat transfer is a subject of widespread interest to the student of Engineering curriculum, practicing engineers and techniques engaged in The design, construction testing and operation of many diverse forms of Heat exchange equipments required in our scientific and industrial technology. Electrical engineers apply their knowledge of heat transfer for the design of the cooling system for motors, generators and transformers. Chemical engineers are concerned with the evaporation, condensation, heating & cooling of the fluids. To estimate the cost, the feasibility and size of the equipment necessary to transfer a specified amount of heat in the given time, a detailed heat transfer analysis must be made. The dimensions of boilers, heaters, refrigerators and heat exchanger depend not only on the amount of heat to be transmitted but rather on the rate at which heat is to be transferred under the given condition The successful operation of equipment such as turbine blades and walls of combustion chambers of gas turbine depends on the possibility of cooling certain metal parts by removing heat continuously at a rapid rate from the surface. These varied examples shows that in almost every branch of engineering, heat transfer problems are encountered, which cannot be solved by thermodynamic reasoning alone but required an analysis based on science of heat transfer .

Nomenclature

A	-Area
a	- Constants
A_s	- Surface area
B,b	- Breadth
C_p	- specific heat at constants Pressure
C_v	-specific heat at constants volume
CVD	- Chemical Vapour deposition
D,d	- Diameter
e	- Constants
F_b	- Buoyancy Force
g	-gravity
H	- Height of the fin
h	- Convective heat transfer coefficients
I	- Current
K	- Thermal conductivity
Log	- logarithm to the base 10
I_n	-logarithm to the base e
L	- Length of the fin
M	- Mass
m	- Mass flow rate
n	- No. of fin
S	- Spacing
L/H	- length to height ratio
Nu_f	- Nusselt Number for forced convection
Nu_n	- Nusselt Number for natural convection
Q,q	- Rate of heat transfer
q_{rad}	- Rate of heat transfer due to radiation
R	- Thermal resistance
S/H	-Spacing to height (S)
T	- Temperature
T_{avg}	- Average Temperature

t - Thickness of the fin

T_w - wall thickness

U - Overall heat transfer coefficient

v - Specific volume

V - Volume

W - Watts, Weight.

GREEK LETTERS

ϕ - Diameter

α **-** Thermal diffusivity

β - Temperature coefficients of volume expansion

, Temperature coefficients of thermal conductivity

Δ - Differences between values

σ -Stefan Boltzmann constants

μ - Absolute Viscosity

ʋ **-**Kinematics viscosity

Dimensionless Numbers

G_z -GraetzNumber

G_r -Grashof Number

N_u - NusseltNumber

P_r - Prandtl Number

R_e - Reynolds Number

R_a - Rayleigh Number

1 Statement of Problem

In the present work we have to study mixed convection heat transfer from plate fin arrays on a horizontal surface. In the proposed work it is proposed to carry experimental study on mixed convection heat transfer in plate fin. The objective of study is that to find different parameters Observations and comparison of all these parameters.

2 Objective of Study

In the present study we have performed experimental work on plate fin arrays. The purpose of this study to show moderate heat transfer takes place in mixed convection mode. And which middle stage of free and forced convection.

3 Modes of heat transfer

The literature of heat transfer generally recognizes three distinct modes of Heat Transmission. Heat transfer is the energy in transits due to temperature difference. Whenever there is exit temperature difference in a body, heat flows from regions of high temperature to the region of low temperature. This heat transfer takes place by three different processes called as modes of heat transfer. There are

1.3.1 Conduction
1.3.2 Convection
1.3.3 Radiation

EXPERIMENTAL SETUP

The objective of this project work on “combined convection heat transfer through plate (by changing different parameter) fin array” was to determine the $\mathbf{G_r/R_e^2}$ = 1 for assisting mode & opposing mode at the different velocities & power output. It also studies the effect of different velocities on combined convective heat transfer coefficients. It was therefore decided to build fin arrays with hot surface with on vertical base.

The fin array was constituted by three geometrical parameters fin length “L” fin height ‘H’ & fin spacing ‘S’. It was decided to use cartridge type heater. This was inserted at the base of fin array thus the fins & spacer pieces made of ‘Mild Steel having small thickness were used, which gives high thermal conductivity? The component of the fin array assembly was put together by using tie rods & nuts. The horizontal & vertical ducts are made up of plywood. The heat transfer by radiation is neglected because black coating is provided inside the duct & heating surface.

2.1 Duct
2.2 Plate Fin Array
2.3 Input power measurement
2.4 Temperature measurement
2.5 Blower’s
2.6 Anemometer

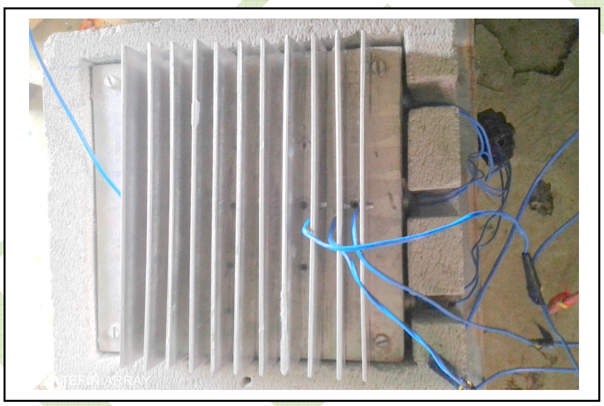


Plate fin array[H = 3cm, L= 150mm,S =6mm]

SPECIMEN CALCULATION

The sample specimen calculation for one reading is shown here.

From observation table, for “**Assisting mode**”, at v=0.15m/s & power = 25 watts.

Plate Fin Array Set :(01)

H = 3 Cm, S=spacing=6mm
1. for heat flow due to natural convection (q_n)

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

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

$T = 44^0C$

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

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

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

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

$$Gr = \frac{9.81 \times 3.21 \times 10-3 \times (44 - 27) \times (0.15)3}{(16.48X10-6)2}$$

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

6. Gr. Pr = 1.25×10^6

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

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

$$= 0.59(1.25X10^6)^{0.25}$$

$$Nu_n = 19.74$$

(08) $$h_n = \frac{Nun\ XK}{L}$$

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

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

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

$$= 15.33X0.2121X\ (44-21)$$

$$Q_{nat} = 11.04\ W$$

Heat flow due to forced convection

(10) $$Re = \frac{V\ X\ D}{v}$$

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

$$Re = 1334.51$$

(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 ,

$$h_f = \frac{Nuf\ x\ k}{L}$$

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

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

(13) $Q_f = hfA\Delta T$

$$= 7.57 \times 0.2121 \times (44\text{-}27)$$

$$= 8.89W$$

III Heat flow due to radiation

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

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

$$Q_{rad} = 4.58W$$

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

$$= 11.04 + 8.89 + 4.58$$

$$= 24.73W$$

(16) Qsupplied = V X I

$$= 53.1 \times 0.452$$

$$=24.00\ W$$

$$\frac{Gr}{Re2} = \frac{8.16\ x\ 106}{(1334.51)2}$$

= 1.010

Note: The calculated value of Gr/Re2 = 1.010 within the prescribed zone i.e.(1 to 10) which indicating the combined convection region was present in the experimentation .

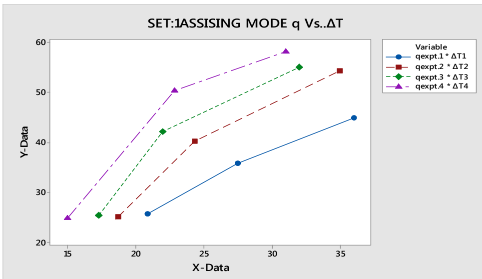
1 OBSERVATION TABLE (ASSISTING MODE)

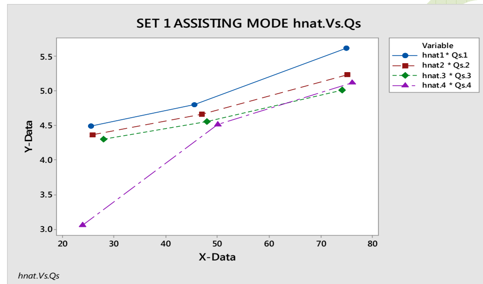
Set (01) H=3cm,S=6mm n= 15

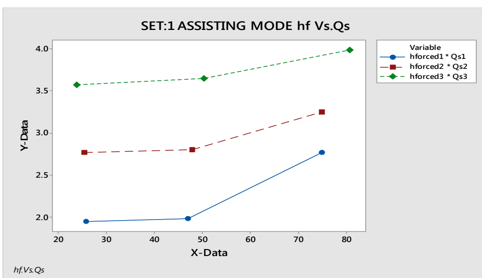
Sr no	Velocity (m/s) v	Voltage (v)volts	Current (I) amp	Power (watts)	T1 (0c)	T2 (0c)	T3 (0c)	T4 (0c)	T=T1+T2+ T3+T4/4 (0c)	Ta (0c)
1	0	51.9	0.44	22.836	51.6	46	48.4	45.5	47.95	27
	0.05	51.9	0.440	22.836	50.5	43.2	46	43.1	45.7	27
	0.10	52	0.441	22.932	49.9	41.8	44.5	42	44.55	27
	0.15	53.1	0.452	24.00	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

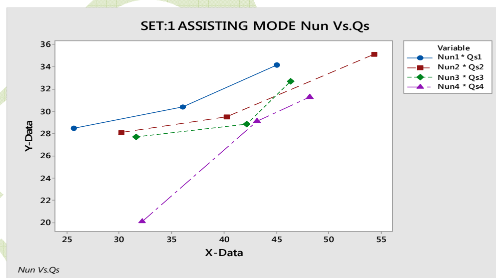
RESULT AND GRAPHS

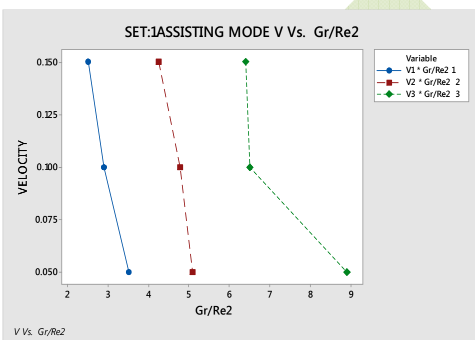
Plate Fin Array SET.1 [L=150mm,S=mm & H=3cm] Assisting Mode Graph Result

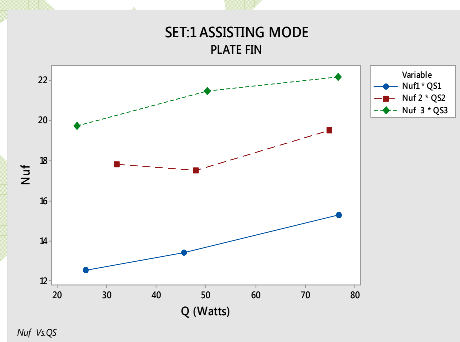












CONCLUSION

The observation, result & discussions made in previous Articles enable one to predict, the heat transfer rate from fin array, losing by combined convection. In this experiment we use the velocity of air in between 0 m/s to 0.15 m/s for the combined convection.

Overall conclusions

From the experimental analysis of set up, the following conclusion can be summarized.

1. The heat transfer coefficient for natural & forced condition are comparable with each other .indicating the combined convection region was present in the experiments.
2. The temperature of finned system decreases with increase in air velocity, as expected.

3. The specimen temperature are increasing in opposing mode when compare with assisting mode.
4. The observed value of G_r/Re^2 within the prescribed zone i.e. 1 to 10 which is the combined convection effect.
5. From graph, it is clear that the value of heat transfer coefficient increase with increase in air velocity for given heat input.
6. it's seen that value of Reynolds Number increase with increasing in air velocity.

FUTURE SCOPE

1) Heat Transfer by radiation is also a factor of consideration. This can be studied by surface of the fin arrays made of polished & dull by providing a black coating etc.
2) The work was concerned with the combined convection heat transfer from circular,square,rhombic fin array. It is worthwhile to carry out the work on vertical fin arrays under forced and natural convection condition also.
3) it may also be possible to change the specimen material from aluminum to copper A alloy cast iron etc. because the heat transfer rate & the thermal conductivity for different material is different .
4) In future the similar experiment may be studied for the various cross sectional specimen such as .triangular trapezoidal etc .by using different material of the specimen & using different working fluids.

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