ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Special Issue
National Conference on Advances in Civil and Mechanical Engineering (NCACME 17)

Enhancement of Heat Transfer with Different Geometries of Fin

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***Abstract:-* The Heat transfer rate is enhanced byincreasingthe heat transfer coefficient & by the area of heat transfer.Free convection has the only method for increasing heat transfer area by providing extended surfaces. The enhancement ratio of heat transfer depends on the fins orientations and the size and shape of fin arrays. The Aluminum material was used for testing and the experiment was carried out on different fin geometries. The experimentation procedure and the analytical calculations have been carried out successfully and values of heat transfer coefficient for both notched & un-notched fins are defined. It is proved that the heat transfer coefficient is highest for the set of fins with triangular notch (7.161W/m2k) at base temperature 700c and (8.193W/ m2k) at base temperature 100°c.**

I. INTRODUCTION

There is wide scope for the development of extended surfaces .Finned surfaces will increase the rate of heat transfer. Therefore we have mainly concentrating on geometric development because the role of fin length in enhancement of heat transfer is of limited range, as larger lengths might create problem like space and material. The science of heat transfer is mainly concerned with the analysis of the rate of heat transfer taking place within the system. The rate of energy transfer by heat flow cannot be measured directly, but the concept has physical meaning because it is related to the measurable quantity called temperature. Since heat flow takes place whenever there is a temperature gradient in a system and the knowledge of temperature distribution in the system is essential in heat transfer studies. Temperature distribution in a medium is controlled by the combined effects of the three modes of heat transfer; therefore, it is not actually possible to isolate entirely one mode from interactions with the other modes.

1.1 Extended Surfaces

The major heat transfer takes by two modes i. e. by conduction or by convection. Heat transfer through the solid to the surface of the solid takes place through conduction where as from the surface to the surroundings takes place by convection. Further heat transfer may be by natural convection or by forced convection. The rate of heat transfer from a surface at a temperature Ts to the surrounding medium at T0 is given by Newton’s law of cooling as

$$Q = hAs(Ts - To)$$

Where A_S is heat transfer surface area, and h is the convection heat transfer coefficient. When the temperatures ’T_S’ and ‘T_0’are fixed by design considerations, as is often the case, there are two ways to increase heat transfer rates:

- To increase convection heat transfer coefficient ‘h’.
- To increase the surface area A_S. Increasing ‘h’ may require the installation of a pump or fan, or replacing the existing pumps or fans with a larger ones.

II. LITERATURE SURVEY

In order to understand the phenomena of heat transfer through fin surface and effect of different parameters, this step is carried out. Many researchers have explained the enhancement of heat transfer through fin which limits because of geometrical constraints and flow instability.

S. A. Nada [1] reported in his paper, natural convection heat transfer in horizontal and vertical closed narrow enclosures with heated rectangular finned base plate. Natural convection heat transfer and fluid flow characteristics in horizontal and vertical narrow enclosures with heated rectangular finned base plate have been experimentally investigated at a wide range of Rayleigh number (Ra) for different fin spacings and fin lengths. Quantitative comparisons of finned surface effectiveness (e) and heat transfer rate between horizontal and vertical enclosures have been reported. In comparison with enclosure of a bare base plate, insertion of heat conducting fins always enhances heat transfer rate. Optimization of fin-array geometry has been addressed.

H. G. Yalcin et. al [2] the paper aim to investigate the effects of clearance parameters on the steady-state heat transfer. In order to solve the three-dimensional elliptic governing equations, a finite volume based CFD code was used. The clearance gap between fin tips and shroud, the base and fin temperatures and the size and configuration of the finned surfaces were varied during the parametric study. The numerical results have been compared to existing experimental values from the literature and the comparison showed a good agreement. It is found that the heat transfer coefficient increases with the increase in the clearance parameter and it approaches to the value of heat transfer coefficient obtained for enshrouded fin arrays.

J.C. Sanders et.al.[3] carried out the cooling tests on two cylinders, one with original steel fins and one with 1-inch spiral copper fins brazed on the barrel. The copper fins improved the overall heat transfer coefficient from the barrel to the air 115 percent. They also concluded that in the range of practical fins dimensions, copper fins having the same weight as the original steel fins will give at least 1.8 times the overall heat transfer of the original steel fins.

III.EXPERIMENTAL SET-UPS

To investigate the performance of the heat transfer fins with and without notches, the experimental setup consists of a base plate made up of aluminum material. Five slots are created on this base plate so that five fins may be attached to this base plate. A set of five fins with or without notches depending on the type of case are mounted on this base plate. The whole experimental setup is enclosed in wooden box so as to avoid external wind disturbances. The enclosure also helps in developing a pure natural convection transfer through the set of fins by isolating the experimental setup from the surrounding effects. The setup shown in fig 1 below also includes temperature sensor, heating coil with temperature indicator and dimmerstat to regulate electrical input to voltage.

Fig 1: Experimental Set Up For Testing Of Fins

Fig 2:Base Plate With Different Types Of Fins

Base plate and set of fins are shown in Fig 2 with different notch geometries which are made up of aluminum. Selection criteria for a aluminum is based on thermal conductivity, density, cost and from manufacturing point of view which have thermal conductivity of 237.4 w/mk and density of 2712 kg/m^3.

Wooden case and Asbestos form an essential part of the experimental support in the sense that it functions both as support to the base plate-set of fins and also as an insulator. The heating element is placed between Asbestos and the base plate, which is mounted on wooden case.

Fig:3 Triangular Fins Arranged

IV. EXPERIMENTATION

Tabulation of the data so obtained is done on the basis of type of notch in the fin. For each type of fin a different table is made so that further calculations are made easy and comparison of the data is also made easy and a suitable conclusion can be drawn from the obtained data. Further tabulation is also made on the basis of temperature of the base plate. The experimentation is performed for 70 and 100 degree temperature of the base plate. In the observation table suffixes f1, f2, f3 stand for the fins, b1 and b2 stand for the two locations on the base plate at which the temperatures are measured by using digital temperature indicator. The atmospheric temperature is taken as 33.5 degree as per average. The experimental procedure and the results of the experimentation have been discussed in following sections

A) Fins without Notch

Table No.1 :Base Plate temperature T_b = 70 °c

Sr.No.	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	70	70	65	65	65
2	70	70	65	64	65
3	70	70	65	65	65

Table No.2: Base Plate temperature T_b = 100 °c

Sr. No.	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	100	100	90	91	90
2	100	100	91	91	90
3	100	100	92	92	91

B) Fins with Rectangular notch

Table No.3: Base Plate temperature T_b = 70 °c

Sr.No	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	70	71	66	66	67
2	70	70	67	68	67
3	70	70	65	66	65

Table No.4: Base Plate temperature T_b = 100 °c

Sr.No.	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	100	100	94	93	94
2	100	100	95	95	94
3	100	100	92	92	93

C) Fins with Triangular Notch

Table No.5 Base Plate temperature T_b = 70 °c

Sr.No	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	70	70	68	68	68
2	70	70	67	67	67
3	70	71	67	67	67

Table No.6 Base Plate temperature T_b = 100 °c

Sr.No	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	100	100	98	98	98
2	100	100	95	95	96
3	100	100	95	95	96

D) Fins with Circular Notch

Table No.7 Base Plate temperature T_b = 70 °c

Sr.No	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	70	70	65	66	66
2	70	70	65	65	65
3	70	70	65	65	66

Table No.8 Base Plate temperature T_b = 100 °c

Sr.No.	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	100	100	92	92	93
2	100	100	92	94	94
3	100	100	93	95	96

E) Fins with Trapezoidal Notch

Table No.9 Base Plate temperature T_b = 70°c

Sr.No	Base Temp (° c)		Fin Temp (° c)		
	T_{b1}	T_{b2}	T_{f1}	T_{f2}	T_{f3}
1	70	70	65	64	66
2	70	70	65	65	65
3	70	70	66	65	66

Table No.10 Base Plate temperature $T_b = 100$ °c

Sr.No	Base Temperature (° c)		Fin Temperature (° c)		
	Tb1	Tb2	Tf1	Tf2	Tf3
1	100	100	93	92	94
2	100	100	92	92	93
3	100	100	93	93	92

Analytical Calculations

To find average temperature of base plate (T_b)

$$T_b = \frac{T_{b1} + T_{b2}}{2}$$

$T_b = 70^\circ$c

To find average temperature of fins (T_f)

$$T_f = \frac{T_{f1} + T_{f2} + T_{f3}}{3}$$

$T_f = 64.89^\circ$c

To find temperature of whole body (T_{body})

$$T_{body} = \frac{T_b + T_f}{2}$$

$T_{body} = 67.445\ ^\circ$c

Temperature Difference Between Body & Surrounding Temperature (ΔT)

$$\Delta T = T_{body} - T_{Surrounding}$$

$\Delta T = 33.945\ ^\circ$c

TO FIND MEAN FILM TEMPERATURE (T_{LM})

$$T_{Lm} = \frac{T_{body} + T_{Surrounding}}{2} + 273$$

T_{LM} = 323.47 K

To find coefficient of volume expansion (β)

$$\beta = \frac{1}{T_{Lm}}$$

B= 0.003091 K^{-1}

Grashof number (Gr)

$$Gr = \frac{g\ \beta\ \Delta T\ Lc^3}{\nu^2}$$

GR = 918807.89

Rayleigh number (Ra)

$$Ra = Gr \times Pr$$

RA = 650515.99

Nusselt number (Nu)

$$Nu = 0.59\ (Ra)^{1/4}$$

NU = 16.75

heat transfer coefficient (h)

$$Nu = \frac{h.\ Lc}{K}$$

H = 7.097 W/M^2 K

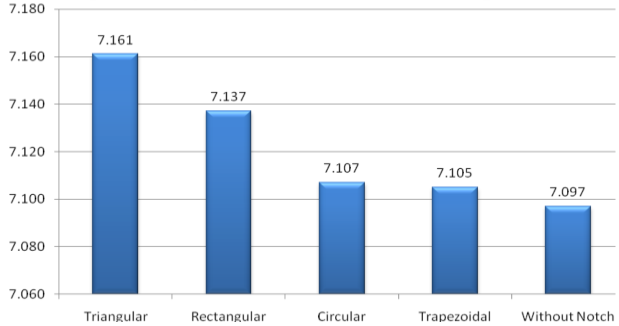
V. RESULT AND DISCUSSION

The experimentation procedure and the analytical calculations has been carried out successfully and defined the value of heat transfer coefficient for notched fins. In this the comparison has been made on the basis of heat transfer coefficient value at 70^0 C and 100^0 C temperature. The conclusion has been made for selecting the best fins within.

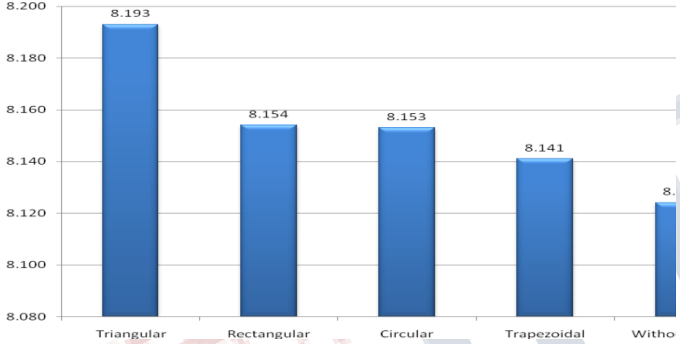
S.No	Notch Geometry of fin	Heat transfer coefficient (W/ m² k)	
		T base 70 °c	T base 100 °c
1	Fin without notch	7.097	8.124
2	Fin with Trapezoidal notch	7.105	8.141
3	Fin with Circular notch	7.107	8.153
4	Fin with Rectangular notch	7.137	8.154

5.1 *Graphical Representation*

Comparison of H.T.C. at 70^0 C Base temperature



Comparison of H.T.C. at 100^0 C Base temperature



From the above result table, it has been found that Fin with Triangular notch has highest heat transfer coefficient.
By providing the notch, the tip surface area increases as compare to fin without notch. Different geometries of notches help in proper circulation of air within pitch and notch area

Experimental analysis is successfully carried out to predict HTC for the fins with and without notch. From experimentation and analytical calculations HTCs are predicted for different fins at 70^0 C and 100^0 C base temperature.

VI. CONCLUSIONS

1) It is proved that the heat transfer coefficient is highest for the set of fins with triangular notch (**7.161W/m^{2}k**) at base temperature 70^{0}c and (**8.193W/ m^{2}k**) at base temperature 100°c. This has been shown by the experimental analysis.

2) From the experimental analysis it has been observed that temperature distribution for the notched fins is more uniform than the fins without notch.

3) It is observed that the Heat transfer coefficient varies with notch geometry. As area removed from the fin at the air entry ends of the fin, it provides chance to get greater amount of fresh air in contact.

4) From economical point of view, along with increasing HTC it saves the fin material and indirectly cost of the production.

REFERENCES

[1]S. A. Nada., "Natural convection heat transfer in horizontal and vertical closed narrow enclosures with heated rectangular finned base plate". J. Heat Transfer, Vol 116, pp. 75-81.

[2]H. G. Yalcin et. al, "Study of effects of clearance parameters on the steady-state heat transfer" ASME Journal of Heat Transfer, Vol 103, pp. 616-623.

[3]J.C.Sanders, et al. (1942). Cooling test of an air-cooled engine cylinder with copper fins on the barrel, NACA Report E-103

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