Thermal Analysis of Slotted Fins in Automobile Engines

[1] Giridhar Manoj.M, [2]Shurendher Kumar.S, [3]Venkatesh.M, [4]Jaikrishna.S, [5]Godfrey.R
Department of Mechanical Engineering
Panimalar Engineering College, Chennai 123

***Abstract*—Fins are the vital and simple extensions that are used for the removal of heat from a Heat generating system. We have various types of Fins namely Longitudinal Fins, Fins, Annular fins, plate fins, etc. In all the cases the heat rejection is accomplished by conduction and convection.Usually heat convected rate depends upon the Surface area exposed to the ambient Fins provide an extra surface area for the convection to take place. Here we consider Fins alone and its optimization. In order to increase the heat transfer due to convection a slot can be made longitudinally on the Fin so as to increase the convection surface area.This method of making slots also reduces the material usage and maintains the dimensions of the fin. But the slot made considerably decreases the conduction heat transfer, Thus this causes an increase in the heat removal rate without much disturbance to the dimensions.**

***Index Terms*— Longitudinal Fins, Annular fins, convection, ambient Fins.**

I. INTRODUCTION

Fins are the extended surfaces that are used in many thermal systems for the need to dissipate the heat energy from it. Fins conduct the heat by conduction, convection and radiation. The major heat transfer in the fin is carried out by convection, which means heat transfer between a surface and the fluid surrounding. According to Fourier law, the rate of heat transfer is directly proportional to the surface area which is exposed to the ambient and the temperature between the surface and the ambient. Hence fins provided an effective increase in the surface area causing the heat dissipation without any coolant or pumps .The performance of the fin can be measured by effectiveness or efficiency. In order to increase the efficiency a slot can be provided on the fins causing an increase in the surface area exposed to the ambient. This further causing decrease in the mass of the fin and considerably reducing the material required. In order to increase the heat transfer the analysis is carried out by various lengths at constant temperature.

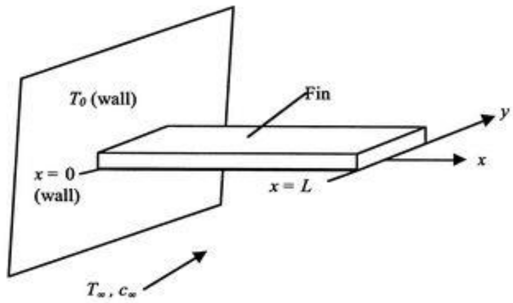
A. Assumptions

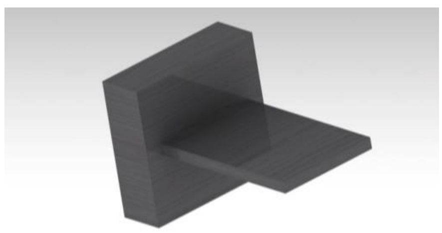
1.Heat transfer coefficient is constant throughout the system.
2. Steady state is achieved in the system.
3. Thermal conductivity of the fin material is uniform.
4. Heat transfer is considered for one dimensional.
5. Fin is in perfect contact within the system.
6. Ambient does not changes its temperature due to heat generated within the system.

B. Notations

Q- Heat transferred by fin (watt)
A -Cross sectional area of Fin (m^2)
N_u-Nusselt's Number
T_o – Base temperature(K)
T_∞ -Ambient temperature(K)
L- length of the fin (m)
Gr - Grashof number
Pr- Prandtl number
h- Heat transfer coefficient (W/m^2K)
K- Thermal conductivity (W/ mK)

II. ANALYSIS OF HEAT TRANSFER IN A NORMAL RECTANGULAR FIN:





Let us consider a fin of cross sectional area A and perimeter P. Some amount of heat is conducted and convected. We neglect radiation in this system. They can be brought up under two cases. They are i) with end insulated ii) without end insulated.

For Fins with end insulated, the amount of heat transferred is given by

$$Q = (hPKA)^{0.5}(T_o\text{-}T_\infty)\ \tanh(mL)$$

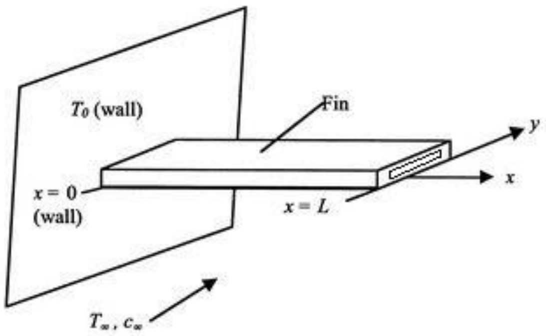
wherem=$(hP/KA)^{0.5}$ Assuming some constants h=50w/m^2k.

k=30w/ mk. T_B=90° C, T_∞ = 30 °C.
A=0.02*0.02m²

For various length of the fin, the heat transferred is calculated as follows.

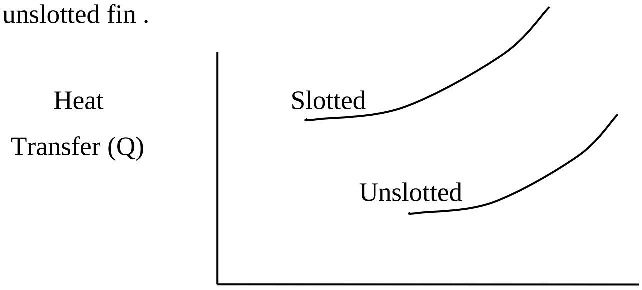
LENGTH OF THE FIN(m)	HEAT TRANSFER(W)
0.05	9.4996
0.10	12.4802
0.15	13.0358
0.20	13.1276

III. ANALYSIS OF HEAT TRANSFER IN A SLOTTED FIN:



Here we take a longitudinal slot on the fin in order to increase the surface area of the system. Now taking the same parameters as considered earlier, the heat transfer rate at various lengths can be calculated as follows.
Here, P=4(0.02) +4(0.01) m.
A= $(0.02)^2-(0.01)^2$m².

Here ,the heat transfer rate is increased by introducing a slot of varying the length of the fin.The graph is plotted for the Slotted and unslotted fin .



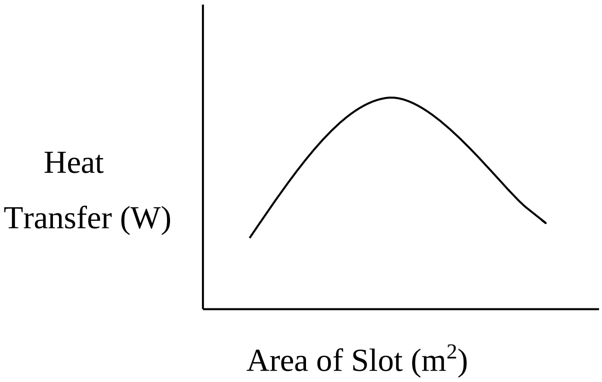
IV. EFFECT ON HEAT TRANSFER BY SLOTTED AREA:

If we introducing a slot in the fin there is an increase in the convection surface area, also there is an increase in the effective surface area. As far as the strength of the fin is not considered, the slot can be increased for a certain maximum level

Now considering the same constant values the heat transfer rate is calculated as follows.

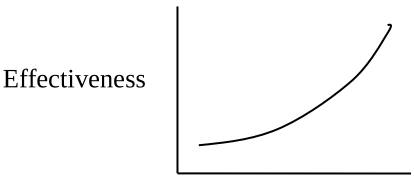
LENGTH OF THE FIN(m)	HEAT TRANSFER(W)
0.05	11.9821
0.10	13.7841
0.15	13.9306
0.20	13.9418

AREA OF SLOT(m²)	HEAT TRANSFER(W)
0	9.497
0.005*0.005	77.147
0.01*0.01	11.98
0.012*0.012	11.89



V. EFFECTIVENESS

Effectiveness of the fin is the term that denotes the effect of fin on the heat generating system. It is defined as the ratio of heat transfer from the surface with fin to that of the system without fin.As the heat transfer due to the slotted fin is increased,its effectiveness also considerably increases

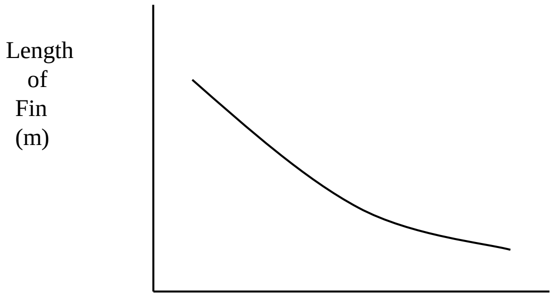


VI. LENGTH REDUCTION

The slotting of fins results in the reduction in the material usage consequently resulting in the reduction in the manufacturing cost also reducing the weight of the components. This causes less weight components in automobiles and aeronautical components. This also helps for the easy installment of fins in any complex location of the mechanical components as it provides the optimum heat transfer with less material usage.

Same heat transfer can be obtained from the fin of smaller fins with slots compared to the fins of larger length without slots. It can be tabulated and plotted as shown below.Heat transfer (Q) is constant for the following cases

Here A- Cross sectional area of Fins without slot



VII. ACTUAL CASE OF CONVECTION IN SLOTTED FINS

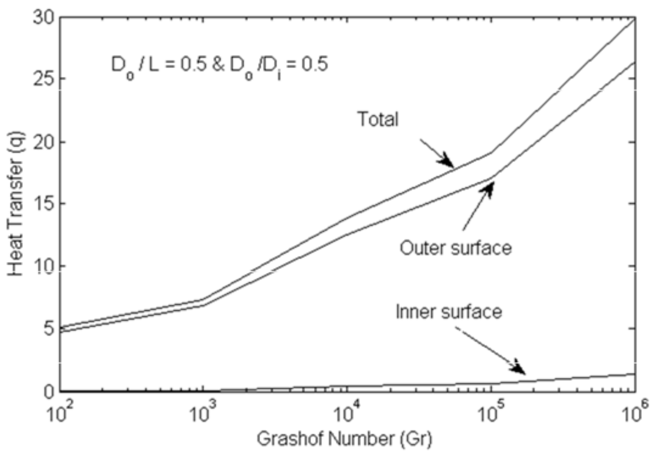
The heat transfer coefficient is assumed to be constant for both internal and external surfaces of the fin. But in practical case, the fluid movement in the ambient is low at the cavity than at the external surfaces. This causes a reduction in the Grashof's number.

$$h = (N_u K)/x$$

Here the Nusselt's number depends on the Grashof's number

$$Gr = \frac{g\beta dTx3}{\gamma 2}$$

Hence it causes an reduced heat transfer coefficient at the slot than at the external surface. Therefore in actual case the internal heat transfer is negligible for very small slot. The heat transfer increases with the increase in the cavity size. The variation of heat transfer with respect to the Grashof number is shown in the graph from ref [1]



Area of Slot	Required Length of Fin(m)
0.2A	0.021
0.4A	0.018
0.6A	0.016

VIII. CONCLUSION

From the analysis, the heat transfer rate in increased by introducing a slot in the fin. Thus there is an increase in the heat transfer with considerable amount of saving the mass of the material used.

REFERENCES

[1] Tari.I., Mehrtasan.M Natural convection and heat transfer from horizontal and slightly inclined plate-fin Heat sinks, Applied Thermal Engineering,61(2013), pp.728-736

[2] Numerical Design of efficient slotted surface based on the field synergy principle Y.P.Cheng Z.G.QU,W.Q Tao