

A REVIEW ON DIFFERENT GEOMETRICAL FINNS AND THEIR EFFECT ON HEAT TRANSFER RATES

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Abstract— Fins are the extended surface which is used for dissipating the heat energy evolved in combustion chamber of an IC engine, radiators, condenser, cooling towers etc. The fins are widely classified based on its geometry like flat fin, wedge fins, annular fins etc. The heat transfer within fins is basically due to its conduction phenomenon and the heat transfer between fins surface and surrounding is due to the convective heat transfer. The temperature at the root of the fin is maximum while it is gradually decrease with respect to its length. And the lowest temperature will achieved at the tip of the fin. Fin efficiency is predicted on the basis of the ratio of its actual heat transfer to the maximum amount of heat which can be dissipated through the same fin. The fin efficiency can be graded up by either increasing the length of the fin or by changing the geometrical configuration of the fin and by iterating the number of fins over the length of the surface. The effectiveness of the fin is the ratio of heat transfer using fins and the heat transfer without fins. The need of fin can be estimated on the basis of effectiveness. The maximum efficient fin is that in which the tip temperature of the fin will be the same as that of the ambient temperature of the surrounding air.

Keywords— Fins, Perforated geometry, Fin effectiveness, Fin efficiency, Heat flux, Film coefficient

INTRODUCTION

Convection heat transfer between a hot solid surface and the surrounding colder fluid is governed by the Newton's cooling law which states that "the rate of convection heat transfer is directly proportional to the temperature difference between the hot surface and the surrounding fluid and is also directly proportional to the area of contact or exposure between them". Newton's law of cooling can be expressed as

$$Q_{conv} = h A (T_s - T_{\infty})$$

Where,

h = convection heat transfer coefficient

T_s = Hot surface temperature

T_{∞} = Fluid temperature

A = area of contact or exposure

Therefore, convection heat transfer can be increased by either of the following ways

1. Increasing the temperature difference (T_s) between the surface and the fluid.
2. Increasing the convection heat transfer coefficient by enhancing the fluid flow or flow velocity over the body.
3. Increasing the area of contact or exposure between the surface and the fluid.

Most of the times, to control the temperature difference is not feasible and increase of heat transfer coefficient may require installation of a pump or a fan or replacing the existing one with a new one having higher capacity, the alternative is to increase the effective surface area by extended surfaces or fins.

Fins and its applications

Fins are the extended surface protruding from a surface or body and they are meant for increasing the heat transfer rate between the surface and the surrounding fluid by increasing heat transfer area. Example of surfaces where fins are used

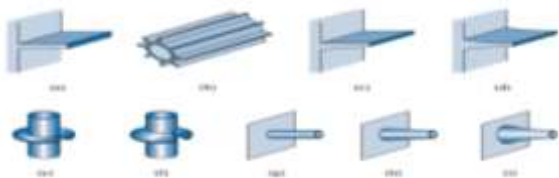
1. Air cooled I.C. engines
2. Refrigeration condenser tubes
3. Electric transformers
4. Reciprocating air compressors
5. Semiconductor devices
6. Automobile radiator

Types of fin

Fins can be broadly classified as:

1. Longitudinal fin
 2. Radial fin
 3. Pin fin
- (a) Longitudinal fin - Rectangular profile
 - (b) Longitudinal fin - Rectangular profile
 - (c) Longitudinal fin - Trapezoidal profile
 - (d) Longitudinal fin - Concave parabolic

- (e) Radial fin – Rectangular profile
- (f) Radial fin – Triangular profile
- (g) Pin fin – Cylindrical
- (h) Pin fin – Tapered profile
- (i) Pin fin – Concave parabolic



Types of fin

Fin Performance

It is essential to evaluate the performance of fins to achieve high heat transfer rate or minimum weight etc. Fin effectiveness, fin efficiency and total efficiency are some methods used for performance evaluation of fins.

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LITERATURE REVIEW

Moitsheki, R. J., & Rowjee, A. et al. [1] apply the Kirchoff transformation on the governing equation. Exact solutions satisfying the realistic boundary conditions are constructed for the resulting linear equation. Symmetry analysis is carried out to classify the internal heat generation function, and some reductions are performed. Furthermore, the effects of physical parameters such as extension factor _the purely geometric fin parameter_ and Biot number on temperature are analyzed. Heat flux and fin efficiency are studied.

Allouache, N. et al. [2] study deals with a solid adsorption refrigerator analysis using activated carbon/methanol pair. It is a contribution to technology development of solar cooling systems. The main objective consists to analyse the heat and mass transfer in an annular porous adsorber that is the most important component of the system. The porous medium is contained in the annular space and the adsorber is heated by solar energy. A general model equation is used for modelling the

transient heat and mass transfer. Effects of the key parameters on the adsorbed quantity, the coefficient of performance, and thus on the system performance are analysed and discussed.

Roux, S. M et al. [3] the purpose of this study to experimentally measure the flow field within a staggered array of short dimpled pin-fins and use the results to predict possible heat transfer enhancement on the end wall. Chen, H. T [4] et al. The finite difference method in conjunction with the least-squares scheme and experimental measured temperatures is applied to predict the average heat transfer coefficient h and fin efficiency h_f on a vertical annular circular fin of finned-tube heat exchangers for various in spacings in forced convection.

Demirel, Y. A. S et al. [5] A combination of the first and second law of thermodynamics has been utilized in analysing the convective heat transfer in an annular packed bed. The bed was heated asymmetrically by constant heat fluxes. Introduction of the packing enhances wall to fluid heat transfer considerably, hence reduces the entropy generation due to heat transfer across finite temperature deference. However, the entropy generation due to fluid friction increases. The net entropy generations resulting from the above effects provide a new criterion in analysing the system.

Chen, H. T et al. [6] The finite difference method in conjunction with the least-squares scheme and experimental temperature data is used to predict the average heat transfer coefficient and fin efficiency on the fin of annular-finned tube heat exchangers in natural convection for various fin spacings. The radiation and convection heat transfer coefficients are simultaneously taken into consideration in the presented study. Raj, M. H et al. [7] presents the heat transfer characteristics of the M20 refrigerant mixture, through a fin-and-tube evaporator, experimentally studied in an appliance tested in a psychometric test facility.

Shaeri, M. R et al. [8] The primary task of the fins employed in highly effective heat exchangers is to increase the heat transfer surface and heat transfer coefficient. Such a double effect can be achieved by a densely populated surface with elements in the form of interrupted lamellae or profiles with a smaller cross-section compared with their length.

Paul, S. C et al. [9] Natural convection thermal boundary layer adjacent to the heated inclined wall of a right angled triangle with an adiabatic fin attached to that surface is investigated by numerical simulations.

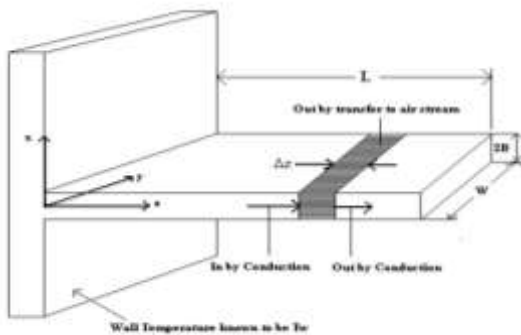
D. Merwin Rajesh K. et al. [10] A parametric model of piston bore fins has been developed to predict the transient thermal behaviour. The parametric model is created in 3D modelling software Pro/Engineer.

FIN EFFICIENCY AND EFFECTIVENESS

Fin efficiency, η

This quantity is more often used to determine the heat flow when variable area fins are used. Fin efficiency is defined as the ratio of heat dissipation by the fin to the heat dissipation takes place if the whole surface area of the fin is at the base temperature T_w .

Fins are employed to increase the rate of heat transfer from a surface by increasing the effective surface area. In the absence of fins, the heat convected by the base area is given by $Ah(T_w - T_\infty)$, where A is the base area. When the fins are present the heat transferred by the fin, can be calculated.



Fin Nomenclature

Physical Significance of the Effectiveness of Fins

The physical significance of the effectiveness of the fin is

1. For effectiveness $\epsilon_f = 1$ indicates that the addition of the fin to the surface does not affect heat transfer at all. In other word, the heat transfer to the fin through the base area A_w is equal to the heat transferred from the same area A_w to the surrounding medium.
2. An effectiveness of $\epsilon_f < 1$ indicates that the fin actually acts as insulation, slowing down the heat transfer rate from the surface to the surrounding. This situation can occur when fins made of low thermal conductivity materials.
3. An effectiveness of $\epsilon_f > 1$ indicates that the fins are enhancing heat transfer rate from the surface to the surrounding. However, the role of a fin cannot be justified unless η is sufficiently larger than 1. Finned surfaces are designed on the basis of maximizing effectiveness of a specified cost or minimizing cost for a desired effectiveness.

CONCLUSIONS

1. Thermal conductivity of the fin material should be high to give large fin effectiveness. This leads to the choice of aluminium and its alloys.
2. The ratio P/A should be as large as possible. This requirement can be achieved by the use of thinner fins. Use more thin fins of closer pitch than fewer thicker fins at longer pitch.
3. Effectiveness will be higher if heat transfer coefficient, h is lower. Generally convection in gas flow, and heat flow under free convection lead to lower values of heat transfer coefficient, h . Hence fins are used on the gas side of heat exchangers.

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