

# Optimization of Annular Fins by Modifying its Geometry with and without Perforations: A Review

Bhushan Pathak<sup>1</sup>, Purushottam Kumar Sahu<sup>2</sup>, Jagdish Saini<sup>3</sup>

<sup>1</sup>Research Scholar, BM College of Technology, Indore

<sup>2</sup>Professor & HOD, Dept of Mechanical Engineering, BM College of Technology, Indore

<sup>3</sup>Professors, Dept of Mechanical Engineering, BM College of Technology, Indore

\*\*\*

**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 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.

Annular fins are of cylindrical shapes and having extended surfaces on its periphery the shape of extended surface of fin may vary from disc shape, wedge shape etc. the number of extended surfaces may take into account for optimum performances.

**Key Words:** Fins, Perforated geometry, Fin effectiveness, Fin efficiency, Heat flux

## 1. INTRODUCTION

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.

### 1.1 Types of Fins and its applications

Fins are the extended surface that protrudes from a surface or body and are intended to increase the heat transfer rate between the surface and the surrounding fluid by increasing the heat transfer area. Example of area where fins are used

1. Air cooled I.C. engines
2. Refrigeration condenser tubes
3. Electric transformers

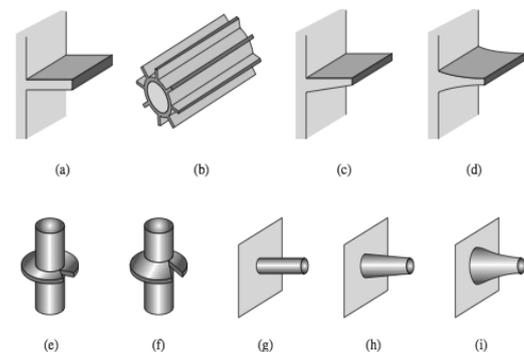
4. Reciprocating air compressors
5. Semiconductor devices
6. Automobile radiator

Finally, complete content and organizational editing before formatting. Please take note of the following items when proofreading spelling and grammar:

### 1.2 Fin Classification

Fins can be broadly classified as:

1. Longitudinal fin
2. Radial fin
3. Pin fin



**Figure: 1.1** Different types of fins

[Kraus, A. D., Aziz, A., & Welty, J. (2002). Extended surface heat transfer. John Wiley & Sons.p. 7]

- (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

### 1.3 Fin Efficiency

It is defined as the ratio between the actual heat transfer rate that occurs in the rib and the maximum possible heat transfer rate that could occur in the rib when the entire fin is at base temperature.

The entire fin has its fundamental temperature only if the fin material has an infinite thermal conductivity.

$$\eta_{\text{fin}} = Q_{\text{act}} / Q_{\text{max, possible}}$$

### 1.5 Fin Effectiveness

It is defined as the ratio between the heat transfer rate of the fins and the heat transfer rate without fins.

$$\epsilon_{\text{long end}} = Q_{\text{fin}} / Q_{\text{(endless)}}$$

### 1.6 Generalized equations:

The temperature between the hot surface and the surrounding liquid is proportional to the range of contact or exposure between them. "The Newtonian cooling law can be expressed as

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

Where,

$h$  = convection heat transfer coefficient

$T_s$  = Hot surface temperature

$T_{\infty}$  = Fluid temperature

$A$  = area of contact or exposure

Therefore, the convective heat transfer can be increased in one of the following ways:

1. Increase the temperature difference ( $T_s$ ) between the surface and the liquid.
2. Increase the convective heat transfer coefficient by improving the fluid flow or flow rate in the body.
3. Increase the contact or contact area between the surface and the liquid.

In most cases, controlling the temperature difference is not possible, and increasing the heat transfer coefficient may require installing a pump or fan or replacing the existing fan with a new one. At a higher capacity, the alternative is to increase the usable area through extensive areas or fins.

The heat is conducted from the base to the wing at the root, and while traveling along the length of the rib, the heat is also transferred from the surface of the fin with the heat transfer coefficient to the ambient fluid by convection of  $h$  in  $W / m^2\text{-Kelvin}$ , Consider a differential element of the fin of length  $dx$ .

Let  $Q_x$  is the heat conducted in to the element along  $x$ -direction given by

$$Q_x = -kAc (dT/dx) \quad \text{(from Fourier law of heat conduction)}$$

Where  $k$  = thermal conductivity of fin material

$A_c$  = Area of cross section of the fin

## 2. LITERATURE REVIEW

Fins are crucially used for many applications like in IC engine, radiators, condenser, cooling towers etc. Researchers do a number of things for improvement in effectiveness and efficiency of fins. Some of them are described as follows:

Brown, A. in 1965 [1] derived an equation relating the optimum dimensions of uniform annular fins to the heat transfer and thermal properties of the fin and the heat-transfer coefficient between the fin and coolant. Ullmann [2] et. Al. in 1989 examines Four different cross-section shapes namely constant thickness, constant area for heat flow, triangular and parabolic fin shapes. The fin efficiency together with the optimized dimensions are presented, which enables the design of the best fin for any practical use. Niazmand, H et al. [3] in 2012 investigated the performance of annular fins of different profiles subject to locally variable heat transfer coefficient.

Ganji et al. in 2011 [4] used homotopy perturbation method to evaluate the temperature distribution of annular fin with temperature-dependent thermal conductivity and to determine the temperature distribution within the fin. Arslanturk, C. et al [5] in 2005 obtained a Simple correlation equations for optimum design of annular fins with uniform cross section. The data from the present solutions is correlated for a suitable range of Biot number and the fin volume. Keller, H. H et al [6] in 1959 proposed a two-dimensional solution for annular fins, given in graphical form with the efficiency plotted versus the design-parameter group. Malekzadeh, P et al [7] in 2007 presented an incremental differential quadrature (IDQ) analysis of the two-dimensional nonlinear transient heat transfer analysis of variable section annular fins is presented.

## 3. CONCLUSION

From literature it can be concluded that the fins are having a wide range of applications and are continuously being optimized from a decade researchers have worked a lot for its optimization including heat dissipation rates, fin geometries, static and variable heat transfer coefficients, fin perforation to optimize mainly two important parameters associated namely fin efficiency and fin effectiveness and it can be concluded that there is still a vast scope to carry on work on fin optimization in some or other different ways.

## 4. FUTURE SCOPE

Although a lot of research is being carried out in annular fins but a researcher may carry some kind of analysis to

optimize the fin performance to even a better level and for that the researcher may optimize the fin material, fin geometry, may include the perforations in the extended surfaces to optimize the fin efficiency and fin effectiveness. One may carry some fruitful analysis for design optimization either in a real environment or in some kind of virtual environment or may go for the different software packages to retrieve the best possible solution.

Different kind of shapes of elongated fins may be used either with number of fins used, the kind of perforations along with different perforation sizes may be used and also by varying the geometry of fin surfaces like simple disc shape, wedge shape etc.

## REFERENCES

- [1] Brown, A. (1965). Optimum dimensions of uniform annular fins. *International journal of heat and mass transfer*, 8(4), 655-662.
- [2] Ullmann, A., & Kalman, H. (1989). Efficiency and optimized dimensions of annular fins of different cross-section shapes. *International journal of heat and mass transfer*, 32(6), 1105-1110.
- [3] Niazmand, H., & Dabzadeh, I. (2012). Numerical simulation of heat and mass transfer in adsorbent beds with annular fins. *International Journal of Refrigeration*, 35(3), 581-593.
- [4] Ganji, D. D., Ganji, Z. Z., & Ganji, H. D. (2011). Determination of temperature distribution for annular fins with temperature dependent thermal conductivity by HPM. *Thermal Science*, 15(5), 111.
- [5] Arslanturk, C. (2005). Simple correlation equations for optimum design of annular fins with uniform thickness. *Applied Thermal Engineering*, 25(14-15), 2463-2468.
- [6] Keller, H. H., & Somers, E. V. (1959). Heat transfer from an annular fin of constant thickness. *Journal of Heat Transfer*, 81(2), 151-156.
- [7] Malekzadeh, P., & Rahideh, H. (2007). IDQ two-dimensional nonlinear transient heat transfer analysis of variable section annular fins. *Energy conversion and management*, 48(1), 269-276.