 ISSN: 2321-8169
1353 – 1357

Performance of Annular Fin with Different Profile Subjected to Heat Transfer Coefficient by using FEA

Akash Jain
Mechanical Engineering Department
Institute of Engineering and technology, DAVV
Indore (M.P.), India
Akashjain0104@gmail.com

Mr. Santosh Kansal
Mechanical Engineering Department
Institute of Engineering and Technology, DAVV
Indore (M.P.), India
skansal@ietdavv.com

***Abstract*—**Performance of annular fins of different profiles subject to heat transfer coefficient is investigated in this paper. The concept of heat transfer through annular fin of different profiles is one of the methods for improving heat transfer rate by natural convection in heat exchangers. Annular fins are used in heat exchange devices to enhance the heat transfer rate. Temperatures vary with the geometry of the fins and along the fluid flow direction. Temperature changes according to its geometry and profile of fins. The heat transfer from the fin is dominated by natural convection, the analysis of fin performance based on locally variable heat transfer coefficient would be of primer importance. The local heat transfer coefficient as a function of the local temperature has been obtained using the available correlations of natural convection for plates.By using the ANSYS software find the temperature profile and its effect on different profile of annular fins and find the maximum heat transfer theoretically.Results have been obtained and presented in a table for annular fins of hyperbolic, triangular, concave parabolic and convex parabolic profiles.

Temperature distribution at different sections and total heat flow is estimated for the finned tube with fins of triangular profile, concave and convex parabolic and hyperbolic profile. A comparison has been made among finite element analysis.

Keywords-*Extented surface, Heat transfer coefficient, Maximum heat transfer, Temperature distribution, Heat exchanger. ANSYS*

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INTRODUCTION

Annular fins find numerous applications in compact heat exchangers, in specialized installations of single and double-pipe heat exchangers, in electrical apparatus in which generated heat must be efficiently dissipated, on cylinders of air cooled internal-combustion engines, etc. In a conventional heat exchanger heat is transferred from one fluid to another through a metallic wall. The rate of heat transfer is directly proportional to the extent of the wall surface, the heat transfer coefficient and to the temperature difference between one fluid and the adjacent surface. The heat transfer rate may be increased by increasing the surface area across which convection occurs. This may be done by using fins that extend from the wall of heat exchanger into the surround fluid. The thermal conductivity of the fin material has a strong effect on the temperature distribution along the fin and thus the degree to which the heat transfer rate is enhanced. However, the average surface temperature of these strips (fins), by virtue of temperature gradient through them, tends to decrease approaching the temperature of the surrounding fluid so the effective temperature difference is decreased and the net increase of heat transfer would not be in direct proportion to the increase of the surface area and may be considerably less than that would be anticipated on the basis of the increase of surface area alone. However, the average surface temperature of these strips (fins), by virtue of temperature gradient through them, tends to decrease approaching the temperature of the surrounding fluid so the effective temperature difference is decreased and the net increase of heat transfer would not be in direct proportion to the increase of the surface area and may be considerably less than that would be anticipated on the basis of the increase of surface area alone.

The heat transfer is directly proportional to the heat transfer coefficient and temperature difference between fin surfaces to fluid. Increasing the temperature difference between the object and the environment, increasing the convection heat transfercoefficient or increasing the surface area of the object increases the heat transfer

For various fins can dissipate different amounts of heat because of the different shape and geometry. The goal of fin optimization is to find the shape of the fin which would maximize the heat dissipation for a given fin volume.

Increasing the temperature difference between the fin and the environment, increasing the convection heat transfer coefficient or increasing the surface area of the object increases the heat transfer. Sometimes it is not economical or it is not feasible to change the first two options. Adding a fin to an object, however, increases the surface area and can sometimes be an economical solution to heat transfer problems. Finite element analysis (FEA) has become commonplace in recent years for the analysis of most of the systems which are subjected to different conditions.

The thermal conductivity and heat transfer coefficient are assumed to vary with a linear and power-law function of temperature, respectively. [5]The heat transfer rate is more at the section where the fins are present. Heat transfer rate is also depends on the difference between the local surface temperature and the ambient temperature. [4]

The deviation between the fin efficiency calculated based on constant heat transfer coefficient and that calculated based on variable heat transfer coefficient increases with both the dimensionless parameter m and the radius ratio of the fin.[6]

Objective

The main objectives of this research are to show the performance, find the local heat transfer coefficient and maximum heat transfer of annular fin of different profiles subjected to natural convection

Geometry of Fin Profile

Fig. 1 depicts a general annular fin profile and shows the main geometric profile parameters. The fin profile is defined according to the variation of the fin thickness along its extended length. The general equation of the radial fin profiles studied in the present article is

$$Y_r = Y_b(R_o – R)^n \qquad (1)$$

Where n is the profile index; n=0 represents the constant thickness fin which has a rectangular profile. n=1/2 corresponds to the convex parabolic fin profile while n=1 describes the triangular fin profile with straight surfaces. The value of n=2 gives the concave parabolic profile. All the fin profiles considered in the present study start with a thickness Y_b at the base. The triangular, convex parabolic and concave parabolic profiles have tips at their ends (i.e., y = 0 at r =r_o) while the rectangular has a constant thickness along the fin.

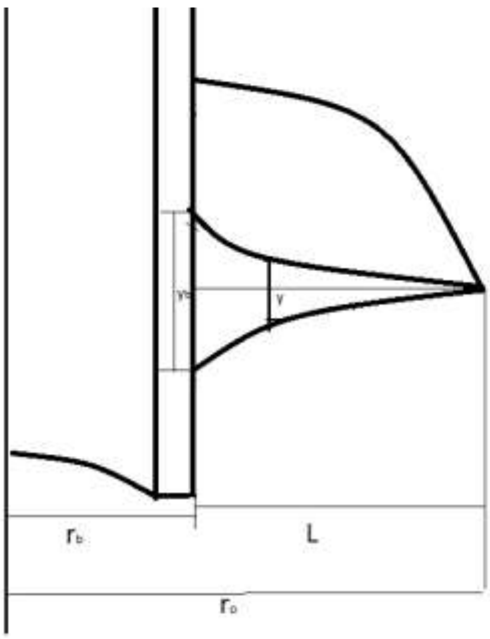


Fig. 1

The annular fins with constant area for heat flow have a hyperbolic profile. For such a profile, the thickness of the fin varies with the radius such that y .r= constant, and the profile can be expressed as

$$Y_r = Y_b\left(\frac{Rb}{R}\right) \qquad (2)$$

Where, $R_b = \frac{rb,}{L}$, $R_o = \frac{r_o}{L}$, $R = \frac{r}{l}$

The hyperbolic fin has a sharp edge at infinity, but in practice, it is cut off at a distance r_o from the axis of symmetry.

Specification of Fin Geometry

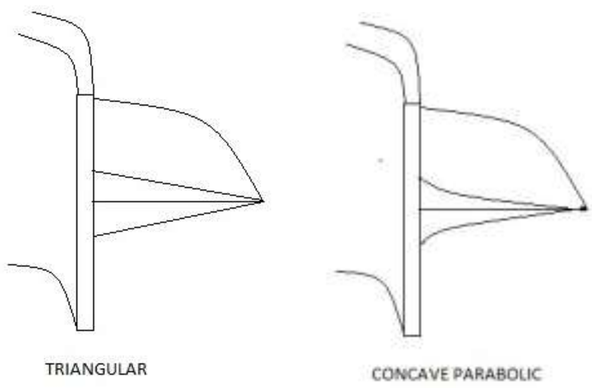
Experimental analysis was done on the heat exchanger (Finned tube heat exchanger) model, inside and outside convection heat transfer coefficients are estimated by passing preheated air through the tube and over the tube by the help of draught fan.

Specifications of Finned Tube Heat Exchanger
Inner diameter of bare tube: 0.051m
Outer diameter of bare tube: 0.064m
Fin material: Aluminum
Thickness of each fin at base: 2.73 m
Height of fin: 11.325 m
Mean temperature of air inside the tube = 80ºC
Length of Intercooler: 0.05m
Inside convective heat Transfer coefficient=26.32W/m²k

Profiles of Fin

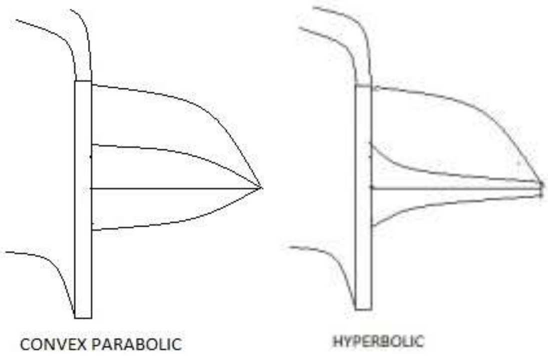
Four different radial fin profiles are used for the fin shape optimization.
The shapes of fins, used in simulations, are shown in fig. 2(a)-(d)

(a) (b)



ISSN: 2321-8169
1353 – 1357

(c) (d)



Design and modeling of annular fin:-

- All the specifications of annular fin such as dimensional parameters of fin, thickness and length of the fin.
- Modeling of fin profile by using CREO PARAMETRIC 2.0

Design procedure:-

1. Sketching- First of all CREO PARAMETRIC Software is being open with a new part file and by selecting an appropriate out of principle planes and using sketcher draw the pipe dimensions and extrude an appropriate length and our 3D model of pipe complete.
2. After successful completion of design of pipe we need to model of profile of annular fin for which select a plane front view of pipe and select a reference which is a base of the fin choose a fin inner thickness and length draw a fin profile.
3. After draw the fin profile revolve it about pipe axes in around of pipe and become a annular fin. And different type of fin profile can be designed and revolve and making a different annular fin.

Theoretical Analysis

the local heat transfer coefficient, h_r, will be calculated approximately using correlations that give the average Nusselt number for free convection from isothermal horizontal surface. This would be a good approximation in which the finite strip of the fin for which the governing equation is applied is considered locally isothermal.

This approximated local heat transfer coefficient, h_r, will be calculated from the following equation:

$$h_r = \frac{Nu.k}{r} \quad (3)$$

Where k =is the ambient fluid thermal conductivity

r = is the local characteristic length (local radius of the fin)

Nu = is the local nusselt number

Local Nusselt number which can be calculated based on the empirical natural convection correlations for plates [7]

$$Nu = 0.54\, Ra_r^{1/4}, \quad 10^4 \leq Ra_r \leq 10^7 \quad (4)$$

Where,

$$Ra_r = \frac{ß.g.\theta.r^3}{\upsilon^2}.\, Pr_r \quad (5)$$

Where, ß= volumetric coefficient of thermal expansion (1/K)

$\Theta = (T_{fin} - T_{atm})$

υ =kinematic viscosity of the ambient fluid (m²/s)

Thermal Analysis

Temperature profile of the annular fins is found out by using ANSYS 14.5for different profiles and surface area of fin calculated by using CREO 2.0.

Fig. 1-4 Show temperature profiles of the annular fin of triangular, concave parabolic, convex parabolic and hyperbolic profile. Which show the different temperature at different radius.

Fig. 1. Temperature profile of triangular shape

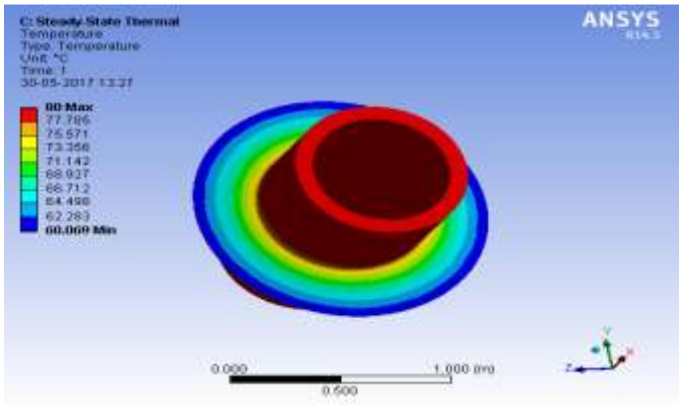


Fig. 2. Temperature profile of parabolic concave shape

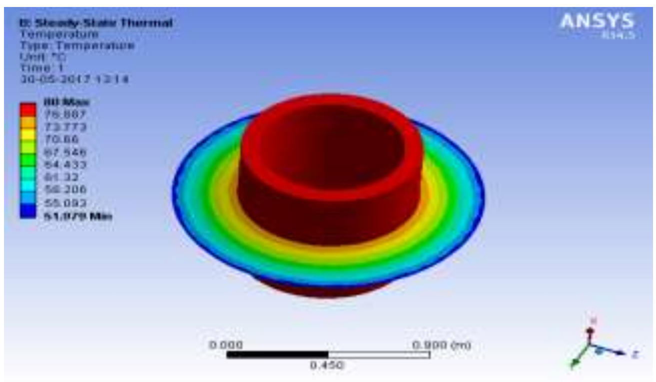


Fig. 3. Temperature profile of parabolic convex shape

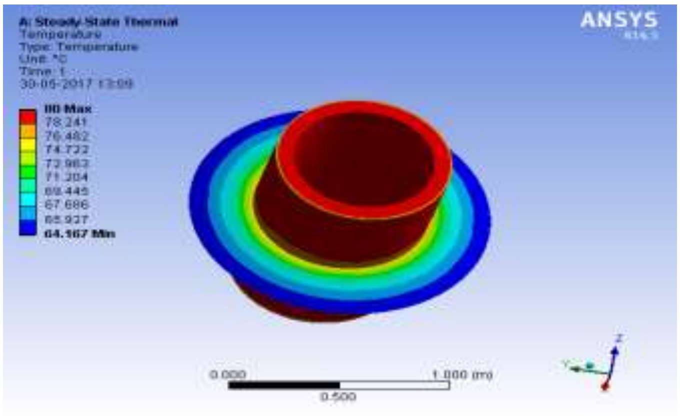
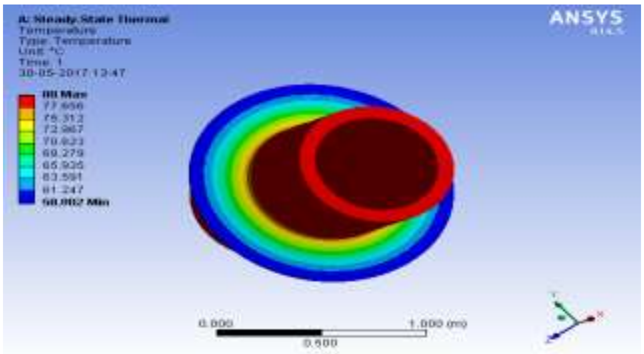


Fig. 4. Temperature profile of hyperbolic shape



Result and Discussion

Temperature at different radius

Fin Profile	Temperature at base	Temperature at center	Temperature at tip
Triangular	75.571	68.927	60.069
Concave parabolic	76.887	67.546	51.97
Convex parabolic	76.482	67.687	64.167
Hyperbolic	75.312	65.925	58.90

Table (1)

Find the heat transfer coefficient by using equation (3), (4) and (5) equations.

Heat transfer coefficient (W/m^2k)

Fin Profile	Heat transfer coefficient base	Heat transfer coefficient at center	Heat transfer coefficient at tip
Triangular	7.81	6.28	5.194
Concave parabolic	7.91	6.15	2.95
Convex parabolic	7.88	6.09	5.617
Hyperbolic	7.71	6	5.018

Table (2)

Estimation of maximum Heat transfer through fin.

$$Q = \eta A_{fin} h_{max} (T_{surface} - T_{atm}) \qquad (6)$$

Where, η is 94%

Find the area of each fin by using CREO 2.0

Fin Profile	Area (m^2)
Triangular	3.09×10^{-3}
Concave parabolic	2.86×10^{-3}
Convex parabolic	3.10×10^{-3}
Hyperbolic	3.189×10^{-3}

Table (3)

The consideration of maximum possible heat transfer coefficient and temperature along the fin as those at the base would result in a large value of the maximum possible heat transfer from the fin compared to that calculated based on the actual heat transfer coefficient from the fin while considering only the temperature to be the maximum possible of that at the base.

Calculate the maximum heat transfer by using equation (6).

Maximum Heat transfer

Fin Profile	Q_{max} (W)
Triangular	0.560
Concave parabolic	0.596
Convex parabolic	0.551
Hyperbolic	0.561

Table (4)

Concave parabolic profile fins are generally adopted as the heat transfer is more when compared to the other profile. To know the heat transfer with concave parabolic fin, the intercooler is modeled and analyzedin ANSYS withthe same conditions as that of circular fin of other profile.

Results obtained for annular fins subject to variable heat transfer coefficient are presented in table 2for annular fins of hyperbolic, triangular, concave and convex profiles, respectively.

Conclusion

Heat transfer from annular fins subject to variable heat transfer coefficient has been studied. The local heat transfer

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1353 – 1357

coefficient as a function of the local temperature has been obtained using the available correlations of natural convection for plates.

Heat flow for annular fins of concave parabolic profile from the analysis is obtained as 0.596 W which is more than the heat flow for annular fins of other profiles.

Fins of concave parabolic profile are suggested because for equivalent heat transfer it requires much less volume (fin material) than other profiles.

But, in view of their larger manufacturing costs, annular fin of triangular profile is commonly used , which is justified as the heat flow is only 6.04% more in case of concave parabolic fins.

The use of the present results by the designers of heat transfer equipment that involve annular fins subject to natural convection heat transfer mode would result in a considerable reduction in the extended surface area and hence a significant reduction in the weight and size of the heat transfer equipment.

REFERENCES

[1] Milbin Koshy, Optimization of Fins Used in the Heat Exchanger Tubes, IJIRSET Vol. 4, Issue 7, July 2015.

[2] M.T. Darvishi, F. Khani, Numerical investigation for a hyperbolic annular fin with temperature dependent thermal conductivity,

[3] Syed M. Juber, Efficiency and optimization of an annular fins with combined heat and mass transfer, International journal of refrigeration, 30 (2007).

[4] S. Pashah, Abdurrahan Moinuddin, Syed M. Zubier, Thermal performance and optimization of hyperbolic annular fins under dehumidifying operating conditions – analytical and numerical solutions, International journal of refrigeration 65 (2016)

[5] Sikindar Baba.Md, Nagakishore.S, Prof. M. Bhagvanth Rao, Thermal analysis on a finned tube heat exchanger of a two stage air compressor, IJRASET, Vol.2Issue V, May 2014.

[6] Esmail M.A. Mokheimer, Performance of annular fins with different profile subjected to variable heat transfer coefficient, International Journal of Heat and Mass Transfer 45 (2002) 3631–3642.

[7] Younus A. Cengel, Heat Transfer a Practical Approach, McGraw-Hill, New York, Second Edition.

[8] I. G. Aksoy, Thermal analysis of annular fins with temperature-dependent thermal properties, Appl. Math. Mech. -Engl. Ed., 34(11), 1349–1360 (2013)