iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** XI **Month of publication:** November 2016

DOI:

www.ijraset.com
IC Value: 13.98

Volume 4 Issue XI, November 2016
ISSN: 2321-9653

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Calculation of Effectiveness on the Fin Inside One-Tube Plate Finned-Tube Heat Exchanger

Dibya Tripathi[1], Dwivesh Kumar Dubey[2], Surya Ved Prakash[3], Meeraj Ahmad[4], Vivekanand[5]
[1,3]*Student*
[2,4,5]*Faculty, Rajkiya Engineering College, Azamgarh, U.P*

Abstract: The finite difference method in conjunction with the least-squares scheme and the experimental temperature data is proposed to calculate fin effectiveness, on the fin inside one-tube plate finned-tube heat exchangers for various air speeds and the temperature difference between the ambient temperature and the tube temperature. Previous work has been done to predict fin efficiency. Fin effectiveness is also a measure significant in fin study.

Keywords- Heat Exchanger, Fin, Effectiviness.

I. INTRODUCTION

The fins in heat exchanger are always applied to increase the flow rate per unit area. Tube fin exchangers are extensively used as condensers and evaporators in air conditionings and refrigeration applications, for cooling of water or oil of vehicles or I.C.engines, and as air cooled exchangers in the process and power industries.

Comini et al. 2009 has studied the 'one dimensional design procedure of finned tube heat exchanger' and has assumed that the temperature distribution is one-dimensional.

Nomenclature

A_f	area of the whole plate fin, m^2	Re_d	Reynolds number
A_j	area of the jth sub-fin region, m^2	r_o	outer radius of the circular tube, m
$[A]$	global conduction matrix	S_1	outer boundary surface of the circular tube
d_o	outer diameter of a tube, m	T	temperature
$[F]$	force matrix	T_j	temperature measurement on the jth sub-fin region
h	local heat transfer coefficient, W/m^2 K	T_o	outer surface temperature of the circular tube
$\bar{h}$	unknown average heat transfer coefficient on the whole plate fin, W/m^2 K	T_∞	ambient temperature
$\bar{h}_j$	unknown average heat transfer coefficient on the jth sub-fin region, W/m^2 K	ΔT	temperature difference, $T_o - T_\infty$
k	thermal conductivity of the fin, W/m K	V_{air}	frontal air speed, m/s
L	side length of a square plate fin, m	X, Y	spatial coordinates, m
ℓ	distance between two neighboring nodes in the x- and y-directions	x, y	dimensionless spatial coordinates
m	dimensionless parameter defined in Eq. (5)		*Greek symbols*
$\bar{m}_j$	unknown dimensionless parameter on the jth sub-fin region defined in Eq. (10)	δ	fin thickness
N	number of temperature measurements on the fin	η_f	fin efficiency
N_x	number of nodes in the x-direction	ν	kinematic viscosity of the air, m^2/s
N_y	number of nodes in the y-direction	θ	temperature difference, $T - T_\infty$
Q	total heat flux dissipated from the whole plate fin, W	$[\theta]$	global temperature matrix
q_j	heat flux dissipated from the jth sub-fin region, W		*Superscripts*
		cal	calculated value
		mea	measured data

Lee kim 2009 has studied 'Air-side heat transfer characteristics of spiral-type circular fin-tube heat exchangers' to investigate the air-side heat transfer characteristics. Lee et al. 2010 has studied 'Air-side heat transfer characteristics of flat plate finned-tube heat exchangers with large fin pitches under frosting conditions.

Chen et al. 2012 studied the 'Study of heat-transfer characteristics on the fin of two-row plate finned-tube heat exchanger' and

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

applied the experimental and numerical inverse methods to determine the average heat transfer coefficient and heat transfer coefficient under the isothermal situation on a vertical square fin of the two-row plate finned-tube heat exchangers.

II. ANALYSIS

In this study fin is analyzed to calculate fin effectiveness on one fin inside one-tube plate fin. Fin is inserted in tube of circular shape and air is flowing in cross flow direction and water is flowing through the tube, and thus heat is transmitted. To study, the fin is divided into six sub fin region.

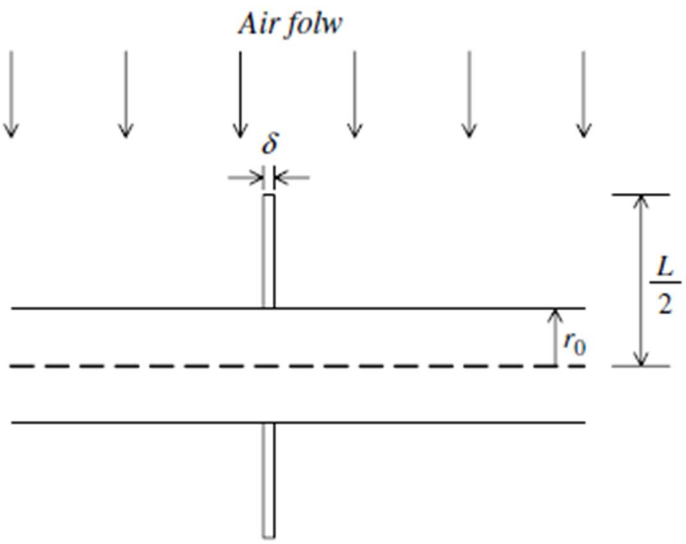


Figure1. Schematic diagram of on tube plate fin.

This shows the physical model of the two-dimensional thin plate fin inside a one-tube plate fin heat exchanger, where ro, L and d denote the outer radius of the circular tube, the side length of the square plane fin and the fin thickness, respectively. The ‘‘insulated tip’’ assumption can be an adequate approximation provided that the actual heat flux dissipated through the tip. Under the assumptions of the steady state and the constant thermal properties, the two dimensional heat conduction equation for the continuous thin fin inside a plate finned-tube heat exchanger.

$$\partial^2T/\delta X^2 + \partial^2T/\delta Y^2 = 2h(X, Y)(T-T\infty)/k\delta \quad (1)$$

Its corresponding boundary conditions are-

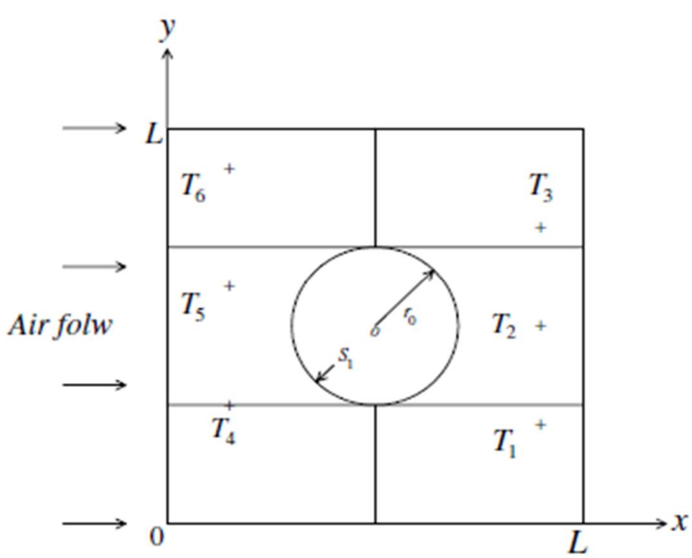


Figure 2. geometry of fin.

$\partial T/\partial X=0$, at $X=0$ and $X=L$ (2)
$\partial T/\partial Y=0$, at $Y=0$ and $Y=L$ (3)
$T=T0$ (X, Y) on S1 (4)

Where T is the fin temperature. X and Y are Cartesian coordinates.
S1 denotes the boundary of the circular tube with radius ro. k is the thermal conductivity of the fin.
For convenience of the inverse analysis, the following dimensionless parameters are introduced as-

$x=X/L$, $y=Y/L$, and $m(x, y)=2L^2h(x, y)/k\,\delta$ (5)

Substitution of Eq. (5) into Eqn (1)–(4) gives the following equations-

$\partial^2\theta/\partial x^2 + \partial^2\theta/\partial y^2 = m(x, y)\theta$ (6)
$\partial\theta/\partial x=0$, at $x=0$ and $x=1$ (7)
$\partial\theta/\partial y=0$, at $y=0$ and $y=1$ (8)
And
$\theta=0$ (x, y) on S1 (9)
Where $\theta = T-T\infty$

In the present study, the whole plate fin is divided into N sub-fin regions. The heat transfer coefficient on each sub-fin region is assumed to be constant. With the application of the finite difference method to Eq. (6) can produce the following difference equation on the *kth* sub-fin region as-

$(\theta i+1,j - 2\theta i,j + \theta i-1,j)/l^2 + (\theta i+1,j -2\theta i,j + \theta i-1,j)/l^2 = \bar{m}k\theta i,j$ (10)

For k=1,2,3...............,N

Where, l is the distance between two neighbouring nodes in the x- and y-directions and is defined as-

l = 1/(Nx-1) = 1/(Ny-1)

where Nx and Ny are the nodal numbers in x- and y-directions, respectively. $\bar{m}k$ denotes the unknown dimensionless parameter on the *k*th sub fin region and is defined as $\bar{m}k$= $2L^2\bar{h}k/(K\delta)$, where $\bar{h}k$ denotes the average heat transfer coefficient on the *k*th sub fin region.

Rearrangement of eqn (10) in conduction with difference equations in the neighbouring of the circular tube can yield the following matrix equation.

[A][θ] = [F] (18)

Where [A] is global conduction matrix. [θ] is a matrix representing the nodal temperature. [F] is a force matrix. With this a set of N algebraic equations are obtained, and by solving equations, heat transfer coefficient, and heat transfer are obtained for sub-fin region.

III. FIN EFFECTIVENESS

Effectiveness is a measure of thermal performance of a heat exchanger. It is defined for a given heat exchanger of any flow arrangement as a ratio of the actual heat transfer rate from the hot fluid to the cold fluid to the maximum possible heat transfer rate *qmax* thermodynamically permitted. "It is defined as the ratio of the fin heat transfer rate to the heat transfer rate that would exist without the fin".

The effectiveness of the plate fin ε is calculated from the formula-

$\varepsilon = q_{with\ fin}/q_{w/o\ fin}$

$\varepsilon = \sqrt{(kp/hA)}$

$\varepsilon = \sqrt{(k/h\delta)}$

$\varepsilon_{fin} = 1$ Does not affect the heat transfer at all.

$\varepsilon_{fin} < 1$ Fin act as insulation (if low k material is used)

$\varepsilon_{fin} > 1$ Enhancing heat transfer (use of fins justified if $\varepsilon_{fin}>2$)

IV. RESULT

In this work attempt has been made to calculate fin effectiveness for various velocity of air flowing through plate fin. Heat transfer coefficient for different sub fin region is calculated first and then effectiveness.

Volume 4 Issue XI, November 2016
ISSN: 2321-9653

	V1	V2	V3	V4	V5
h1	5.5875	5.5869	7.5878	9.6146	10.4938
h2	5.7941	15.5606	18.9656	18.4412	25.9454
h3	5.3104	6.6349	8.6208	11.0224	12.8045
h4	5.1242	9.211	9.2462	12.1108	12.9194
h5	43.8683	47.5002	96.4123	131.7694	157.7106
h6	11.3691	12.3908	41.2363	39.8819	38.4363

The result has been shown below for the three different material steel, aluminum, and copper. The thermal conductivity of these three materials are-

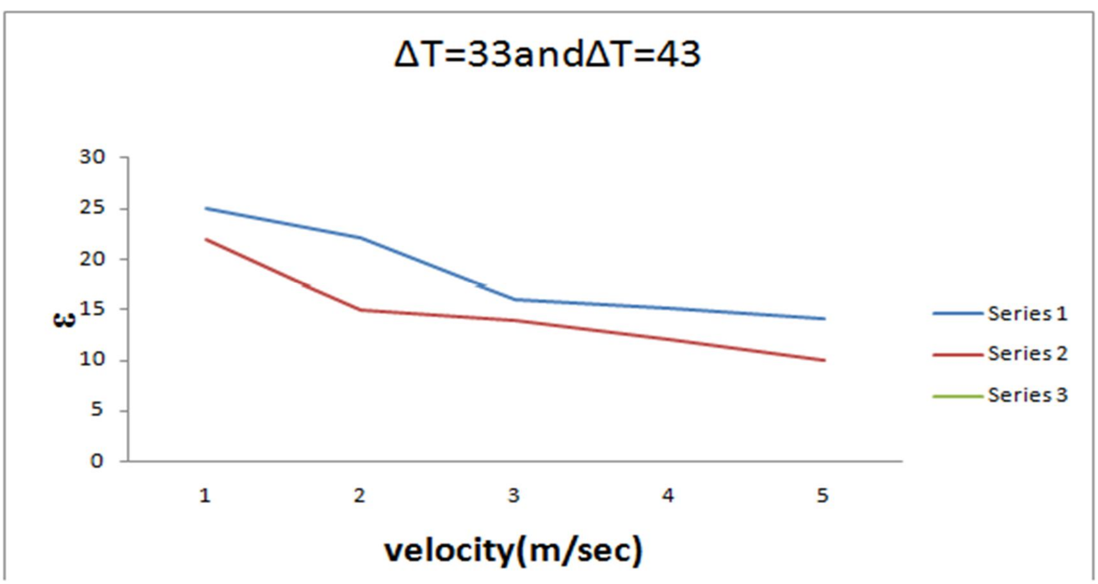
Ksteel = 14.5 W/mk
Kal=200 W/mk
Kcu=400 W/mk

εsteel	25	22	16	15	14
εal	69	61	45	40	38
εcu	80	71	52	47	44

V. CONCLUSION

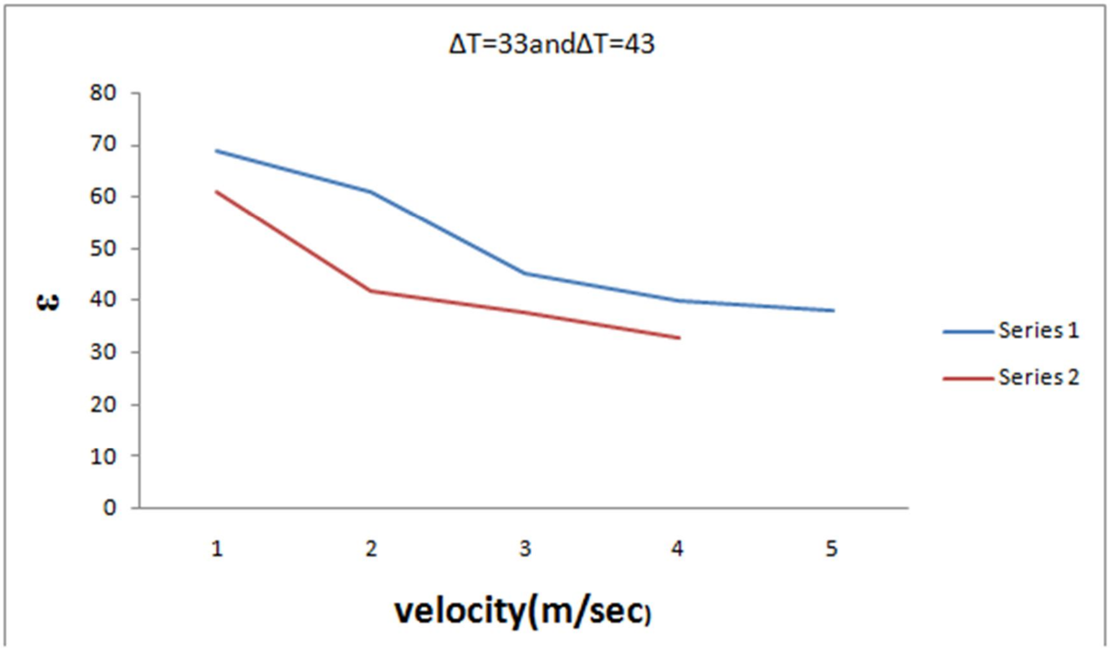
It is seen that aluminum is preferred for fin material of a heat exchanger, because it has low cost, low weight, and ability to resistance corrosion.Though the effectiveness of copper is more than the aluminum but cost of aluminium is cheaper than copper. Thus from economic point of view aluminium is used as fin material. Effectiveness of fin made of copper is more than aluminium, because the thermal conductivity of copper is more.

The variation of effectiveness with velocity of air for three material are shown below-

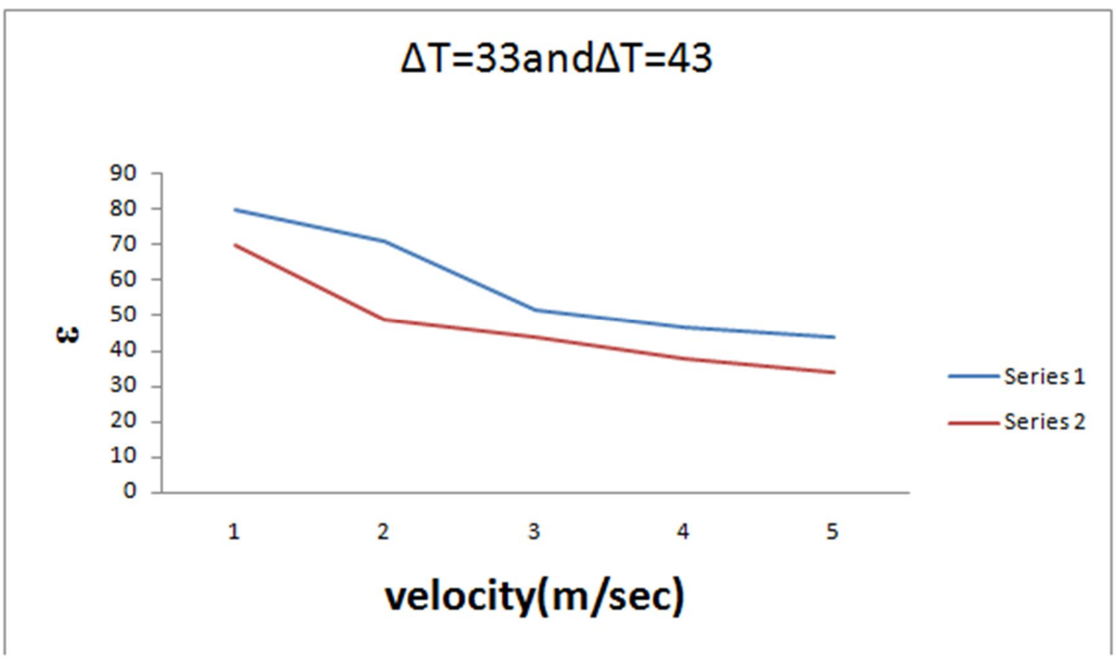


Variation of **ε** under various ΔT conditions for steel

Volume 4 Issue XI, November 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)



Variation of **ε** under various ΔT conditions for aluminium



Variation of **ε** under various ΔT conditions for copper

REFERENCES

[1] Chen, join rong, "Study of heat transfer characteristics of two row plate finned tube heat exchanger," International journal of heat and mass transfer vol.55, (2012), 4088-4095
[2] Comini, savino,"Accuracy of one-dimensional design procedures for finned-tube heat exchangers", Applied Thermal Engineering 29 (2009) 2863–2869
[3] Han-Taw Chen, chou, "Investigation of natural-convection heat transfer coefficient on a vertical square fin of finned-tube heat exchangers",International Journal of Heat and Mass Transfer 49 (2006) 3034–3044
[4] Han-Taw Chen, wei-lun Hsu, "Estimation of heat transfer coefficient on the fin of annular-finned tube heat exchangers in natural convection for various fin spacings" International Journal of Heat and Mass Transfer 50 (2007) 1750–1761

[5] Han-Taw Chen, wei-lun Hsu, "Estimation of heat-transfer characteristics on a vertical annular circular fin of finned-tube heat exchangers in forced convection", International Journal of Heat and Mass Transfer 51 (2008) 1920–1932

[6] Jang, J.T. lai, "Numerical and experimental analysis of heat transfer in finned tube heat exchanger", International conference on CFD and mineral processing CSIRO (1997)

[7] Jiong, kim, yuon, "A study on the correlation between the thermal contact conductance and effective factors in fin–tube heat exchangers with 9.52 mm tube", International Journal of Heat and Fluid Flow 25 (2004) 1006–1014

[8] Jiong, kim, yuon, "A study on the thermal contact conductance in fin–tube heat exchangers with 7 mm tube", International Journal of Heat and Mass Transfer 49 (2006) 1547–1555

[9] Jung, yang, "3D numerical and experimental analysis for thermal–hydraulic characteristics of air flow inside a circular tube with different tube inserts, "Applied Thermal Engineering 29 (2008) 250–258.