IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

ANALYSIS AND COMPARISON OF DIFFERENT TYPES OF FINS IN NATURAL CONVECTION USING ANSYS WORKBENCH

Aqive Ahmad, Akhlesh Kumar Shakya

Student, Professor
Mechanical Engineering,
All Saints College of Engineering, Bhopal, India

Abstract:
In this thesis during the analysis of various fins configurations using ANSYS WORKBENCH be can compare the The heat transfer rate from the fins, outer wall and the overall heat transfer rate has been calculated and compared for various fin configurations. Also the surface nusselt number and surface overall heat transfer co-efficient has been found out. Temperature contours for various fin configuration has been plotted showing the convection loops formed around the heated pipe surface. Velocity contours for various fin configurations has been plotted and the motion of heated fluid is shown. The assumptions during the analysis have been taken considering the manufacturing and practical applications and working conditions. Hence the results obtained can be referred to while solving any such kind of problems in the practical field where only natural convection is under consideration. After comparing it is shown that we can find that the best configuration for this type of convective heat transfer of a heated pipe is a TRAPEZOIDAL fin as they have the highest total heat transfer rate .

All the main parameters which can significantly influence the heat transfer performance of finned tube has been analyzed. Natural convection in a vertical tube without fins was taken as the reference tube and different fin patterns such as a single fin with large no. of turns like coiled shape and large no. of fins with single turn is compared with reference tube on the basis of different parameters such as heat transfer rate, surface nusselt number, heat transfer coefficient, fin effectiveness etc. There are some dimensionless numbers which affect the natural convection such as nusselt number which is the function of Reynolds number, grshof number and prandlt number, Rayleigh number which is the product of grashoff and prandtl number. After getting best fin configuration compared it with different fin profile such as rectangular cross section, tapered fin with trapezoidal cross section and hyperbolic cross section. All the computer simulation has been done on the ANSYS 13.0 .

This study has been undertaken to investigate the determinants of stock returns in Karachi Stock Exchange (KSE) using two assets pricing models the classical Capital Asset Pricing Model and Arbitrage Pricing Theory model. To test the CAPM market return is used and macroeconomic variables are used to test the APT. The macroeconomic variables include inflation, oil prices, interest rate and exchange rate. For the very purpose monthly time series data has been arranged from Jan 2010 to Dec 2014. The analytical framework contains.

***Index Terms* – Heat Transfer, Heat Exchangers, Fins, Conduction, Convection, Radiation, Concave, Trapezoidal.**

I. INTRODUCTION

Whenever the available surface is found inadequate to transfer the required quantity of heat with the available temperature drop and convective heat transfer coefficient, extevded surfaces or fins are used. Invariably , is found necessary in heat transfer between a surface and gas as the convective heat transfer coefficient is rather low in these situations. A fin is a thin component or appendage attached to a larger body or structure. Fins typically function as foils that produce lift or thrust, or provide the ability to steer or stabilize motion while traveling in water, air, or other fluid media. Fins are also used to increase surface areas for heat transfer purposes, or simply as ornamentation. Fins first evolved on fish as a means of locomotion. Fish fins are used to generate thrust and control the subsequent motion. Fish, and other aquatic animals such as cetaceans, actively propel and steer themselves with pectoraland tail fins. As they swim, they use other fins, such as dorsal and anal fins to achieve stability and refine their maneuvering.

- Fins are most commonly used in heat exchanging devices such as
- Radiators in cars,
- Computer CPU
- Heat sinks, and
- Heat exchangers in power plants.
- They are also used in newer technology such as hydrogen fuel cells.
- Economizers for steam power plant,
- Convectors for steam and hot water heating systems,
- Air cooled engine cylinder heads,
- Cooling coils and condenser coils in refrigerators,
- Transformers and Electric and Electronic Instruments.
- Nature has also taken advantage of the phenomena of fins. The ears of jackrabbits and Fennec Foxes act as fins to release heat from the blood that flows through them.
- Various types of fins are usually used:
- Straight fins of uniform cross section
- Straight fins of non-uniform cross section
- Annular fins
- Cylindrical fins

1.2 HEAT TRANSFER BY EXTENDED SURFACE:

Convection heat transfer is governed by the relation:

$$Q = h\,A\,(T_w - T_\infty)$$

To increase the heat transfer rate the following ways can be adopted.

1. Increasing heat transfer co-efficient (h). However increasing the value of h does not significantly influence the value of Q.
2. Surrounding fluid temperature (T_∞) can be decreased. But it is often impractical as in most cases the surrounding is atmosphere.
3. Hence the only way is by increasing the surface area across which convection occurs.

The increase in cross sectional convection area can be achieved by using fins that exted from the wall of the convection shell. The thermal conductivity of the fin material has a very strong effect on the temperature distribution across the wall of the convection shell and thus the degree to which the heat transfer rate is enhanced.

Interrupted fins in the form of strips or louvered fins provide both a heat transfer surface area increase and also increase in the Effective heat transfer coefficient. Therefore these are particularly effective in obtaining high heat transfer rates. The mechanism which leads to high heat transfer coefficients of such fins is the periodic interruption of boundary layer around the fins and in this way also achieving better mixing with different temperature fluid streams. The exchange of heat energy is studied on a tube with circular cross-section and with specific inner and outer radius having outer disc shaped fins. The fins attached with the tube can be of variable shape and size. Three basic types of fins are considered and the transfer of heat energy from a tube with such fin configurations is estimated. Natural convection occurs due to temperature difference which produces the density difference which results in mass movement, this process is called natural or free convection. For example, assume a plate which is maintained isothermal at temperature T_w and the surrounding temperature is T_∞. On getting heated, the fluid near the wall moves up due to the effect of buoyancy and this hot fluid is replaced by cold fluid moving towards the wall. Hence a circular current is set up due to density difference. There is a boundary layer adjacent to the plate where the velocity and temperature and velocity vary from plate to free stream. Initially the velocity increase with increasing distance from the surface and reaches a maximum and then decrease to approach zero value. This is because of action of viscosity diminishes rapidly with distance from plate, while density difference decreases more slowly

- Pin fins
- Rectangular
- Conical
- Parabolic
- Trapezoidal

Rectangular

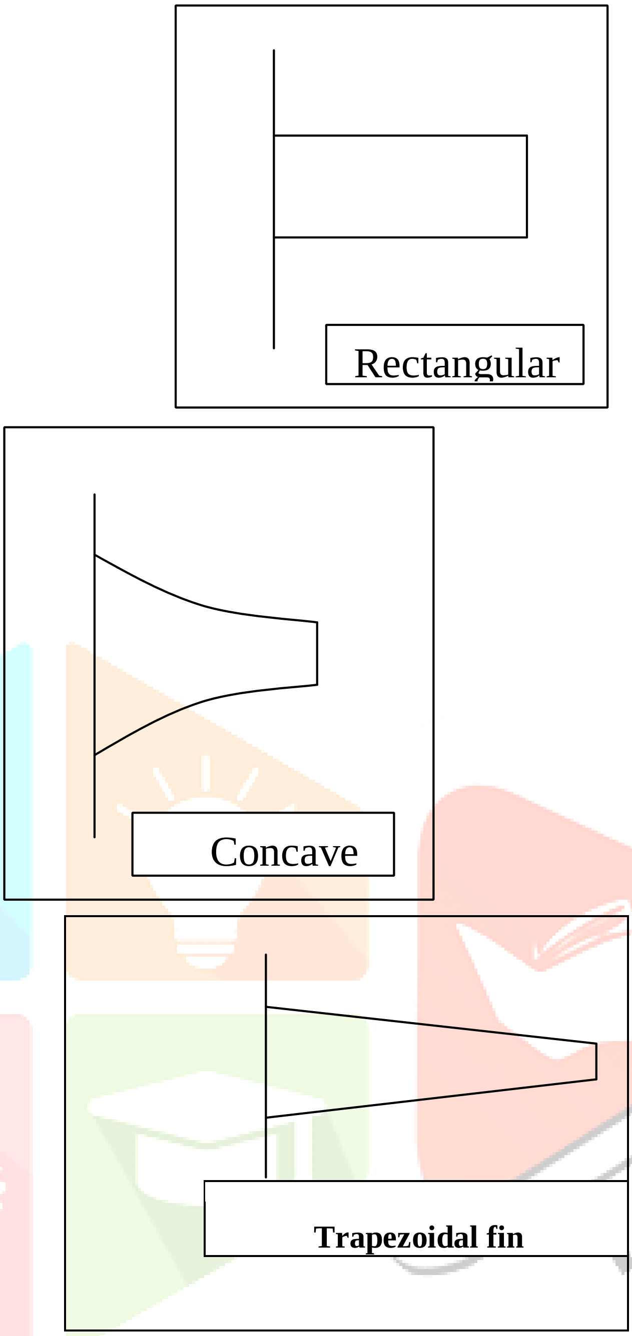


Fig 3 : Diff. types of fins.

The choices of the particular passive method depend greatly on the mode of the convective heat transfer (natural or forced convection) and on the fluids used to transfer heat. When argumentation of heat transfer has to be provided, the thermal resistance in the direction of the heat flow has to be considered. E.g. it is not advantageous to invest in the reduction of already low thermal resistance. It is known that gases, owing to their low thermal conductivity, are characterized with much higher resistance for the heat flow compared with liquids. Therefore in gas-liquid heat exchangers, the argumentation measures should generally be applied to the gas side.

The most effective heat transfer enhancement can be achieved by using fins as elements for the heat transfer surface area extension. In the past a large variety of fins have been applied for these purposes, leading a very compact heat exchangers with only gas or gas and liquid as the working media. Plate fin rotary regenerators and tube fin are widely encountered compact heat exchangers across the industry. Here the area of interest is the tube fin configuration.

2. LITERATURE SURVEY

Fins are the extended surfaces which are used to enhance the rate of heat transfer dissipation from heated surfaces to air. Fins can be placed on plane surfaces, tubes, or other geometries. These surfaces have been used to increase heat transfer rate by adding additional surface area and encouraging mixing. When number of fins are used to enhance heat transfer under natural convection conditions the optimum geometry of fins (corresponding to a maximum rate of heat transfer) should be used, provided this is compatible with available space and financial limitations. The common fins used extensively to increase the rates of natural convection heat transfer from systems are rectangular fins because such fins are simple and cheap, to manufacture. The heat transfer to the fluid flowing through a cylindrical pipe by the heat dissipating surfaces can be obtained mainly by using the mechanisms of heat transfer by forced convection, natural convection and by radiation heat transfer. This paper mainly concerned with those issues related to the heat transfer obtained mainly by natural convection.

A great number of experimental and analytical work has been done on vertical and horizontal finned tube subjected to natural convection. Kayansayan studied the thermal characteristic of fin and tube heat exchanger, Rao studied the heat transfer from horizontal fin array, Yang , conducted an experiment on mixed convective cooling of a fin in a channel, Sharif and Bergman , worked on enhancement of PCM melting in enclosure with horizontal finned internal surface. Myhren, worked on improving thermal performance of ventilation radiators using internal fins. Baek, studied on heat transfer enhancement using straight and twisted internal fins.

Muñoz et al., done analytical work on internal helically finned tubes for parabolic trough design by CFD tools. The application of finned tubes to the design of parabolic trough collectors has some losses as the pressure losses, thermal losses and thermo-mechanical stress and thermal fatigue. The result shows an improvement potential in parabolic trough solar plants efficiency by the application of internal finned tubes.

SAZALI, experimental study of a vertical internally finned tube subjected to natural convection heat transfer. The length of tube was 100mm. the tube taken for the experiment has inner diameter 80mm and the outer diameter 90mm. The tube contains four radial, straight, and equally spaced around the circumference of the tube. Other dimensions like height of the fins are 100mm and the length of the fins are 25mm. Air was used as a working fluid in the experiment. The result shows that the value of Nu for vertical cylinder under variables time varies with the temperature is increasing.

Myhren et al. studied heat output optimization of a ventilation radiator by varying the distribution of vertical, longitudinal convection fins. The investigation was made using Computational Fluid Dynamics simulations while analytical calculations were used for different flow and heat transfer mechanisms. The results showed that heat transfer can be increased in the section where ventilation air is brought into the room by slightly changing the geometry of the fins like decreasing the fin to fin distance. The small change in internal design could mean considerable increase in thermal efficiency for the ventilation radiator as a whole. Wang et al., studied heat transfer performance of internally finned tubes with blocked coretube was numerically investigated by the realizable k–e turbulence model with wall function method using FLUENT. By using 3 kinds of lateral fin profiles, S-shape, Z-shape and V-shape, were studied and compared. The corresponding correlations of Nusselt number and friction factor were obtained for different-shape internally finned tubes. The result showed that tubes with S-shape fins and Z-shape fins were best profile as compared with V-shape fins, and moreover, tube with Z-shape fins had the best performance.

Giri et al., worked on the role of natural convection in many applications like ice-storage air-conditioning. A mathematical formulation of natural convection heat and mass transfer over a shrouded vertical fin array is developed. The base plate were kept at a temperature below the dew point of the surrounding moist air due to this, occurrence of condensation of moisture on the base plate, while the fins may be partially or fully wet. The results showed that beyond a certain stream wise distance, further fin length does not improve the sensible and latent heat transfer performance, and that if dry fin analysis is used under moisture condensation conditions, the overall heat transfer will be lowballed by about 50% even at low buoyancy ratios.

Papadopoulous et al., done the Numerical study of laminar fluid flow in a curved elliptic duct with internal fins. The study of the fully developed laminar incompressible flow inside a curved duct of elliptical cross-section with four thin and internal longitudinal fins is done using the improved CVP method. Results showed that the friction factor increases for large fins and for high Dean numbers and in some cases, it has dependent on the cross-sectional aspect ratio. The thermal results show that the heat transfer rate is increased by the internal fins and that it depends on the aspect ratio.

3. APPROACHES & ASSUMPTION

3.1 The assumptions during the analysis have been taken considering the manufacturing and practical applications and working conditions.

1. Steady state heat convectin/ conduction.
2. No heat generation within the fin.
3. Uniform heat transfer coefficient (h) over the entire surface of the fin.
4. Homogeneous and isentropic fin material.
5. Negligible contact thermal resistence.
6. Negligible radiation.

3.2 MODES OF HEAT TRANSFER

CONDUCTION	RADIATION	CONVECTION

2.2.1 CONDUCTION:

"CONDUCTION' is the heat transfer of heat from one part of a substance to another part of the same substance, or from one substance to another in physical contact with it.The governing equation for conductive heat transfer is:

In **Cartesian coordinates**

$$\Delta f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} + \frac{\partial^2 f}{\partial z^2} = 0.$$

In **cylindrical coordinates**,

$$\Delta f = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial f}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 f}{\partial \phi^2} + \frac{\partial^2 f}{\partial z^2} = 0$$

In **spherical coordinates**,

$$\Delta f = \frac{1}{\rho^2}\frac{\partial}{\partial \rho}\left(\rho^2\frac{\partial f}{\partial \rho}\right) + \frac{1}{\rho^2 \sin\theta}\frac{\partial}{\partial \theta}\left(\sin\theta\frac{\partial f}{\partial \theta}\right) + \frac{1}{\rho^2 \sin^2\theta}\frac{\partial^2 f}{\partial \varphi^2} = 0.$$

3.2.2.2 RADIATION:

"Thermal radiation" is the transfer of heat through space or matter by means other then conduction or convection. Radiation is assumed to propagate in the form of electromagnetic waves. The governing equation for Radiation heat transfer is:

PLANK'S LAW:

$$B_\nu(T) = \frac{2h\nu^3}{c^2}\frac{1}{e^{\frac{h\nu}{k_B T}} - 1}, \text{ or } \quad B_\lambda(T) = \frac{2hc^2}{\lambda^5}\frac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$$

4 DESIGN CALCULATIONS

4.1 The design calculations of the tube and the fin dimensions are done based upon equations suitable for the maximum heat transfer rate at low production costs. The material used for the calculations is considered to be ALUMINIUM. Both the tube and fins are considered to be made up of Aluminium and the fluid inside the tube is Water. ANSYS 13.0 WORKBENCH version is used for the entire simulation processes. Experimental values of the working temperatures and corresponding properties for the fin and tube material along with water is considered and fed to the software. The convection type under consideration is NATURAL CONVECTION. The tube is vertically situated and vertical flow is considered for calculation. A very minimal fluid velocity is assumed and the entire heat transfer process is made to happen under the influence of gravity.

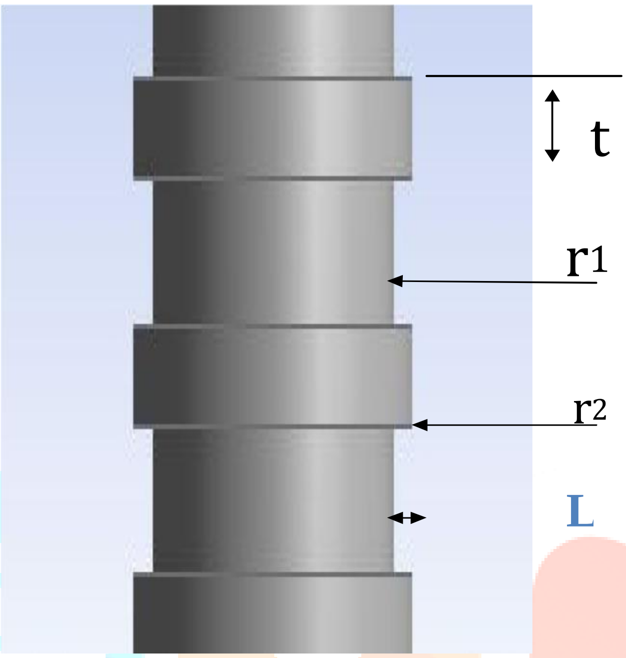


FIGURE 4

The energy balance equation for an element having rectangular fins made of material of uniform thermal conductivity is
The rate of heat conduction into the element
= rate of heat conduction out of element + rate of heat convection from the element surface
The rate of heat conduction in the element is the function of distance x which can be given as

$$Q(x) = -kA_c \frac{dT(x)}{dx}$$

Now, $$Q(x) = Q(x) + \frac{d}{dx}[Q(x)]dx + h_c dA_s[T(x) - T(\infty)]$$

By using element surface area $dA_s = Pdx$, we get

$$\frac{d^2T}{dx^2} - \frac{h_cP}{k}[T(x) - T(\infty)] = 0$$ eq. (11)

Let as assume that

$$\theta(x) = T(x) - T(\infty)$$

$$m^2 = \frac{h_cP}{kA_c}$$

5 MODELING & SOLUTION

METHODOLOGY

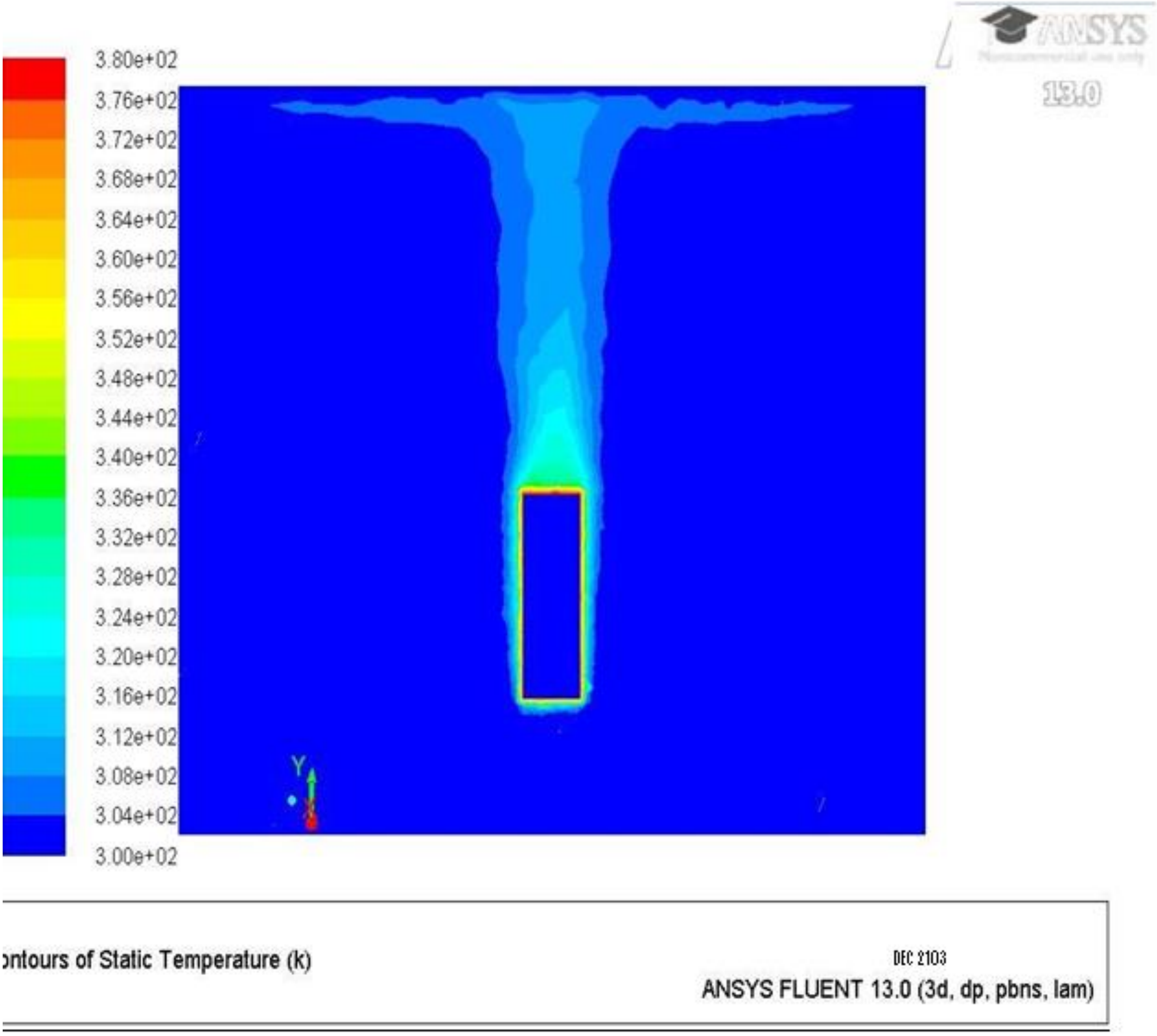
5.1 MESS STATISTICS AND PARAMETERS ASSUMED DURING ANALYSIS:

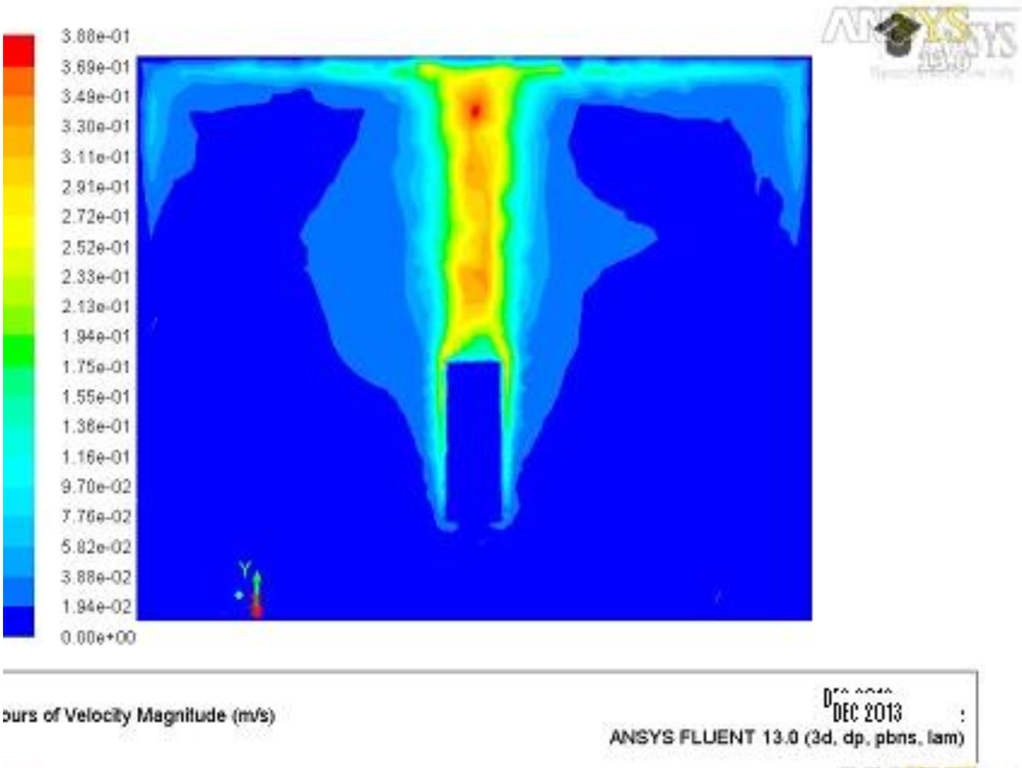
Types of Fins	Tube without fins	Conical fins 6*4mm	Trapezoidal fins 6*4mm	Cylindrical fins 6*4mm
Cross section of tubes	Circular	Circular	Circular	Circular
Outer dia. Of pipe	50 mm	50 mm	50 mm	50 mm
Length of pipe	150 mm	150 mm	150 mm	150 mm
Free stream o fluid	Air	Air	Air	Air
Material fin & tube	Aluminium	Aluminium	Aluminium	Aluminium
Model for convection	Bousinessq	Bousinessq	Bousinessq	Bousinessq
Tube wall temp.	380 k	380 k	380 k	380 k
Free stream air temp.	300 k	300 k	300 k	300 k
Messing method	Trapezoid	Sweep element	Quad / tri element	Quad / tri element
Relevance sizing centre	Fine	Fine	Fine	Medium
Element size	0.0001 m	0.0001 m	0.0001 m	0.0001 m
Initial size seed	Active assembly	Active assembly	Entire assembly	Active assembly
Smoothing	High	High	High	Medium
Transition	Slow	Slow	Medium	Medium
Span angle centre	Fine	Fine	Fine	Fine
Number of nodes	1894	3099	2939	4559
Number of elements	1574	2757	2095	3154
Orthogonality quality	7.32e-01	3.0812e-01	6.1112e-01	6.5467e-01
Aspect ratio	1.55e01	1.82e01	1.01232e01	2.11282e01

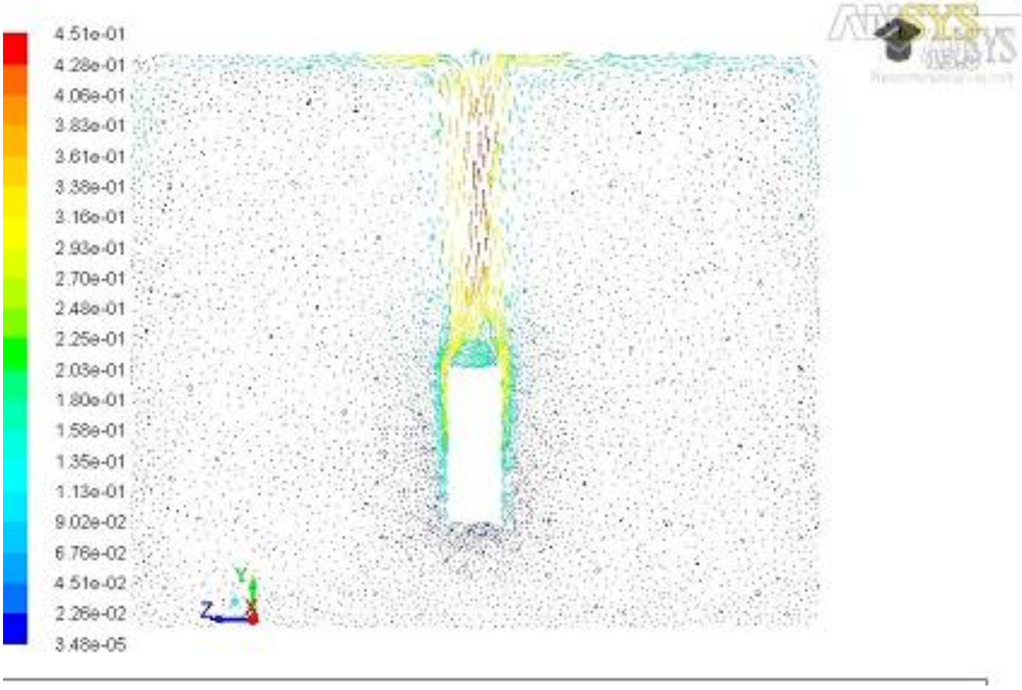
5.2 ANALYSIS FOR TUBE WITHOUT FINS:

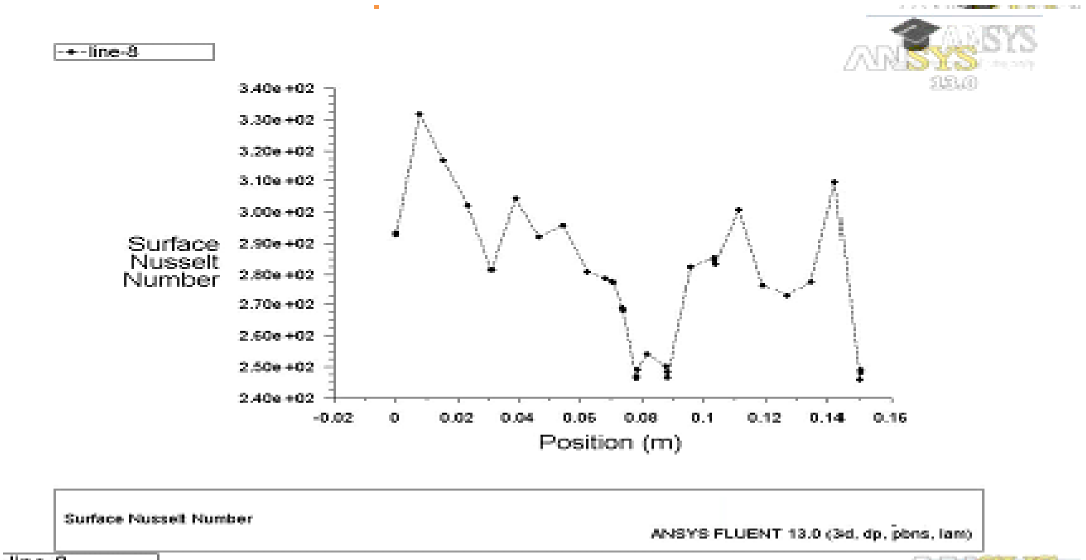
ANALYSIS FOR TUBE WITHOUT FINS:

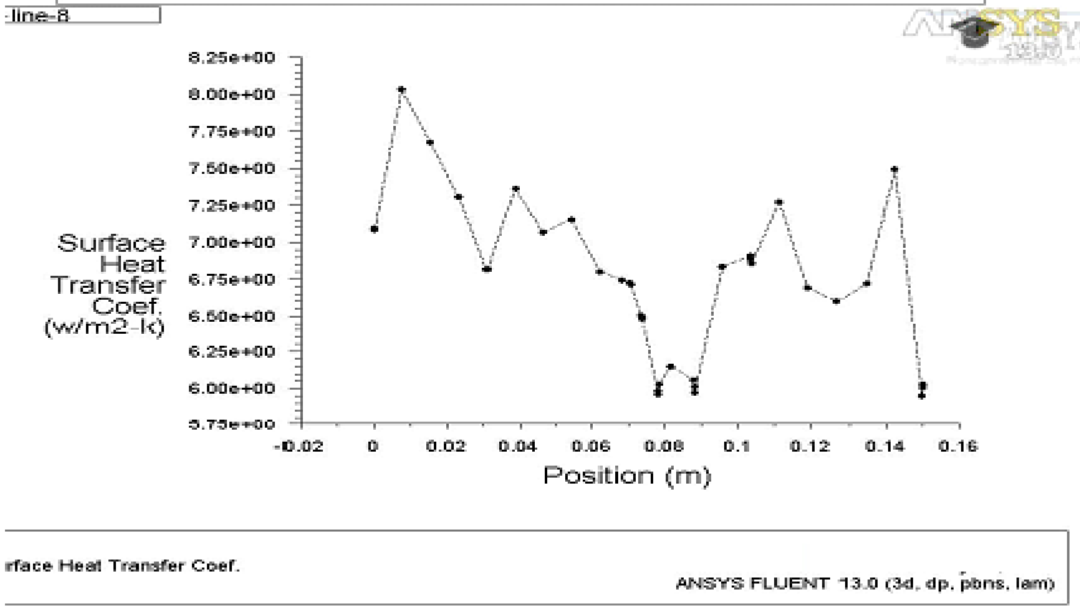
5.2 TEMPERATURE CONTOUR:




3.88e-01
3.69e-01
3.49e-01
3.30e-01
3.11e-01
2.91e-01
2.72e-01
2.52e-01
2.33e-01
2.13e-01
1.94e-01
1.75e-01
1.55e-01
1.36e-01
1.16e-01
9.70e-02
7.76e-02
5.82e-02
3.88e-02
1.94e-02
0.00e+00
Y
ours of Velocity Magnitude (m/s)
DEC 2013
ANSYS FLUENT 13.0 (3d, dp, pbns, lam)


4.51e-01
4.28e-01
4.06e-01
3.83e-01
3.61e-01
3.38e-01
3.16e-01
2.93e-01
2.70e-01
2.48e-01
2.25e-01
2.03e-01
1.80e-01
1.58e-01
1.35e-01
1.13e-01
9.02e-02
6.76e-02
4.51e-02
2.26e-02
3.48e-05
Y
Z
X





6 Result & Discussion

6.1 SOLUTION METHODS ADOPTED DURING ANALYSIS IN FLUENT

S.No.	SCHEME	METHOD
1	SOLUTION SCHEME	SIMPLE
2	GRADIENT	LEAST SQUARE CELL BASED
3	PRESSURE	PERSTO
4	MOMENTUM	SECOND ORDER UPWIND
5	ENERGY	FIRST ORDER UPWIND

TABLE 3

6.2 **BOUSSINESQ METHOD**

S.No.	PARAMETERS	VALUES
1	DENSITY	1.225Kg/m^3
2	SPECIFIC HEAT	1006.43 J/Kg-k
3	THERMAL CONDUCTIVITY	0.0242 W/m-k
4	VISCOSITY	1.7894e – 0.5 Kg/m s
5	THERMAL EXPANSION	0.003334k^{-1}

6.4 TEMPERATURE CONTOURS

FIG shows the temperature contours for various analyses with various fin configurations. These figures show the variation between the maximum and minimum temperature values across the entire length of the pipe section taken into consideration. Also these contours shows the convection loops formed around the pipe cross section.

MAXIMUM TEMPERATURE = 380 K (near the pipe)

MINIMUM TEMPERATURE = 300 K (ambient air temperature)

7 Conclusions

From the above calculated values we can find that the best configuration for this type of convective heat transfer of a heated pipe is a TRAPEZOIDAL fin as they have the highest total heat transfer rate, and the best surface nusselt number along with highest surface heat transfer coefficient.

All the assumptions are made considering the practical manufacturing of fins and the real working conditions. Hence the result thus obtained in the entire project can be referred while dealing with heat transfer related problems where only natural convection is taken into consideration.

REFERENCES:

1. Nag P.K., Heat and mass transfer, New Delhi, TMH, 2010
2. Naser Sahiti: thermal and fluid dynamic performance of pin fin heat transfer surface, Camci, C., Uzol, O. (2001): Elliptical pin fins as an alternative to circular pin fins for gas turbine blade cooling applications, ASME paper 2001-GT-0180, ASME Int. Turbine Conference, New Orleans.
3. Chen, Z., Li, Q., Meier, D., Warnecke, H. J. (1997): Convective heat transfer and pressure loss in rectangular ducts with drop-shaped pin fins, Heat and Mass Transfer 33, pp. 219-224.
4. Ehsan Firouzfar, and Maryam Attaran, A Review of Heat Pipe Heat Exchangers Activity in Asia, World Academy of Science, Engineering and Technology 47 2008
5. gulshan sachdeva, under the supervision of prof. k.s. kasana, computation of heat transfer augmentation in a plate-fin heat exchanger using rectangular / delta wing.
6. Kayansayan N., Thermal characteristics of fin and tube heat exchanger, Experimental thermal and fluid science, 1993, Vol. 7, pg. 177-188
7. Rao V.D., Naidu S.V., Rao B.G., Sharma K.V., Heat transfer from a horizontal fin array by natural convection and radiation, International journal of heat and mass transfer, 2006, Vol. 49, pg. 3379-3391
8. Yang M.H., Yeh R.H., Hwang J.J., Mixed convective cooling of a fin in a channel, International journal of heat and mass transfer, 2009, vol. 53, 760-771
9. Sharif N., Bergman T.L., Faghri A., Enhancement of PCM melting in enclosure with horizontally fixed internal surfaces, International journal of heat and mass transfer, 2011, vol. 54, pg. 4182-4192
10. Myhren J.A., Holmberg S., Improving the thermal performance of ventilation radiator- the role of internal convective fins, International journal of heat and mass transfer, 2010, vol. 50, pg. 115-123
11. Tijing L.D., Baek B.J., A study on heat transfer enhancement using straight and twisted internal fins inserts, International journal of heat and mass transfer, 2006, vol.33, pg. 719-726
12. Munoz J., Abanader A., Analysis of helical finned tubes for parabolic through designed by CFD tools, Applied energy, 2011, vol. 88, pg. 4139-4149
13. Sazali N., Experimental study of natural convection heat transfer in a vertical internally finned tube, 2009
14. Wang Q., Zeng M., Lin M., Effect of lateral fin profiles on turbulent flow and heat transfer performance of internally finned tubes, Applied thermal energy, 2009, vol.29, pg. 3006-3013
15. Giri A., Narasimhan G., Murthy M., Combined natural convection heat and mass transfer from vertical fin arrays, International journal of heat and mass transfer, 2003, vol. 24, pg. 100-113
16. Papadopoulous P.K., Hatzikonstantinou P.M., Numerical study of laminar fluid flow in a curved elliptical duct with internal fins, International journal of heat and fluid flow, vol. 29, April 2009, pg. 540-544
17. Andrew J.L., Ramesh N., Chandratilleke T.T., Laminar convective heat transfer rate in a micro channel with internal longitudinal fins, International journal of thermal sciences, October 2009, vol. 48, pg. 1908-1913
18. Aziz A., Fang T., Alternative solution for longitudinal fins of rectangular, trapezoidal and concave parabolic profiles, Energy conversion and management, 2010, vol. 51, pg. 21882194
19. Donalson I.G., Free convection in a vertical tube with linear wall temperature gradient, 1961
20. Stokes G.G., On the effect of the internal friction of fluids or the motion of pendulums, Transactions of Cambridge Philosophical Society, 1851, vol. 9, page 8