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Research Article

COMPUTIONAL FLUID DYNAMICS AND HEAT TRANSFER ANALYSIS OF HOLLOW HEAT PIPE WITH CIRCULAR FINS

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ABSTRACT

This project is about a study of heat convection become study of circular fins pipe using the Ansys version 16.0.Fins is very important topic of dissection of heat transfer technique. So, many areas are used by the fins. In this research work was circular fins used outer surface of the hollow metallic pipe. Actual cooling system of the furnace was not more effective in cooling cycle. This system was creating more breakdowns in running furnace. Because, water have very high temperature. High temperature of water was creaked the patching of furnace. Patching is used for the internally covering the furnace of melting time. But, we have basic problem the control temperature of water. Whole furnace cooling cycle was depends on the cooling tower. But, we were applied the logic of circular fins pipe replaced of simple pipe. We have to get directly on system all basic geometry of simple pipe. We were review the simple heat pipe and applying the circular fins on this pipe. This circular fins pipe was doing the connected the cooling cycle. After all we were doing CFD analysis of fins pipe and get the very impressive result. Older result of simple heat pipe inlet temperature =350 k (ambient temperature according) outlet temperature = 328 k (near the cooling tower) and after CFD analysis result of fins pipe inlet temperature = 352 k (ambient temperature according) outlet temperature = 305 k (near the cooling tower). We have reduced the 23^0c temperature of water. Finally the overall study we have investigated great result is decrease the temperature of water with use of modify heat pipe (circular fins pipe) and increase the cooling rate of furnace. This technique we are applying other devices and system and get more effective result.

INTRODUCTION

This research work is basically is the problem of industries. The problem of the furnace performance and its efficiency is low. Because is the proper cooling system is not sufficient work. High heated water doesn't have proper cooling of furnace. So, we are some change of cooling system and simple heat pipe change and this replace are fitted the circular fins pipe. And study now ansys fluent and get the best result of the temperature variation and velocity contour. this the study we are its problem and analysis its result work also.

Extended Surface of Fins

Whenever the available surface found inadequate to transfer the required quantity of heat with the available temperature drop and convective heat transfer coefficient, extended surface or fins are used. This practice, invariably, is found necessary in heat transfer between a surface and gas as the convective heat transfer coefficient is rather low in these situation. The finned surfaces are widely used in:

Types of fins

- Straight fins of uniform cross section
- Straight fins of non-uniform cross section
- Annular fins
- Cylindrical fins
- Pin fins

Fins are widely use in industries for many instruments for heat dissipation. And mostly use for low temperature for cooling. Fins surface mostly is common sector and instruments us can know as.

1. Economizers for steam power plants
2. Convectors for steam and hot-water heating system
3. Radiator of automobiles
4. Air-cooled engine cylinder head.
5. Cooling coils and condensers coils refrigerators and air conditioning
6. Electric motor bodies
7. Transformer and electronic instruments

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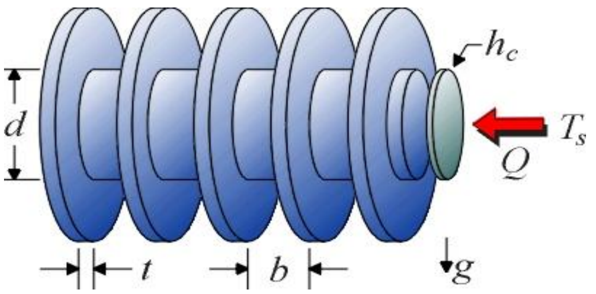


Fig.3 Annular fins

Fig.4 Pin fins

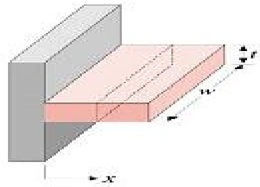


Fig.5 Straight fins of uniform cross section

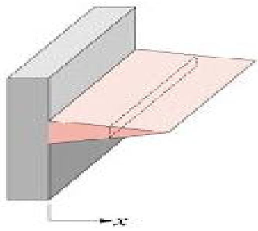


Fig.6 Straight fins of non-uniform cross section

The Function of Fins

Extended surfaces have fins attached to the primary surface on one side of a two-fluid or a multiplied heat exchanger. Fins can be of a variety of geometry—plain, wavy or interrupted—and can be attached to the inside, outside or to both sides of circular, flat or oval tubes, or parting sheets. Pins are primarily used to increase the surface area (when the heat transfer coefficient on that fluid side is relatively low) and consequently to increase the total rate of heat transfer. In addition, enhanced fin geometries also increase the heat transfer coefficient compared to that for a plain fin. Fins may also be used on the high heat transfer coefficient fluid side in a heat exchanger primarily for structural strength (for example, for high pressure water flow through a flat tube) or to provide a thorough mixing of a highly-viscous liquid (such as for laminar oil flow in a flat or a round tube).

Fins Effectiveness

A fin is a thin component or appendage attached to a larger body or structure. Fins typically function as foils that produce lifter 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. In the study of heat transfer, **fins** are surfaces that extend from an object to increase the rate of heat transfer to or from the environment by increasing convection. The amount of conduction, convection, or radiation of an object determines the amount of heat it transfers. Increasing the temperature gradient between the object 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 feasible or economical to change the first two options. Thus, adding a fin to an object increases the surface area and can sometimes be an economical solution to heat transfer problems.

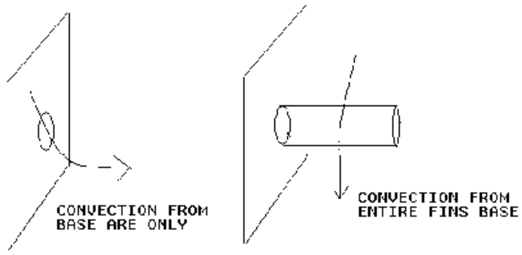


Fig.7 Fins Effectiveness

Fin Effectiveness

$$£_{f} = \frac{q_{f}}{hA_{b}\,\bar{}_{b}}$$

Annular Fin (Circular Fin)

In thermal engineering, an annular fin is a specific type of fin used in heat transfer that varies, radically, in cross-sectional area. Adding an annular fin to an object increases the amount of surface area in contact with the surrounding fluid, which increases the convective heat transfer between the object and surrounding fluid. Because surface area increases as length from the object increases, an annular fin transfers more heat than a similar pin fin at any given length. Annular fins are often used to increase the heat exchange in liquid–gas heat exchanger systems.

To derive the governing equation of an annular fin, certain assumptions must be made. The fin must have constant thermal conductivity and other material properties there must be no internal heat generation.

There must be only one and the fin must be at steady state. Applying the energy conservation principle to a differential element between radii ***r*** and ***r* + Δ*r*** yields

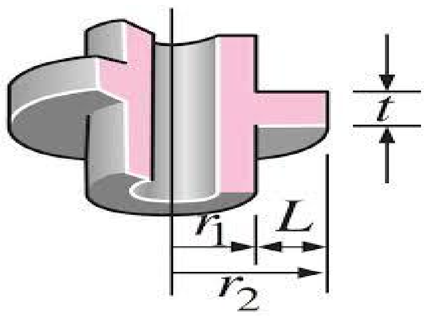


Fig.8 Circular Fin

Aim of the Work

The aim of this work is main we can see this layout. This layout is the induction furnace (1) Furnace (2) feed pump (3) cooling tower. This is cooling system of the furnace show in fig.1. There are cooling water only one cooling system only cooling tower. And meting condition furnace temperature is 1580^0c-1680^0c.in case cooling water is vary heated and should not proper cooling of the system. Is case we are study on the system. And apply fins tube heat pipe (circular fins heat pipe).This case **m/s. Magnum steels limited** and we are short out the problem and apply the circular fins heat pipe (fins heat pipe exchanger). There simple heat pipe inlet temperature is 350k and outlet temperature is 300k. This temperature range will be high and low is depends on weather conditions. High temperature water lacks the efficiency of furnace and its patching crack and suddenly brakes down. So we will apply the circular fins heat pipe on the cooling cycle of the furnace and we can increase the efficiency of furnace.

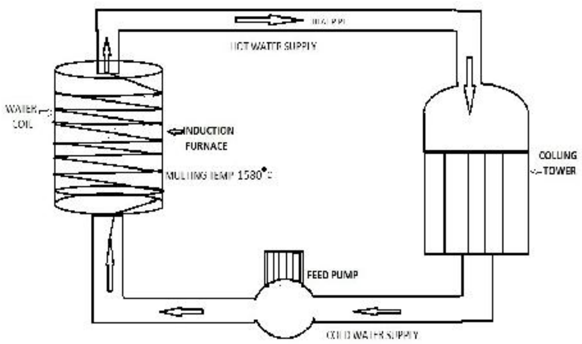


Fig.9 main layout of the heat pipe

This is the natural convection system in show in fig.2. There are applying the circular fins heat pipe. The natural convection heat transfer coefficient is fins and pipe area heat distributing and heat dissipation surrounding the fins and natural cooling is the system. In natural convection, the fluid motion occurs by natural means such as buoyancy. Since the fluid velocity associated with the natural convection is relatively low, the heat transfer coefficient encountered in natural convection is low. Consider fins pipe exposed to the cold air.

The temperature of the outside of the object will drop (as a result of heat transfer with cold air), and the temperature of adjacent air to the object will rise. Consequently, the object is surrounding with a thin layer of warmer air and heat will be transferred from this layer to the outer layer of air.

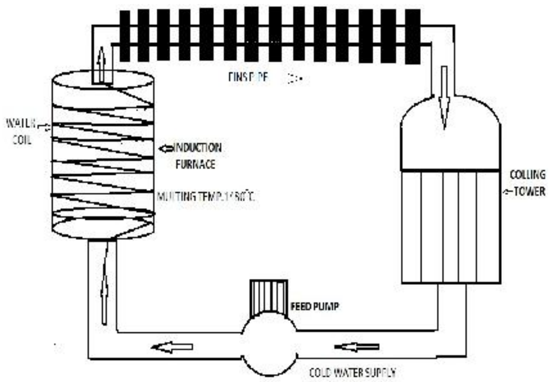


Fig.10 Furnace layout of fins pipe

The benefits of compact shell and tube heat exchanger designs is that they lead to cost saving either in original equipment and installation cost due to reduced size, or in increased production economics due to increase capacity. The augmentation may not only reduce the cost of the tubing, but also those of the heads, shell, baffles and tube sheets (smaller diameters, smaller wall thicknesses, fewer tube holes to drill, less alloy cladding material, etc).

RESULT AND ANALYSIS

Analysis of Simple Heat Pipe

Mess Statistics and Parameters Assumed During Analysis

Table1 value and parameter-simple pipe

Physical parameter	Value
Pipe measurments Pipe Measurments	Length of the pipe= 3500 mm Thickness of pipe=10mm Outer diameter=85mm Inner diameter=75mm
Material of pipe	Mild steels
Temprature(inner and outer)	Inner temperature=400K Outer temperature=300K
Fins material	Mild steels
Initial size seed active assembly	Smoothing High
Velocity of water	40 to 50 m/s
Type of fin without fins	Cross section of the tube Circular
Convection heat transfer coefficient	7.9 to 11.3 w/m^2K
Thermal conductivity	5.1 X 10^{-6} m^2/s
Thermal Diffusivity	6 to 7 mm^2/s

Model of geometry prescribe of pipe (problem)

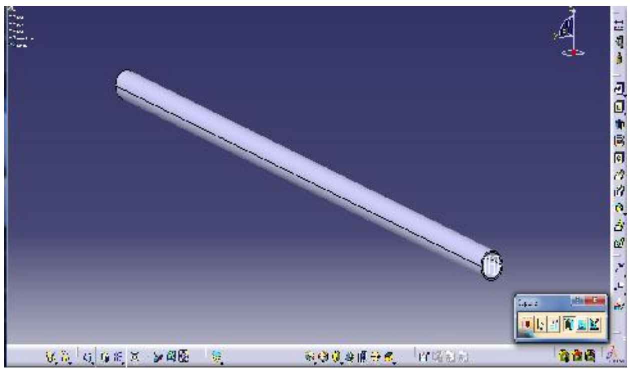


Fig.11 Cross Section pipe model

(In this figure show the 3D-model of hollow pipe which is created through the Catia)

Orthographic Veiw (Heat Pipe) In Catia

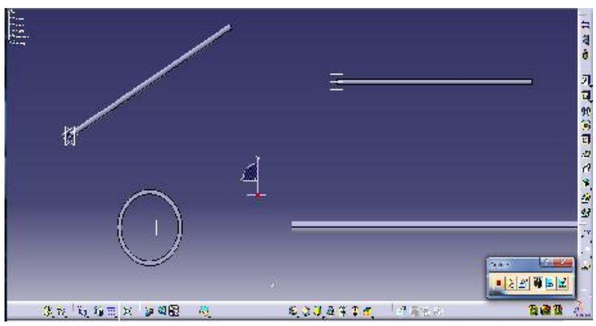


Fig.12 Orthographic Cross Section simple pipe model

(In this figure show the 3D-model of orthographic view hollow pipe which is created through the Catia)

CFD Analysis Simple Heat Pipe Boundary Condition –

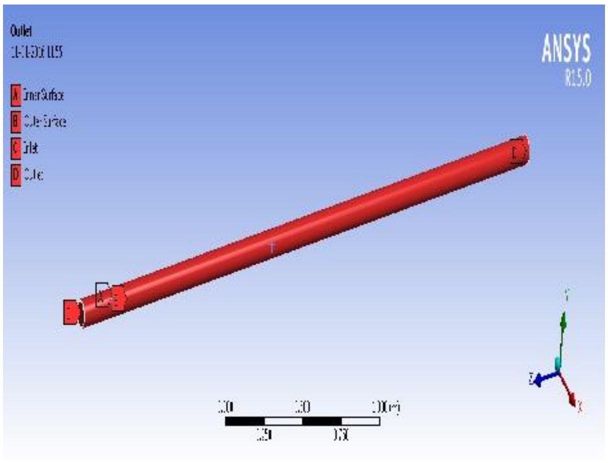


Fig.13 Simple Heat Pipe Boundary Condition

Table.2 Simple Heat Pipe Boundary Condition

Boundary Condition	Surface area	outlet
Simple Heat Pipe	A	Inner surface
	B	Outer surface
	C	Inlet
	D	Outlet

CFD Analysis or Heat Dissipation Simple Heat Pipe

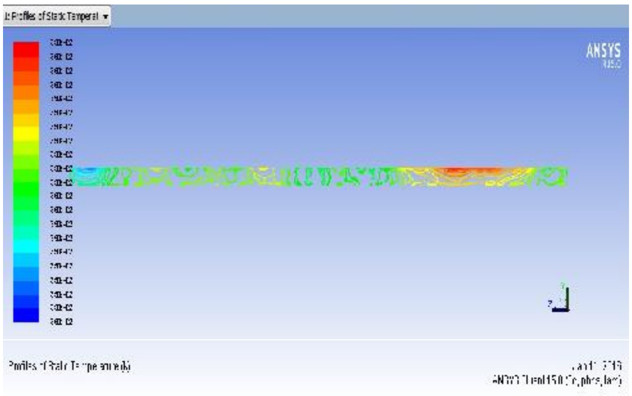


Fig.14 Analysis or Heat Dissipation Simple Heat Pipe

(In this figure show the simple heat pipe heat dissipation which is generated through the ANSYS Fluent in 3-D view)

CFD Analysis or Heat Dissipation Simple Heat Pipe

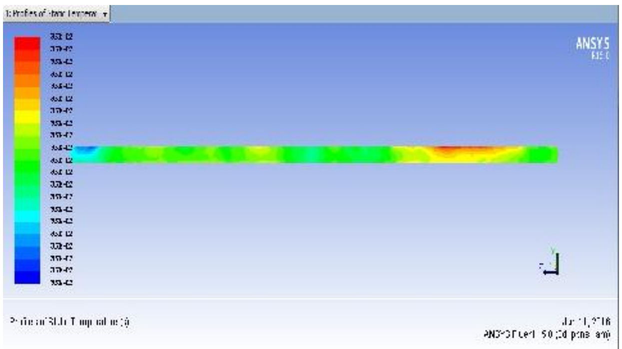


Fig.15 Analysis or Heat Dissipation Simple Heat Pipe

(In this figure show the simple heat pipe heat dissipation which is generated through the ANSYS Fluent in 3-D view)

Simple Heat Pipe

MINIMUM TEMPERATURE = 303 K (ambient temperature according) MAXIMUM TEMPERATURE = 350 K (near the pipe)

Analysis for Fins Pipe:-Sketching And Part Modelling Fins Pipe

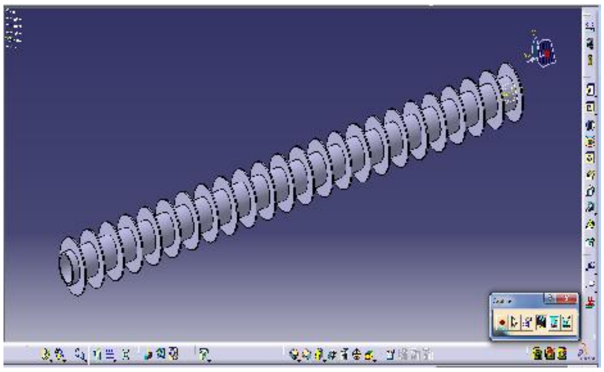


Fig.16 Cross Section Fins pipe model

Orthographic Section Fins Pipe Model

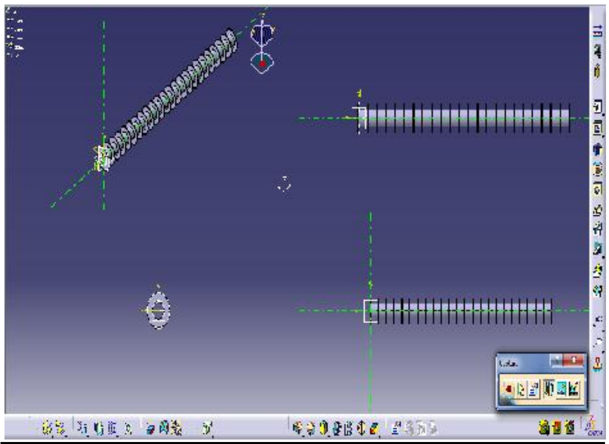


Fig.17 Orthographic Cross Section Fins pipe model

(This figure show the 3D-model of hollow pipe with circular fins of orthographic view which is created through the Catia)

Table.3 Value and parameter-fins pipe

Physical parameter	Value
Pipe measurments	Length of the pipe= 3500 mm Thickness of pipe=10mm Outer diameter=85mm Inner diameter=75mm
Material of pipe	Mild steels
Type of fin	Circular fins
Fins diameter	Outer diameter=150mm inner diameter=85mm thickness=10mm
Temperature(inner and outer)	Inner temperature=400k Outer temperature=300k
Fins material	Mild steels
Initial size seed active assembly	Smoothing high
Number of fins	24
Velocity of water	40 to 50 m/s
Type of fin without fins	Cross section of the tube circular
Convection heat transfer coefficient	7.9 to 11.3 w/m^2k
Thermal conductivity	5.1 x 10^{-6} m^2/s
Thermal diffusivity	6 to 7 mm^2/s

Analysis Process on Ansys Fluent Part Ansys R16.0

Table.4 File Information for FFF

Case	FFF
File Path	F:\fined pipe_files\dp0\FFF\Fluent\FFF.1-2-00083.dat.gz
File Date	24 September 2015
File Time	02:08:34 PM
File Type	FLUENT
File Version	15.0.7

Table.5 Mesh Information for FFF

Domain	Nodes	Elements
body	16366	49317
fluid	15847	12516
All Domains	32213	61833

Table.6 Domain Physics for FFF

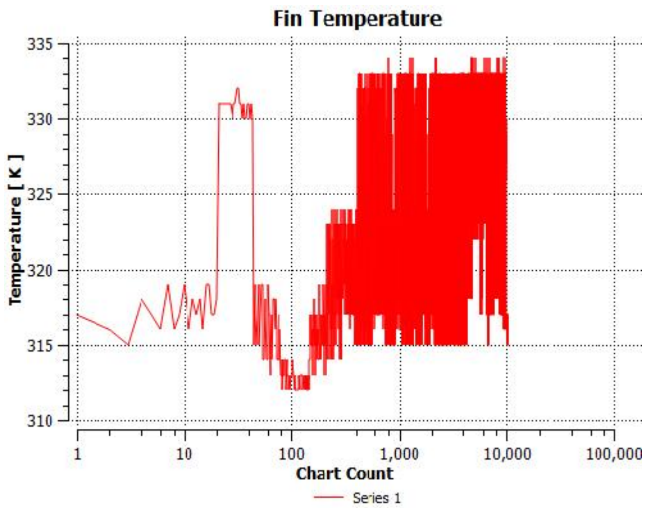
Domain - body	
Type	solid
Domain - fluid	
Type	cell

Table 7 Boundary Physics for FFF

Domain	Boundaries
body	**Boundary - inner_pipe_surface contact region src**
Type	INTERFACE
	Boundary - wall body
Type	WALL
fluid	**Boundary - contact region trg**
Type	INTERFACE
	Boundary - water inlet
Type	VELOCITY-INLET
	Boundary - water outlet
Type	PRESSURE-OUTLET

Fins Temperature Graph

Graph show the 1 to 10,000 iteration of temperature of fins temperature is min and max ratio is show in generated graph there are minimum temperature 313^{0}c and maximum temperature show in graph is 320^{0}c.these are graph show the fins pipe temperature contour. This graph is generating the fluent report of the result and show the actual value of temperature contour.



CFD Analysis or Heat Dissipation Fins Pipe (velocity contour)

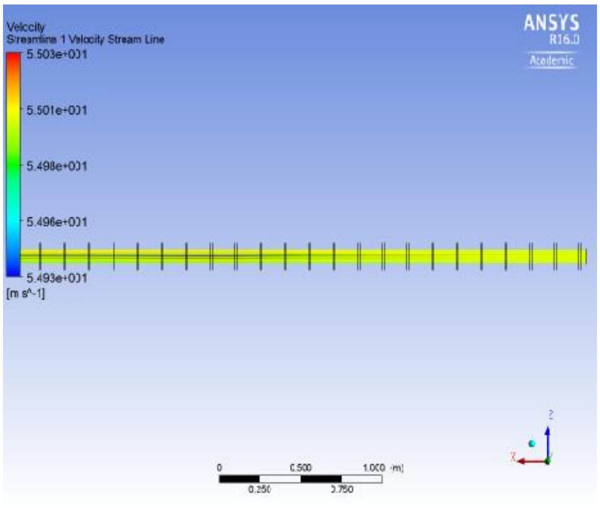


Fig.18 Heat Dissipation Fins Pipe (1)

This figure show the circular fins heat pipe velocity contour which is generated through the ANSYS Fluent in 3-D view there 5.493e+001 show the minimum temperature of the velocity contour. And 5.503e+001 show the maximum temperature of the velocity contour.

CFD Analysis or Heat Dissipation Fins Pipe (Temperature Contour)

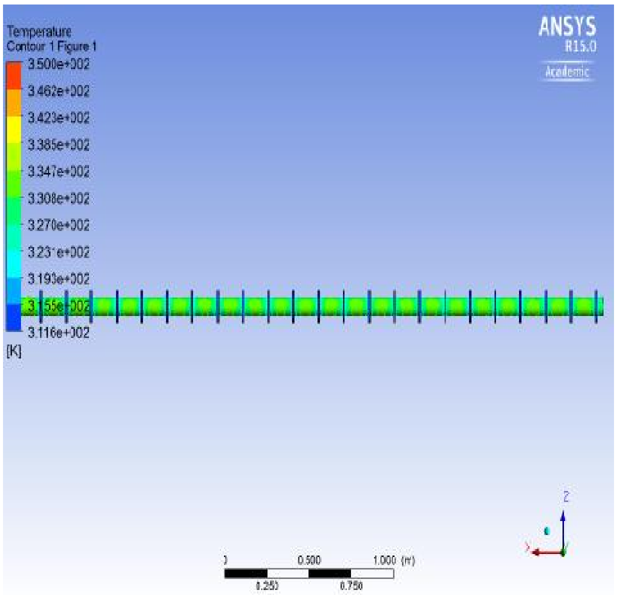


Fig.19 Heat Dissipation Fins Pipe

This figure show the circular fins heat pipe velocity contour which is generated through the ANSYS Fluent in 3-D view there 5.493e+001 show the minimum temperature of the velocity contour. And 5.503e+001 show the maximum temperature of the velocity contour.

CFD Analysis or Heat Dissipation Fins Pipe (Velocity Contour)

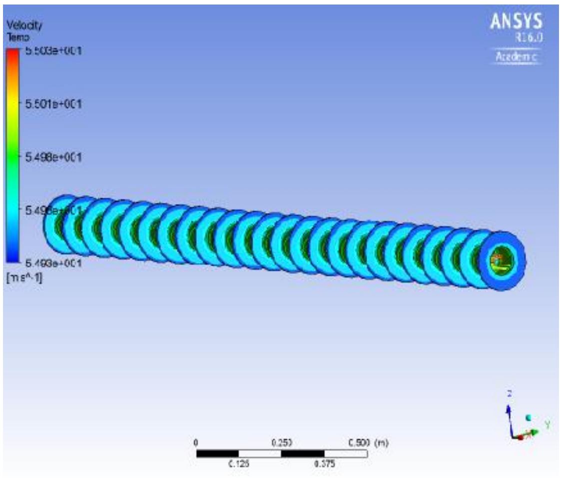


Fig.20 Heat Dissipation Fins Pipe (3)

This figure show the circular fins heat pipe velocity contour which is generated through the ANSYS Fluent in 3-D view there 5.493e+001 show the minimum temperature of the velocity contour. And 5.503e+001 show the maximum temperature of the velocity contour.

CFD Analysis or Heat Dissipation Fins Pipe (Temperature Contour)

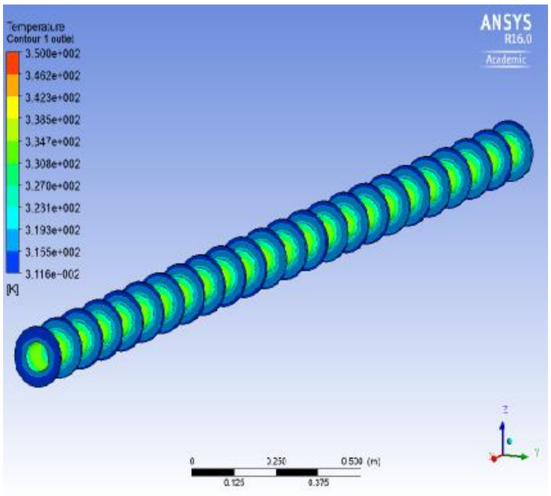


Fig.21 Heat Dissipation Fins Pipe

This figure show the circular fins heat pipe velocity contour which is generated through the ANSYS Fluent in 3-D view there 3.116e+002 show the minimum temperature (outlet) of the temperature contour. And 3.500e+002 show the maximum temperature (inlet) of the temperature contour. There range of 3.423e+002 to 3.193e+002 show the best result of fins pipe is temperature control the fins technology and temperature drop is this order of fins pipe.

Temperature Contour and Heat Transfer Coefficient Fins Pipe

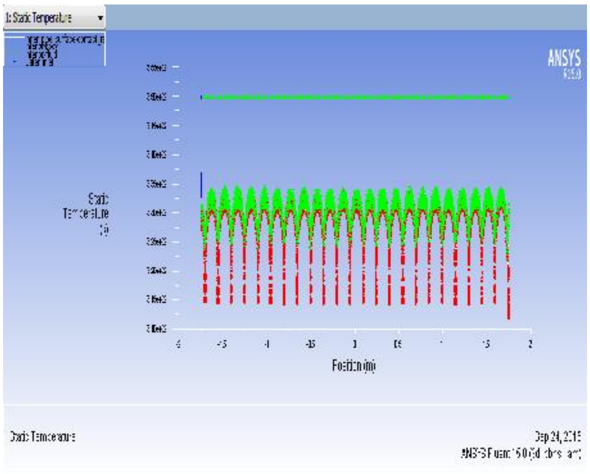


Fig.22 Temperature contour heat dissipation fins pipe

This figure show the circular fins heat pipe velocity contour which is generated through the ANSYS Fluent in 3-D view there 3.116e+002 show the minimum temperature (outlet) of the temperature contour. And 3.500e+002 show the maximum temperature (inlet) of the temperature contour. There range of 3.423e+002 to 3.193e+002 show the best result of fins pipe is temperature control the fins technology and temperature drop is this order of fins pipe.

Temperature Contour and Heat Transfer Coefficient Fins Pipe

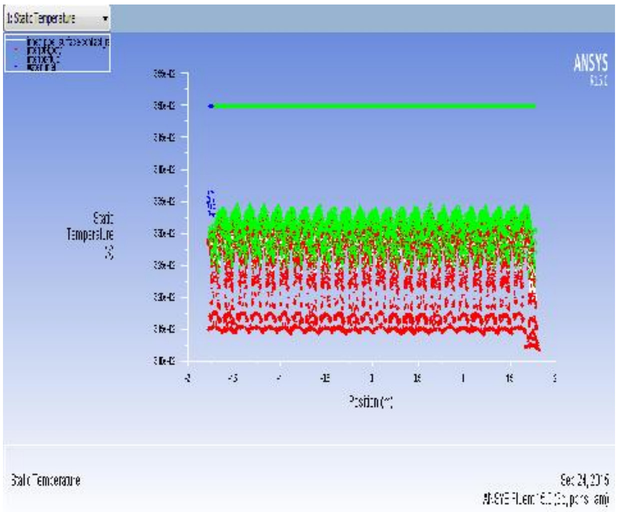


Fig.23 Temperature contour heat dissipation fins pipe

This figure show the circular fins heat pipe temperature contour which is generated through the ANSYS Fluent in 3-D view there 3.55e+002 show the maximum temperature (inlet) of the temperature contour. And 3.10e+002 show the minimum temperature (outlet) of the temperature contour. There range of 3.45e+002 to 3.25e+002 show the best result of fins pipe is temperature control the fins technology and temperature drop is this order of fins pipe.

Temperature Contour and Heat Transfer Coefficient Fins Pipe

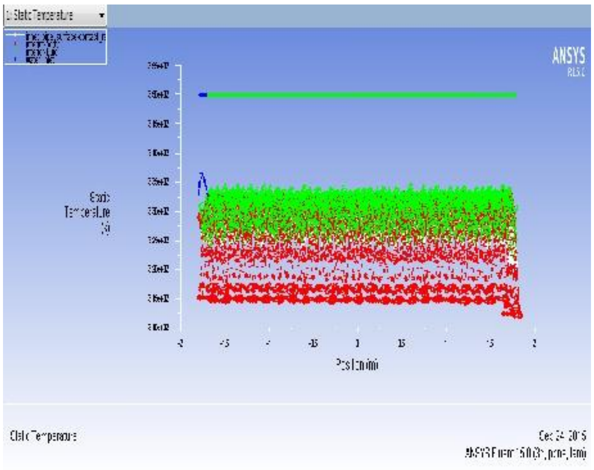


Fig.24 Temperature contour heat dissipation fins pipe

This figure show the circular fins heat pipe temperature contour which is generated through the ANSYS Fluent in 3-D view there 3.55e+002 show the maximum temperature (inlet) of the temperature contour. And 3.10e+002 show the minimum temperature (outlet) of the temperature contour. There range of 3.45e+002 to 3.25e+002 show the best result of fins pipe is temperature control the fins technology and temperature drop is this order of fins pipe. this graph is generated maximum heat distributed in fins area.

Temperature Contour and Heat Transfer Coefficient Fins Pipe

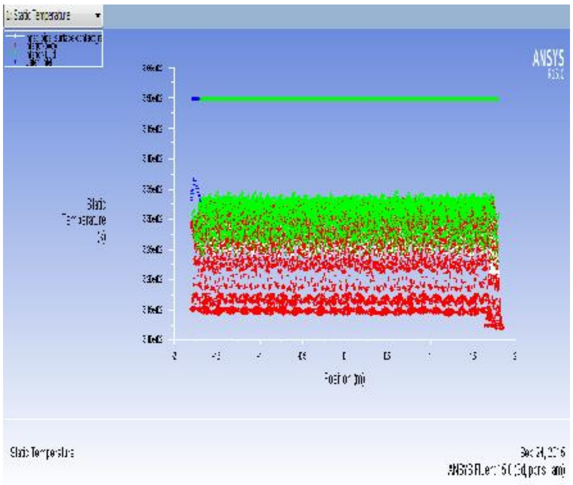


Fig.25 Temperature contour heat dissipation fins pipe

This figure show the circular fins heat pipe temperature contour which is generated through the ANSYS Fluent in 3-D view there 3.55e+002 show the maximum temperature (inlet) of the temperature contour. And 3.10e+002 show the minimum temperature (outlet) of the temperature contour. There range of 3.45e+002 to 3.25e+002 show the best result of fins pipe is temperature control the fins technology and temperature drop is this order of fins pipe. This graph is generated maximum heat distributed in fins area of fins located is green colour is show is clear in figher.

Temperature Contour Heat Dissipation Fins Pipe

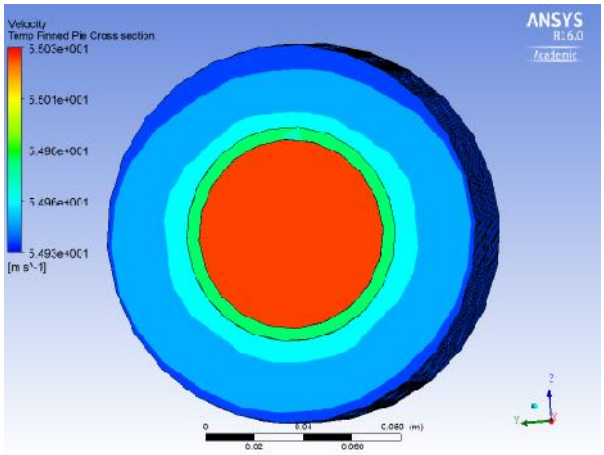


Fig.26 temperature contour heat dissipation fins pipe (cross section)

Show this figure is front view of the fins pipe there are result of fins pipe the outer temperature is minimum is 5.493e+001 is and face of fins is internally is 5.496e+001 is high temperature. And middle of pipe is red colour is higher temperature of flow water. There fins is distributed the temperature of interface and internally drop the temperature

Solution Methods Adopted During Analysis in Fluent

Table.8 Methodology of CFD Analysis

SCHEME	METHOD
Solution scheme	Simple
Gradient	Least square cell based
Pressure	Presto
Momentum	Second order upwind
Energy	First order upwind

Temperature Contours

CFD analysis diagram shows the temperature contours for various analyses with various fin configurations. These figures Show the temperature variation of as simple heat pipe compare to fins heat pipe the maximum and minimum Temperature values across the entire length of the pipe section taken into consideration. Also these contours show the max. Or min temperature ratio of simple heat pipe or fins heat pipe

Simple Heat Pipe

Maximum Temperature (inlet) = 350 K
Minimum Temperature (outlet) = 327 K

Fins Pipe

Maximum Temperature = 352 K (ambient temperature according)
Minimum Temperature = 305 K (near the cooling tower)

CONCLUSION

From this work it can be seen that the use of finned tube can contribute greatly in the development of fins tube heat exchanger designs. The benefits of compact shell and tube heat exchanger designs. This is the simple and easy design and construct to easy. The aim of this work is control the temperature and increases the efficiency of the system.

Temperature control means the reduce the water temperature and increase the cooling effect of the cooling water. Furnace run by 1570^0c and this more temperature. And, cooling system varies important role play of the furnace and its safety and performance. Now cooling system use the water of surrounding the coil. Water directly connected the cooling tower but temperature of water more then 20 to 25^0c is reduce for help of cooling tower. But, if we can use the fins pipe is connected to furnace and cooling tower. We can achieve great result and 20 to 25^0c temperature are reducing of water. And increase the efficiency of furnace and proper work any break down. Now this result of fins heat pipe use ansys fluent and simple heat pipe inlet maximum temperature is 77^0c and outlet minimum temperature 54^0. Now comparison circular fins heat pipe inlet maximum temperature 79^0c and outlet minimum temperature 32^0c. We can reduce 23^0c temperature use of circular fins heat pipe (fins tube heat exchanger).This research work we can use different type of fins and material to get more result and increase the efficiency of furnace also production of industries.

Future Scope

- We can use the different type of fins of pipe and get more result and practical work fins tube heat exchanger.
- Heat exchanger and other instruments work vary comfortably.
- Use different type of fins and more research work we can do it..
- Chimney and other thermal device we can use this technique and get better result.

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