International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 10 Issue 1 ǁ 2022 ǁ PP. 73-81

Design And Analysis Of Double pipe counter flow heat exchanger Using Ansys Fluent Software

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APRIL,2021

ABSTRACT
Heat exchanger is a device that exchange heat between two fluids of different temperature that can have solid barrier or directly mix the two fluids. The heat exchange process happen by one of the three principles such as conduction, convention, andradiation. Here radiation does not play a major role. Heat ex-changer used in many industries to transfer heat between hot and cold fluid. Heat exchangers have many divisions based on different parameters from those parameters direction of flow of fluid in the heat exchanger is the one and accordingly we have parallel and counter flow type heat exchanger. Here in this paper we will design and analyze counter flow of fluid in double pipe heat exchanger, basically in this paper we try to find the best performance of double pipe heat exchanger interms of the heat transfer rate by varying some of its parameter such as flow rate of the fluid in the heat exchange and varying the diameter of the pipe and length of the pipe. In this particular design we have used the inside pipe made of aluminium, the out side or annular pipe made of aluminium, the hot fluid as oil and the cold fluid we have taken is water. We have used ANSYS fluid fluent analysis software for both designing the double pipe heat exchanger and to analyze the counter flow performance of the double pipe heat exchanger.

Date of Submission: 21-12-2021 Date of acceptance: 04-01-2022

Symbols/Abbreviations
LMTD Logarithmic mean temperature difference
CFD Computational FluidDynamics
Q_h Heat transfer of the hot fluid
Q_C Heat transfer of the cold fluid
U Overall heat transfer coefficient
θm Logarithmic mean temperature difference
θ_1 Temperature difference at the inlet
θ_2 Temperaturedifferenceat the outlet
C_p Specific heat capacity
$\dot{m}$ Mass flow rate of the fluid

I. INTRODUCTION

Heat exchangers are the most critical and widely used instruments in almost every industry. These devices exchange and transfer heat between two fluids, which can be gas or liquid, without causing the two fluids to mix. They are also used in the cooling process. Heat exchangers are designed to optimize the surface area of the wall between the hot and cold fluids while minimising fluid flow resistance throught the heat exchanger, and they must have the necessary amount of the thermal energy for either heating or cooling the fluid stream in the process. Heat exchangers are chosen based on heat transfer rate, and they should be configured to meet the appropriate heat transfer rate.

1.1 Counter flow Heat Exchanger

Heat exchangers have different categories based on different parameters among those parameters the direction of the flow of the two fluid in the one and further classified as parallel and counter flow heat exchanger.

We call heat exchanger parallel flow when the two fluids flow in the same direction and counterflow when the fluids flow in opposite direction. In using heat exchanger it is required to achieve the temperature of the cold fluid at the exit in higher temperature than the hot fluid at the exit. This goal is still in difficulty to achieve but it can better attained by the counter flow heat exchanger. So that In comparison with parallel flow heat exchanger counter flow heat exchanger are generally more efficient. Because counter flow heat exchangers provide more uniform temperature difference between the two fluids over the entire length of the heat exchanger and so the heat transfer is even. We can easily see how the high temperature of the cold flow at the exit by visualizing the graph of the parallel flow and counter flow type heat exchanger.

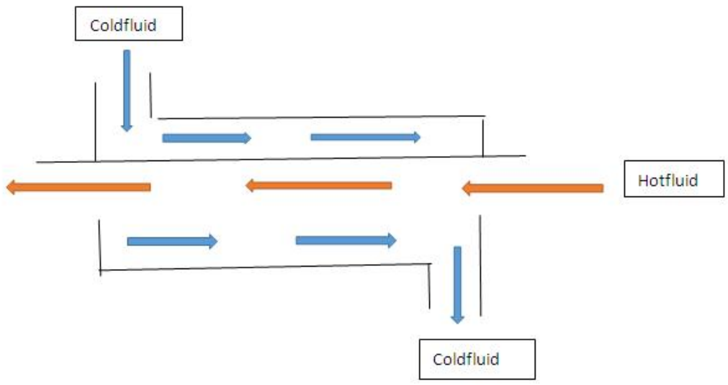
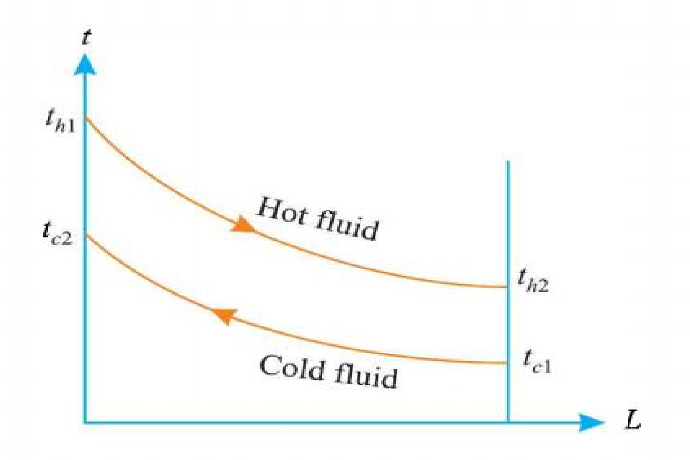


Fig. Flow direction of counter flow heat exchanger



$t_{h2} - t_{C1} = \theta_2$

Length of heat exchanger

Fig. Counterflow Heat exchanger graph

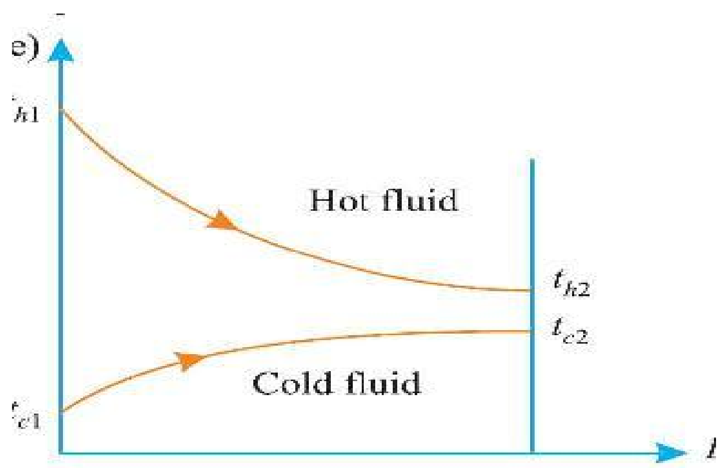
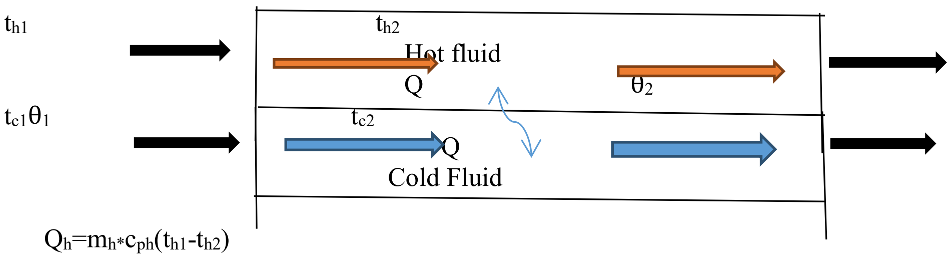


Fig . parallel flow heat exchanger

Logarithmic mean temperature difference of the counter flow heat exchanger is always greater than the that of parallel flow hence it is another reason for high heat transfer rate for parallel flow heat exchanger. To see these statement how lets make some numerical analysis.

Heat transfer rate(Q) is governed by three parameters such:

A) U(Overall heat transfer coefficient)
B) A(Total surface area of heat exchanger)
C) t_1 and t_2, in let and out let temperature of the fluid
Let $\dot{m}$-is mass flow rate
C_p-specific heat of the fluid at constant pressure
t-temperature of the fluid in °C



$Q_h=m_h*c_{ph}(t_{h1}-t_{h2})$
$Q_c=m_c*c_{pc}(t_{c1}-t_{c2})$
$Q=U*A*\theta m$

From the above equation higher θ means higher heat transfer rate(Q). So that for the same heat transfer surface area the counter flow heat exchanger has higher rate of heat transfer.
Where θm is given by the formula

$$\Theta m = \frac{\theta 2 - \theta 1}{Ln\,(\theta 2/\theta 1)}$$

1.1.1 Advantages of counter flow heat exchanger

Counter flow heat exchanger is more advantageous and used widely. It provide more uniform temperature difference between the two fluids so that minimizing the thermal stress through out the heat exchanger. This can be clearly seen from the graph of the counter flow and parallel flow heat exchanger. In case of the parallel flow initially the temperature difference between the two fluids is very high and small at the exit thought his causes thermal stress on the heat exchanger and results failure.This is because expansion and contraction in solid causes damage to the material.

The other advantage of the counter flow heat exchanger is that the uniform temperature difference between the two fluids throughout the heat exchanger also gives uniform heat transfer as heat transfer is directly proportional to change on temperature of the fluid. And in counter flow heat exchanger the outlet temperature of the cold fluid approach the highest temperature better than the parallel flow heat exchanger and larger LMTD.

1.1.2 Disadvantages ofcounter flow heat exchanger

Counter flow heat exchanger is mainly done in the tube heat exchanger. And the limitation is rise due to the use of tube for counterflow. The heat transfer rate is lower than that of aplate heat exchanger, and maintenance is more difficult since a tube cooler needs adequate clearance at one end to remove the tube. The tube cooler's capacity cannot be increased.

NOTE: In a counterflow pipe heat exchanger, there is typically turbulent flow in the device, which results in a high heat transfer coefficient of the surface, which is good for increasing the heat transfer rate.

1.2 Double pipe counter flow heat exchanger

Heat exchanger now a day comes in different shape and construction. Among these constructions double pipe heat exchanger is the one, mostly used and the simple type of heat exchanger.

A double pipe heat exchanger, also known as a pipe in pipe heat exchanger, is a heat exchanger that has one pipe within the other pipe. One pipe is concentrically encased inside a wider pipe. The inner pipe serves as a conductive shield, allowing one fluid to flow through it while another flows through the outside pipe. Here both the principle of convective and conductive heat transfer is used. The convective heat transfer occur between the hot fluid inside the inner pipe and the wall surface of the inner pipe and then there is conductive heat transfer between the inner wall surface and the outer wall surface of the inner pipe and there is again convective heat transfer between the outer surface of the inner wall and the cold fluid flow through the outer pipe. This the way how the double pipe heat exchanger transfer heat between the two fluids.

Fig. DOUBLE PIPE COUNTER FLOW HEAT EXCHANGER

The characteristics of the indirect contact recuperative type, in which the two fluids do not come into direct contact but exchange heat through a dividing wall, are included in the design requirements of the double pipe heat exchanger. A double pipe heat exchanger constructioncanbeusedforboth parallel or counterflow flow. In this paper we will discuss about the counterflow double pipe heat exchanger.

1.2.1 Advantages and disadvantages of double pipe heat exchanger

Double pipe heat exchanger has some required advantage over other complicated heat exchangers. The main importance of it are:

- Double pipe heat exchangers have a high efficiency and a low capital cost, and they are compact and need little room for maintenance while providing a high heat transfer capacity.
- Since double pipe heat exchangers are so common, all of the parts are standardized, making repair and maintenance a breeze.
- They can be used in high temperature and pressure applications
- The exchanger's design allows for more thermal expansion without the need for an expansion stage, and it has a versatile design that allows for easy addition and removal of other components.

As every device has some disadvantage the double pipe heat ex changers also has some disadvantages. These are :

Even though they can be used in parallel flow, they are most commonly used in counter flow designs.
- Because of their heat transfer limitations, they are only used in low-heat applications.
- This form is more prone to leaking.

But still Counter flow design of double pipe heat ex changer take the qualities of the counterflow discussed in the above section such as higher logarithmic mean temperature difference, higher exit temperature of the cold fluid, and minimize the thermal stress through out the heat exchanger. Such that it can transfer more heat. Due to this double pipe heat exchangers are mainly used for counter flow type.

CHAPTER 2 : BACKGROUND

A lot of research have been made in designing counter flow double pipe heat exchange and as far as we refer to previous researches we are able to see that the best performance heat transfer rate for counterflow double pipe is still issue. In case of parallel flow heat exchanger the logarithmic mean temperature difference is less , hence it transfer less heat than counter flow heat exchanger.

In addition to that due to its simplicity to design we are motivated to do research on it. Our point of view is to increase heat exchange rate using minimum expense and comparatively simple and affordable design. Here in our project also the best performance of it will be studied by varying different parameters of the double pipe heat.

CHAPTER 3 IMPLEMENTATION

3.1 Materials used

ANSYS software
The inner pipe is made of : Aluminium
The outer pipe is made of : Aluminium
The hot fluid used : Engine oil
The cold fluid used: Water

3.2 PROBLEM STATMENT

Design a counter flow heat exchanger to cool the engine oil of the large industrial gas turbine engine. Initially we have taken the following values :
Mass flow rate of the oil : 0.01 kg/s
Mass flow rate of the water : 0.3 kg/s
The inlet temperature of the oil : 423 K
The inlet temperature of the water : 293 K

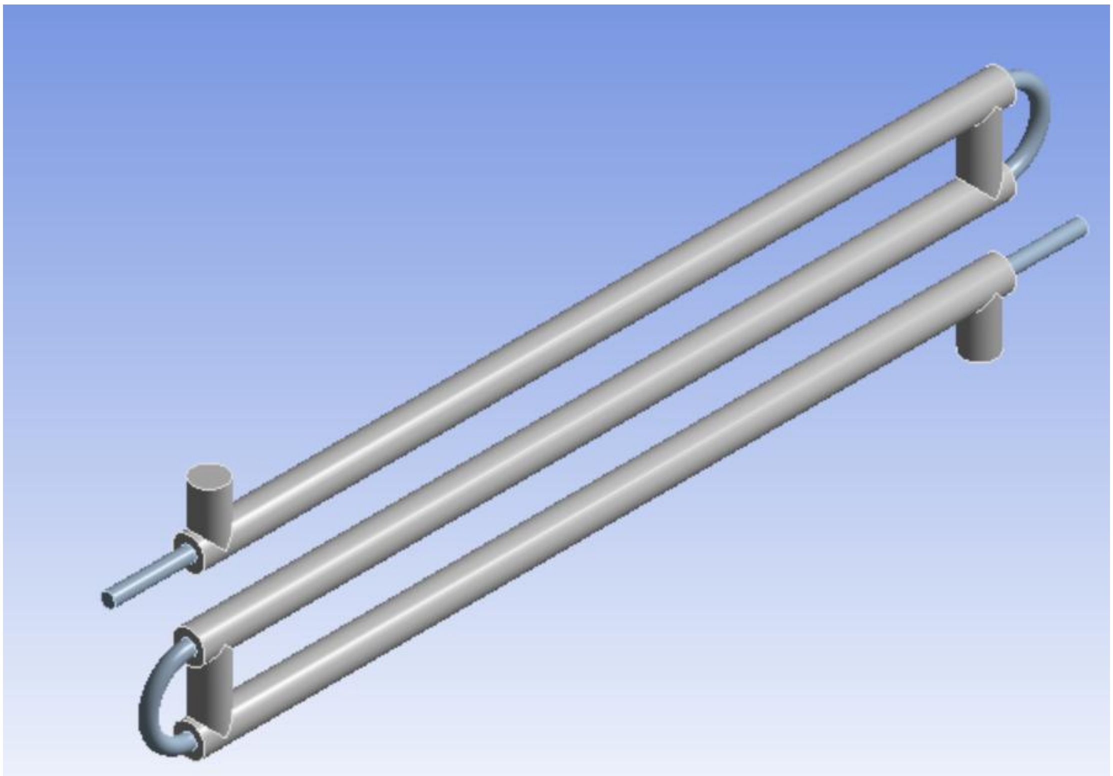
3.2.1 Method

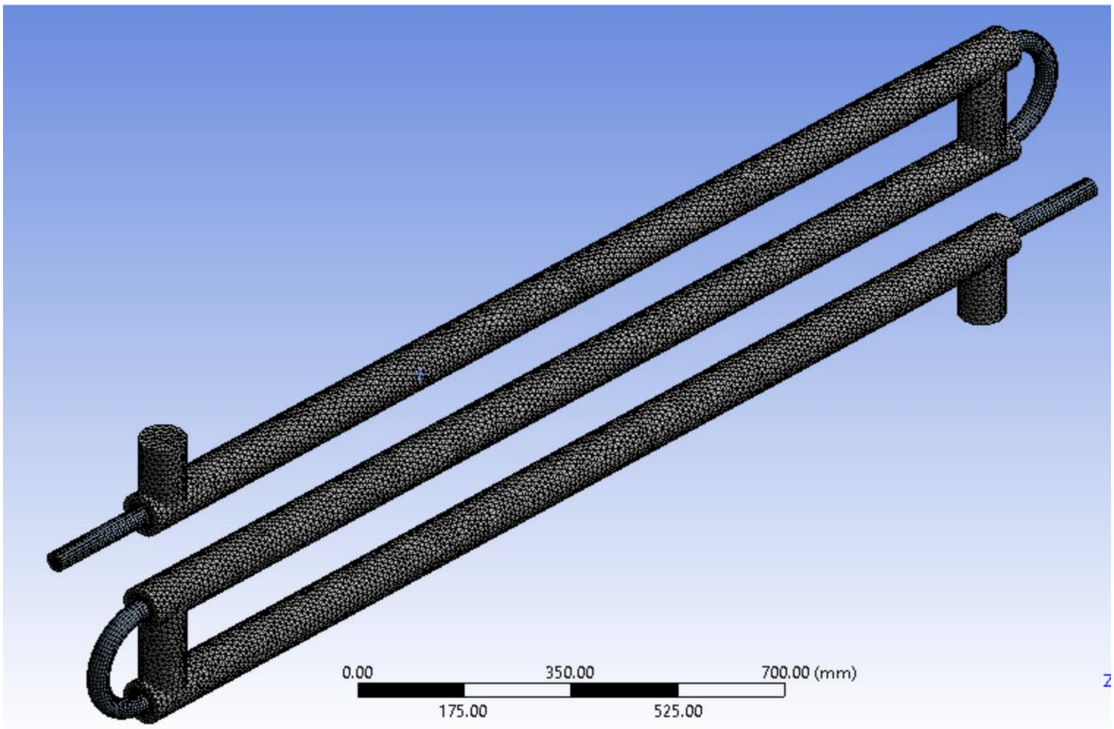
Here in our project we design double pipe heat exchanger by taking some temperature values for both cold and hot fluids at the inlet. And we have used ANSYS CFD fluid fluent for both the designing and analysis purpose.

3.3.2 Design

Pipematerialtaken:Aluminum
Length of the pipe : 2000 mm
Diameter of the inner pipe : 36 mm
Diameter of the outer pipe : 80 mm

Figures

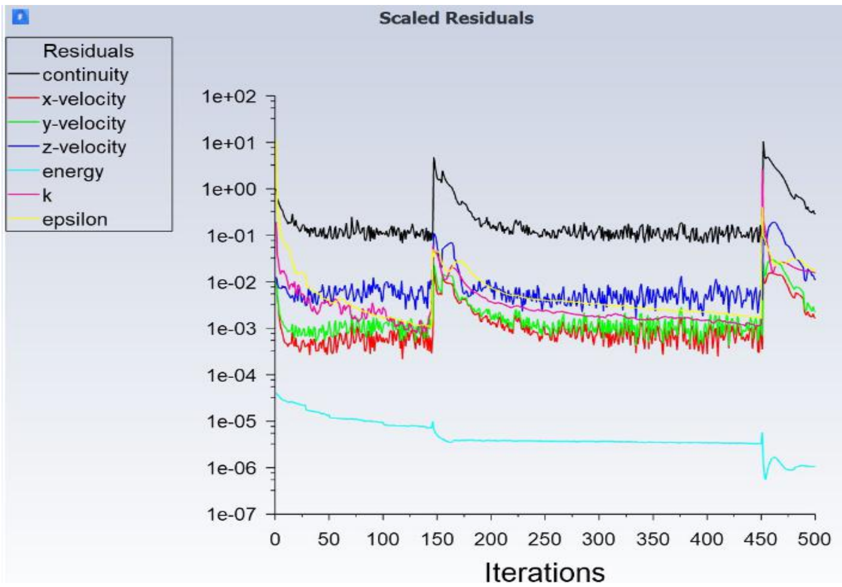




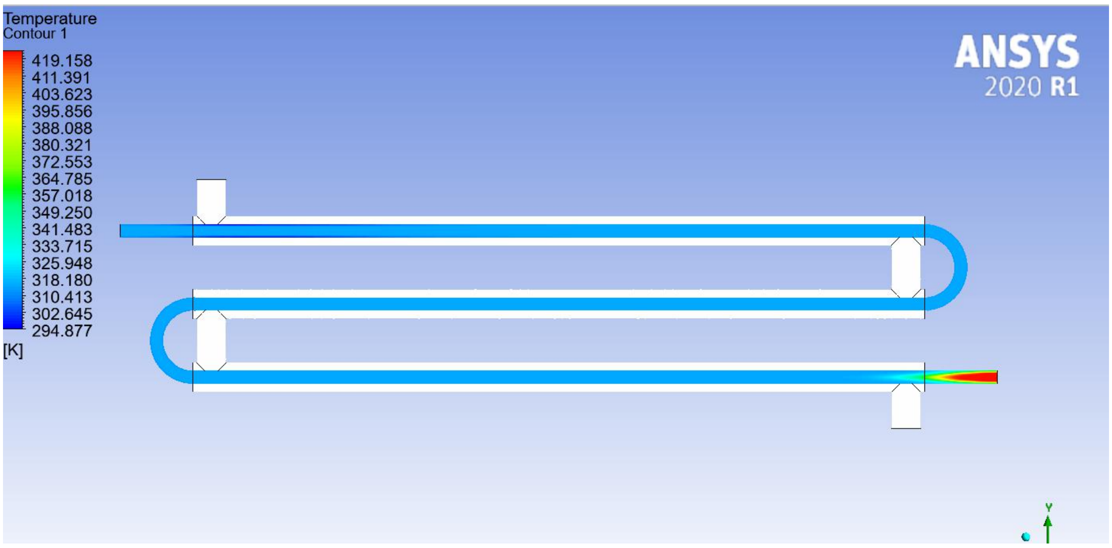
CHAPTER4

RESULT AND DISCUSSION

After designing double pipe counterflow heat exchanger in Ansys workbench , we have done the analysis in fluid fluent CFD. The material we have used for the the design of pipes is aluminium. The two fluids used are engine oil as a hot fluid and water as a cold fluid. The inlet temperature of hot fluid is 423k and after it pass through the heat exchanger its temperature at the outlet is 314k. The inlet and outlet temperatures of water are 293K and 315k respectively. We have seen that the oulet temperature of oil is almost equal with outlet temperature of water.



Temperature distribution


Temperature
Contour 1
419.158
411.391
403.623
395.856
388.088
380.321
372.553
364.785
357.018
349.250
341.483
333.715
325.948
318.180
310.413
302.645
294.877
[K]
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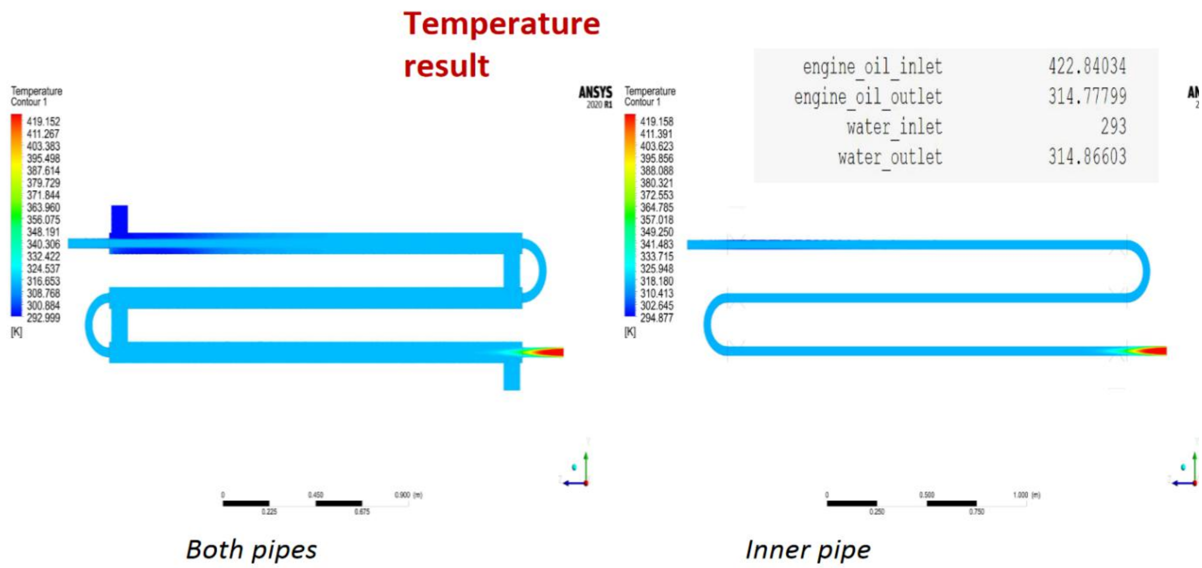
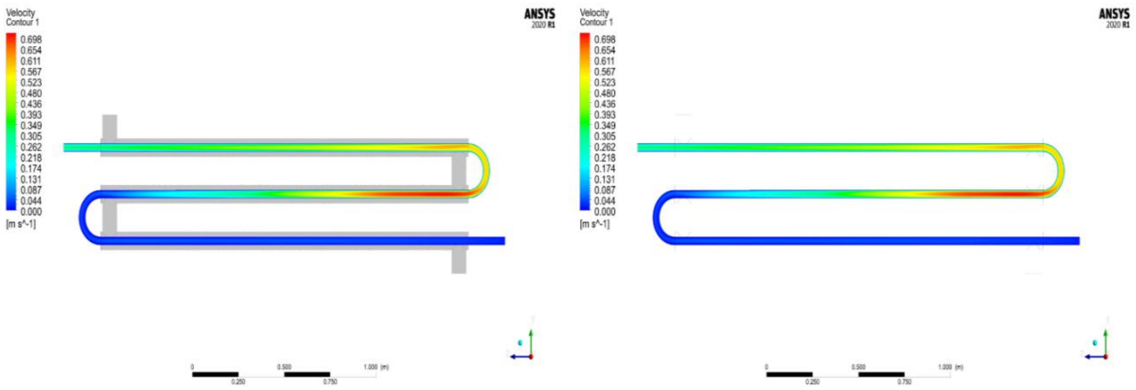

Temperature result
engine_oil_inlet 422.84034
engine_oil_outlet 314.77799
water_inlet 293
water_outlet 314.86603
Both pipes
Inner pipe

VELOCITY RESULT



Both pipes *Inner pipe*

CHAPTER5

CONCLUSION AND SCOPE FOR FUTURE WORK

Using CFD methodology, this study explores the heat transfer and flow characteristics of a double pipe heat exchanger for counterflow. The outlet temperatures of the fluids depends up on the mass flow rate of both fluids and vary when we alter flow rate. When the area of contact between the fluid and pipe increases heat transfer rate also increases significantly. From this we can observe that heat transfer rate is directly dependant on area through which the fluid flow . Thus from the velocity result above, we can conclude that the velocity of the fluid after the fluid temperature increase is high while the velocity of the fluid is getting low. So here our coolant water is getting increased temperature so attain high velocity towards the exist and the engine oil got lower velocity towards the exist. And the from this we can say velocity and temperature are directly proportional and in our analysis the counter flow gives better heat transfer rate in which the temperature of the hot fluid at the outlet is almost equal to the temperature of the cold fluid at the inlet so the counter flow has better efficiency and heat transfer rate.

REFERENCE

www.linkuip.comBYLINQUIPTEAM,Heatexchanger
http://www.ijstm.com/images/short_pdf/1480613781_1332.pdf
https://www.brighthubengineering.com/hvac/64548-double-pipe-heat-exchanger-design/
https://jcequipments.com/double-pipe-heat-exchanger.html
https://www.thomasnet.com/articles/process-equipment/double-pipe-heat-exchangers/
https://jcequipments.com/double-pipe-heat-exchanger.html
HeattransferbookbyEr.R.K.RAJPUT
U. Bolmsted,EncyclopediaofDiaryofscience
Heattransfer,wikbooks