INVESTIGATION ON HEAT TRANSFER ENHANCEMENT OF FLOWING WATER INSIDE A CIRCULAR TUBE HAVING TWISTED TAPE INSERTS USING CFD

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ABSTRACT

Numerical investigations were performed to investigate the airflow friction factor and heat transfer characteristics in an externally heated horizontal tube fitted with different types of inserts. The tested inserts produced flow separation and secondary flow, which prompted turbulence, and, hence, better mixing could be obtained that led to increased heat transfer rates. Friction factor was also much affected due to the presence of inserts. The variations of temperatures, Nusselt number and friction factor in the horizontal tube fitted with twisted tapes with different twist ratio (y/w=2.5, 3 and 3.5) and Reynolds numbers varying from ($5000 \leq Re \leq$ 17,100) have been studied. With the increase in Reynolds number, Nusselt number increased and friction factor decreased.

I.INTRODUCTION

Heat transfer enhancement is one of the key issues of saving energies and compact designs for mechanical and chemical devices and growing patents and hundreds of manufacturers offering products ranging from enhanced tubes to entire thermal systems incorporating enhancement technology. Twisted tapes are the metallic strips twisted with some suitable techniques at desired shape and dimension, inserted in the flow. The twisted tape inserts are popular and widely used in heat exchangers for heat transfer augmentation besides twisted tape inserts promote heat transfer rates with less friction factor penalty on pumping power.Insertion of twisted tapes in a tube provides a simple passive technique for enhancing the convective heat transfer by introducing swirl into the bulk flow and disrupting the boundary layer at the tube surface due to repeated changes in the surface geometry. That is to say such tapes induce turbulence and superimposed vortex motion (swirl flow) which induces a thinner boundary layer and consequently results in a better heat transfer coefficient and higher Nussle number due to the changes in the twisted tape geometry. However, the pressure drop inside the tube will be increased by introducing the twisted-tape to insert. Hence a lot of researches have been carried out experimentally and numerically to investigate the optimal design and achieve the best thermal performance with less frication loss. The enhancement of heat transfer using twisted tapes depends on the Pitch and Twist ratio.

II.OBJECTIVE

1. To investigate heat transfer characteristics and friction factor for plain tube and tube with inserting twisted tape of different twist ratio,under nearly uniform wall temperature conditions using water as test fluid using CFD.
2. To determine the enhancement in heat transfer rate and penalty in pressure drop for plain tube and tube with inserting twisted tape using CFD.

III.CFD ANALYSIS

CASE 1: HEAT EXCHANGER WITHOUT STRIP

Outer Diameter of Outer Tube: 56mm, Inner Diameter of Outer Tube: 52mm,Outer Diameter of inner Tube: 28.4mm,Inner diameter of inner Tube: 25.4mm,Length of Outer Tube: 1300mm,Length of Inner Tube: 1500mm

Table No. 4.1 Inputs For Analysis

Inputs for Analysis:

Model	Mass Flow Rate Hot Fluid(Kg/s)	Mass Flow Rate Cold Fluid(Kg/s)	Inlet Temperature Cold Fluid (K)	Inlet Temperature Hot Fluid (K)
Plain	0.66	0.1315	304.1	317.3
y/w=2.5	0.06598	0.1315	304.1	316.8
y/w=3	0.06598	0.1315	304.1	317.2
y/w=3.5	0.06598	0.1315	304.1	321

At inlet: Hot Fluid domain: Temperature: 317.3 K, mass flow rate: 0.066 Kg/S, Cold Fluid Domain: Temperature: 304.1K, mass flow rate: 0.1315Kg/s, all surfaces of tubes are wall In Output Pressure, Velocity and temperature counter to be viewed

Pressure:

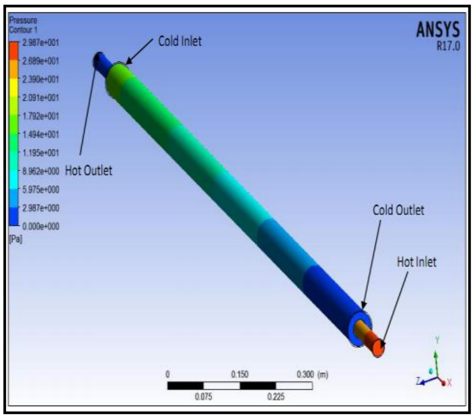


Figure 1: Pressure Contour For Cold Water

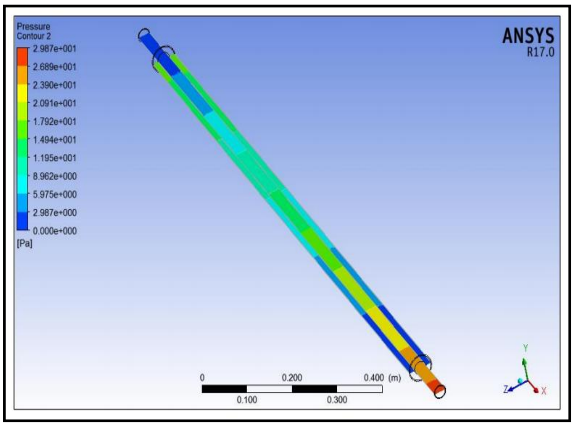
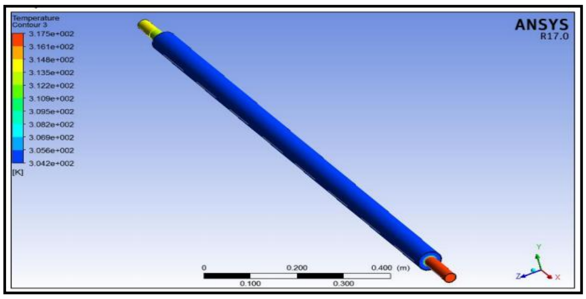


Figure 2: Pressure Contour For Hot Water

Pressure in hot side is at the inlet is 29Pa and reduce to zero at the outlet as it is opening to atmosphere. The pressure in cold side at inlet is 17Pa and outlet is zero.

Temperature:



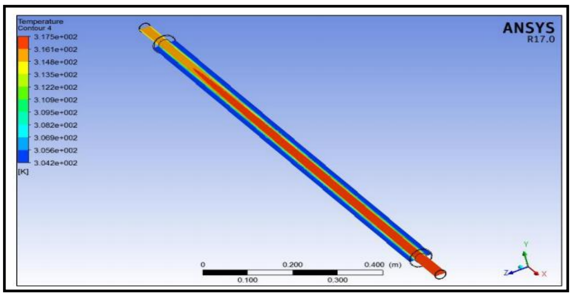
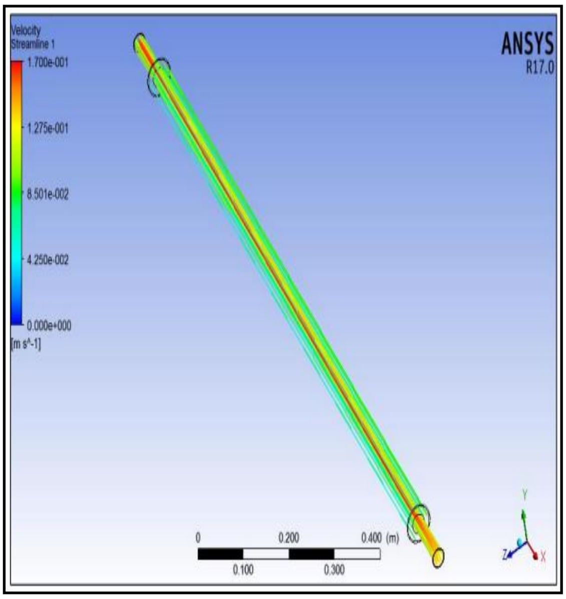


Figure 3: Temperature Contour for Cold Water **Figure 4: Temperature Contour for Hot Water**

The temperature at the inlet of hot side is 317.5K and outlet is 314.8K and there in cold side inlet is 304K but in is heated near to hot fluid tube is app. 310.9K

Velocity:



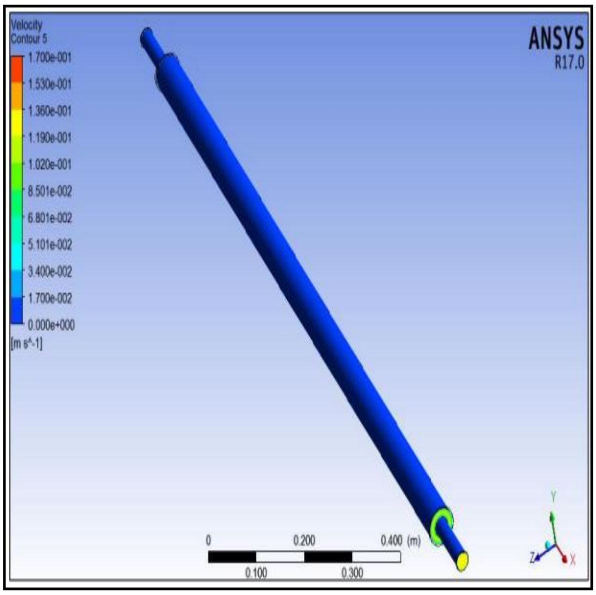


Figure 5: Velocity Streamline for Hot Water **Figure 6: Velocity Streamline for Cold Water**

The velocity of hot side is 0.17m/s and that in cold side is 0.102m/s

CASE 2: HEAT EXCHANGER WITH STRIP (y/w=2.5),

Width of twisted strip (w): 10 mm, thickness of strip: 1.5mm, Pitch of strip (y): 25mm

CAD Model:

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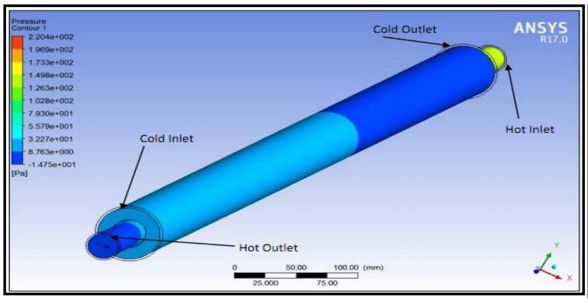
In Ansys Fluent boundary conditions are given as per requirement and the solution is initialized and calculations are iterated for 200 iterations.

At inlet:

Hot Fluid domain: Temperature: 316.8 K,mass flow rate: 0.066 Kg/s, Cold Fluid Domain: Temperature: 304.1K ,mass flow rate: 0.1315Kg/s ,all surfaces of tubes are wall ,In Output Pressure, Velocity and temperature counter to be viewed

Output:

Pressure:



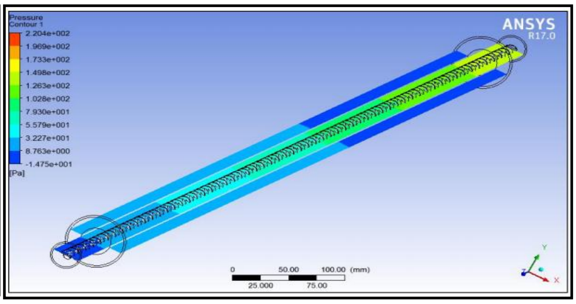
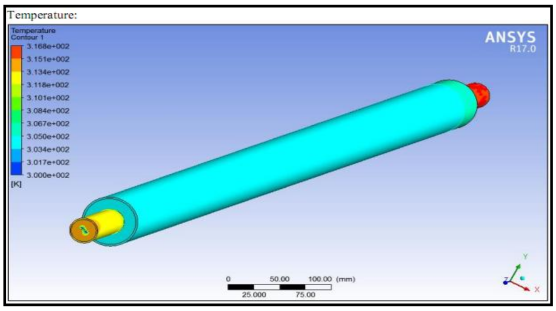


Figure 7: Pressure Contour for Cold Water (y/w=2.5)   Figure 8: Pressure Contour For Hot Water (y/w=2.5)



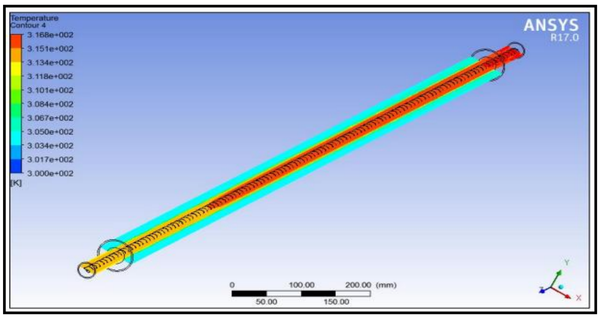
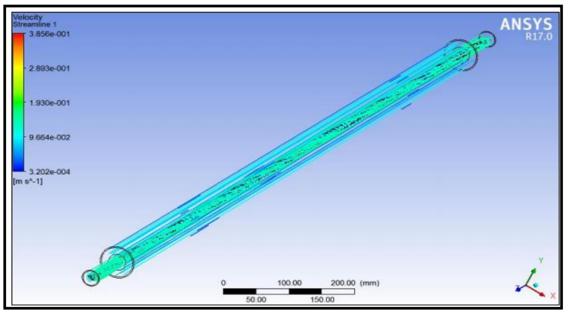


Figure 9: Temperature Contour For Cold Water (y/w=2.5)

Figure 10: Temperature Contour For Hot Water (y/w=2.5)



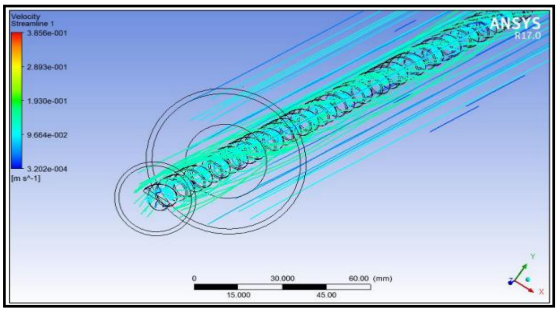


Figure 11: Velocity Streamline For Cold Water (y/w=2.5)

Figure 12: Velocity Streamline For Hot Water (y/w=2.5)

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CASE 3: HEAT EXCHANGER WITH STRIP (y/w=3),

Width of twisted strip (w): 12 mm, thickness of strip: 1.5mm, Pitch of strip (y): 36mm

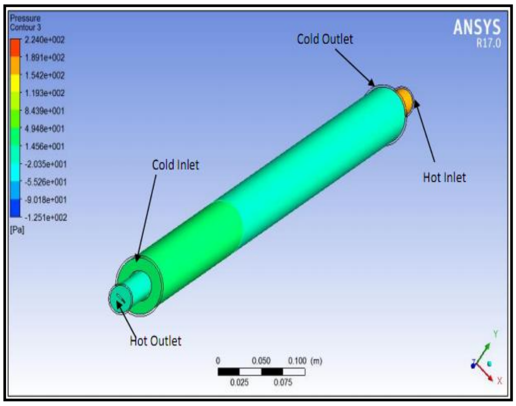
In Ansys Fluent boundary conditions are given as per requirement and the solution is initialized and calculations are iterated for 200 iterations.

At inlet:

Hot Fluid domain: ,Temperature Inlet: 317.2 K, mass flow rate Inlet: 0.066 Kg/s, Cold Fluid Domain: Temperature Inlet: 304.1K ,mass flow rate Inlet: 0.1315Kg/s, all surfaces of tubes are wall. In Output Pressure, Velocity and temperature counter to be viewed

Output:

Pressure:



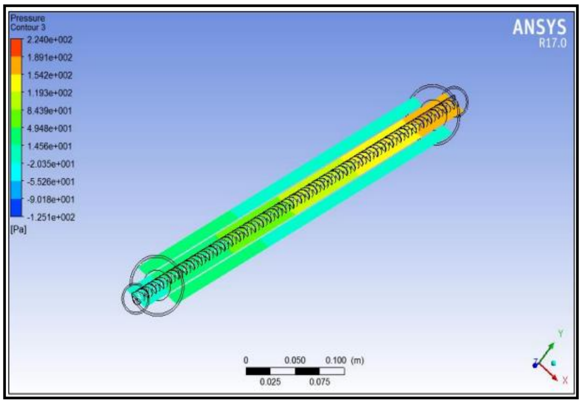
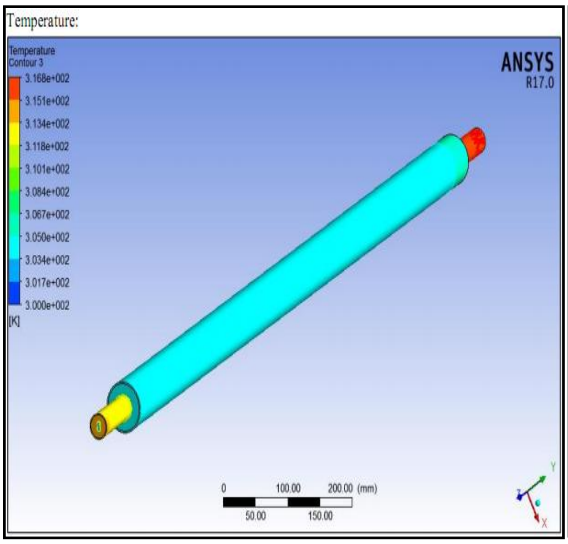


Figure 13: Pressure Contour For Cold water (y/w=3)

Figure 14: Pressure Contour For Hot Water (y/w=3)



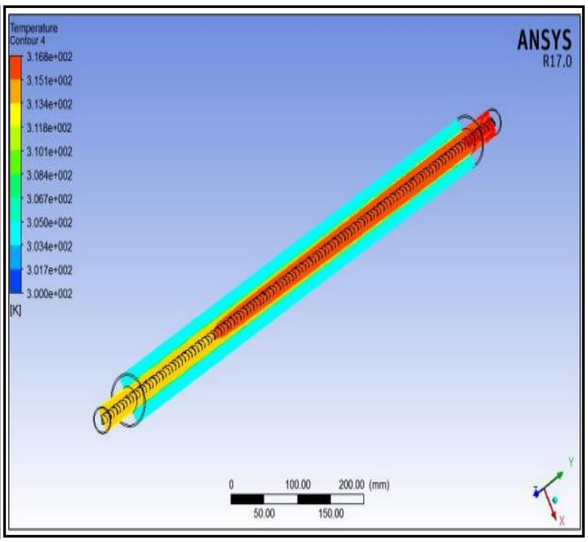


Figure 15: Temperature Contour For Cold Water Tape (y/w=3)

Figure 16: Temperature Contour For Hot Water (y/w=3)

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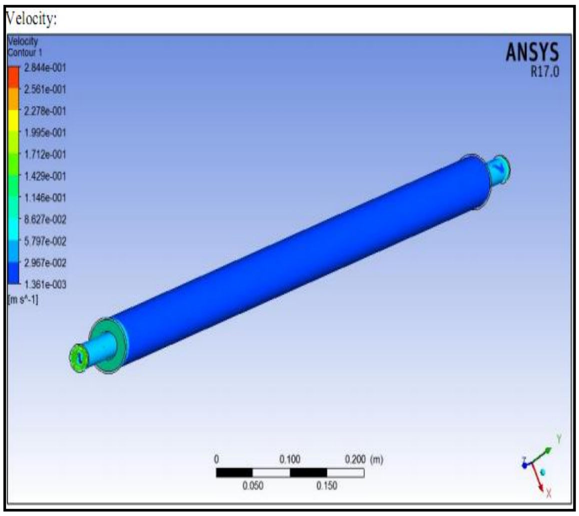


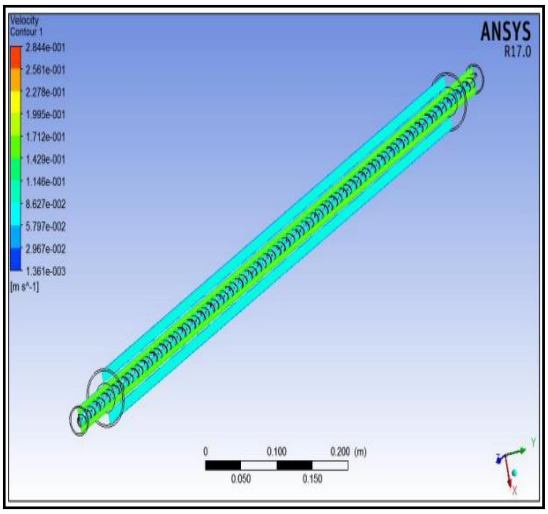
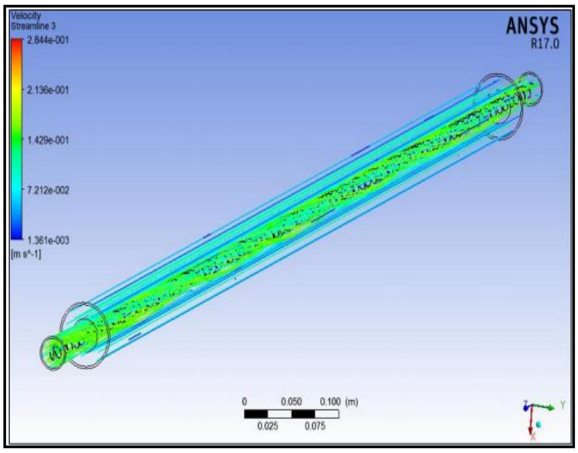


Figure 17: Velocity Contour for Cold Water (y/w=3) **Figure 18: Velocity Contour for Hot Water (y/w=3)**



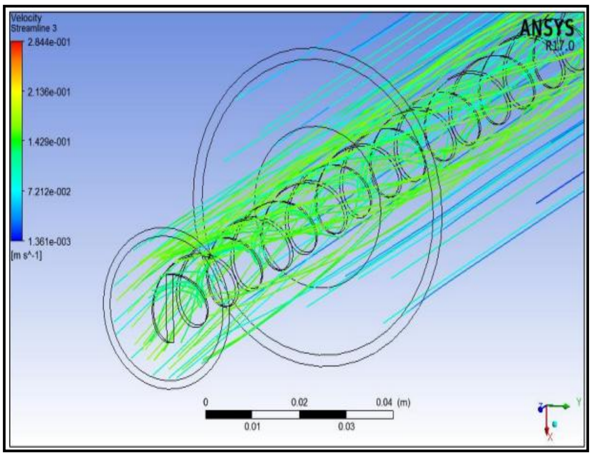


Figure 19: Velocity Streamline For Cold Water (y/w=3)

Figure 20: Velocity Streamline For Cold Water (y/w=3)

CASE 4: HEAT EXCHANGER WITH STRIP (y/w=3.5),

Width of twisted strip (w): 14 mm, thickness of strip: 1.5mm

Pitch of strip (y): 49mm.

In Ansys Fluent boundary conditions are given as per requirement and the solution is initialized and calculations are iterated for 200 iterations.

At inlet: Hot Fluid domain: Temperature Inlet: 321 K, Mass flow rate Inlet: 0.066 Kg/s,

Cold Fluid Domain: Temperature Inlet: 304.1K, Mass flow rate Inlet: 0.1315Kg/s

All surfaces of tubes are wall In Output Pressure, Velocity and temperature counter to be viewed

Output:

Pressure:

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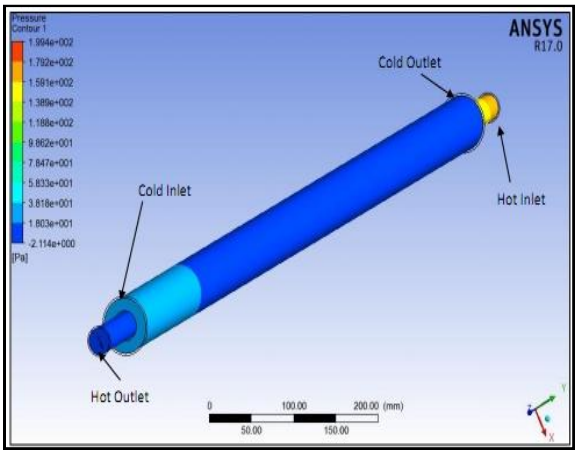

Figure 21: Pressure Contour
For Cold Water (y/w=3.5)

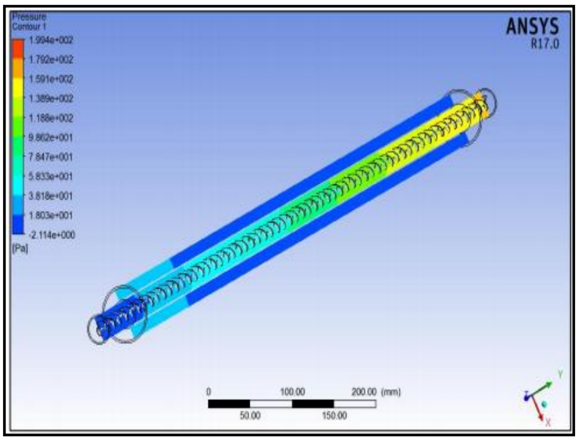

Figure 22: Pressure Contour
For Hot Water (y/w=3.5)

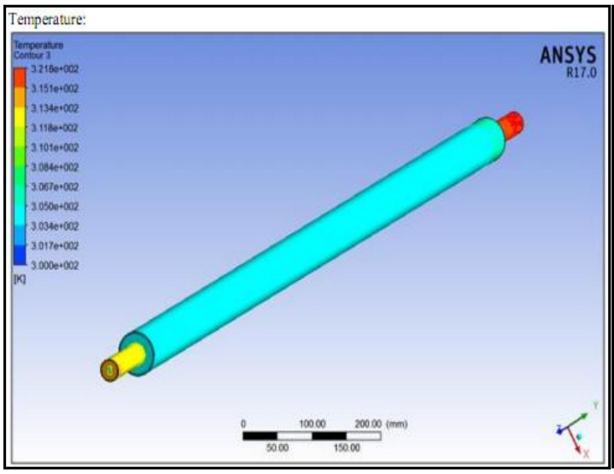

Figure 23: Temperature Contour
For Cold Water (y/w=3.5)

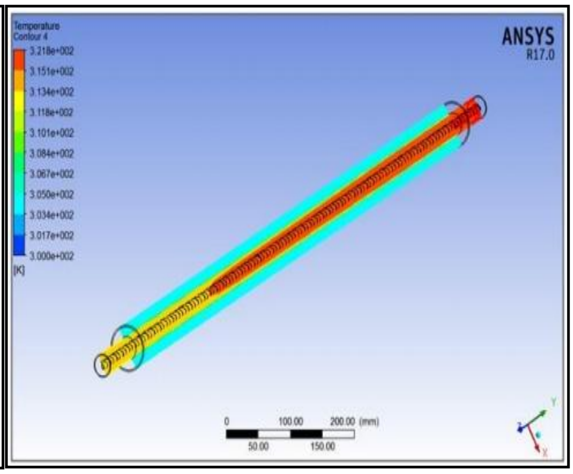

Figure 24: Temperature Contour
For Hot Water (y/w=3.5)

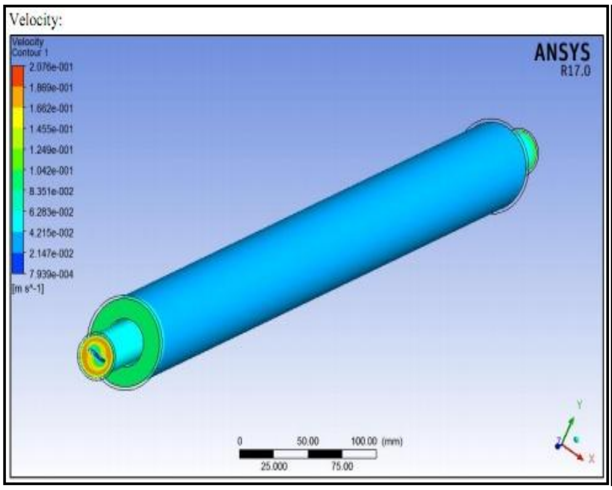

Figure 25: Velocity Contour
For Cold Water (y/w=3.5)

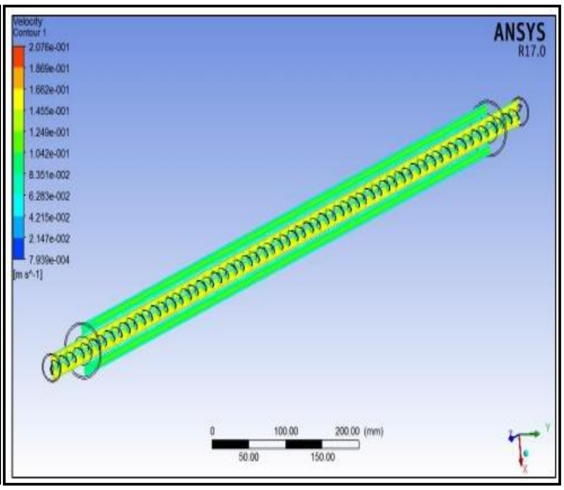

Figure 26: Velocity Contour
For Hot Water (y/w=3.5)

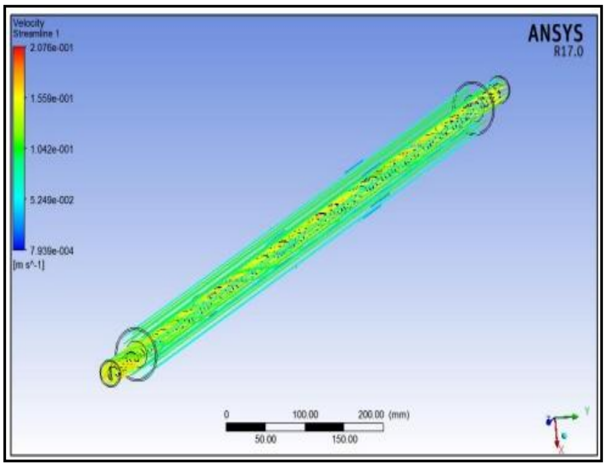

Figure 27: Velocity Streamline For Cold Water (y/w=3.5)

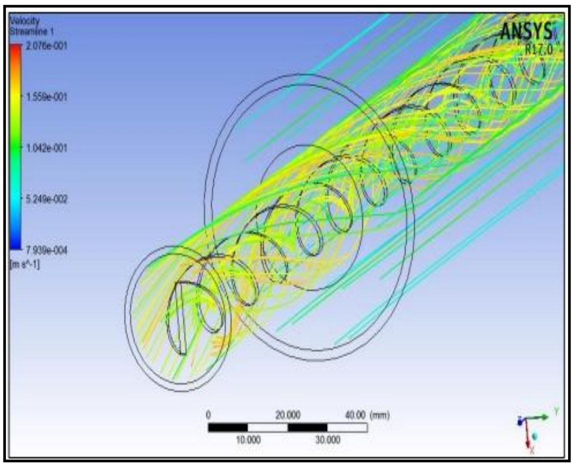

Figure 28: Velocity Streamline For Hot Water (y/w=3.5)

IV.CONCLUSION

It is observed that the Reynolds number varies largely between inlet and outlet of the heat exchanger in the case of heat exchanger with twisted tape, whereas in heat exchanger without twisted tape Reynolds number remains constant. When we are concern about the pressure, pressure drop is larger in with twisted tape than without twisted tape. Our concern is about the enhancement of heat transfer so we can ignore the pressure drop. By using passive techniques that is by inserting twisted tape inserts the heat transfer enhancement increased with the cost of reasonable allowable pressure drop .In this report we achieved enhancement of heat transfer effectively.

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