CFD Analysis for the Enhancement of Heat Transfer in a Heat Exchanger with Twisted Tape Inserts & Dimpled Tube

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Abstract— In the concentric tube heat exchanger, by using dimpled tube for outer shell and by providing twisted tapes in the inner tube, the heat transfer, Reynolds number, temperature, pressure, velocity variations are analysed. Twisted tapes and dimpled tube are used to augment the heat transfer by creating turbulence in the fluid flow. In this report the analysis is conducted by two cases comprised of counter flow arrangement with the dimpled tube i.e outer shell is made of copper, the inner tube is made of aluminium and the twisted tape is made by copper, In the second case comprised with the arrangement of dimpled tube i.e outer shell is made of aluminium, the inner tube is made of copper and the twisted tapes is made by aluminium. The hot water is passed inside inner tube and cold water is passed between the annulus in counter flow in both cases. Out of two cases is compared with concentric tube heat exchanger without twisted tape and without dimple tube are compared. Here using Fluent in ANSYS software the analysis are done.

Key words: Reynolds Number, Copper, Aluminium, Twisted Insert, Dimpled Tube, Counter Flow

I. INTRODUCTION

Heat exchangers are devices that facilitate the exchange of heat between two fluids that are at different temperatures while keeping them from mixing with each other. Heat exchangers are commonly used in practice in a wide range of applications, from heating and air-conditioning systems in a household, to chemical processing and power production in large plants. Heat exchangers differ from mixing chambers in that they do not allow the two fluids involved to mix. In heat exchangers the temperature of each fluid changes as it passes through the exchangers and hence the temperature of the dividing wall between the fluids also changes along the length of the exchanger. Heat exchangers are designed to deliver a certain heat transfer rate for a certain specified condition of flow rates and temperatures. A double pipe heat exchanger is a normal heat exchanger consisting of hot and cold fluid channels aligned properly. Heat transfer in a heat exchanger usually involves convection in each fluid and conduction through the wall separating the two fluids. In the analysis of heat exchangers, it is convenient to work with an overall heat transfer coefficient U that accounts for the contribution of all these effects on heat transfer. The rate of heat transfer between the two fluids at a location in a heat exchanger depends on the magnitude of the temperature difference at that location, which varies along the heat exchanger. In general, for any heat exchanger the heat transfer coefficient depends mainly on.

- Velocities in the tube and shell
- Tube outside diameter
- Baffle spacing
- Baffle cut no. of tubes
- Length of the tubes
- Logarithmic mean temperature difference.

II. SOLID MODELLING

The solid modelling is designed using solid works software. The inner tube cut section and full view of concentric tube heat exchanger is shown in the Fig 1

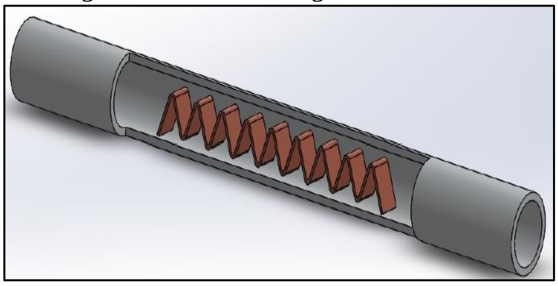

Fig. 1: Inner Tube with Twisted Tape Cut Section View

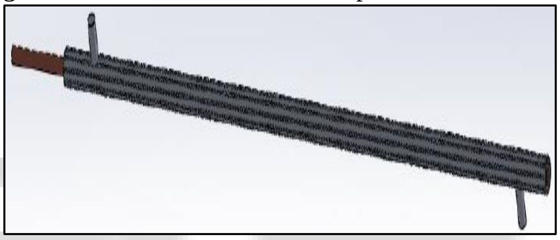

Fig. 2: Solid Modelling of Concentric Tube Heat Exchanger

III. ANALYSIS

ANSYS Fluent software contains the broad physical modeling capabilities needed to model flow, turbulence, heat transfer, and reactions for industrial applications ranging from air flow over an aircraft wing to combustion in a furnace, from bubble columns to oil platforms, from blood flow to semiconductor manufacturing, and from clean room design to wastewater treatment plants. Special models that give the software the ability to model in-cylinder combustion, aero acoustics, turbo machinery, and multiphase systems have served to broaden its reach. The designed heat exchanger is imported into the ANSYS Fluent Workbench. It is meshed by using mesh module. Meshing is done as discussed in the previous units. In this regard 3D unstructured meshing is used to mesh the object regard 3D unstructured meshing is used. The following fig 3 shows the meshing parts.

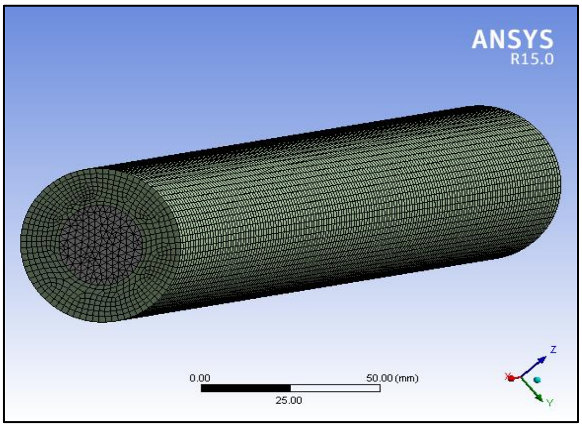

Fig 3 Meshing of Heat Exchanger with Twisted Tape and Dimple Tube

After the completion of meshing the design is opened in ANSYS Fluent. In fluent boundary conditions are given as per requirement and the solution is initialized and calculations are iterated. It is shown in fig 4

At inlet

- Hot fluid – water (335k)
- Cold fluid – water (300k) at normal pressure
- Velocity -100.8 m/s

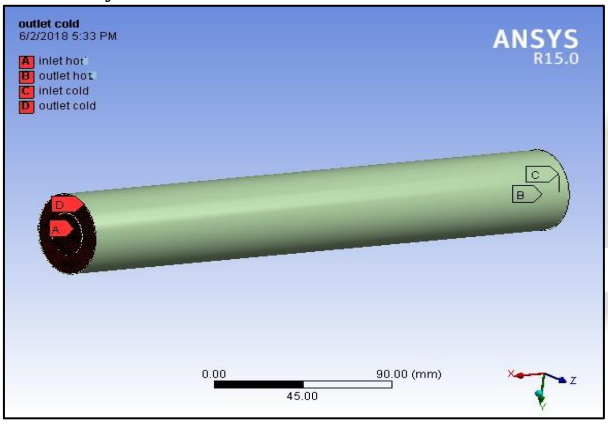

Fig. 4: Boundary Conditions

Below table 1 gives the material detail for case 1

Case	Section	Material
1	Outer dimple tube	Copper
	Inner tube	Aluminium
	Twisted tape	Copper

Table 1: Material Details for Case 1

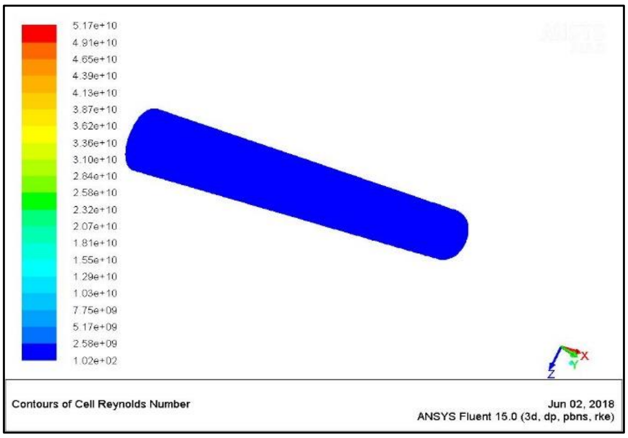

Fig. 5: Reynolds Number Variation in Heat Exchanger with Twisted Tape

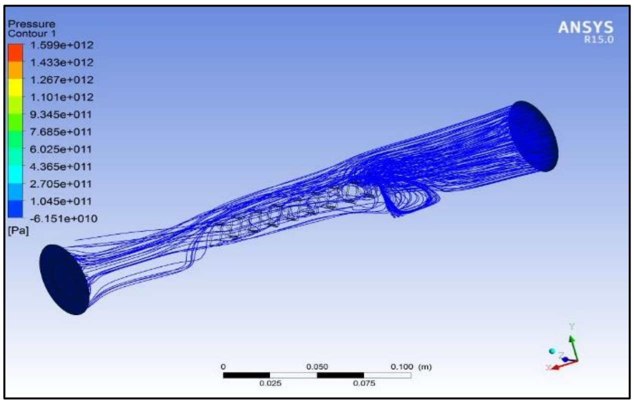

Fig. 6: Pressure Contour for Case 1

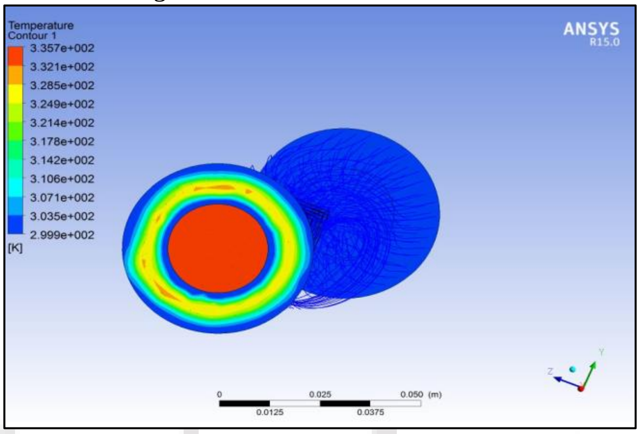

Fig. 7: Temperature Contour of Inlet Section for Case 1

Case	Section	Material
2	Outer dimple tube	Aluminium
	Inner tube	Copper
	Twisted tape	Aluminium

Table 2: Material Details for Case 2

The fig 8,9,10 shows the Reynolds number variation, pressure and temperature contour.

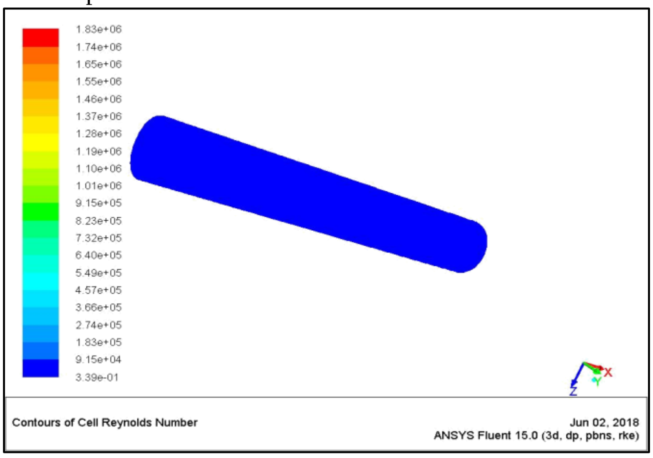

Fig. 8: Reynolds Number Variation in Heat Exchanger for Case 2

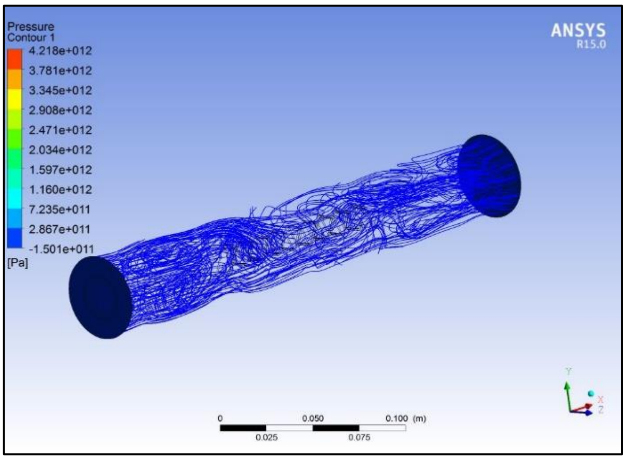

Fig. 9: Pressure Contour for Case 2

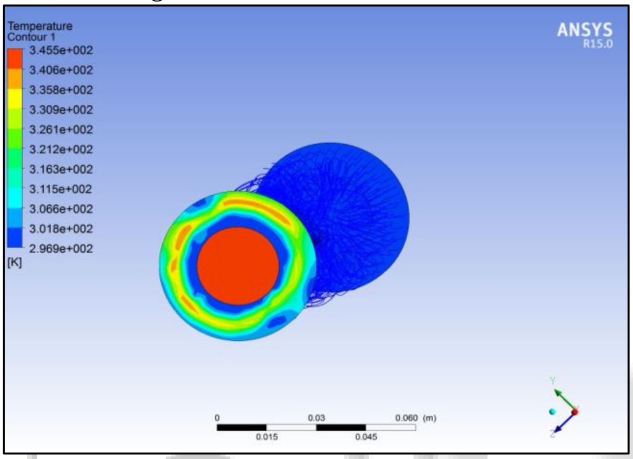

Fig. 10: Temperature Contour of Inlet Section for Case 2

In the above figures we can observe that the Reynolds number is increasing from inlet of the heat exchanger to the outlet of the heat exchanger. This is because of the reason that, during the flow of fluid over the twisted tapes a disturbance is created in the flow, thus turbulence is created .This results in the increase of the Reynolds number.

IV. RESULTS & DISCUSSION

The table III and IV shows the results from analysis

Parameters	Hot fluid inlet	Hot fluid outlet	Cold fluid inlet	Cold fluid outlet
Pressure (pa)	1.15e11	1.1e11	-6.3e10	-6.2e8
Reynolds no	4.35e5	4.6e6	1.27e6	1.38e6
Temperature(k)	3.21e02	3.00e02	2,99e02	3.01e02

Table 3: Results for case 1at v=100 m/s

Parameters	Hot fluid inlet	Hot fluid outlet	Cold fluid inlet	Cold fluid outlet
Pressure (pa)	1.15e11	1.1e11	-6.3e10	-6.2e8
Reynolds no	4.35e5	4.6e6	1.27e6	1.38e6
Temperature(k)	3.40e02	3.00e02	2,99e02	3.01e02

Table 4: Results for case 2 at v=100 m/s

The table 5 is taken from the previous journals analysis[6]

Parameters	Hot fluid inlet	Hot fluid outlet	Cold fluid inlet	Cold fluid outlet
Pressure (pa)	1.05e5	9.98e5	9.27e4	9,2e4
Reynolds no	2.01e5	2.03e5	1.92e5	1.94e5

Table 5: Results from Previous Analysis at v=100 m/s

The fig 11 & 12 gives comparison between Reynolds no and temperature for different cases

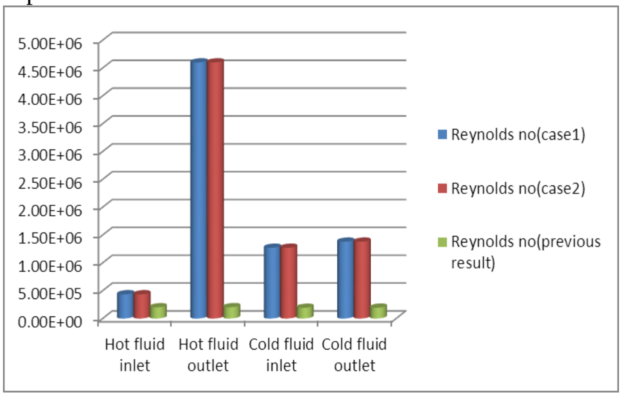

Fig. 11: Comparison of Reynolds Number

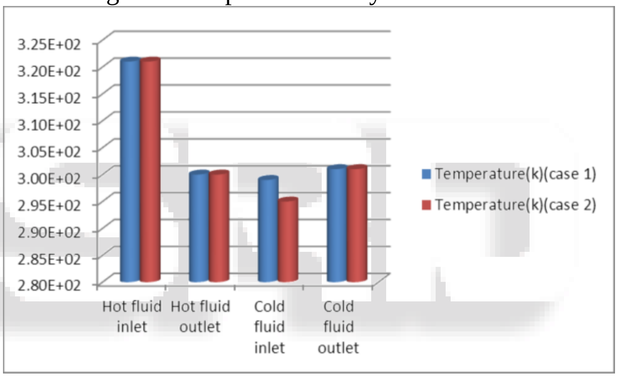

Fig. 12: Comparison of temperature variation

From the graph comparison it shows the case 1 shows better Reynolds number which is due to more turbulence by using twisted tape.

V. CONCLUSION

From the above comparison graph it shows that Reynolds number increased in both case 1 and case 2 compared to without twisted tape tube heat exchanger. It is because of more turbulence due to twisted tapes and dimpled tube used in both the cases. The pressure and Reynolds value are more are less same in case 1 and 2 because of same twisted tape but the temperature variation is due to material change. Our concern is about the enhancement of heat transfer so we can ignore the pressure drop. But according to the temperature distribution the material design plays a major place from the graph the case 1 of having better results than case 2. Because of inner pipe made with aluminum material the thermal conductivity is more and also of material twisted tape placed with copper the results are better. Hence case 1 material design can be suggested. Hence the CFD analysis is done for the concentric tube heat exchanger by suing passive technique of using dimple tube and twisted tape inserts and properties were analysed. The future work may extended to:

- By using different cold fluid medium instead of water.
- By varying the velocity check the heat transfer rate
- By changing the dimension of the twisted tape check the properties variation

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