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Design And Performance Analysis of Double Pipe Heat Exchanger In Counter Flow

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ABSTRACT

Heat exchangers are important devices commonly used in various industries such as processes, petroleum refining, chemicals, oil industries, power plants, paper, etc. The demand for high-efficiency heat exchangers has been driven by energy and material saving requirements and environmental challenges in the industry. To improve the heat exchanger's efficiency, one must think of heat transfer enhancement in the heat exchanger. In addition, heat transfer improvement makes it possible to reduce the size of the heat exchanger significantly. For a compact heat exchanger, a high heat transfer rate with minimum space requirement is required. The counter flow heat exchanger increases the heat transfer feature of the double pipe heat helical fins that have been mounted on the inner tube's outer surface, and the additional insert is used to improve the effectiveness. The heat pipe model is designed by the software CREO PARAMETRIC and analyses by the ANSYS software. To check the temperature difference in varying hot water flow rates. Furthermore, compare and select the best model of the double pipe heat exchanger.

I. INTRODUCTION

The double pipe heat exchanger could be a method to simplify to exchange heat b/w two fluids while not mixing at different temperatures. In a heat exchanger, two kinds of heat transfer happen like convection & conduction. Typically convection happens in each operating fluids & conduction through walls of heat exchanger that separates the fluids.

The heat transfer coefficient improvement capability beside a minimum loss in friction factor defines the inserts. Tube inserts are utilized for heat transfer improvement in different industrial fields like fossil fuel refineries and chemical plants for several years.

There may be several different flow patterns for a heat exchanger. Common types of heat exchangers are counterflow, parallel flow, and crossflow. The most effective flow method of the three is a counter flow heat exchanger.

A counterflow heat exchanger is a warm fluid that enters at one end of the heat exchanger, and the cold fluid exits at the same end of the flow path. Counterflow is the most popular type of fluid to the fluid heat exchanger since it is the most effective type.

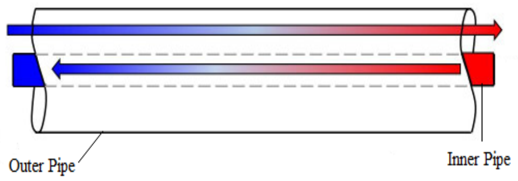

Fig. 1.1 Counter Flow Heat Exchanger

II. LITERATURE REVIEW

PragneshkumarPrajapati*et al.* (May 2016) observed a large difference in NusseltNumber between the plain tube and in the heat exchanger with twisted tape insert. The heat transfer improved by 22% to 33% in temperature outlet at various Reynolds numbers. Using inserts at y=45 and heat transfer improved by 15% to 45% at various Reynolds numbers using inserts at y=15. Its increase of pressure drop is more by using y=15 geometrical spacing pentagonal shape inserts in the cold pipe of concentric tube type heat exchanger compared to plane tube presented by **Kanika Joshi *et al.* (May 2017).**

KalapalaLokesh*et al.* (May 2017), the twisted tape insert setup is more efficient because the twisted tape creates turbulence in the region where the hot fluid flows. Through inserting twisted tapes, an improvement of about 30 percent in output is observed at low mass flow rates. The DPHE with various angles of fins to research in the heat exchanger flow and temperature, Attempts have been made to investigate the effects and heat transfer characteristics of DPHE for six different fine inclinations: 0°, 5°, 10°, 15°, 20°, and 25°. The heat transfer rate is better for 20° helical fins in a double pipe heat exchanger, to say **Bandu*et al.* (Aug2017).**

Vijayasagar&Appalanaidu (Aug2017), The friction factor of 0.4% ZnONanofluid flowing in a tube with H / D=3 twisted tape configuration increases 12.16% at a Reynolds number of 3000 and 15.32% at a Re of 8000 compared to the same concentration liquid without warped tape inserts. The CFD predictions match the experimental results within the limits of experimental errors reasonably well. A correlation has been developed based on the results to calculate the helical coil's internal heat transfer coefficient. Based on the confidence gained in the CFD predictions, the results obtained under different conditions can be further used to obtain a generalized correlation applicable to different coil configurations developed by **Jayakumar*et al.* (Oct 2017).**

YaminiPawar&AshishSarode (Dec 2017), the experimental comparison of coils with circular diameter coil against coil with notches, was also noted inside Nu, heat transfer coefficient, and Dean number these parameters increase by 3.75% and hence here prove that coil with notches is superior to simple circular tube coils. The heat transfer rate for the helical wire insert rises to 74.7 percent. The rise for the twisted clip is 57.5 percent, and the corrugated tube is 20.2 percent. For helical wire attachment, the overall heat transfer coefficient increases to 95%.This increase for the twisted clip is 56.5 percent, and the corrugated tube is 33 percent. For helical wire insert, which is 0.55 to say the **Deepak Sen&AlkaAgrawal (Jan 2018),** the Effectiveness quality is optimum.

Harsh Ladani*et al.* (April 2018).The heat transfer rate and efficiency are low due to temperature reduction and pressure drop in the heat exchanger through a finned tube. The new model type heat exchanger has increased the overall heat transfer rate, and also the heat exchanger's efficiency for circular fins is increased by 4%-6%. The double pipe heat exchanger's efficiency for helical fine and Nanofluid is also increased by 12%-16%. It is also observed that there is an enhancement in heat transfer using helical and circular fin.The twist of the internal tube was added from one to three turns; an increase up to 3% in the Nusselt number was calculated. The biggest increase, up to 9%, was calculated when five turns were simulated to develop the **Miyer Valdes *et al.* (May 2019).**

Kola David &Abhishekkumar (May 2019), When we compare the radiator's different geometries, the helical type tube is the better model because the heat transfer rate value is more for helical type tube radiator is the better model.

III. PROBLEM IDENTIFICATION

The double pipe heat exchanger has already developed technology for the quick response of heat transfer. The method of heat transfer provided better results and suitable for a few applications in large scale industries. The advantages of technology should applyto all sectors to reduce investment. So, the present work has been processed under this area to improved heat transfer efficiency.

IV. MATERIAL SELECTION

Table 4.1 Material Property

Description	Steel	Copper	Aluminum
Density (kg/m^3)	8030	8978	2719
Specific Heat (j/kg K)	502.48	381	871
Thermal Conductivity (w/m K)	16.27	387.6	202.4

Steel: Galvanized steel was the standard piping material for water and wastewater transport in the piping sector. This technology provided the metal pipe with a reasonable level of internal and external protection. This pipe is used to cold water flow in the process.

Copper: Copper tubing is almost widely used in hot and cold water supply and as a heat exchanger line. Furthermore, high thermal conductivity in the copper. It's used in the hot water flow process and Helical fins.

Aluminum: To improve the tube, aluminum inserts with a flat plate profile are inserted into the copper tube.

Table 4.2 Hot & Cold Water Properties

Description	Cold Water (30 ℃)	Hot Water (60 ℃)
Density (kg/m^3)	995.215	983.2
Specific Heat (j/kg K)	4180.15	4184.3
Thermal Conductivity (w/m K)	0.614	0.654
Viscosity (kg/m s)	0.000827	0.000466

V. DESIGN & ANALYSIS OF DOUBLE PIPE HEAT EXCHANGER

A double pipe heat exchanger, in its simplest form, there is only one pipe inside to flow the hot water, and another outside pipe is wider flows between the two pipes through the annulus. The internal pipe wall is the site for heat transfer.

There are three different model analysis based on computational fluid dynamics. The model shows Fig. 5.1, 5.2 & 5.3.

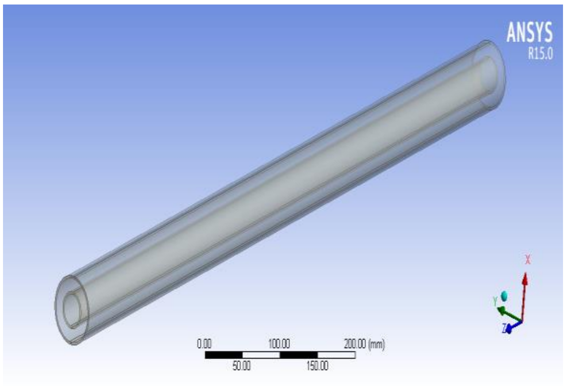

Fig. 5.1 Normal DPHE

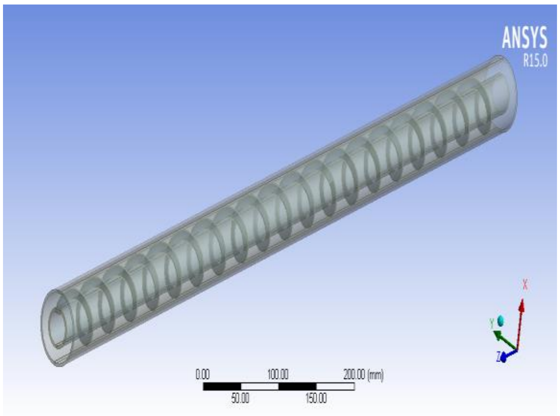

Fig. 5.2 Helical Fins

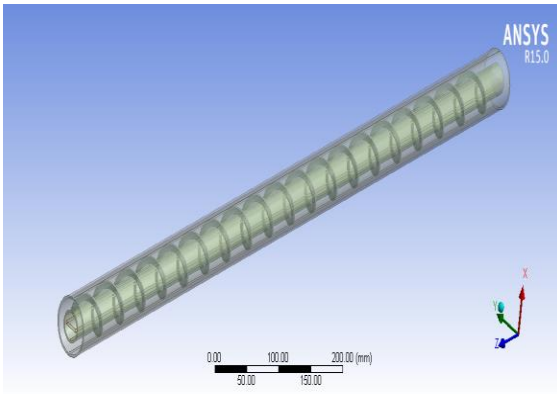

Fig. 5.3 Helical Fins with Flat Plate

Meshing

Meshing is nothing but discretization in the finite number of elements of the continuous body. The double pipe heat exchanger model meshing image is shown in Fig. 5.4, and the number of elements & nodes represented in Table 5.1.

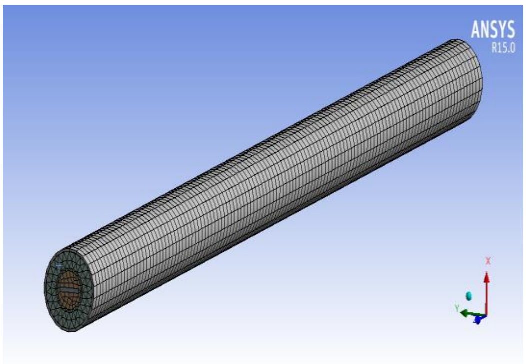

Fig. 5.4 Meshing

Table 5.1 Number of Elements & Nodes

Types	Number of Elements	Number of Nodes
Normal	31600	45240
Helical Fins	151904	59263
Helical Fins with Flat Plate	146649	54252

VI. ANALYSIS RESULT

The double pipe heat exchanger is an analysis of three designs (Normal, Helical Fins&Helical Fins with Flat Plate) in the same condition of varying hot water flow of (2, 4 & 6 LPM) in 60℃ and the cold water flow rate is constant of 10 LPM in 30℃. All the design one by one explains.

A. Normal DPHE

Table 6.1 Temperature Difference in Normal DPHE

Hot Water			Cold Water		
Flow Rate LPM	Inlet ℃	Outlet ℃	Flow Rate LPM	Inlet ℃	Outlet ℃
2	60	53.19	8	30	31.75
4	60	55.49	8	30	32.25
6	60	56.56	8	30	32.54

The Normal DPHE model shows the best flow rate temperature difference in Numerical & graphically represented below Fig. 6.1 & 6.2. Furthermore, Pressure and Velocity graphically mention Fig. 6.3 & 6.4.

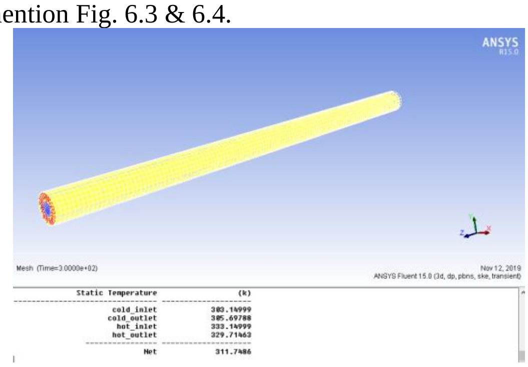

Fig. 6.1 Numerical Temperature Difference in Normal DPHE

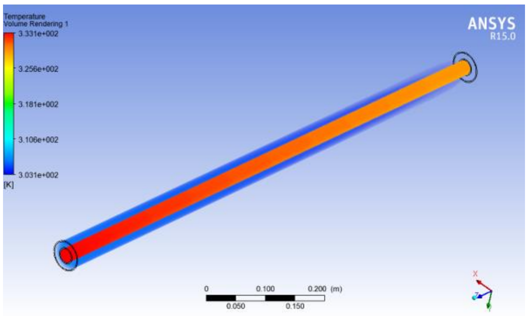

Fig. 6.2Graphically Temperature Difference in Normal DPHE

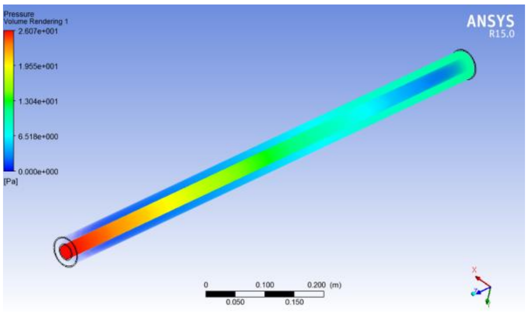

Fig. 6.3Pressure Difference in Normal DPHE

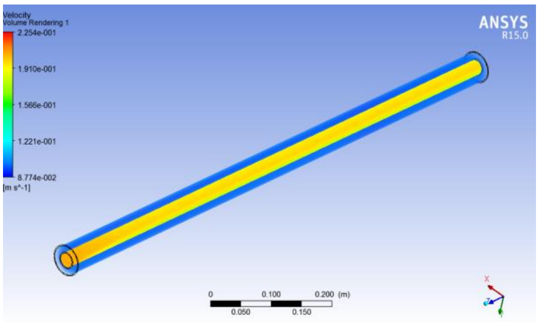

Fig. 6.4Velocity Difference in Normal DPHE

B. Helical Fins

Table 6.2 Temperature Difference in Helical Fins

Hot Water			Cold Water		
Flow Rate	Inlet	Outlet	Flow Rate	Inlet	Outlet
LPM	℃	℃	LPM	℃	℃
2	60	51.94	8	30	32.09
4	60	54.10	8	30	32.97
6	60	55.21	8	30	33.57

The Helical Fins model shows the best flow rate temperature difference in Numerical & graphically represented below Fig. 6.5 & 6.6. Furthermore, Pressure and Velocity graphically mention Fig. 6.7 & 6.8.

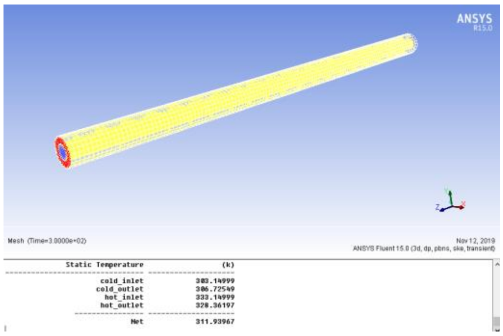

Fig. 6.5 Numerical Temperature Difference in Helical Fins

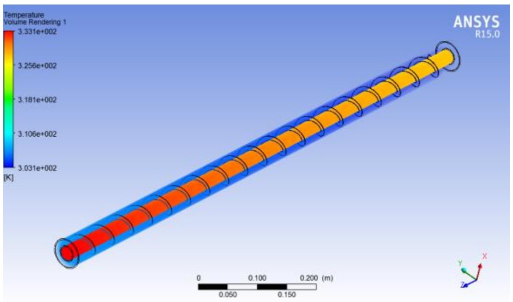

Fig. 6.6Graphically Temperature Difference in Helical Fins

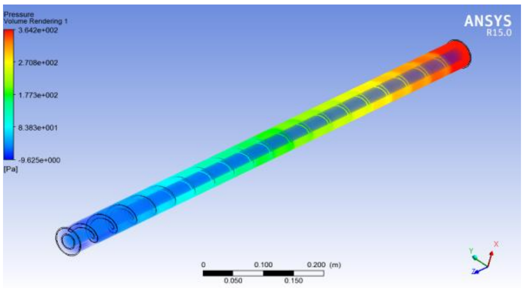

Fig. 6.7Pressure Difference in Helical Fins

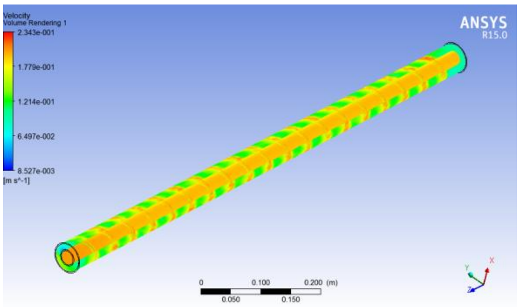

Fig. 6.8Velocity Difference in Helical Fins

C. Helical Fins with Flat Plate

Table 6.3 Temperature Difference in Helical Fins with Flat Plate

Hot Water			Cold Water		
Flow Rate	Inlet	Outlet	Flow Rate	Inlet	Outlet
LPM	℃	℃	LPM	℃	℃
2	60	51.29	8	30	32.22
4	60	53.67	8	30	33.16
6	60	54.91	8	30	33.78

The Helical Fins with Flat Plate model shows the best flow rate temperature difference in Numerical & graphically represented below Fig. 6.9 & 6.10. Furthermore, Pressure and Velocity graphically mention Fig. 6.11 & 6.12.

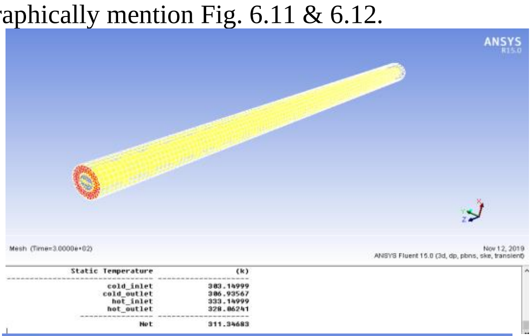

Fig. 6.9 Numerical Temperature Difference in Helical Fins with Flat Plate

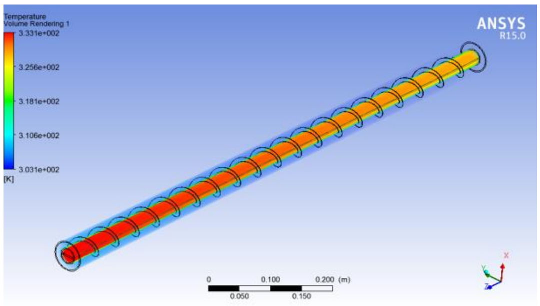

Fig. 6.10Graphically Temperature Difference in Helical Fins with Flat Plate

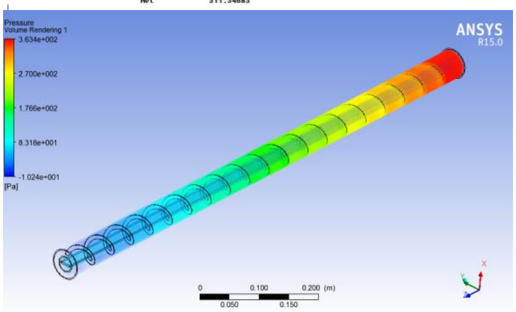

Fig. 6.11Pressure Difference in Helical Fins with Flat Plate

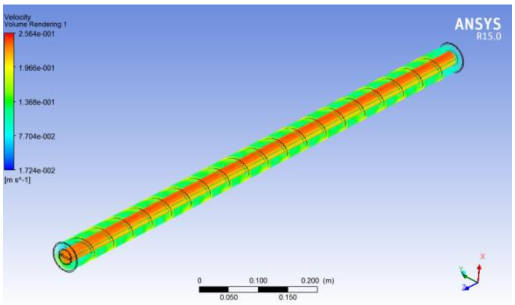

Fig. 6.12Velocity Difference in Helical Fins with Flat Plate

VII. RESULT & CONCLUSION

Table 7.1 Overall Temperature Difference

Input Data				Normal		Helical Fins		Helical Fins with Flat Plate	
Hot Flow Rate	Cold Flow Rate	Hot Inlet	Cold Inlet	Hot Outlet	Cold Outlet	Hot Outlet	Cold Outlet	Hot Outlet	Cold Outlet
LPM	LPM	℃	℃	℃	℃	℃	℃	℃	℃
2	8	60	30	53.19	31.75	51.94	32.09	51.29	32.22
4	8	60	30	55.49	32.25	54.10	32.97	53.67	33.16
6	8	60	30	56.56	32.54	55.21	33.57	54.91	33.78

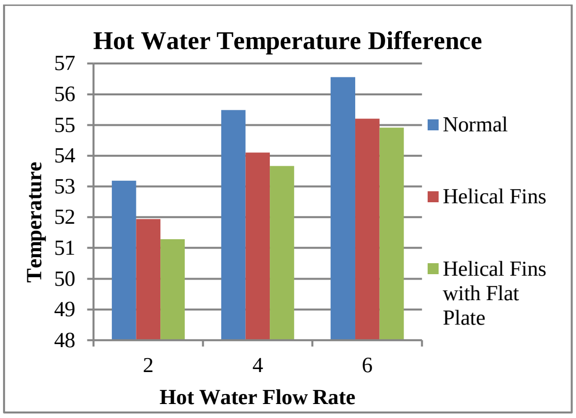

Fig. 7.1 Hot Water Temperature Difference

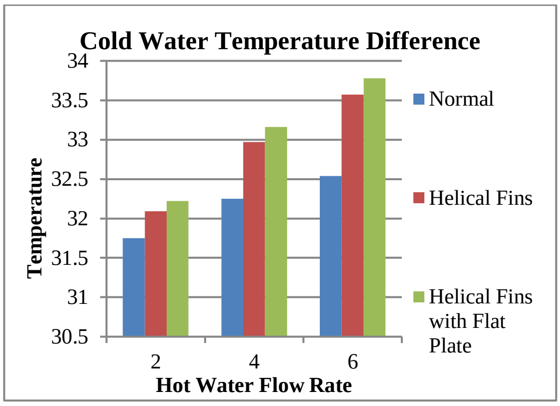

Fig. 7.2 Cold Water Temperature Difference

CONCLUSION

In our project area double pipe heat exchanger in Plain tube (PT), Plain tube with Helical fins, and Helical fins with inserts, yields better thermal performance due to the effect of Helical fins with an insert which acted as an additional turbulator which improves turbulent intensity in the flow path that leads to higher heat transfer enhancement.

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