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Analysis of Helical Shape Tube Type Heat Exchanger using CFD

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ABSTRACT

Heat Exchangers are generally used for transferring of heat from one part/ fluid to another. There are various types of heat exchangers. Among all, tube type heat exchangers with helical profile show better result. The flow in heat exchangers can be Parallel flow or counter flow.

In the present work, CFD analysis of a helical shaped heat exchanger for parallel as well as counter flow conditions has been done. In this work, CFD analysis for the performance analysis of counter-flow type flow condition has been carried out. The various parameters such as temperature plots, velocity vectors, Nusselt number, heat transfer rate from the wall of the tube has been calculated using ANSYS 13.0. It has been found out that the results are approximately similar for counter-flow and parallel flow conditions for the considered helically shaped tube type heat exchanger.

KEYWORDS: *heat exchangers, helical coil tube type heat exchangers, CFD, parallel flow, counter flow*

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INTRODUCTION

Heat exchangers are commonly used to transfer heat flux from one place to another. Heat exchanged between flowing fluids is one of the most important physically processes of concern in many industries. Different types of heat exchangers are used according to different requirements such as, in food industries, in refrigeration and air-conditioning plants, nuclear power plant etc.

Tubular heat exchangers are one of the best types of heat exchangers, built mainly of circular tubes. These heat exchangers are used in a large amount due to flexibility in design parameters such as the diameter, length and the arrangement of coils and they can be easily modified. These types of heat exchangers are basically used for liquid-to-liquid heat transfer.

This type of heat exchangers are classified into shell and tube, double pipe and spiral tube heat exchangers.

The double pipe or the tube in tube kind device is a sort of device consisting of 1 pipe placed concentrically within another pipe having a bigger diameter. In these types of devices 2 varieties of flows are possible: parallel flow and counter-flow. They are often organized in a heap of series and parallel in line with totally different heat transfer needs. The curvature of the tubes creates a secondary flow that is traditional to the first axial direction of flow. This secondary flow will increase the heat transfer rate between the wall and also the flowing fluid and provide a bigger heat transfer space at intervals eithin low volumes, with bigger heat transfer coefficients.

Various configurations of these kind of heat exchangers are possible. The fundamental and most typical style consists of a series of stacked helically involute tubes placed in an exceedingly cylindrical outer cowl. The tube ends are connected to manifolds that act as fluid entry and exit locations. The outer tube is additionally given each manifold so cooling fluid can easily pass through it.

The tube bundle is made of variety of tubes stacked atop one another, and also the entire bundle is placed within a turbinate casing, or shell. The advanced fluid-dynamic inner arced coil heat exchangers offers them benefits over the performance of tubes in terms of magnitude relation of area/volume and enhancing of warmth and mass transfer constant.

LITERATURE REVIEW:

Nephron P., 2007, studied regarding the thermal performance and pressure drop of the spiral-coil device with and while not helical crimped fins. **Jayakumar J.S. et al., 2008,** studied work done by several researchers for increasing of warmth transfer with the help of spiral coil device. **Goodarzi et al., 2015** by experimentation investigated the result of various practical valence teams on the thermal physical properties of carbon nano-tubes. **Hasanpour et al., 2016**, by experimentation studied a double pipe device with tubing furrowed full of numerous classes of twisted tapes from standard to changed sorts. **Hussain et al., 2016,** studied regarding the assorted heat exchangers. **Deshmukh et al., 2016**, used FLUENT to seek out temperature contours for spiral coil heat exchangers.

Nilay et al., 2017, ended that CFD could be a sensible tool to predict the performance of heat exchangers. **Nilay et al., 2017** have used CFD for analysis of spiral whorled device. **Sheeba et al**, 2019, did experimental and numerical investigations on a spiral coil double pipe device. **J.S. Jayakumar** developed a correlation so as to judge the HTC of the coil. The analysis was carried out for boundary conditions for constant wall temperature and constant wall heat flux. **S.M. Mahajani** studied the constant thermal and transport properties of the heat transfer medium and their result on the prediction of HTC. **Nawras H. Mostafa** studied regarding the mechanical and thermal performance of elliptical tubes used for compound heat exchangers. **Timothy J. Rennie** studied about the heat flux transfer characteristics of a double pipe spiral coil device for parallel as well as counter flow conditions. **Maher Rehaif Khudhair** by experimentation validated the numerical results with experimental values and analysed results along with development of a correlation for the inner heat transfer constant. **Ramachandran Manickam** showed that the symmetry of the plane assumption worked well for the length of the heat flux exchanger however not within the outlet and body of water regions. It had been advised that the model might be improved by opting Reynold Stress models. The HTC was found to get on the lower facet as a result of there wasn't abundant contact between the fluids. It had been advised that the performance along with design might be improved by considering the cross flow regions rather than the parallel flow.

PROBLEMS AND OBJECTIVES

Problem Identification

Available experimental data regarding the behavior of the fluid in helical coils is not properly. Heat transfer between any surface and the fluid within the zone has been a major issue.

Objective of the work

- To determine the heat transfer characteristics for different design parameters
- To find the heat transfer characteristics for a helical coil heat exchanger for different flow regimes.
- Study different types of fluid flow range extending from laminar flow through transition to turbulent flow.

METHODOLOGY

In Computational Fluid Dynamics (CFD), study of any system starts with the design of desired geometry and meshing for modeling the domain. Meshing is known as the discretization of the considered domain into tiny volumes wherever the flow equations are resolved by the assistance of repetitive ways. Modeling starts with the describing of the boundary and initial conditions for the dominion. Finally, it's followed by the analysis of the results, graphical plots, computed values using function calculator.

Modeling and Meshing

Heat exchanger is designed in CATIA. The design specifications of the helically coiled heat exchanger are shown in Fig. 1. For next step, the geometric model is imported to ANSYS for CFD analysis

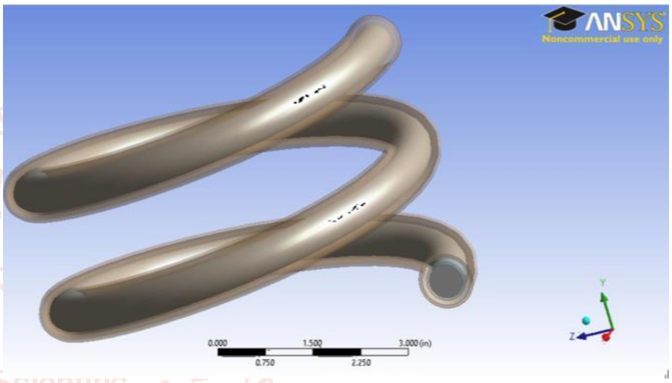

Fig 1: Geometry of considered helically coiled heat exchanger

The next action is to discretize the domain. Automatic meshing has been used for descritisation.

Boundary Conditions

For any simulation boundary conditions are needed to be specified. The specified boundary conditions are specified in Table 1.

Table 1: Boundary Conditions

	Boundary condition	Velocity magnitude m/s	Turbulent Kinetic Energy m^2/s^2	Turbulent Dissipation Rate m^2/s^3	Temp. k
I.I.	V.I.	0.994	0.01	0.1	348
I.O.	P.O.	-	-	-	-
O.I.	V.I.	1.88	0.01	0.1	283
O.O	P.O.	-	-	-	-

RESULTS AND DISCUSSIONS-

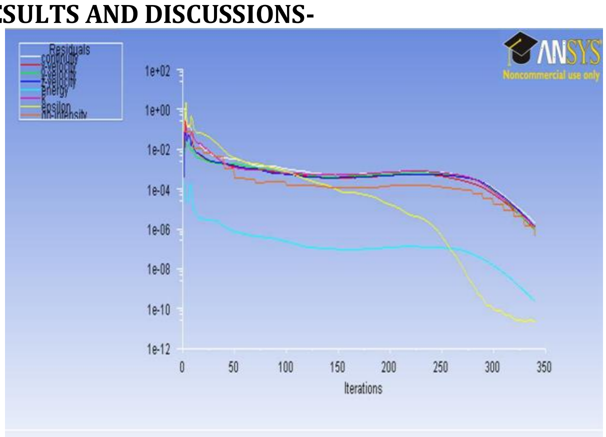

Fig 2: Scaled Residuals

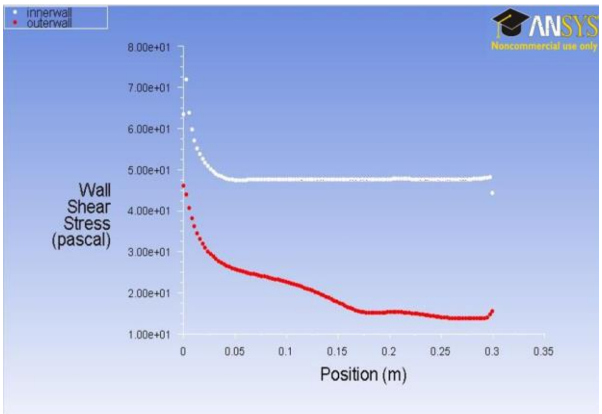

Fig 3: Wall Shear Stress Plot

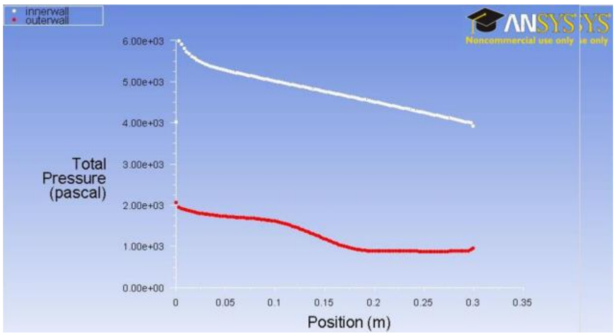

Fig 4: Total Pressure Plot for Inner-wall And Outer-wall

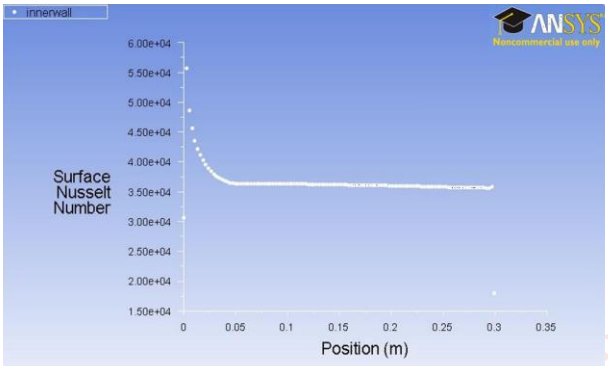

Fig. 5: Surface Nusselt Number Plot for Inner-wall

Table 2: Values of Heat Transfer Rate at various location

Heat Transfer Rate (Total)	(w)
inner_inlet	30626.679
inner_outlet	-23526.716
outer_inlet	-13529.476
outer_outlet	6429.4192
Net	-0.094444952

CONCLUSIONS

The CFD results in comparison with the experimental results from various studies show that the error was found to be within acceptable limits. This study shows that there's not a lot of revision in heat transfer for parallel likewise as counter flow for the desired device.

So, it may be finished that there's not a lot of distinction within the heat transfer performance of the parallel-flow and also the counter-flow configurations. Nusselt number was additionally calculated at many different points on the pipe length using the numerical information. The value of Nusselt number for the pipes was found to be varying from 335-360. From the velocity vector plot it had been found that the fluid particles were undergoing associate degree oscillating motion within each the pipes. From the pressure and temperature contours it had been found that on the outer facet of the pipes the rate and pressure values were higher as compared to the inner values.

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