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CFD Simulation of Heat Transfer Enhancement in Twisted Tape Insert Heat Exchangers

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Abstract— This study investigated the influence of twisted tape inserts on heat transfer enhancement within a heat exchanger using Computational Fluid Dynamics (CFD) analysis. The primary objective was to elucidate the correlation between the number of turns in the twisted tape and key performance parameters such as heat transfer rate, pressure drop, and overall exchanger effectiveness. A three-dimensional CFD model of the heat exchanger geometry was developed, incorporating twisted tape inserts with varying numbers of turns. The employed turbulence models accurately captured the complex flow behaviour induced by the twisted tapes. By simulating fluid flow and thermal behaviour within the exchanger, the research aimed to establish a relationship between twisted tape geometry, flow patterns, and the resulting heat transfer performance.

Index Terms- CFD (computational Fluid Dynamics), HE (Heat Exchanger) NA (Numerical Analysis).

I. INTRODUCTION

It is well known that heat transfer is considerably improved if the flow is stirred and mixed well. This has been the underlying principle in the development of enhancement techniques that generate swirl flows. Helical tape insert mixes the bulk flow well therefore heat transfer increases. Among the techniques that promote secondary flows, helical-tape inserts are perhaps the most convenient and effective. They are relatively easy to fabricate and fit in the tubes of shell-and-tube or tube-fin type heat exchangers.

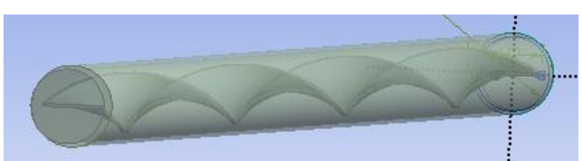
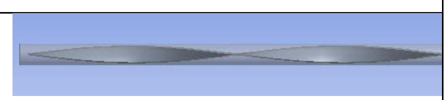
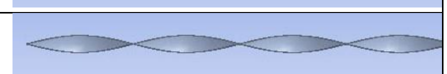


Fig. CAD model of twisted tape pipe

II. METHODOLOGY

The basic objective of the thesis is to optimize the performance of heat exchanger by mean of using twisted inserts inside the pipe. The geometric parameter and flow parameter is optimize by minimising the rate of entropy generation. The model under analysis is shown in the figure the heat exchanger consist of constant heat flux on the outer wall of the pipe. The diameter of the pipe is consider as 0.026 m with 2 mm thickness and overall length of the pipe is taken as 1 m.

Pitch of helical twisted tape Heat Exchanger

S. No.	Par a-met er	Si ze	Diagram
1	No of Tur n	3	
2		4	
3		5	

- Meshing of Geometry

In the pre-processor phase, along with the geometry of the structure, the constraints, loads and mechanical properties are defined. Thus, in pre-processing, the entire body is completely defined by the geometric model. The model or structure represented by nodes and elements is called "mesh".

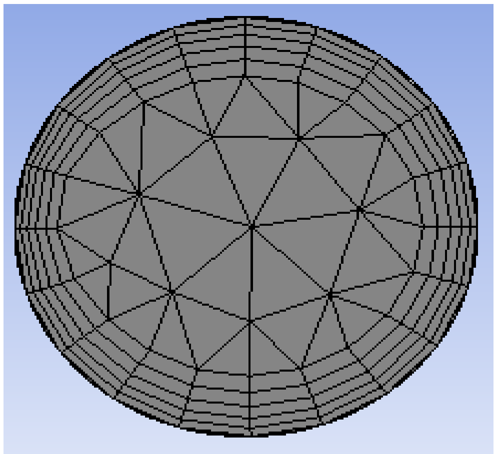


Fig. Meshing of Pipe End

III. RESULT AND DISSUSION

The current research work is based on the investigation of effect of using twisted tape in the heat transfer between the cold and hot media with add of different twist in helical tape. In order to find out the best suitable configuration of pitches or turn of tape we using 3, 4 and 5 no. of turn for twisted tape and applied the same boundary condition for all. The CFD result of the combination of assembly of pipe for heat exchanger is presented here to critically analyse and choose the correct combination.

- CFD Result of Twisted Tape

In order to analyse the result obtained by simulation of heat exchanger we compare the result of CFD analysis with the result obtained by all configuration of HE with twisted tape. After the 1000 simulation in between the time and energy with respect to x and y axis and heat exchanger we got following result which shown on table below. Here the inlet velocity of cold water is 0.05 m/s while the temperature difference between hot and cold fluid is maintain as 30K.

CFD result of twisted tape insert tube with varying no. of turns

S No	No of Turn	Inlet Velocity of Hot Water (M/S)	Wall Temp. (K)	Inlet Temp. of Cold Water (K)	Outlet Temp. of Cold Water (K)
1	3	0.05	330	300	307
2	4				311
3	5				313
4	6				313.2
5	7				313.8

A prominent effect of twisted tape inserts is the generation of a swirling or secondary flow within the heat exchanger channel. As the twisted tape winds its way through the tube, it disrupts the laminar boundary layer that naturally forms near the walls. This stagnant layer hinders heat transfer between the hot fluid and the tube wall.

By disrupting this layer, the swirling flow created by the twisted tape promotes a more thorough mixing of the working fluid. Fresh, cooler fluid is brought closer to the hot wall, facilitating a more efficient transfer of thermal energy from the hot stream to the cold stream.

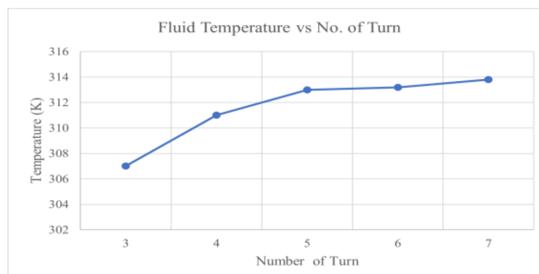
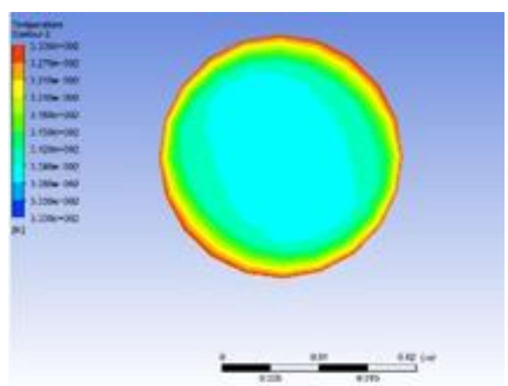


Fig. CFD result of Twisted tape inserts



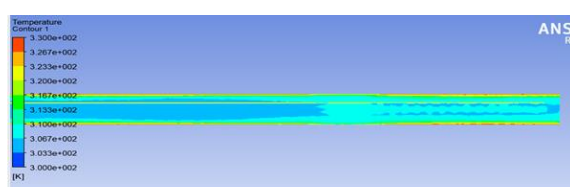


Fig. CFD result of Twisted Tape with 3 Turn

CONCLUSION

The CFD analysis employed a three-dimensional model of the heat exchanger geometry, incorporating twisted tape inserts with varying numbers of turns. By simulating fluid flow and thermal behaviour, we sought to establish a correlation between twisted tape geometry, flow patterns, and heat exchanger performance.

The results from the CFD analysis revealed a clear trend: increasing the number of turns in the twisted tape insert generally led to a positive impact on heat transfer. This improvement can be attributed to the following mechanisms:

- Swirling Flow and Boundary Layer Disruption: Twisted tapes induce a secondary or swirling flow within the heat exchanger channel. This disrupts the stagnant boundary layer that forms near the walls, hindering heat transfer. By promoting the mixing of the working fluid, fresh, cooler fluid is brought closer to the hot wall, facilitating a more efficient transfer of thermal energy.
- Enhanced Turbulence: Twisted tapes also introduce turbulence into the flow. While this turbulence increases pressure drop, it further enhances heat transfer. Turbulent eddies act as miniature mixers, constantly bringing hot and cold fluid parcels into closer contact, accelerating thermal energy exchange.

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